May 1893.

T. Parkinson.

A MANUAL

OF

BOTANY

INCLUDING THE

STRUCTURE, CLASSIFICATION, PROPERTIES, USES, AND FUNCTIONS OF PLANTS

BY

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FIFTH EDITION

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To

HENRY BOWMAN BRADY, F.R.S., F.L.S., F.G.S., &c.

A FORMER PUPIL,

WHO HAS HIGHLY DISTINGUISHED HIMSELF

BY HIS RESEARCHES

ESPECIALLY ON THE FORAMINIFERA

This Work is Dedicated

WITH EVERY FEELING OF REGARD AND ESTEEM

AND IN GRATEFUL REMEMBRANCE OF AN UNBROKEN FRIENDSHIP

THROUGH A LONG SERIES OF YEARS

BY HIS VERY SINCERE FRIEND

THE AUTHOR

PREFACE

TO

THE FIFTH EDITION.

In the Preface to the First Edition of this Manual, the author fully explained the objects he had more especially in view in its preparation, and the principal sources from whence he had derived the materials necessary for its compilation. That such a work was needed, is proved in a marked degree by the sale of four very large editions; and in issuing this Fifth Edition, the Author cannot but express the gratification he feels at the satisfactory results which have attended his labours, and he also takes this opportunity of again returning his sincere thanks to many kind friends and correspondents for the assistance they have rendered him, by their suggestions, and by the communication of many valuable facts.

In the last edition attention was especially directed to the fact that, in consequence of the very great advances made within the last few years in the science of Botany on the Continent of Europe, and more especially in Germany, the work had been very carefully revised throughout, and in the subjects of Histology, Physiology, and the Reproductive Organs of the Cryptogamia, almost rewritten. The great and continued advances in these subjects since the last edition have again rendered it necessary to make numerous changes and alterations in these portions, and to add several new woodcuts; and in so doing the author has to express his obligations to Mr. J. W. Groves, Curator of the Anatomical Museum, and

Demonstrator of Practical Biology in King's College, London, for the valuable assistance he has rendered generally, but more especially for, in a great degree, revising the Third Book on Physiology. In this edition, so far as the above subjects are concerned, the standard works of Sachs, De Bary, Eichler, Strasburger, Van Tieghem, Luerssen, Vines, and Bower have been more particularly consulted, besides a large number of original memoirs published in this country and elsewhere.

In the part treating of the properties and uses of plants, many alterations have been also rendered necessary by the progress of science, and the recent issue of a new edition of the 'British Pharmacopœia.' The very large number of plants to be here noticed has compelled the author to be very brief in his descriptions of them individually; but so far as the principal plants employed in medicine are concerned, those readers who require more detailed information are referred to Bentley and Trimen's 'Medicinal Plants,' where coloured figures, botanical descriptions, and other full particulars may be found; and to Flückiger and Hanbury's 'Pharmacographia.'

While the work in all the above particulars has thus been very carefully revised, the most marked change that will be noticed is in the part relating to the Classification of Plants, which, so far as the Phanerogamia are concerned, has been very materially modified, and in some parts rewritten, in order to adapt it in all essential particulars to the arrangement adopted in the great work on that subject, the 'Genera Plantarum' of Bentham and Hooker, which has been published in a complete form since the last edition of this Manual was issued; and which cannot fail to be the standard work on the subject for many years. Important changes have also been made in the Classification of the Cryptogamia, but, so far as these plants are concerned, their arrangement at present must be regarded as transitional; and hence, as their full description is beyond the scope of this Manual, advanced students must refer to special treatises for detailed notices of the arrangement and characters of the several groups of the Cryptogamia, and more especially of the Thallophytes.

The present edition having been thus carefully revised in all its parts, adapted, as far as possible, to the present state of botanical science, and supplemented by very copious and carefully prepared indexes, which have been kindly prepared for him by a friend, the author confidently believes that it will, even better than the preceding editions, serve as a convenient, intelligible, and correct as well as comprehensive Manual for students ; and will also be very useful as a work of reference to those engaged in commercial pursuits, who, having constantly to make use of substances derived from the Vegetable Kingdom, require accurate and condensed information on the Properties and Uses of Plants.

LONDON : *January*, 1887.

PREFACE

TO

THE FIRST EDITION.

THE principal design of the author in the preparation of the present volume was, to furnish a comprehensive, and at the same time a practical, guide to the Properties and Uses of Plants, a part of Botany which in the majority of manuals is but very briefly alluded to. He hopes that in this respect the present Manual may serve as an introduction to works devoted particularly to Materia Medica and Economic Botany; and thus form a text-book of especial value to medical and pharmaceutical students; as well as a work of reference generally for those engaged in commercial pursuits who have daily to make use of substances derived from the Vegetable Kingdom.

Another prominent motive of the author was, to furnish the pupils attending his lectures with a class-book, in which the subjects treated of should be arranged, as far as possible, in the same order as followed by him in the lectures themselves. It may be noticed that this order differs in several respects from that commonly followed, but long experience as a teacher has convinced him that it is the most desirable one for the student. Great pains have been taken in all departments to bring the different subjects treated of down to the present state of science; and much care has been exercised in condensing the very numerous details bearing upon each department, and in arranging them for systematic study.

The author makes no claims for this work to be regarded as a complete treatise on the different departments of Botany; it is only intended as a guide to larger and more comprehensive works; but he trusts, at the same time, that it will be found to contain everything which the student of Botany really requires, whether he is pursuing it as a branch of professional or general education, or for pleasure and recreation.

The vast number of facts, observations, and terms necessarily treated of, in the departments of Structural, Morphological, and Systematic Botany, have compelled the author to give but a brief account of the Physiology of Plants; he hopes, however, that, even here, all the more important subjects bearing upon the education of the medical practitioner and pharmacist will be found sufficiently comprehensive. Those who require a more complete knowledge of this department, he would refer to the Second Part of Balfour's 'Class-Book of Botany,' in which valuable work full details upon Physiological Botany will be found.

The author had a great desire, also, to include in the present volume an Appendix upon Descriptive Botany, and a Glossary of Botanical Terms; but the Manual having already exceeded the limits desired, he is unable to do so. The Index itself will, however, serve as a glossary by referring to the pages in which the different terms are defined and explained; and with regard to Descriptive Botany, the author would especially recommend every reader of this work to obtain a small but very valuable work on that subject which has been recently published by Dr. Lindley.

In compiling this volume the author has been necessarily compelled to refer to many works and original memoirs on botanical science, and he hopes that in all cases he has given full credit to the different authors for the assistance they have afforded him. If he has omitted to do so in any instance, it has arisen from inadvertence, and not from design. To the valuable works of Mohl, Jussieu, Schleiden, Mulder, Hofmeister, Asa Gray, and Schacht, among foreign botanists; and to those of Lindley, Balfour, Henfrey, Hooker, Berkeley, Pereira, and Royle, among British botanists, he begs to express his obligations. To his friend, Daniel Hanbury, he is also indebted for much valuable information communicated during the progress of the work. To Lindley's 'Vegetable Kingdom,' Pereira's 'Materia Medica,' and to the many valuable articles upon the Anatomy of Plants in Griffith and Henfrey's 'Micrographic Dictionary' by the lamented Henfrey, the author is more especially indebted.

The last three works will always bear ample testimony to the great research and abilities of their respective authors.

The author has further to express his obligations to his spirited publisher, for the numerous woodcuts which he has liberally allowed him, and to Mr. Bagg for the great skill he has shown in their execution. A large number of these woodcuts have been taken from Le Maout's 'Atlas élémentaire de Botanique,' several from Jussieu's 'Cours élémentaire de Botanique;' others have been derived from the works of Schleiden, Mohl, Hofmeister, Lindley, Henfrey, Balfour, &c.; and many are from original sources. By the judicious use of these woodcuts in the text of the volume, it is believed that the value of the work as a Class-book of Botanical Science has been materially increased.

LONDON: *May* 1, 1861.

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Page 189, line 24 from the top, *before* LEAVES, *add* GENERAL VIEW OF THE

,, 282, line 5 from the top, after *marginal*, *add* or *sutural*,

,, 368, line 6 from the bottom, *before* cone, *erase* scale,

,, 424, line 6 from the top, *after* series, *add* in the Monochlamydeæ and Monocotyledones (see pages 648 and 692)

,, 490, line 10 from the bottom, *after* eye, *add* and teeth, &c.

,, 537, between *Parkinsonia* and *Poinciana*, insert—

Piscidia Erythrina, Jamaica Dogwood.—The bark of the root is employed in the West Indies to catch fish. It is said to be a powerful narcotic like opium, and especially useful in neuralgic affections.

,, 608, bottom line, for *Algicera*. read *Ægiceras*.

,, 616, between *Roupellia* and *Tabernæmontana*, insert—

Strophanthus.—The seeds of one or more species of this genus from Equatorial and Western Africa, have been lately introduced into medical practice. *Strophanthus* exerts a much more powerful action upon the heart, and a less energetic action upon the blood-vessels, than digitalis. It is also a good diuretic. The seeds of *S. hispidus* are also said by Fraser to be the active constituents of the Kombé arrow poison.

,, 676, line 15 from the bottom, *after* which, *add* as here defined.

,, 752, line 16 from the top, *for* 100, *read* 350.

MANUAL OF BOTANY.

GENERAL INTRODUCTION.

The various bodies which are situated on the surface of the earth, or combined so as to form its substance, are naturally arranged, both by the common observer and scientific investigator, in three great divisions, called, respectively, the Animal, Vegetable, and Mineral Kingdoms; and as those comprised in the two former are possessed of life, they form the Organic creation; while those of the latter, not being endowed with life, constitute the Inorganic creation. It is our province in this work to treat of the lower members of the organic world, called Plants or Vegetables. The science which has this for its object is termed Botany, from the Greek word βοτάνη signifying an herb or grass.

Departments of Botany.—Botany in its extended sense embraces everything that has reference to plants either in a living or fossil state. It investigates their nature; their internal structure; their outward forms; the laws by which they are enabled to grow and propagate themselves; and their relations to one another, and to the other bodies by which they are surrounded. As a science, therefore, it is of vast extent, and one which requires for its successful prosecution the most careful and systematic study. It may be divided into the following departments:—1. *Morphological Botany*, or the *Comparative Anatomy of Plants*: this comprises everything which relates to the outward forms of plants and their various parts or organs. 2. *Structural Botany*: this treats of plants and their organs in reference to their internal structure, including the description of elementary structure, or *Vegetable Histology*. 3. *Physiological Botany*: this comprises the study of plants, and their organs, in a state of life or action. 4. *Systematic Botany*: this considers plants in their relations to one another, and comprehends a knowledge of the principles upon which they are described, and of their arrangement and classification. 5. *Geographical Botany* is that department which explains the laws which regulate the distribution of plants over the surface of the earth at the present time. And 6, *Palæontological* or *Fossil Botany* is that which describes the nature and distribution of the plants which are found in a fossil state in the different strata of which the earth is composed. The first four departments are those only that come within the scope of the present work ; the two latter being of too special and extensive a nature to be treated of in this Manual. There are also several departments of what may be called *Applied Botany*, which are founded on a knowledge of the above departments, such as *Descriptive Botany*, *Vegetable Materia Medica*, *Agricultural*, *Horticultural*, and *Economic Botany*. To these special works are commonly devoted ; but, so far as the Properties and Uses of Plants are concerned, they will be particularly referred to in this work under Systematic Botany.

Distinctions between Animals, Plants, and Minerals.— Botany being the science which treats of plants, it would naturally be expected that we should commence our subject by defining a plant. No absolute definition of a plant can, however, be given in the present state of our knowledge of the organic world, neither is it probable that, as our knowledge increases, such will ever be the case ; for hitherto the progress of inquiry has shown that there is no distinct line of demarcation between plants and animals, the one passing gradually and imperceptibly into the other. Indeed, until quite recently, it was believed by many that there existed certain organisms which were plants at one period of their lives and animals at another. Thus De Bary, in the year 1859, described the germinating spores of *Æthalium* as producing naked, motile, protoplasmic bodies, which eventually coalesced to form amœboid masses of protoplasm (*plasmodium*), which were destitute of a cell-wall, were able to creep over the surface of the substance upon which they were growing, and to take into their interior and digest solid matters, after the fashion of a true *Amœba*, of the animal nature of which there can be no doubt ; and so while in this stage he regarded *Æthalium* as an animal. After a time, however, the plasmodium becomes quiescent, divides into an immense number of small portions, each of which clothes itself with a wall of cellulose, and becomes a spore ; and in this later stage he regarded *Æthalium* as a plant. But as the more recent researches of De Bary and others show that this amœboid condition is of frequent recurrence in certain stages of many organisms, of the plant nature of which there can be no possible question, *Æthalium* is now relegated to the Vegetable Kingdom alone. Nevertheless, even if the belief in the double nature (plant and animal) of certain organisms does not now exist, naturalists are far from agreeing as to what in all cases shall be regarded as a plant or as an animal. Thus, while Stein looks upon such a complex structure as

Volvox as undoubtedly animal, other authors of equal repute acknowledge it as a plant.

There are, indeed, even some naturalists who believe that there is no line of demarcation between plants and minerals, but that simple organisms can be, and are, formed out of inorganic matter; but, notwithstanding the ability and ingenuity with which these views have been supported, we hold such notions to be purely speculative, and continue to maintain that the possession of individual life and power of reproduction in the former, constitute at once, without further investigation, a broad and well-marked line of demarcation from the latter. Even when we compare plants with animals, so long as we confine our researches to the higher members of the two kingdoms, the distinctions are evident enough; difficulties only occur when we look deeply into the subject and compare together those bodies which are placed lowest in the scale of creation, and stand as it were on the confines of the two kingdoms. It is then that we find the impossibility of laying down any certain characteristics by which all the members of the two kingdoms may be absolutely distinguished. We shall at present, therefore, confine our attention to those characters by which plants may as a general rule be distinguished from animals, but to which exceptions may be found when we compare particular individuals, leaving the more extended investigation of the subject to the future pages of this volume.

In the first place, we find that plants hold an intermediate position between minerals and animals, and derive their nourishment from the earth and the air or water by which they are surrounded, and that they alone have the power of converting this inorganic or mineral matter into organic. Animals, on the contrary, live on organic matter, and reconvert it into inorganic. In other words, plants produce organic matter, and animals consume it.

Secondly, plants are generally fixed to the soil, or to the substance upon which they grow, and derive their food immediately by absorption through their external surface: while animals, being possessed of sensation and power of voluntary motion, can wander about in search of the food that has been prepared for them by plants and by other animals, and which they receive into an internal cavity or stomach. Plants are, therefore, to be regarded as destitute of sensation and power of voluntary motion, and as being nourished from without; while animals are possessed of such attributes, and are nourished from within.

Thirdly, the action of plants and animals on the atmosphere is different. Thus, during the process of what has been called assimilation, plants decompose the carbon-dioxide of the air or water in which they are growing, and, uniting the carbon, which is obtained from this decomposition, with the elements of water, to form starch or some other carbohydrate, restore the oxygen to the atmosphere or water. Animals, on the contrary, during the process of respiration take into their tissues free oxygen, and return, in its place, to the surrounding medium in which they live, carbon-dioxide, the result of the combination of the superfluous carbon in the animal system with the oxygen which has been inhaled. Plants, therefore, in assimilation absorb carbon-dioxide and eliminate oxygen ; while animals in respiration absorb oxygen and eliminate carbon-dioxide.

Fourthly, while all plants and animals are made up of cells, those of the latter do not develop upon their exterior any substance materially differing from the more internal protoplasm ; but the whole substance of the cell is more or less homogeneous, and consists throughout of matter which is essentially composed of the four elements, Carbon, Oxygen, Hydrogen, and Nitrogen, together with some Sulphur and Phosphorus. The protoplasmic mass of the cells of plants, which is also essentially composed of the same constituents, on the other hand, sooner or later, as a general rule, becomes changed on its outer surface, where a membranous covering is developed termed the *cell-wall*, composed of *cellulose*, and therefore consisting entirely of the three elements, Carbon, Oxygen, and Hydrogen. Plants, then, are made up of cells, the protoplasm of which is enclosed in a cell-wall of cellulose, while animals are made up of cells which have no such cell-wall.

Fifthly, the presence of starch was also formerly considered as a diagnostic character of plants ; but it is now known that this substance, or at least one isomeric with, and presenting the same general appearances as it, is also to be found in the tissues of animals.

In reference to the above distinctive characters, therefore, it should be especially noticed that they are only general, namely, those derived from comparing together, as a whole, the members of the Animal and Vegetable Kingdoms ; and that to all such characters some exceptions may be found when we compare particular individuals. We arrive accordingly at the conclusion that it is impossible to give a complete and perfect definition of a plant, or, in other words, to lay down any single character by which plants can in all cases be distinguished from animals. In determining, then, whether an organism under investigation be a plant or an animal, the naturalist must first take into his consideration, not any one character alone, but the sum of all the characters which it may exhibit.

Since there are many organisms which it is very difficult to assign with any certainty either to the Vegetable or Animal Kingdom, as some of their characters indicate that they belong to the one and some to the other kingdom, Haeckel proposes that all these should be grouped together into a third kingdom to be called ‘ Protista.’

BOOK I.

MORPHOLOGICAL AND STRUCTURAL BOTANY.

THE most superficial examination by the unassisted eye of any of the more highly developed plants enables us to distinguish various parts or organs, as root, stem, leaves, and the parts of the flower. A similar examination of plants of lower organisation presents to our notice either the same organs, or organs of an analogous nature to those of the higher plants. By a more minute examination of these several organs by the microscope, it will be found that they are all made up of others of a simpler kind, in the form of little membranous closed sacs, called cells, and elongated tubular bodies, of various forms, sizes, and appearances, which are combined in various ways. Hence, in describing a plant we have two sets of organs to allude to, namely, the compound organs or those which are visible to the naked eye, and the elementary structures of which they are composed. A knowledge of these elementary structures or building materials of plants is absolutely essential to a complete and satisfactory acquaintance with the compound organs; but, previously to describing them, it will materially assist our investigations if we give a general sketch of the compound organs and of the plants which are formed by their union. According to the number of these compound organs, and the greater or less complexity which they exhibit, so, in a corresponding degree, do plants vary in such particulars. Hence we find plants exhibiting a great variety of forms; that part of Botany which has for its object the study of these forms and their component organs is called Morphology; while that part which relates to their internal structure, including the description of elementary structure or Vegetable Histology, is commonly termed Structural Botany. These two parts together constitute what has been termed Organography. These parts are most conveniently studied together; we shall therefore, after describing the general morphology of the plant, and the elementary structures which are common to all parts of plants, proceed to consider separately the different organs which are made up of these elementary structures both with reference to their outward forms and internal stucture.

CHAPTER 1.

GENERAL MORPHOLOGY OF THE PLANT.

THE simplest plants, such as the Red Snow (*Protococcus*), or *Glœocapsa*, consist of a single membranous sac, or *cell* as it is termed, which in form is more or less spherical or oval. In *Protococcus* (*fig.* 1) the cells separate almost as soon as formed, while in *Glœocapsa* they remain bound together by an environing capsule of gelatinous matter, formed from the cell-wall, for a

FIG. 1.

FIG. 2.

Fig. 1. Several Red Snow plants (*Protococcus* (*Palmella*) *nivalis*), magnified.
Fig. 2. Two plants of *Oscillatoria spiralis.*

longer or shorter period. As, however, this matter absorbs more water, it is gradually dissolved away and the cells are set free. In plants immediately above these in point of complexity we find the cells still all alike, but instead of being separated and each forming a distinct plant, they are joined end to end and form a many-celled filament which is either straight or variously curved, as in *Oscillatoria* (*fig.* 2). All these plants—so far at least as is known—multiply by division of their cells only; but a little higher in the scale we meet with plants in which certain of their cells perform the function of nutrition, while others are set apart for the purpose of reproduction. Thus, in the Moulds, such as *Mucor* (*fig.* 3), or *Penicillium* (*fig.* 4), the cells which serve as organs of nutrition are elongated simple or branched filaments, termed *hyphæ* (see page 49), which lie upon the surface of the substance furnishing the plants with food; while those destined to reproduce the individual are developed in globular cavities (*sporangia*), as in *Mucor* (*fig.* 3); or are arranged in necklace-like branches at the end of special filaments, as in *Penicillium* (*fig.* 4).

Yet a little higher in the scale of vegetable life we find the cells so combined as to form leaf-like expansions (*fig.* 5), or solid axes (*fig.* 6), as well as special organs of reproduction (*fig.* 5, *t*, *t*).

But these cells are all more or less alike, so that no true distinction can be drawn between the often very different looking parts we meet with in such plants as a sea-weed or a mushroom. Such a combination of similar cells, whatever the precise form may be, which presents no differentiation of leaf, stem, and root, is called a *thallus* or *thallome*, and every thallus-producing plant is therefore termed a *Thallophyte* or *Thallogen*. Under the head of Thallophytes we comprise all those simpler forms of plants which are commonly known as Algæ, Lichens, and Fungi.

FIG. 3.

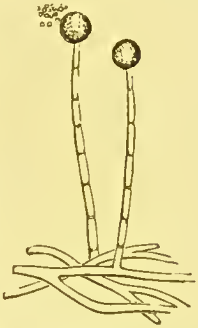


FIG. 4.

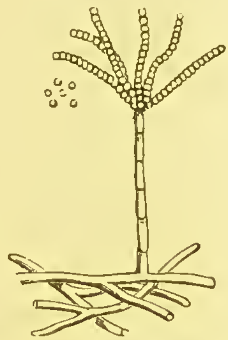


Fig. 3. A species of Mould (*Mucor*), with branched mycelium (*hyphal tissue* or *hyphæ*) below, from which two stalks are seen to arise, each of which is terminated by a sac (*sporangium* or *ascus*), from which a number of minute bodies (*spores*) are escaping.——*Fig.* 4. Another Mould (*Penicillium glaucum*), with branched mycelium (*hyphal tissue*), and a stalk bearing several rows of cells, which are the germinating spores (*conidia*).

FIG. 5.

Fig. 5. Thallus or thallome of the common Bladder Sea-weed (*Fucus vesiculosus*). *t*, *t*. The fructification. *v*, *v*. Bladders of air.

FIG. 6.

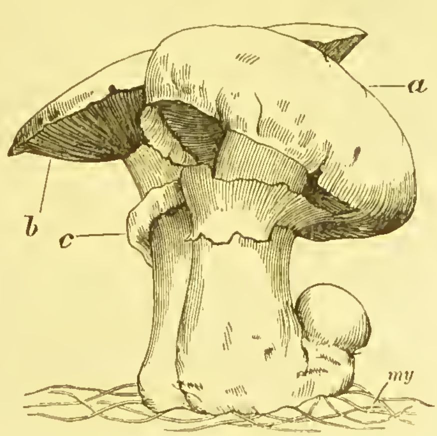


Fig. 6. The common Mushroom (*Agaricus campestris*). There are three receptacles (*fructification*), arising from the mycelium, *my*, below : one young and nearly globular, and two mature. *a*. Pileus. *b*. Lamellæ. *c*. Annulus.

Again, as all Thallophytes are composed of cells which approach more or less closely to the spherical or oval form, or if elongated are thin-walled and commonly flexible, they are also

Fig. 7.

Fig. 8.

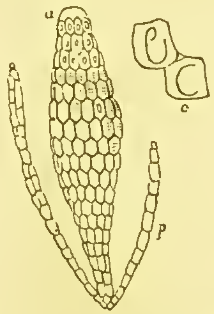
Fig. 9.

Fig. 10.

Fig. 7. A portion of the flat thallus-like stem of *Marchantia polymorpha*, showing an antheridial receptacle, *r*, supported on a stalk, *s*.——*Fig.* 8. *Jungermannia bidentata*. The stem is creeping, and bears numerous small imbricated leaves.——*Fig.* 9. Female plant of the Hair-moss (*Polytrichum commune*), with its leaves, stem, and fructification.——*Fig.* 10. The male plant of the same, with its stem and leaves, and terminated by the male organs (*antheridia*).

termed *Cellular Plants*, in contradistinction to those above them in order of development, which are called *Vascular Plants*, on account of their commonly possessing, in addition to these cells which are termed parenchymatous, elongated thick-walled cells, called prosenchymatous or wood-cells (see page 39); and also, in most cases, except in the intermediate orders of Liverworts and Mosses, variously formed tubular organs which are known under the name of vessels.

Fig. 11.



From the Thallophytes, by various intermediate stages, through an order of plants called Liverworts, we arrive at another order—the Mosses. In the lower forms of the Liverworts, e.g. *Marchantia* (*fig.* 7), we have a green flat thallus-like stem bearing upon its under-surface scale-like appendages, the first representatives of true leaves. In the higher forms, as *Jungermannia* (*fig.* 8), the stems and leaves are both more highly developed. In the Mosses, e.g. *Polytrichum* (*figs.* 9 and 10), the stems often contain elongated cells, which are to a certain extent thickened, and differ little from the true wood-cells met with in the more highly developed plants; this tissue, too, is often prolonged into the leaf, when it forms a midrib. Correlated with this greater development of the organs of nutrition we find the reproductive apparatus similarly advanced in complexity of structure. The female element, or *oosphere*, consists of a mass of protoplasm, called the *germ* or *embryonic cell*, situated in the interior of a flask-shaped cellular organ, the *archegonium*, and this is fertilised by small spirally-wound filaments or *antherozoids*, which are developed in cells, termed sperm-cells (*fig.* 11, *c*), formed inside a cellular sac-like structure called the *antheridium* (*fig.* 11, *a*). The result of this fertilisation is what is commonly termed the fructification (*fig.* 9), which will be hereafter described.

Fig. 12. Fig. 13.

Fig. 11. Antheridium, *a*, of the Hair-moss (*Polytrichum*), containing a number of cells, *c*, in each of which there is a single *antherozoid*. *p. Paraphyses*, surrounding the antheridium.——*Fig.* 12. The common Club-moss (*Lycopodium clavatum*).——*Fig.* 13. Fructification of the Great Water Horse-tail (*Equisetum maximum*), forming a cone-like mass at the end of the stem.

The Liverworts and Mosses are, however, destitute of true roots and vessels, such as exist in the next and all the higher groups of plants.

Still ascending, we find in the Club-mosses (*fig.* 12), Selaginellas, Pepperworts, Horsetails (*fig.* 13), and Ferns (*fig.* 14), a continued advancement in complexity of structure, vessels of different kinds make their appearance for the first time, and the stems are frequently of considerable size and height. *Cala-*

Fig. 14.

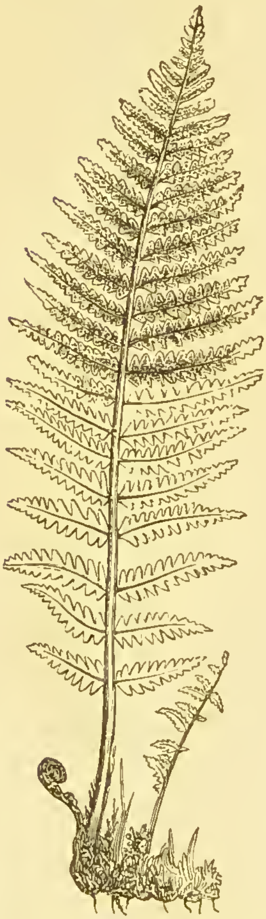


Fig. 15.

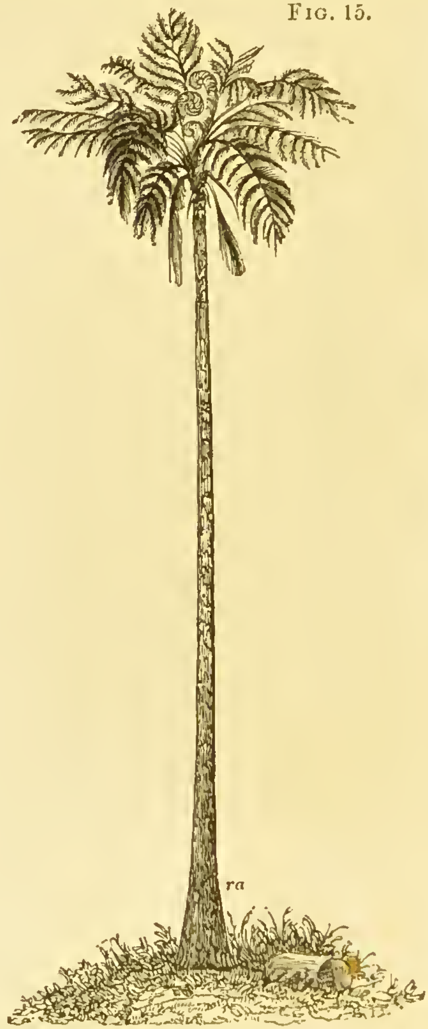


Fig. 14. The Male Fern (*Aspidium Filix-mas*).——*Fig.* 15. A Tree-fern, showing a tuft of leaves (*fronds*) at the apex of a cylindrical stem, which is enlarged at its base, *ra*, by the development of a mass of aerial adventitious roots.

mites, an order of plants nearly allied to the Horsetails, and which were extremely abundant during the formation of our coal measures, would appear to have reached the height of our loftiest trees; while at the present day in the tropics and warmer parts of the earth Ferns will frequently attain the height of twenty feet (*fig.* 15), and sometimes even as much as forty feet, bearing on their summit a large tuft of leaves, or, as they are commonly called, *fronds*, a term applied to leaves which, like those of Ferns, bear their fructification or organs of reproduction. In these plants true roots first also appear, but they are generally broken up into numerous small fibres and never become enlarged as in the tap-roots (*fig.* 20, *r*), of the higher flowering plants.

Cryptogamous Plants or Cryptogams.—In all the plants above mentioned we have no evident flowers as in the higher plants, hence they are called *Flowerless*; but their organs of reproduction are very small and inconspicuous, and therefore they are also termed *Cryptogamous*, that is to say, plants with concealed or invisible reproductive organs. These Cryptogamous plants, or Cryptogams as they are commonly termed, are again divided into two groups, called *Cormophytes* and *Thallophytes*; the latter comprising the simpler forms of plants, which, as previously noticed, are commonly known as Algæ, Fungi, and Lichens, and which present no distinction of root, stem, and leaf (*figs.* 5 and 6); and the former group those plants, such as the Liverworts (*figs.* 7 and 8), Mosses (*figs.* 9 and 10), Club-mosses (*fig.* 12), Selaginellas, Pepperworts, Horsetails (*fig.* 13), and Ferns (*figs.* 14 and 15), which present us with an evident stem, bearing leaves, and also, except in the Liverworts and Mosses, true roots and vessels of different kinds.

Phanerogamous Plants or Phanerogams.—All plants above the Cryptogams, from possessing evident flowers or reproductive organs, are termed *Phanerogamous*, *Phanerogams*, or *Flowering*. These latter plants are also reproduced by true *seeds* instead of *spores*, as is the case in all Cryptogams which possess reproductive organs; a seed being essentially distinguished from a spore, from containing within itself in a rudimentary condition all the essential parts of the future plant in the form of an embryo (*fig.* 16); while a spore merely consists of a single cell, or of two or more united, and never exhibits any distinction of parts until it begins to develop in the ordinary process of vegetation, and then only in certain cases.

These Phanerogams also present two well-marked divisions, called respectively the *Angiospermia* and *Gymnospermia*: the former including those plants in which the ovules are enclosed in a case called an ovary (*fig.* 33, *o*, *o*); and the latter, such plants as the Fir and Larch, in which the ovules are naked (*fig.* 17, *ov*) or not enclosed in an ovary. In the Phanerogams we have the highest and most perfect condition of vegetation, and it is to these that our attention will be more especially directed in the following pages. But before proceeding to describe in detail the elementary structures of these and other plants and the different parts or organs which they form by their combination, it will be necessary for us to give a general sketch of the nature and characters of these compound organs, and to explain the meaning of the various technical terms which are employed for their description.

We have already stated that a seed contains an embryo, in which the essential parts or organs of the future plant are present in a rudimentary state. The embryo of the common Pea may be taken for the purpose of illustration (*fig.* 16). Here we find a distinct central axis, *t*, which is sometimes termed the *tigellum* or *tigelle*, the lower part of which is called the *radicle*, *r*; and its upper extremity, which is terminated by two or more rudimentary leaves, is termed ~~the~~ *plumule* or *gemmule*, *n*. This axis is united to two fleshy lobes, *c*, *c*, whose office is of a temporary nature, and to which the name of *cotyledons* has been given. But some seeds only contain one cotyledon in

Fig. 16.

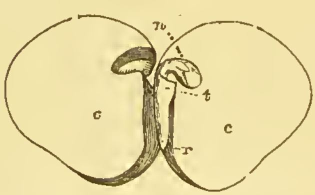


Fig. 17.

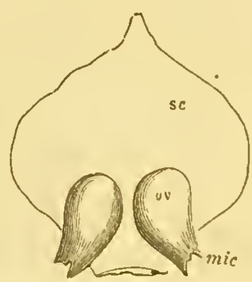


Fig. 16. Dicotyledonous embryo of the Pea, laid open (magnified). *r*. The radicle. *t*. The axis (*tigellum*), terminated by the plumule, *n*. *c*, *c*. The cotyledons.——*Fig.* 17. Bract or carpellary leaf, *sc*, of a species of *Pinus*, bearing two naked ovules, *ov*, at its base. *mic*. The micropyle or foramen.

their embryo, (*fig.* 19, *c*), instead of two as just described in the Pea (*fig.* 16, *c*, *c*); and hence we divide the Phanerogams, or those plants which are reproduced by seeds, into two great classes, called, respectively, Dicotyledones (*two cotyledons*), and Monocotyledones (*one cotyledon*). The two great divisions of plants are, therefore, the Cryptogamia and the Phanerogamia; the former being again subdivided into the Thallophyta and Cormophyta; and the latter into Angiospermia and Gymnospermia, if reference be made to the position of their ovules, or into Monocotyledones and Dicotyledones, if we regard the number of cotyledons.

When a seed is placed under favourable circumstances (which will be treated of hereafter in speaking of the process of germination), its embryo begins at once to develop (*figs.* 18 and 19); the lower part of its axis, *t*, or radicle, or one or more branches from it, growing in a downward direction, while the upper part elongates upwards, carrying the plumule with it, and at the same time the cotyledonary portion becomes developed and forms the first leafy organs. This development of the embryo is termed germination; the office of the cotyledonary portion is, however, only of a temporary nature, being simply designed to afford nutriment to the rudimentary parts of the future plant in the early stages of their growth; but by the development of the central axis in two opposite directions we have formed a lower portion which is called the *descending axis* or *root* (*fig.* 18, *r*), and an upper part termed the *ascending axis* or *stem*. Upon this ascending axis or its

Fig. 18.

Fig. 19.

This description is wrong because this Cotyledon remains embedded in the albumen.

Fig. 18. Germination of the Harleot or French Bean, a Dicotyledonous plant, *r*. The roots, springing from the lower end of the axis, *t* (*tigellum*). *c*, *c*. The cotyledons. *d*, *d*. The leaves.——*Fig.* 19. Germination of Maize, a Monocotyledonous plant. *t*. The axis, giving off roots from its lower extremity. *c*. The cotyledon. *g*. The leaves and young stalk.

divisions all the future organs of the plant are arranged; those which immediately succeed the cotyledons, *c*, *c*, constitute the first true leaves of the plant, *d*, *d*; and all which succeed the leaves in the order of development, such as the flower and its parts, are merely modifications designed for special purposes of those organs which have preceded them. Hence these three organs, namely, root, stem, and leaves, which originally exist in the embryo in a rudimentary state, or are developed as soon as germination commences, form the *fundamental organs of the plant*. They are commonly called *organs of nutrition*, because they have for their object the nutrition and growth of the plant to which they belong; while the flower and its parts, having assigned to them the office of reproducing the plant by the formation of seeds, are termed *organs of reproduction.*

In like manner, a spore in the course of its growth either simply develops parts which, as we have seen, perform equally both nutritive and reproductive functions ; or a certain special apparatus is designed for the latter purpose, as is the case in by far the larger number of Cryptogams. We have here, therefore, as in Phanerogams, two manifestly distinct series of organs, one adapted for nutrition, and another for reproduction. Hence in treating of the different organs of plants, both in reference to their structure and functions, we arrange them in two divisions, namely : 1. *Organs of Nutrition* ; and 2. *Organs of Reproduction.* But before proceeding to describe these in detail, it is necessary that we should briefly define them, and explain the terms used in describing their principal modifications.

1. Organs of Nutrition. a. *The Root.*—The root (*fig.* 20, *r*) is that part of a plant which at its first development in the embryo takes a downward direction, and is hence called the descending axis, avoiding the light and air, and fixing the plant to the earth or to the substance upon which it grows ; or it is suspended in the water when the plant is placed upon the surface of, or in, that medium. The divisions of a root, which are given off irregularly and without any symmetrical arrangement, are termed branches (*fig.* 20, *r*).

Fig. 20.

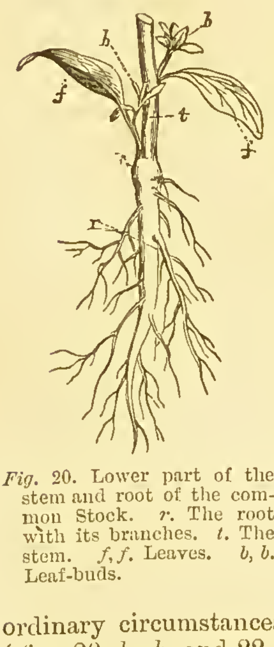


Fig. 20. Lower part of the stem and root of the common Stock. *r.* The root with its branches. *t.* The stem. *f, f.* Leaves. *b, b.* Leaf-buds.

b. *The Stem or Caulome.*—The stem (*fig.* 20, *t*) is that organ which at its first development passes upwards, and is hence termed the ascending axis, seeking the light and air, and bearing on its surface leaves, *f*, *f*, and other leafy appendages. The leaves are always developed at regular points upon the surface of the stem, which are called *nodes*, and in the axil of every leaf (that is, in the angle produced by the junction of the base of the upper surface of the leaf with the stem) we find, under ordinary circumstances, a little conical body called a *leaf-bud* (*figs.* 20, *b*, *b*, and 22, *b*). From these leaf-buds the branches are subsequently produced, and hence, in the stem, these are symmetrically arranged, and not irregularly, as in the root, where there is no such special provision for their formation. It is in the presence of leaves and leaf-buds that we find the essential characteristics of a stem, as both these organs are absent in the root.

c. *The Leaf or Phyllome.*—The leaf is commonly a more or less flattened expansion of the stem or branch (*figs.* 21 and 22). As already stated, the point from which it arises is called a *node* ; and the space between two nodes is therefore termed an *internode.* In its highest state of development the leaf consists of three parts ; namely, of an expanded portion, which is usually more or less flattened (*figs.* 21, *l*, and 22, *l*), called the *lamina* or *blade* ; of a narrower portion, by which the lamina is connected with the stem, termed the *petiole* or *leaf-stalk* (*figs.* 21, *p*, and 22, *p*) ; and of a third portion at its base, which either exists in the form of a sheath (*fig.* 21, *d*) encircling the stem, or as two little leaf-like appendages on each side, which are called *stipules* (*fig.* 22, *s*, *s*). These three portions are by no

FIG. 21.

FIG. 22.

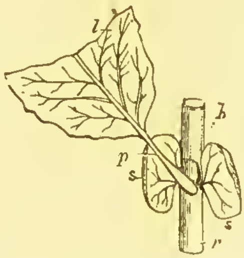


Fig. 21. Leaf and piece of stem of *Polygonum Hydropiper*. *l*. Lamina or blade. *p*. Petiole. *d*. Sheath or stipular portion.——*Fig.* 22. Leaf and portion of a branch of *Salix aurita*. *r*. Branch. *b*. Leaf-bud. *l*. Lamina with the upper portion removed, and attached by a petiole, *p*, to the stem. *s*, *s*. Caulinary stipules.

means always present, for it frequently happens that one or two of them are absent ; and in such cases, when the petiole is absent, the leaf is said to be *sessile*, and if the stipulate portion is wanting the leaf is described as *exstipulate.* When a leaf becomes thick and fleshy, instead of presenting its ordinary flattened appearance, it is termed *succulent.*

2. ORGANS OF REPRODUCTION.—As already noticed, the parts of a flower are only leaves in a modified condition adapted for special purposes ; and hence a flower-bud is analogous to a leaf-bud, and the flower itself to a branch the internodes of which are but slightly developed, so that all its parts are situated in nearly the same plane.

a. *The Flower-stalk or Peduncle.*—The stalk which bears a solitary flower, as in the Tulip, or several sessile flowers (*fig.* 23, *fl*)—that is, flowers without individual stalks—is called the *flower* *stalk* or *peduncle* (*fig.* 23, *p*) ; or if the stalk branches and each branch bears a flower, the main axis is still called a *peduncle*, and the stalk of each flower a *pedicel* (*fig.* 24, *ped*, *ped*) ; or if the axis be still further subdivided, the general name of peduncle is applied

FIG. 24.

FI . 23.

FIG. 25.

Fig. 23. Inflorescence of a species of Broom-rape (*Orobanche*). *p*. Peduncle. *b*, *b*. Bracts. *fl*. Flower. The flowers are sessile on the peduncle, and form that kind of inflorescence which is termed a spike.——*Fig.* 24. Inflorescence of Rampion (*Campanula Rapunculus*). *p*. Peduncle. *ped*, *ped*. Pedicels. *b*, *b*. Bracts.——*Fig.* 25. Flower of the common Wallflower (*Cheiranthus Cheiri*). *c*. Calyx, composed of parts called sepals. *p*, *p*. Petals of which there are four arranged in a cruciform manner, the whole forming the corolla. *e*. Summit of the stamens, which enclose the pistil.

to the whole, with the exception of the stalks immediately supporting the flowers, which are in all cases called pedicels. The leaves which are placed upon the flower-stalk, and from the axils of which the flower-buds arise, are termed *bracts* (*figs.* 23 and 24, *b, b*). In some cases these bracts are of a green colour, and in other respects resemble the ordinary foliage leaves, but usually they are distinguished from the leaves of a branch by differences of colour, outline, and other peculiarities. The flowers are variously arranged upon the peduncle, and to each mode of arrangement a special name is applied; the term *inflorescence* being used in a general sense to include all such modifications.

b. *The Flower.*—A flower in its most complete state of development (*fig.* 25) consists of four distinct series of organs, that is, of *two internal or essential organs* of reproduction (*fig.* 26), enclosed in two particular envelopes, which are especially designed for their protection, termed *floral envelopes* (*fig.* 25). The essential organs are called the *Andrœcium* (*fig.* 26, *ec, ec*), and *Gynœcium* (*figs.* 26, *sti*, and 32, *o, sti*); and the floral envelopes are termed *Calyx* (*fig.* 25, *c*), and *Corolla*, *p, p*. The extremity of the peduncle or pedicel upon which the parts of the flower are placed, is called the *Thalamus* or *Receptacle* (*figs.* 26, *r*, and 31, *r*); but the latter term is more properly applied in a special sense, as will be explained hereafter when treating of the Peduncle in detail. The four series of organs thus forming the flower are arranged as four circles, or whorls as they are commonly termed, in the following order, from without inwards:—1. Calyx, 2. Corolla, 3. Andrœcium, 4. Gynœcium.

The *Calyx* (*fig.* 25, *c*) is the whorl or circle of leaf-like organs forming the outer envelope of the flower. Its parts are called *sepals*, and these are generally green, and of a less delicate texture than those constituting the corolla. In texture, appearance, and other characters they bear commonly a great resemblance to the true or foliage leaves.

The *Corolla* (*fig.* 25, *p, p*), is the whorl or whorls of flattened organs situated within the calyx, and forming the inner envelope of the flower. Its parts, which are called *petals*, are frequently decorated with the richest colours; by which character, and by their more delicate nature, they may be usually known from those of the calyx.

The calyx and corolla are sometimes spoken of collectively under the name of *Perianth*. This term is more particularly applied to the flowers of Monocotyledons where the floral envelopes generally resemble each other, and are usually of other colours than green, *i.e. petaloid* in their nature (*fig.* 28). The Tulip, the Iris, and the Crocus may be taken as familiar examples.

The floral envelopes are also called the *non-essential* organs of the flower, because their presence is not absolutely necessary for the production of the seed. Sometimes there is only one floral envelope, as in the Goosefoot (*fig.* 29); this is then properly considered as the calyx, whatever be its colour or other peculiarity, and the flower is described as *apetalous*, or it is technically said to be *Monochlamydeous*. Some botanists, however, use the term perianth in this case, as will be described hereafter in treating of the Calyx in detail. At other times, as in the Ash (*fig.* 30), and Willow (*figs.* 34 and 35), both the floral envelopes are absent, when the flower is termed *naked* or

FIG. 26.

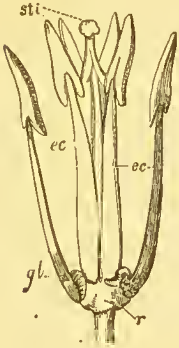


FIG. 27.

FIG. 28.

Fig. 26. Flower of the Wallflower with the calyx and corolla removed, in order to show the essential organs of reproduction. *r.* Thalamus. *gl.* Glands. *ec, ec.* Stamens, of which there are six, four long and two short, the whole forming the andrœcium. *sti.* Stigma, the summit of the gynœcium or pistil.——*Fig.* 27. One of the stamens of the Wallflower. *f.* Filament. *a.* Anther. *p.* Pollen, which is being discharged through a slit in the anther. ——*Fig.* 28. Flower of a species of Squill (*Scilla italica*). The parts composing the floral envelopes here closely resemble one another, and form collectively the perianth.

Achlamydeous. When both floral envelopes are present the flower is said to be *Dichlamydeous.*

The *Andrœcium* constitutes the whorl or whorls of organs

FIG. 29.

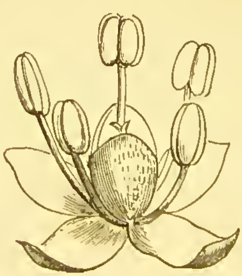


FIG. 30.

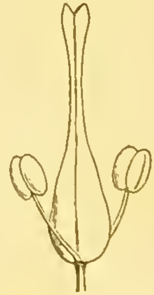


Fig. 29. Flower of Goosefoot (*Chenopodium*), with only one floral envelope (*monochlamydeous*).——*Fig.* 30. Flower of the common Ash (*Fraxinus*), in which both floral envelopes are absent (*achlamydeous*).

situated on the inside of the corolla (*fig.* 26, *ec, ec*). Its parts are called *stamens.* Each stamen consists essentially of a case or bag, called the *anther* (*fig.* 27, *a*), which contains in its interior a powdery, or more rarely waxy, substance, called the *pollen*, *p*. This pollen, the nature of which can only be seen when highly magnified, is found to be formed of innumerable minute grains, or more properly cells, the *pollen grains* or *pollen cells*, each of which encloses a granular fluid protoplasm, the *fovilla*, which constitutes the male fertilising element. The pollen when ripe is discharged, as represented in the figure, through little slits or holes formed in the anther. The anther with its contained pollen is the only essential part of a stamen ; but it generally possesses in addition a little stalk, called the *filament*, *f*, which then supports the anther on its summit. When the filament is absent, the anther is said to be *sessile*. The staminal whorl is termed the *Andrœcium*, from its constituting the male system of Flowering Plants.

FIG. 31.

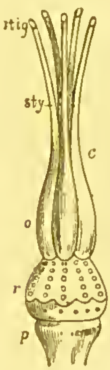


FIG. 32.

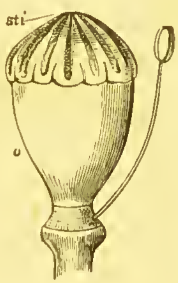


FIG. 33.

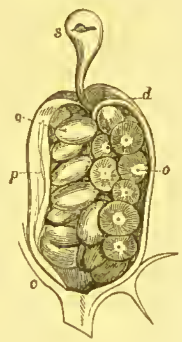


Fig. 31. Gynœcium of Columbine (*Aquilegia vulgaris*). *p*. Peduncle. *r*. Thalamus. *c*. Carpels, each with an ovary, *o* ; style, *sty* ; and stigma, *stig*. ——*Fig.* 32. Gynœcium of Poppy (*Papaver*), with one stamen arising from below it. *o*. United ovaries. *sti*. Stigmas.——*Fig.* 33. Vertical section of the gynœcium of the Pansy (*Viola tricolor*). *c*. Remains of the calyx. *d*. Ovary. *p*. Placenta. *o*, *o*. Ovules. *s*. Stigma on the summit of a short style.

The *Gynœcium* (or *Pistil* as it is also called) is the only remaining organ ; it occupies the centre of the flower (*fig.* 26, *sti*), all the other organs being arranged around it when these are present. It is termed the *gynœcium* from its constituting the female system of Flowering Plants, and consists of one or more parts, called *carpels*, which are either distinct from each other (*apocarpous*), as in the Columbine (*fig.* 31, *c*), or combined into one body (*syncarpous*), as in the Poppy (*fig.* 32). Each carpel consists of a hollow inferior part, called the *ovary* (*figs.* 31, *o*, and 33, *d*), in which are placed one or more little bodies called *ovules* (*fig.* 33, *o*, *o*), attached to a part called the *placenta*, *p*, and which ultimately by fertilisation from the pollen become the seeds ; and of a *stigma*, or space of variable size, which is either placed directly on the top of the ovary, as in the Poppy (*fig.* 32, *sti*), or it is situated on a stalk-like portion prolonged from the ovary, called the *style* (*fig.* 31, *sty*). The only essential parts of the carpel are the ovary and stigma ; the style being no more necessary to it than the filament is to the stamen.

The andrœcium and gynœcium are called *essential organs* because the action of both is necessary for the production of the seed. It frequently happens, however, that either the gynœcium or andrœcium is absent from a flower, as in the Willow (*figs.* 34 and 35), in which case the flower is termed *unisexual* ; and it is then still further characterised as *staminate* or *male* (*fig.* 34), or *pistillate*, *carpellary*, or *female* (*fig.* 35), according as it possesses one or the other of these organs.

Fig. 34.

Fig. 35.

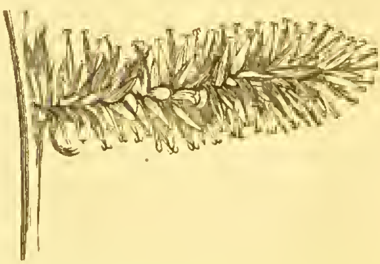


Fig. 34. Staminate flowers of a species of Willow (*Salix*). —— *Fig.* 35. Pistillate or carpellary flowers of the same.

e. *The Fruit and Seed.*—At a certain period the anther opens (*fig.* 27, *a*), and discharges the pollen, *p*, which is then carried to the stigma by insects, or borne by the wind ; this is called *pollination*, and is the first step in the process which subsequently takes place, which is properly termed *fertilisation*, and which consists in the commingling of the fovilla or male fertilising element of the pollen with the female element of the ovule—the *oosphere*. After fertilisation has been effected, important changes take place in the pistil and surrounding organs of the flower, the result being the formation of the fruit, which consists essentially of the mature ovary or ovaries, containing the impregnated or fertilised ovule or ovules, then termed *seeds*. But in some cases, besides the mature ovary or ovaries, other parts of the flower, and even the peduncle, as will be explained hereafter when describing the fruit in detail, also become a part of the fruit. The fruit, when perfectly formed, whatever be its composition, consists of two parts : namely, the *shell* or *pericarp*, and the *seed* or *seeds* contained within it. At varying periods, but commonly when the fruit is ripe, the pericarp opens so as to allow the seeds to escape; or it remains closed, and the seeds can only become free by its decay. In the former case the fruit is said to be *dehiscent*; in the latter, *indehiscent*.

Fig. 36.

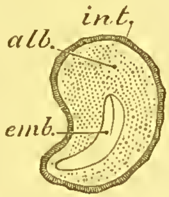


Fig. 36. Vertical section of the seed of a species of Poppy (*Papaver*). *int.* Integuments. *emb.* Embryo. *alb.* Albumen or endosperm. The parts within the integuments form what is commonly termed the nucleus of the seed.

The *seed*, as already noticed, is the fertilised ovule. It consists essentially of two parts; namely, of a *nucleus* or *kernel* (*fig.* 36, *emb*, *alb*), and *integuments*, *int.* There are usually two seed-coats or integuments, the external of which is commonly designated as the *testa* or *episperm*, and the inner as the *tegmen* or *endopleura*. The nucleus or kernel may either consist wholly of the embryo, which is alone essential to it (*fig.* 16), or of the embryo (*fig.* 36, *emb*), enclosed in nourishing matter, called the *endosperm* or *albumen*, *alb.*

The parts of the embryo having been already described, we have now finished our general sketch of plants in different degrees of organisation, together with the compound organs which they respectively present, and are, therefore, now able to proceed with the description in detail of the elementary structures of which they are composed.

CHAPTER 2.

ELEMENTARY STRUCTURE OF PLANTS, OR VEGETABLE HISTOLOGY.

Section 1. Of the Cell as an Individual.

The description of the elementary structure of plants is termed Vegetable Histology.

All the lower kinds of plants, as we have seen (pp. 6–9), are made up of one or more membranous closed sacs called *cells*; and all other plants, however complicated in their appearance and structure, are also made up of these simple bodies, variously modified in form, size, and texture, and in their modes of combination, according to the different surrounding conditions in which they are placed, and the functions which they have to perform (see page 37). The cell is therefore the only elementary organ possessed by a plant, and hence necessarily demands our first and particular attention. We shall begin, then, by first describing the nature of the cell and its contents; and then pass on to a more detailed examination of its various forms, sizes, and structure.

I. Nature of the Cell and its Contents.—In the very earliest stage of a plant's existence—in, for example. the germinal vesicle (*oosphere*) of the higher plants—the cell consists only of a naked mass of a semifluid substance to which the name of *protoplasm* has been given. In a few cases the cell remains in this condition, and is then termed a *primordial cell*. But as a general rule this protoplasm very shortly surrounds itself on the outside with a thin transparent skin of *cellulose*—the *cell wall*—and in this condition three distinct parts can be observed in the cell (*fig.* 37): (1) the cell wall, *a*; (2) the internal protoplasm above mentioned, *b*; and (3) the nucleus, *c*, which is a rounded, denser portion lying in the midst of the protoplasm. At first the protoplasm completely fills the cavity, but as the cell grows larger, cavities (*vacuoles*) containing a clear watery fluid (which in the very young cells is generally diffused), called the *cell-sap* (*figs.* 38 and 39, *s′*, *s′*), make their appearance in it, and the nucleus, *k′*, is then suspended in the cell and connected to the protoplasm lining its inner wall by slender threads or bands of the same substance (*fig.* 39, *p′*, *p′*). (De Vries has stated recently that these vacuoles are enclosed by a distinct membrane, and he regards this vacuole membrane as a special organ to which he has given the name of *tonoblast*, and which has for its function the production of turgidity in the cell.) As the cell continues to enlarge, these vacuoles coalesce and form a single central sap-cavity (*fig.* 39, *s*, *s*), and the protoplasm is then confined to a thin layer lining the interior of the cell-wall—the *primordial utricle*, *p*, with the nucleus, *k*, *k*, showing as a denser mass in an enlargement of the protoplasm on one side. In this perfect cell, as it may be termed, we distinguish, (1) the cell-wall, (2) the protoplasm, (3) the nucleus, (4) the cell-sap. These structures may be well seen in *Vallisneria*.

Such is the nature of cells so long as they retain their active vital state, but after a time the protoplasm with its contained nucleus disappears, leaving the cell filled with air alone or water. Those cells only which contain protoplasm can grow, form chemical combinations, and produce new cells; while all others, as the cells of the wood and bark, are of use only in virtue of their physical properties, as, for example, giving firmness, and acting as protecting envelopes to the living cells beneath, and in other ways. We must now describe the parts of the cell in the order as placed above.

see note p. 21.

1. The Cell-wall (*figs.* 37, *a*, and 39, *h*).—We have just seen that the original cell, from the after divisions of which the future structure is built up, consists of protoplasm alone—that, in other words, it has no cell-wall. Very shortly, however, this condition of things disappears; for the protoplasm, having

elaborated molecules of cellulose ($C_6H_{10}O_5$), passes them to its outer surface, where they form a thin, colourless, transparent, continuous membrane. This membrane increases in thickness by the intussusception of new molecules between the older ones, and eventually there are generally developed upon it various markings, which may either be protuberances as in the case of some pollen-cells (*fig.* 73), and frequently of the cells forming the hairs on the surface of plants; or internal depressions, as may be seen in spiral, annular, reticulated, scalariform, and pitted cells (see pp. 42–46). Those cells which are isolated, or on the surface of the plant, have the various markings on their outer or free surface, while those that are united to form tissues have them on

FIG. 37.

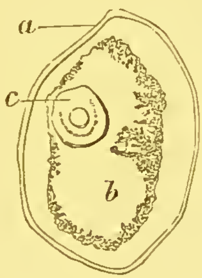


FIG. 38.

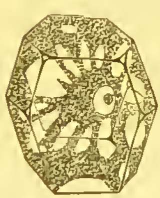


FIG. 39.

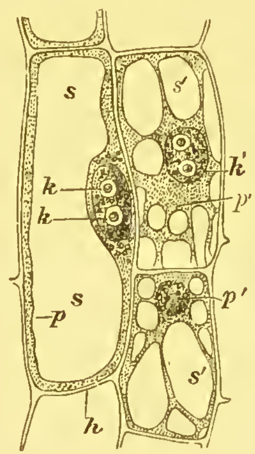


Fig. 37. A cell from the root of the Lizard Orchis (*Orchis hircina*). *a*. The cell-wall. *b*. The protoplasm contracted by alcohol. *c*. The nucleus with a nucleolus. After Thomé.——*Fig.* 38. Cell with nucleus and nucleolus and vacuoles.——*Fig.* 39. Cells from the root of *Fritillaria imperialis*. *h*. Cell-wall. *k'*. Nucleus. *k*, *k*. Nucleus with nucleoli. *p*. Primordial utricle. *p'*, *p'*. Protoplasmic threads. *s*, *s*. Cell-sap cavity. *s'*, *s'*. Vacuoles. After Sachs.

the internal surface of their cell-wall. The former is termed centrifugal thickening; the latter centripetal thickening.

This cellulose is insoluble both in cold and in boiling water, also in alcohol, ether, and dilute acids; but entirely soluble in an ammoniacal solution of oxide of copper. By the action of strong sulphuric acid at ordinary temperatures, the cellulose is disintegrated and converted into dextrin, and then, if water be added and the mixture boiled, the dextrin is converted into glucose. When cellulose is steeped in dilute sulphuric acid, and then treated with a solution of iodine, or if it is acted upon by Schulze's solution of iodine in zinc chloride, it acquires a more or less blue colour. The cell-wall contains in addition to the molecules of cellulose a small quantity of mineral ash.

It rarely happens that cellulose can be found pure, as, in addition to the mineral ash above mentioned, it generally is rendered more or less impure by the protoplasm which remains after the death of the cell. That which is furnished by the cells of hairs, such as Cotton, is generally the most free from extraneous matters. The cell-wall is frequently hardened by the conversion of its cellulose into a substance called *lignin*. This lignification takes place where hardness or strength is required, as in the tissue forming the shell of nuts, or in the elongated cells of the wood of trees. The outer walls of cells also, which lie on the surface of plants, and are consequently exposed to more active chemical influences, usually become cuticularised (see page 59), as in the epidermis of leaves and in the cork cells of the bark; the cell-wall in such cases becomes thickened and impervious to moisture, and it is owing to this circumstance that delicate plants are enabled to withstand the scorching and withering heat of the hot sun; it is also this cuticularisation of the cork cells of the bark which protects the internal living parts of trees from the damaging influence of frost in winter.

Besides the above-mentioned changes which take place in the cell-wall, others occur which are the result of *degradation*. The mucilage of plants, as that of the Mallow, or the slimy substance given off by Seaweeds, or the gelatinous matrix of such organisms as *Nostoc* and *Glœocapsa*, are examples of this; gums and resins are also the products of the degradation of the cell-walls of special cells of the wood of the trees in which they occur.

slimy on damp walls

2. THE PROTOPLASM is the only part of the cell, and therefore of the whole plant, which is possessed of life; and the differences in the form, size, and nature of cells is due to the vital energy which it is capable of exerting. If this energy is exerted equally in all directions, and there are no other counterbalancing forces, such as pressure from neighbouring cells, the form which the cell will assume will be one approaching to a sphere (*fig.* 62). If, on the other hand, this energy is exerted in one direction only, the cell will assume an elongated form (*fig.* 70). If again in two directions, flattened or tabular cells will be the result (*fig.* 68) (see Forms of Cells). This internal energy, which is peculiar to living protoplasm, is frequently spoken of as *vital force*.

see note p 21

The appearance of protoplasm is as varied as is the form of the cells which it produces. It may be granular and somewhat opaque, or perfectly transparent; it may be almost fluid, or of the consistency of dough; or again it may be stiff or even brittle; generally, however, it is of a light grey colour and more or less granular; but it is never a true fluid. In those cases where the protoplasm is granular it consists of an outer thin denser layer or film called the *ectoplasm*, which is transparent and free from granules; and of an inner portion known as the *endoplasm*, in which there are numerous minute particles or granules (*microsomata*) and fibrillæ so arranged as to form a kind of network. According to Sachs, that matter only ought to be regarded as protoplasm which is perfectly transparent, and the granules where they occur are to be looked upon as 'probably finely divided, assimilated food-material.'

FIG. 40.

FIG. 41.

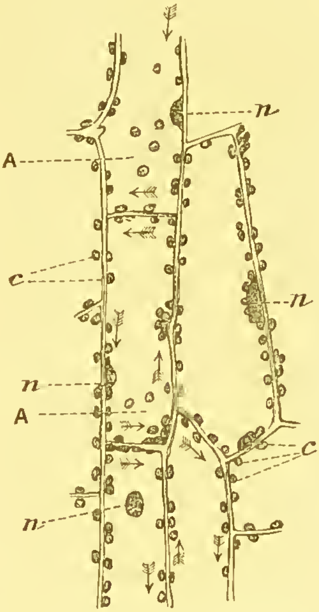


Fig. 40. Three cells of one of the hairs of the common Potato plant (*Solanum tuberosum*), showing the circulation of the contents of each cell in reticulated currents. In the central cell the direction of the currents is in part indicated by arrows. After Schleiden.——*Fig.* 41. Cells of the leaf of *Vallisneria spiralis*, showing rotation of the protoplasm. A, A. Cells in which some chlorophyll corpuscles are passing up one side of each cell, across, and down on the other side. The direction of the currents is indicated by the arrows. *n, n, n, n.* Nuclei. *c, c.* Chlorophyll corpuscles. After J. W. Groves.

The Movements of Protoplasm.—Doubtless during the whole time that the cells are growing the protoplasm is in a constant state of motion, although in many cases too slow to be observed; but in some cells, such as those forming the hairs of certain plants—*e.g.* in those of the Potato (*fig.* 40), and those on the filaments of *Tradescantia*; or again in the cells forming the leaves of many water-plants, *e.g. Vallisneria* (*fig.* 41), *Nitella*, &c.—this motion is readily observable. It would seem as though these movements existed for the purpose of bringing every part of the living matter into constant communication with the nutriment-bearing sac.

In most cases the presence of protoplasm may be readily detected by the use of reagents. Alcohol and weak acids cause it to shrink from the cell-wall (*figs.* 37 and 42); a solution of iodine colours it brown, while sugar and sulphuric acid make it assume a pink colour. Protoplasm is extremely rich in albuminoids, which chemically consist chiefly of carbon, hydrogen, oxygen, nitrogen, sulphur, and phosphorus, the most distinctive element being that of nitrogen. The gluten of Wheat is a good example of an albuminoid, and may be easily obtained by washing ordinary flour in a coarse muslin bag till all the starch has been got rid of. It then appears as a pale, grey, sticky substance, and when burnt gives off an offensive odour like that of burnt meat. Protoplasm also frequently contains globules of oil, granules of starch, and other similar substances.

FIG. 42.

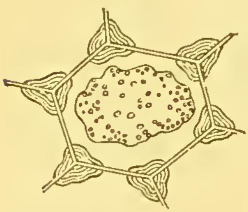


Fig. 42. Cell of the leaf of *Jungermannia Taylori*, showing the protoplasm contracted by alcohol. After Mohl.

It has been recently shown by Gardiner, Hillhouse, Russow, Bower, and others, that in many plants the protoplasm of one cell is in communication with that of the cells around it, by means of threads of protoplasm which pass through the cell walls (*fig.* 43); and in many other instances where the continuity has not yet been clearly demonstrated, threads are found to pass from the main mass of the cell protoplasm to adjacent parts of the adjoining walls (*fig.* 44, 1), and this may occur where there are no pits nor pores as well as where such thin or pervious spots exist. To what extent the continuity of protoplasm may by-and-by be found to obtain, it is useless to speculate, as at present it has only been proved in some parts of certain plants; though these plants have widely different classificatory value, some being Phanerogams (*fig.* 44, 1, 2, 3), while others are so low as the Algæ (*figs.* 43 and 44, 4).

The *Primordial Utricle* (*fig.* 39, *p*), as has already been observed, is the thin layer of protoplasm which lines the cell-wall and forms the boundary of the central cavity filled with cell-sap. It is frequently so thin and transparent that it cannot be detected without the aid of reagents, which either colour it or cause it to separate from the cell-wall as mentioned above (*fig.* 42). Whilst living the primordial utricle is always in organic connexion with the cell-wall, which latter indeed is only matter that has been manufactured by the protoplasm, and then deposited upon its outer surface. By some authors the primordial utricle is differently characterised, and defined as the outer thin homogeneous layer or *ectoplasm* of the protoplasm. This is the sense in which it was essentially understood by Mohl.

3. THE NUCLEUS, which exists in all the cells of the higher plants, and is absent from only a few of the lower forms, is differentiated from the surrounding protoplasm as a denser portion of the same substance (*figs.* 37, *c*, and 38). It appears to consist of a homogeneous matrix termed *achromatin*, in which a network of fibrillæ (*chromatin*) is contained. It usually presents a more or less rounded outline, and contains one (*figs.*

FIG. 43.

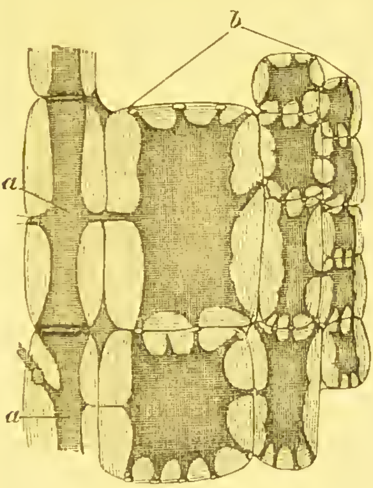


FIG. 44.

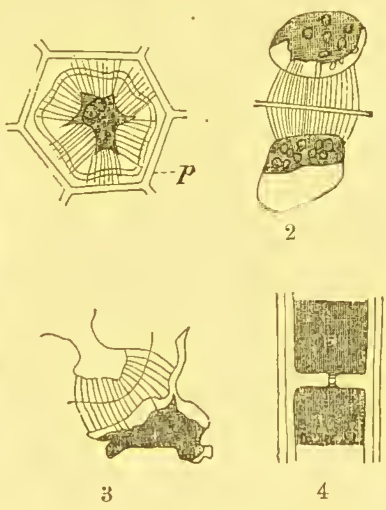


Fig. 43. Semi-diagrammatic longitudinal section of an old and stout portion of *Ceramium rubrum*, showing continuity between the protoplasmic contents of the axial or central cells, *a*, *a*, at their ends; and laterally with the cortical cells, *b*, by protoplasmic threads, and also that of the cortical cells *inter se* by threads radiating from the central mass in each cell. After T. Hick.——*Fig.* 44. 1. Endosperm cell of *Strychnos Ignatia*, swollen up in water, showing threads of protoplasm (plasmolytic threads) running to the cell-wall, *p*. 2. The lumen of two endosperm cells of *Strychnos Nux-Vomica*, showing plasmolytic threads passing into intramural ones, thus demonstrating continuity. 3. Plasmolytic threads from endosperm of *S. Ignatia*. 4. Top of a branch of *Callithamnion* sp., showing cell junctions and continuity of protoplasm. After Le M. Moore.

37, *c*, and 38), or more (*fig.* 39, *k′*, *k′*), much smaller bodies, called *nucleoli*. It is always situated in, and more or less enclosed by, the protoplasm, as we have already seen, and never lies loose in the cell cavity. It is, when present, the most vitally active part of the living substance or protoplasm. (See also 'Formation of Cells,' in the Physiology of Plants.)

4. THE CELL-SAP is the watery fluid which is found in the interior of the cell; it contains dissolved or suspended in it all those food materials which are necessary for the life and growth

of the cell. In the early stages of the cell's life, as we have already seen (page 22), before any vacuoles have appeared, the cell-sap as a substance distinct from the protoplasm does not occur, but is diffused generally through it and the cell-wall, and it is only as the cell enlarges that it first appears in vacuoles in the protoplasm (*fig.* 38 and 39, *s′*, *s′*), and which by ultimately coalescing form a single cavity filled with sap, *s*, *s*. Besides containing substances which are necessary to the life of the cell, it contains also many things which have been thrown out from the protoplasm as no longer serviceable. Of this nature are the crystals of calcium carbonate and calcium oxalate; hence the cell-sap may be regarded from one point of view as the food upon which the protoplasm lives, and from another point of view as the reservoir into which it pours out certain of its waste products.

Beside the fluid cell-sap, there are other important cell-contents, some of which, such as *chlorophyll*, *starch*, *raphides*, *aleurone grains*, and *crystalloids*, now require description.

Chlorophyll and Chlorophyll Granules. a. *Chlorophyll.* This is the colouring material which gives to leaves their well-known green appearance. Its chemical composition, owing to the great difficulty there is of obtaining it pure, is not positively known; but there seems much reason to believe that it is closely allied to wax. It is not soluble in water, but is readily so in alcohol, ether, or benzole. By soaking leaves in any of these substances a beautiful green solution is obtained when viewed by transmitted light, but which is red when observed by reflected light. If a weak alcoholic solution of chlorophyll is shaken up with an excess of benzole, the mixture separates into two distinct layers, the upper one of benzole which is coloured bright green, and the lower one of alcohol which is coloured bright yellow; by which it would seem that chlorophyll is not a simple substance, but is a mixture made up of two or more colouring principles. Thus, according to Frémy, chlorophyll is composed of two colouring principles—one blue, called *phyllocyanin*, and the other yellow, termed *phylloxanthin*; while the more recent investigations of Michell, Stokes, Müller, Pringsheim, and others, render it probable that chlorophyll is even a more complex substance, as will be described hereafter when treating of the Physiology of Plants.

In many fruits, such as the Cherry, Tomato, and common Arum, the chlorophyll of the pericarp becomes first changed to yellow and then red, as the fruit approaches maturity. In many plants, such as the brown Seaweeds, *e.g. Fucus*, the green chlorophyll is obscured by an olive-green pigment, *melanophyll*; or again in the red Seaweeds, such as *Ceramium*, by a red pigment, *phycoerythrin.* In these cases the pigments are more readily soluble in alcohol than the chlorophyll, so that by steeping portions of the plants for a short time in spirit, the colouring matters which veiled the chlorophyll are dissolved out, and the presence of chlorophyll made manifest. Again, in some of the lower plants, such as *Oscillatoria* and *Nostoc*, there exists a blue pigment, *phycocyan*; this may be obtained by soaking well-bruised specimens in cold water, to which it imparts a beautiful blue colour when viewed by transmitted light, and a beautiful red when seen by reflected light.

b. *Chlorophyll Granules.*—It is not to be supposed that the chlorophyll exists indiscriminately in every part of the cell, for, on the contrary, it is confined to special portions of the protoplasm which have been differentiated from the general mass. These portions of protoplasm are the so-called *chlorophyll granules* or *chlorophyll grains*, or, as they are also termed, *chlorophyll bodies* and *chlorophyll corpuscles*; hence these structures are granules of protoplasm coloured by chlorophyll. These granules appear as soft, doughy, more or less rounded masses, which are always enveloped by the surrounding protoplasm and never lie loose in the cell cavity. If a plant is grown in the dark or etiolated, these granules remain pale coloured; but if it is exposed to sunlight, they speedily become coloured green by chlorophyll (hence light is necessary, with rare exceptions, for the formation of chlorophyll); and when so coloured they have the power of breaking up the carbon dioxide of the air or the water in which they are growing, and, returning the oxygen to the air, retain the carbon, which they are able to mix with the elements of water in such proportions as to build up a molecule of starch, $C_6H_{10}O_5$, and some other carbohydrates. This process of building up starch and other carbohydrates out of the carbon dioxide of the air or water has been termed *assimilation*. (See 'Formation of Organic Compounds by Leaves,' in the Physiology of Plants.)

It has been said that chlorophyll is confined to the protoplasm forming the chlorophyll granules; this is true in all the higher plants, but there are some plants amongst the lower orders in which the green-coloured portions form plates or spiral bands, as in *Spirogyra*; or the whole protoplasm, with the exception of the ectoplasm, may be capable of being coloured, as in *Glœocapsa* and *Oscillatoria*.

STARCH.—There is no substance contained in the cells which has given rise to more discussion as to its origin and nature than starch. It is, with the exception of protoplasm, the most abundant and universally distributed of all the cell-contents, occurring as it does, more or less, in all parenchymatous cells (*fig.* 45) except those of the epidermis. In its fully developed state it is, however, most abundant in the matured structures of plants, as the pith of stems, and in seeds, roots, and other internal and subterranean organs which are removed from the influence of light. In these respects it presents a marked contrast to chlorophyll, which, as we have seen, occurs only in young and vitally active structures placed near the surface of plants, and directly exposed to light.

Starch is not only widely distributed through the different parts of a plant, but it also occurs in varying quantity in all classes of plants with the exception of the Fungi. West Indian Arrow-root (*fig.* 46), Sago (*fig.* 47), Tous-les-mois (*fig.* 48), and Potato starch (*fig.* 49) may be mentioned as familiar examples of starches derived from different plants. In all cases starch is a transitory product stored up for future use, resembling in this respect the fat of animals. When thus required for the nutrition of the plant, it is converted previously, as will be afterwards seen, into dextrin and sugar, which are soluble substances, and can therefore be at once applied to the purposes of nutrition, which is not the case with starch in its unaltered condition, as it is then insoluble.

When fully formed starch is found floating in the cell-sap (*fig.* 45) in the form of colourless granules or grains, which are either distinct from one another as is usually the case (*figs.* 46 and 47), or more or less combined so as to form compound granules (*fig.* 50), as described on page 33.

FIG. 45.

FIG. 46.

FIG. 47.

Fig. 45. Cell of the Potato containing starch granules.——*Fig.* 46. West-India Arrowroot (× 250).——*Fig.* 47. Sago meal (× 250).

In form the separate granules are always spherical or nearly so in their earliest condition. In some cases this form is nearly maintained in their mature state, as in Wheat starch (*fig.* 51), but the granules frequently assume other forms, as ovate, elliptical, more or less irregular, club-shaped, or angular (*figs.* 46–49 and 52). Such forms arise from the unequal development of the sides of the granules, or from mutual pressure—the same causes, indeed, as we shall see, which give rise in a great measure to the varying forms of the cells in which they are contained. Starch granules vary also extremely in size in different plants, and even in the same cell of any particular plant. The largest granules known appear to be those of Canna starch, or, as it is commonly termed, 'Tous-les-mois,' where they are sometimes as much as the $\frac{1}{300}$ of an inch in length (*fig.* 48); while the smallest granules, among which may be mentioned those of Rice starch (*fig.* 52), are frequently under $\frac{1}{5000}$ of an inch in length.

Development of Starch.—Starch first makes its appearance as minute colourless granules in the interior of the chlorophyll grains when exposed to sunlight, as previously noticed at page 29. These primary starch granules rarely grow to any considerable size, but are dissolved, chemically altered, and poured out into the sap, of which they then form a part. A part of this primary starch may be used by the protoplasm of the cell in which it is formed for the manufacture of its cell-wall, but by far the greater part is handed down from one cell to another

FIG. 48.

FIG. 49.

Fig. 48. Tous-les-mois (× 250).——*Fig.* 49. Potato starch (× 250).

till it arrives at particular parts of the plant, when it becomes reorganised and stored up for future use. In this latter state starch assumes its more characteristic appearance. Thus in a well-developed Tous-les-mois or Potato granule (*figs.* 48 and 49), we may observe a roundish dark spot, which is termed the *nucleus* or *hilum*, situated near one end of the granule ; and

FIG. 50.

FIG. 51.

FIG. 52.

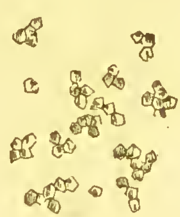


Fig. 50. Compound starch granules of West-India Arrowroot. After Schleiden.——*Fig.* 51. Wheat starch (× 250).——*Fig.* 52. Rice starch (× 250).

surrounding this a variable number of faint lines which alternate with other darker ones, so that the whole presents the appearance of a series of more or less irregular concentric shells placed around a common point. The cause of these appearances has given rise to much discussion ; thus at first sight it is almost impossible to help believing that the granule must have been built up in the same manner as a crystal, namely, by the deposition of fresh matter over the older, or, in other words, that the outer rings of the starch granule have been deposited over those which are more internal, and that therefore they are the youngest portion of the granule. But the observations of Nägeli have proved this not to be the case, for he has shown that the appearance of stratification in the starch granule is really due to the difference in the quantity of water which exists in the different parts of the granule, and he has also proved that the outermost layer, instead of containing the greatest amount of water, as it ought to do if it was the youngest part of the granule, contains the least, while the nucleus on the other hand is the most watery of all. Nägeli concluded from these observations that the growth of the starch granule was precisely the same as that of the cell-wall (see page 42); namely, by intussusception of fresh particles of the starch-compound between those of an older date; and hence that the regular alternation of dense layers with more watery ones around a nucleus or hilum produces the peculiar appearances of starch granules. That the different layers vary in density may be at once proved by the action of polarised light, when each granule usually exhibits a black cross. Seeing then that the growth of the starch granule is by intussusception, it will be readily understood why it is that this growth cannot be carried on except so long as the granule is imbedded in the substance of the living protoplasm, and that as soon as the protoplasm of the cells in which the starch is being formed is used up or killed, all further development of starch becomes impossible.

FIG. 53.

Fig. 53. Laticiferous vessel from *Euphorbia splendens*; the latex contains starch granules of a peculiar dumb-bell and somewhat rod and bone-like form. From Thomé.

In some cases, as for instance in the *Euphorbiaceæ*, starch granules are found floating in the contents (*latex*) of the laticiferous vessels (*fig.* 53), and this would seem to be in contradiction to the above-mentioned law that starch granules can only be formed while enveloped in protoplasm, but the mode of formation of these granules has not been observed.

The starch granules of different plants vary very much in the character of their hilum and in the distinctness and general arrangement of their concentric lines, in the same way, as we have seen, they vary much in form and size under the same circumstances; those, however, which are derived from the same plant are more or less uniform in appearance, so that a practised observer may distinguish under the microscope the different kinds of starch and refer them to the particular plants from whence they have been derived. Sometimes there is more than one hilum in a starch granule, and then as growth takes place round each, compound granules are formed, as mentioned on page 30.

Composition and Chemical Characteristics of Starch, $C_6H_{10}O_5$.—The starch granule consists of the true *starch-compound* and *water.* The starch-compound is again formed of two substances, which are intimately blended together, viz. *granulose* and *cellulose.* The granulose makes up by far the greater part of the starch-compound, being in the proportion of 95 to 5 of the cellulose. It is capable of being dissolved out of the cellulose by saliva and dilute acids, and it is to this granulose that the starch granule owes the violet-blue colour which it assumes when treated with a solution of iodine. The cellulose on the other hand, being not soluble, is left behind as a skeleton, and is not coloured blue by the iodine solution.

Starch is, therefore, composed chemically of carbon and the elements of water; it never occurs, however, naturally in a perfectly pure condition, but always contains a very small quantity of mineral constituents, and also a certain proportion of the peculiar secretions of the plant from whence it has been derived. These impurities can never, under ordinary circumstances, be entirely removed, and from their varying amount in commercial starches arises in a great degree the differences in their value for food and other purposes.

Starch is insoluble in cold water, alcohol, ether, and oils. By the action of boiling water it swells up and forms a mucilage or paste; and if to this when cooled iodine be added, a deep blue colour is produced; but this colour is at once destroyed again by the application of heat or alkalies. If starch be exposed to a temperature of about 320° F. for a short time, it is converted into a soluble gummy substance, called *dextrin* or *British gum.* A similar change is produced in starch by the action of diluted sulphuric acid, and also by diastase, a peculiar nitrogenous substance occurring in germinating seeds. Starch was formerly considered as peculiar to plants, and its presence therefore was regarded as an absolute distinctive mark between them and animals. Of late years, however, as already noticed (page 4), a substance presenting the chemical reactions and general appearance of starch has been found in some animal tissues. Such a distinctive character, therefore, can be no longer absolutely depended upon.

RAPHIDES.—This name is now more generally applied to all inorganic crystals of whatever form which are found in the cells of plants, although the term *raphides* (which is the Greek for needles) was originally given to those only that had the form of a needle (*figs.* 56 and 57). Raphides may be found more or less in nearly all orders of plants, and in all their organs; generally, however, they are most abundant in the stems of herbaceous plants, in the bark of woody plants, and in leaves and roots. In some plants they occur in such enormous quantities that they exceed in weight the dried tissue in which they are deposited: this may be specially observed in some Cactaceæ; thus Edwin Quekett found in the dried tissue of the stem of the Old-man Cactus (*Cereus senilis*) as much as 80 per cent. of crystals. Professor Bailey also found in a square inch of Locust bark of the thickness of ordinary writing paper, more than a million and a half of these crystals. The dried root of that kind of Rhubarb now known as China Rhubarb, commonly contains from 35 to 40 per cent., and hence when chewed it is very

FIG. 54.

FIG. 55.

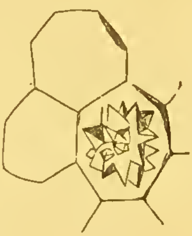


FIG. 56.

Fig. 54. Solitary crystals or raphides in the cells of the inner bark of the Locust tree. After Gray.——*Fig.* 55. Conglomerate raphides or sphæraphides of the Beet.——*Fig.* 56. Acicular or true raphides of a species of *Rumex*. Two cells contain raphides, and three of them chlorophyll granules.

gritty; and as this variety of Rhubarb usually contains a larger proportion of raphides than other kinds, this grittiness has been employed as one means of distinguishing it from them. The raphides are usually contained in cells, in which starch, chlorophyll, and other granular structures are absent (*fig.* 56), although this is by no means necessarily the case. These crystals are more commonly found in the cavities of the cells, but they also occur in their walls; in all cases, however, they are mineral salts which have crystallised naturally out of the cell-sap. They may be especially found in the walls of cells in the Coniferæ and Gnetaceæ.

The raphides occur either singly in the cells, as in those of the inner bark of the Locust tree (*fig.* 54); or far more commonly there are a number of crystals in the same cell. In the latter case they are usually either placed side by side, as in the stem of *Rumex* (*fig.* 56); or in groups radiating from a common point, and then assuming a clustered or conglomerate appearance, as in the stem of the common Beet (*fig.* 55). The former have been termed *acicular raphides*, and the latter *conglomerate raphides*.

In some interesting researches into the nature of raphides made several years since by Professor Gulliver, he has distinguished the acicular crystals (*fig.* 56), which he called *true raphides*, from those which occur either singly (*fig.* 54), or in more or less globular or conglomerate masses (*fig.* 55), which he has termed *Sphæraphides*. He believes that the presence or absence of the former or *true raphides*, and their comparative abundance, afford characters by which the species of certain orders may be distinguished at once from the allied species of neighbouring orders. He has instanced the plants of the Onagraceæ, especially, as being in this way readily distinguished from the plants of allied orders. Gulliver speaks very strongly upon this point as follows : 'No other single diagnosis for the orders in question is so simple, fundamental, and universal as this ; and the orders to which it applies should be named *raphis-bearing* or *raphidiferous*.'

With regard to Sphæraphides, Gulliver believes that there are few, if any, orders among Phanerogams in which they do not exist ; hence it is questionable how far their distribution might be rendered available as a means of distinguishing plants from one another. Their presence, however, he finds universal in every species of the orders Caryophyllaceæ, Geraniaceæ, Paronychiaceæ, Lythraceæ, Saxifragaceæ, and Urticaceæ ; hence he regards the presence of Sphæraphides as especially characteristic of these orders.

In the common Arum, where raphides are very abundant, and in some other Araceæ, the cells which contain the raphides are filled with a thickened sap, so that when they are moistened with water endosmose take place, by which they are distended and caused ultimately to burst and discharge their crystals from an orifice at each end (*fig.* 57). Such cells were called *Biforines* by Turpin, who erroneously regarded them as organs of a special nature.

In many plants belonging to the families of the Urticaceæ, Moraceæ, and Acanthaceæ, there may be frequently observed just beneath the surfaces of the leaves, or sometimes more deeply situated, peculiar crystalline structures, to which the name of *Cystoliths* or *Lithocysts* has been applied. These consist of an enlarged cell containing commonly a globular (*fig.* 58), or somewhat club-shaped (*fig.* 59) mass of crystals, suspended from the top by a kind of stalk formed by an ingrowth of the cell-wall, upon which the crystals are deposited as upon a nucleus.

Crystals of various composition have been described as occurring in different plants, but more accurate observations show that all the crystals hitherto found are composed of calcium carbonate, as those in the cystoliths, and in some of the lower Fungi ; or of calcium oxalate. The latter salt crystallises in two forms according to the proportion of water it contains. Thus in the one case when the crystals contain six equivalents of water of crystallisation, they form octahedra (*fig.* 55), as in the conglomerate raphides or sphæraphides ; and, on the other hand, when there are only two equivalents of water of crystallisation, then bundles of acicular crystals or true raphides are produced (*figs.* 56 and 57).

Fig. 57.

Fig. 58.

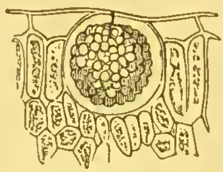


Fig. 59.

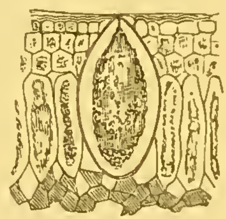


Fig. 57. True or acicular raphides of an Arum being discharged through endosmose under the influence of water.——*Fig.* 58. Cystolith, from *Parietaria officinalis.*——*Fig.* 59. Cystolith, from the leaf of *Ficus elastica.* After Henfrey.

see note 33

Aleurone Grains, Crystalloids, and Globoids.—Besides the inorganic crystals just described, it frequently happens that some of the protoplasmic matter in the cells, more generally in those of the albumen and cotyledons of ripe seeds—that is, in those cells in which reserve food material is stored up—assumes a crystalline form and becomes cubical, octahedral, tetrahedral, rhomboid, &c. (*fig.* 60). These are not however true crystals, as is seen by their angles not being very clearly defined by the action of various reagents, such as dilute caustic potash, which causes them to swell up and increase very much in volume. These crystalline masses are known as *crystalloids* or *proteine crystals.* They are readily seen when a transverse section of the albumen of the Castor-oil seed is placed in dilute glycerine and water (*fig.* 60).

In the cells again of the albumen and cotyledons of ripe seeds we have, in addition to starch and oily matter, small roundish and colourless albuminous grains, which are termed *proteid* or *aleurone grains* (*fig.* 61, *a*, *a*). They are especially abundant in oily seeds, as in those of the Castor-oil plant, where they appear to replace starch ; but in those seeds where starch is abundant, these grains may be seen between the starch-grains, as in the Pea (*fig.* 61, *a*, *a*), Bean, Sweet Chestnut, and Grasses. In these grains the crystalloids just described are frequently found imbedded, and also peculiar small rounded bodies termed *globoids* (*fig.* 60), which are composed of double phosphate of calcium and magnesium.

The aleurone grains and crystalloids are evidently reservoirs of protein, to be used when growth becomes active in the process of germination, in the same way as starch and oily matters are reservoirs of hydrocarbons for use in a like manner. Aleurone grains are insoluble in alcohol, ether, benzole, or chloroform, but soluble in water. They are coloured brown by iodine, and other re-agents show that they are of an albuminoid nature.

The experiments of Weyl and Sidney Vines indicate that the proteids exist in these grains as globulins, which hitherto have been known only to occur in animals, that is, as *myosin-globulin* and *vitellin-globulin*. Vines has also found in the aleurone grains of the Pæony a large quantity of *hemialbumose*, a substance allied to the peptones.

Fig. 60.

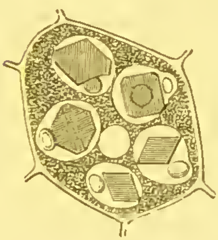


Fig. 61.

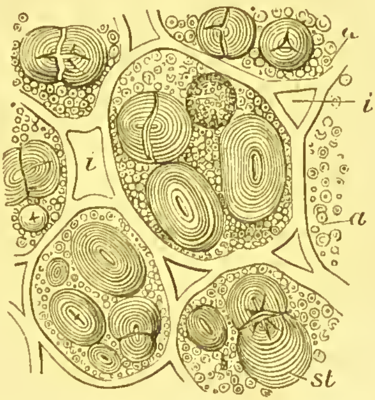


Fig. 60. Cell from the endosperm or albumen of the seed of the Castor-oil plant (*Ricinus communis*) in dilute glycerine, showing large transparent proteid or aleurone grains, with crystalloids and globoids imbedded in them. After Sachs.——*Fig.* 61. Cells of a very thin section through a cotyledon of the embryo in a ripe seed of the common Pea (*Pisum sativum*). *a*, *a*. Aleurone grains. *st*. Starch granules. *i*, *i*. Intercellular spaces. After Sachs.

II. Forms and Sizes of Cells.—Having now described the nature of cells and their contents, we proceed to give a detailed account of the various forms and sizes which they are found to assume in different plants, and in various parts of the same plant.

1. *Forms of Cells.*—Cells are of various forms ; thus, in the first place, as we have already partially seen on page 24, when the growth is uniform, or nearly so, on all parts of the cell-wall, we have a *spherical* or *rounded* cell (*fig.* 62) ; but when it is greater at the two extremities than at the sides, the form is *oval* or *oblong* (*fig.* 63). In the above cases, also, the cells are

almost, or entirely, free from pressure. But, under other circumstances, in consequence of the mutual pressure of surrounding cells, they assume a *polygonal* form (*figs.* 64 and 65), the number of the angles depending upon the number and arrangement of the contiguous cells. Thus, in a perfectly regular arrangement, when the contiguous cells are of equal size, we have *dodecahedral* cells, presenting, when cut transversely, an hexagonal appearance (*fig.* 66). It is rarely, however, that we find

FIG. 62.

FIG. 63.

FIG. 64.

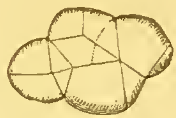


FIG. 65.

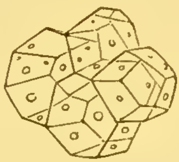


Fig. 62. Rounded cells.——*Fig.* 63. Elliptic or oblong cell.——*Figs.* 64, 65. Polygonal cells in combination : those of the latter figure being pitted.

cells of this regular form, since, in consequence of the unequal size of the contiguous cells, the polygons which result from their mutual pressure must be more or less irregular, and exhibit a variable number of sides (generally from three to eight).

Secondly, when the growth is nearly uniform on all sides of the cell-wall, but not equally so at all points of its surface, we have cells which maintain a rounded form in the centre, but having rays projecting from them in various directions, by which they acquire a more or less star-like appearance (*figs.* 67 and

FIG. 66.

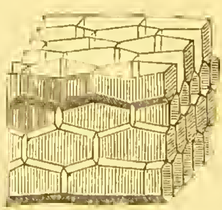


FIG. 67.

Fig. 66. Transverse section of regular polygonal cells.——*Fig.* 67. Stellate cells.

93) ; and hence such cells are called *stellate.* These rays may be situated in one plane, or project from all sides of the cell. It is rarely the case that such cells have the rays at regular intervals, or all of one length, but various degrees of irregularity occur, which lead to corresponding irregular forms in such cells.

Thirdly, when the growth takes place chiefly in one direction, we have cells which are elongated, either horizontally or vertically. Among the forms resulting from an extension of the cell in an horizontal direction, we need only mention *tabular* cells (*figs.* 68 and 94), that is, six-sided flattened cells, with the upper and lower surfaces parallel, or nearly so. Of those cells, which are extended in length or vertically, we have such forms as the *cylindrical* (*fig.* 69) and *fusiform* (*fig.* 70), and which, by the mutual pressure of contiguous cells, often become *prismatic*. In the Fungi and Lichens again we have a very marked form. Thus the cells are here thin-walled and very long and thread-like, and either simple or branched (*fig.* 71). Such cells are sometimes termed *fibrilliform*, (see page 48).

The cells, when in combination with other cells so as to form a tissue, are generally bounded by more or less flattened (*figs.* 65, 66, 68, and 69) or rounded surfaces (*figs.* 62 and 72); but

FIG. 68.

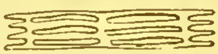


FIG. 69.

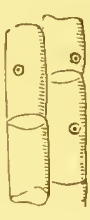


FIG. 70.

FIG. 71.

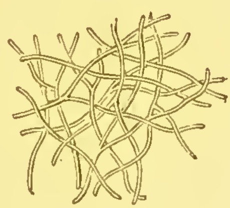


Fig. 68. Tabular cells.——*Fig.* 69. Cylindrical cells. The small rounded body in the interior of three of these cells is the nucleus.——*Fig.* 70. Elongated fusiform cells.——*Fig.* 71. Fibrilliform cells (*hyphæ*).

when in combination also with the vessels of the plant, so as to form what are called the *fibro-vascular bundles*, they are elongated, and have pointed extremities (*fig.* 70). These variations in the condition of the cells lead to corresponding differences in their arrangement; thus, in the former case, the cells are placed one upon another (*fig.* 69), or side by side (*fig.* 68); while in the latter their tapering extremities overlap each other, and become interposed between the sides of the cells which are placed above and below them (*fig.* 70). From this circumstance cells have been divided into *parenchymatous* and *prosenchymatous*; parenchymatous being the term applied to those cells which are placed end to end or side by side; and prosenchymatous to those which are attenuated, and overlap one another when combined together to form a tissue. Another distinction commonly observed between parenchymatous and prosenchymatous cells arises from the condition of their cell-walls; thus, those of parenchymatous cells are usually thin (*figs.* 66 and 69), while those of prosenchymatous cells are more or less thickened (*figs.* 96 and 97). These latter cells are commonly termed *fibres.* The above distinctions between parenchymatous and prosenchymatous cells are evident enough in the extreme forms of the two divisions, but various transitional states occur which render it impossible to draw, in many cases, a distinct line of demarcation between them.

When cells are so placed as to be uncombined with other cells, or with the vessels of the plant, or but partially so, they

FIG. 72.

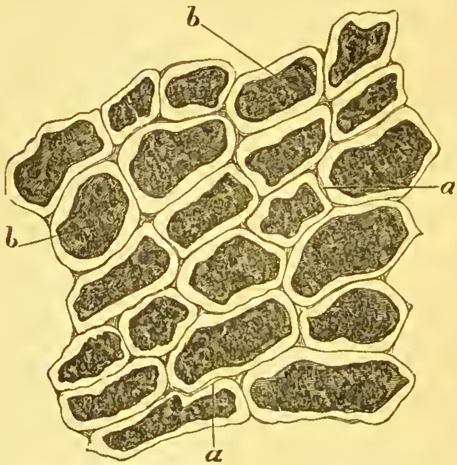


Fig. 72. A portion of the frond of *Nitophyllum laceratum.* *a, a.* Cell walls. *b, b.* Contents of the cells. After H. B. Brady.

are more or less unrestrained in their development; but even in such circumstances, as in their combined state, their typical form is to be more or less rounded. This form is, however, rarely maintained as they grow older, although instances of such occur in many of the lower Algæ, as *Protococcus* (*fig.* 1); in pollen cells (*fig.* 73); and in spores; but more frequently, in such cases, the cells assume a more or less elongated form and become oblong (*fig.* 77), cylindrical (*fig.* 74), &c. In such cells, again, we frequently find that certain points of the cell-wall acquire a special development (see page 23), and become elevated from its general surface as little papillæ (*fig.* 73), warty projections (*fig.* 74), or cilia (*figs.* 75, 76, and 77); or are prolonged into tubular processes, or branched in various ways (*fig.* 78). The hairs which are produced on the surface of plants afford good illustrations of cells which are more or less unrestrained in their development (*figs.* 137–143); other instances occur in the germination of most spores, and strikingly so in those of many Algæ, as *Botrydium* (*fig.* 78); also when the pollen cells fall upon the stigma; and in numerous other cases.

2. *Sizes of Cells.*—The cells vary much in size in different plants, and in different parts of the same plant. The parenchymatous cells, on an average, vary from about $\frac{1}{250}$ to $\frac{1}{1200}$ of an inch in diameter; others again are not more than $\frac{1}{5000}$; while in some cases they are so large as to be visible to the naked eye, being as much as $\frac{1}{50}$ or even $\frac{1}{30}$ of an inch in diameter. The largest occur in the pith of plants, in succulent parts, and in water plants.

The dimensions of prosenchymatous cells generally afford a

FIG. 73.

FIG. 75.

FIG. 76.

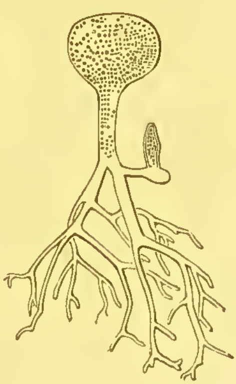


FIG. 74.

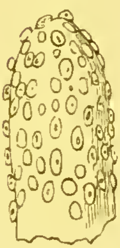


FIG. 77.

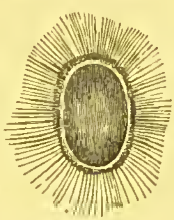


FIG. 78.

Fig. 73. Spherical pollen cell with small projections or papillæ on its outer surface.——*Fig.* 74. Cylindrical cell covered with warty projections.——*Figs.* 75–77. Ciliated cells.——*Fig.* 78. Branched cell (*Botrydium granulatum*).

striking contrast to those of the parenchymatous, for while we find that their transverse diameter is commonly much less, averaging about $\frac{1}{1500}$ of an inch, and frequently not more than $\frac{1}{3000}$, they become much more extended longitudinally, some having been measured as much as $\frac{1}{4}$ of an inch or more long, and according to Schleiden, those of the inner bark are often four, five, or more inches in length. The prosenchymatous cells of the wood and inner bark of trees generally vary, however, from about the $\frac{1}{40}$ to the $\frac{1}{12}$ of an inch in length.

Those cells again which have an unrestrained development are frequently also far more extended in length. Thus, the cell of which each filament of cotton is formed (*fig.* 157, *a*) is sometimes as much as one or two inches long; while in some of the Cryptogamous water plants, as *Chara*, the cells are also much elongated.

III. General Properties and Structure of the Cell-wall.—As has been already stated (page 23), the cell-wall of young cells is very thin, colourless, transparent, smooth, and free from any openings or visible pores, so that each cell is a perfectly closed sac. The cell-wall, however, although free from visible pores, is readily permeable by fluids.

As the cell-wall increases in age, however, it becomes thickened by the intussusception or incorporation of new matter into its substance, and then alterations occur by which it becomes variously marked and sculptured on its inner surface. This increase in thickness may be specially observed in the prosenchymatous cells of the wood and inner bark, and in the hard cells of the stone of the Peach, Cherry, and other similar fruits. This thickening, however, of the cell-wall is by no means confined to the prosenchymatous cells of the wood, or the other cases above mentioned, but it may be observed more or less in all cells where active changes are going on; thus it may be especially seen in those of the pith of *Hoya carnosa* (*fig.* 79). A section of one of these cells gives an appearance as if the walls had been formed by concentric layers of cellulose with branching capillary tubes or canals stretching from the cavity of the cell to its periphery (*fig.* 79). The irregular ringed appearance is due to the difference in the degree of hydration, such as was seen in the case of the starch granule (page 32); while the canals are true passages, which have been caused by the passage of the sap during the life of the cell preventing the deposition of cellulose. In these cells the membrane has been still further changed by the conversion of the cellulose into lignin. It is to these two conditions that the firmness of the wood of plants and the hardness of the stones of many fruits are due, and hence the name of *Sclerenchymatous* (from a Greek word signifying hardness) has been given to such cells.

Fig. 79.

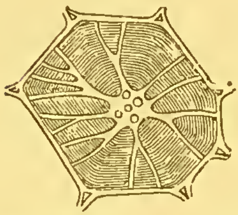


Fig. 79. Transverse section of a thick-walled cell of the pith of *Hoya carnosa*. From Mohl.

see note. 21 II

Pitted or Dotted Cells.—When the cell-wall has thus become thickened it commonly presents (instead of the smooth and homogeneous appearance as is the case, as we have seen, when it is in a young condition) a greater or less number of dots or slits of various kinds (*figs.* 80 and 81, *e*, *e*). These dots and slits were formerly considered as actual openings in the walls of the cells, and hence such cells were called *porous cells*; but, when carefully examined, it may be readily discovered that these markings are caused by canals which run from the cavity of the cell to the inside of its wall, and are closed (always at least in their young state) by the originally thin membrane of which it is at such points composed (*figs.* 79 and 81, *a*, *a*), and thus give to the parts of the cell-wall in which they are found, when viewed by transmitted light under the microscope, a more transparent appearance than that possessed by the thickened membrane surrounding them. Such cells are, therefore, improperly called *porous*, and hence are now correctly termed *pitted* or *dotted cells.* These canals thus terminating in the wall of one cell correspond exactly with the ends of those of the adjoining cells; and thus the sap can readily pass through the intervening cell-wall notwithstanding the general thickening which the walls have otherwise undergone (*fig.* 81). It frequently happens that two or more canals unite together at varying distances from the wall of the cell, and thus form a common opening into its cavity (*fig.* 79).

Although, as thus shown, the dotted appearance is not caused by holes or perforations in the original walls of the cells, yet as the latter advance in age, and lose their active vitality, they

Fig. 80.

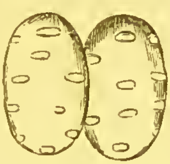


Fig. 81.

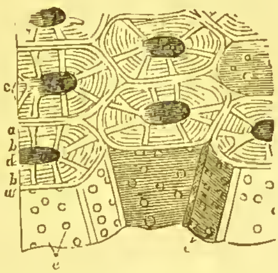


Fig. 80. Pitted cells.——*Fig.* 81. Thick-walled cells from the fruit of a Palm. *a*,*a*. Cell-walls. *b*. *b*. Concentric layers of thickening. *c*. Canals extending from the central cavity to the inside of the wall of the cell. *d*. Cavity of the cell. *e*, *e*. External dotted appearance. From Unger.

frequently become perforated, in consequence of their thin primary wall becoming more or less absorbed, or breaking away. Such perforations are well seen in the *Sphagnum*, where they are sufficiently large to allow of the passage through them of minute granular matters.

Cells with Bordered Pits or Disc-bearing Wood-cells.—In the cell-walls of the wood-cells of certain trees we find, in addition to the ordinary pits, large circular discs which encircle them so that each pit looks as if it had a ring surrounding it (*fig.* 82); hence such cells have been termed *cells with bordered pits* or *disc-bearing wood-cells.* This appearance is produced by circular patches of the cell-wall remaining thin after the general thickening has commenced and the rim growing obliquely inwards, leaving only a narrow orifice in the centre; or, in other words, the opening of the canal into the interior is narrow, while the outer opening by the cell-wall is broad (*fig.* 83, *a*, *b*, *c*). As these thickenings occur always in twos, that is, one on each side of the cell-wall, they appear as two watch-glasses would do if placed rim to rim, and separated by a thin sheet of paper. To carry out the comparison, however, completely, the watch-glasses must be supposed to be perforated in their centres (*fig.* 83, *b*). The central lighter spot when examined by transmitted light is caused by the light having to pass only through the thin unthickened cell-wall or membrane (*fig.* 83, *c*, *w*), while the darker colour of the border is caused by the light having to pass through the thicker substance of the rim. It frequently happens that this intervening membrane (*fig.* 83, *b* and *d*) becomes absorbed, and then direct communication takes place between the adjoining cells.

These bordered pits or discs occur either in single rows (*fig.*

FIG. 82.

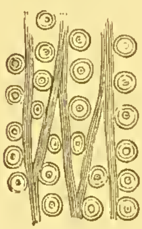


FIG. 83.

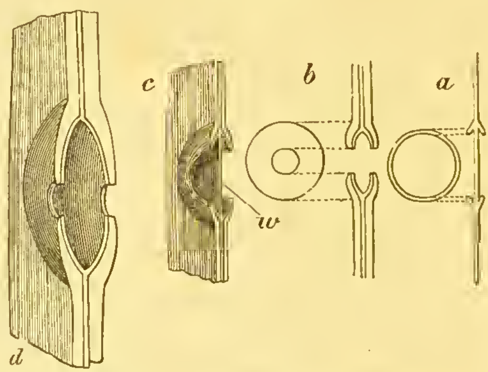


Fig. 82. Bordered pits of the wood-cells of the Pine, with a single row of discs on each cell.——*Fig.* 83. Bordered pits of the wood cells of the Pine (diagram). *a.* Young stage with unthickened cell-wall or membrane. *b.* Older stage where the intervening membrane has been absorbed. *c.* Semi-profile view, showing position of membrane, *w*. *d.* The same where the membrane has been absorbed. After Sachs.

82), or in double (*figs.* 84 and 85), or triple rows (*fig.* 86). In those cases where there is more than one row of bordered pits, those in each row may be either on the same level, as is more commonly the case (*fig.* 84), or at different levels, and hence alternate to each other, as in the Araucarias and allied trees (*figs.* 85 and 86).

Cells presenting such a characteristic appearance are of universal occurrence in the wood of the Coniferæ and Taxaceæ, where they are also most distinctly observed. But somewhat similar bordered pits of smaller size may also be found in many of the Phanerogamia.

Fibrous Cells.—It frequently happens that the thickening of the cell-wall (instead of taking place so as to give the appearance of a perforated membrane, and thus giving rise to the pitted cells just described), forms delicate threads or bands of varying thickness called *fibres*, which assume a more or less spiral direction upon its inner surface (*figs.* 87–89), and thus give rise to what are called *fibrous cells*. Such cells occur in various plants and parts of plants; thus in the leaves of *Sphagnum*, the hairs of many *Cacti* and other plants, in the integuments of some

FIG. 84.

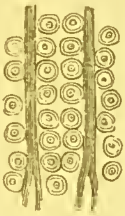


FIG. 85.

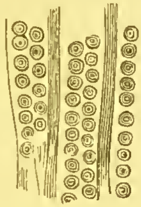


FIG. 86.

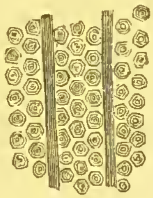


Fig. 84. Cells with bordered pits or disc-bearing wood-cells of the Pine, with a double row of discs, which are on the same level, or opposite to each other. After Nicol.——*Fig.* 85. Cells with bordered pits or disc-bearing wood-cells of *Araucaria excelsa*, with double rows of discs, which are alternate with each other.——*Fig.* 86. Cells with bordered pits or disc-bearing wood-cells of *Araucaria*, with double and triple rows of alternate discs. After Nicol.

seeds and fruits, as those of *Salvia* (*fig.* 152), *Cobœa scandens*, and *Collomia*, inthe spore-cases of certain Flowerless plants, in the inner lining of all anthers, in the root-sheath of the aerial roots of many Orchids, and in several other instances.

These fibrous cells also present some differences of appearance as regards the distribution of their fibres. Thus, in some cells the fibre forms an uninterrupted spiral from one end to the

FIG. 87.

FIG. 88.

FIG. 89.

FIG. 90.

FIG. 91.

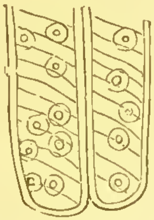


Fig. 87. Spiral cell.——*Fig.* 88. Annular cell.——*Fig.* 89. Reticulated cells. ——*Fig.* 90. Pitted and reticulated cell.——*Fig.* 91. Wood-cells of the Yew (*Taxus baccata*). After Mohl.

other (*figs.* 87 and 152): such are termed *spiral cells*. In other cases the fibre is interrupted at various points, and assumes the form of rings upon the inner surface of the cell-wall (*fig.* 88), and hence such cells are called *annular*. Instances also occur even more frequently, in which the fibres are so distributed as to produce a branched or netted appearance (*fig.* 89); in which case the cells are termed *reticulated.* It is also by no means an uncommon circumstance to find in the same cell intermediate conditions of all these forms.

The fibres in most cases are wound from left to right, although instances occur where they have a contrary direction. The turns of the fibre, or the rings, may be nearly in contact, or more or less separated by intervals of cell-wall; this latter appearance is probably due to the growth of the cell-wall after the deposition of the fibre. The turns of the fibre, or of the rings, again, may be either intimately attached to the cell-wall, or but slightly adherent, or altogether free. As a general rule, the less the cell-wall grows after the deposition of the fibre, the more firmly is it attached to it.

In some cases, again, as in the Yew (*fig.* 91), we find a spiral fibre or fibres developed in addition to the pits; such cells have been sometimes termed *tracheides.*

These different kinds of fibrous cells are connected by a number of intermediate forms (*fig.* 90) with the pitted cells already treated of, but all are formed on the same plan. That is, by the living protoplasm secreting the cellulose out of its own substance, and depositing it upon its external surface in different parts in varying thicknesses.

Section 2. Of the Kinds of Cells, and their Connexion with one another.

We have already seen (page 39), that if the cells are of such forms that when combined together they merely come in contact with one another without perceptibly overlapping, they are called *parenchymatous*; but that when elongated and pointed at their ends, so that in combination they overlap one another, they are termed *prosenchymatous.* We have also seen that such extreme forms are connected by all sorts of transitional ones. But, besides these elongated prosenchymatous cells, other lengthened tubular organs are also found in plants, which are termed vessels (see Vessels, page 51). Formerly, all these elongated organs were supposed to have an entirely distinct origin from the ordinary parenchymatous cells, and were described under the names of Woody Fibres, and Vessels or Ducts; but it is now known that they are all derived originally from such cells, and owe their peculiar appearances either to various modifications in form, which the latter undergo in the course of growth, or to their combination and union with one another. This common origin of the Woody Fibres of old authors and of the Vessels with the parenchymatous cells, is proved by the fact, that gradual transitional forms from the one to the other may be commonly observed; and also by tracing their development, when it will be found that all these organs, however modified in form and appearance, are derived originally from one or more of the ordinary cells. All the observations made previously, therefore, as to the chemical and general properties of cell-membrane, as well as to its mode of growth and thickening, apply equally to the Vessels. We have already stated this to be the case with regard to the Woody Fibres, which we have spoken of under the names of Prosenchymatous cells and Wood-cells. By the combination of the different kinds of cells and vessels, we have various compound structures formed which are called Tissues; the most important and the most abundant of them all is parenchyma, which must therefore be first alluded to.

1. Parenchyma.—This is composed of comparatively thin-walled cells, whose length commonly does not exceed their

Fig. 92.

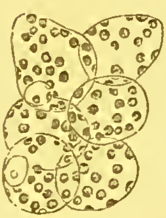


Fig. 93.

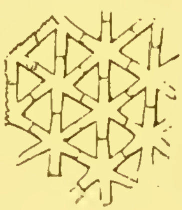


Fig. 94.

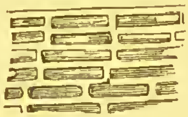


Fig. 95.

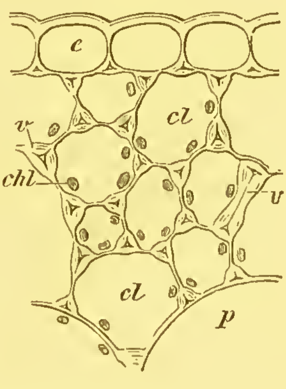


Fig. 92. Round or oval parenchyma. In two of the cells a nucleus with a nucleolus may be seen.——*Fig.* 93. Stellate or spongiform parenchyma, composed of stellate cells with three-cornered intercellular spaces.——*Fig.* 94. Muriform parenchyma.——*Fig.* 95. Transverse section of the petiole of a species of *Begonia*. *e.* Epidermis with cuticle above and hypoderma below, the latter formed of collenchymatous cells *cl*, *cl*, with thickened angles *v*, *v*. *chl.* Chlorophyll granules. *p.* General parenchyma, below hypoderma. After Sachs.

breadth, or in which the proportion of the two diameters does not vary to any remarkable extent. There are several varieties of parenchyma, depending chiefly upon the forms of the component cells, and their modes of combination; the following are the more important:—

a. *Round or Oval Parenchyma* (*figs.* 62 and 92).—This is formed of rounded, or more or less oval cells, with small spaces between them. It commonly occurs in succulent plants, and also in those parts where the tissues are of a lax nature. It is connected by various transitional forms with—

b. *Stellate or Spongiform Parenchyma*, which consists of stellate cells (*figs.* 67 and 93), or of cells with an irregular outline produced by projecting rays, and in contact only by the extremities of such rays, so as to leave large irregular spaces between them (*fig.* 124, *c*). This occurs commonly in the tissue on the under surface of most leaves; and frequently in the air-passages of plants, particularly in the stems and leaf-stalks of such as grow in water, or in marshy places, *e.g.* the Rush and Water-lily.

c. *Regular or Polyhedral Parenchyma.*—This is formed of polyhedral cells, the faces of which are frequently nearly equal (*figs.* 65 and 66), and so combined as to leave no interspaces. It is commonly found in the pith of plants.

d. *Elongated Parenchyma.*—This is composed of cells elongated in a longitudinal direction so as to become fusiform (*fig.* 70), cylindrical (*fig.* 69), or prismatic, and closely compacted. It occurs frequently in the stems of Monocotyledonous plants.

e. *Tabular Parenchyma* is that which consists of tabular, closely adherent cells. It is found in the epidermis and other external parts of plants (*figs.* 68, 95, *e*, and 123–125). A variety of this kind of parenchyma is called *muriform*, because the cells of which it is composed resemble in their form and arrangement the courses of bricks in a wall (*fig.* 94); this variety occurs in the medullary rays of the stems of Dicotyledons.

Such are the commoner varieties of parenchyma, all of which are connected in various ways by transitional forms; but other special kinds also occur. Thus, in the tissue which is placed below the epidermis of plants, which has been termed the palisade cells. *hypoderma*, we sometimes find the parenchyma composed of cells which are especially thickened at their angles (*fig.* 95, *cl*, *cl*); and these thickened portions swell up considerably when such cells are placed in water. This kind of parenchyma is called *collenchyma*; it never becomes lignified. Another variety of parenchyma is termed *sclerenchyma*; this consists of cells which have become much hardened by thickening layers and lignified, as in the stem of Palms (see page 95). When the parenchymatous cells become thickened so as to form *pitted* or *fibrous* cells, the tissues formed by their combination constitute respectively the *Pitted Cellular Tissue* and *Fibro-cellular Tissue*, of some authors.

In some of the lower orders of plants there is a kind of tissue present which is quite as distinct from parenchyma as this is from prosenchyma and the tissues formed by the vessels of plants. To this the names of *Tela contexta* and *Interlacing fibrilliform Tissue* have been given. It occurs in the Fungi (*figs.* 3 and 4), and Lichens (*fig.* 71), and consists of very long thread-like cells, or strings of cells, simple or branched, with either thin, soft, readily destructible walls, as in Fungi; or dry and firm ones, as in Lichens; the whole inextricably interwoven or entangled with each other so as to form a loose fibrilliform tissue (*fig.* 71). This tissue, which is usually known under the name of *hyphæ* or *hyphal tissue*, constitutes, as a general rule, the vegetative portion of all Fungi and Lichens ; and in the larger Fungi this same tissue also forms a more compact structure at certain parts, as on their surface, where it is arranged as a kind of skin, and then constitutes what is termed *pseudo-parenchyma.* Hyphal tissue is also found in the thallus of some Algæ.

The varieties of parenchyma as just described constitute the entire structure of the lower orders of plants, or Thallophytes, such as the Algæ, Fungi, and Lichens, which are hence frequently termed Cellular Plants ; while all plants above them, which contain, commonly, vessels and prosenchymatous wood-cells, in addition to parenchymatous cells, are called Vascular Plants (see page 8). In these higher orders of plants, parenchymatous cells constitute all the soft and pulpy parts ; and in cul-

FIG. 96.


FIG. 97.


FIG. 98.


FIG. 99.

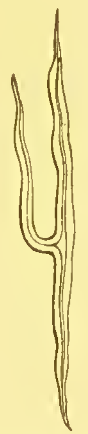

FIG. 100.


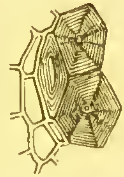
FIG. 101.


Fig. 96. Prosenchymatous or wood-cells.——*Fig.* 97. Transverse section of prosenchymatous cells, showing the thickness of their walls.——*Fig.* 98. Prosenchymatous cells in combination.

Fig. 99. Upper end of a liber cell.——*Fig.* 100. Branched liber cell. After Schleiden.——*Fig.* 101. Transverse section of liber-cells, showing the thickness of their walls.

tivating plants or parts of plants for culinary purposes and for food generally, the great object aimed at is to develop this kind of tissue as much as possible. Parenchyma is connected by various intermediate conditions with *prosenchyma*, which must now be described.

2. PROSENCHYMA.—The most perfect form of prosenchyma is that commonly termed *Woody Tissue* or *Woody Fibre.* This tissue consists of very fine cells, elongated and tapering to their extremities, their walls being much thickened (*fig.* 96), and when in contact with one another overlapping by their pointed ends, so that they are firmly compacted together and leave no

interspaces (*fig.* 98). The woody portions of all plants consist in a great part of this form of tissue. It is also found in the liber or inner bark mixed with parenchyma and certain vessels, and in the veins of leaves and those of other appendages of the stem and its divisions.

Three kinds of prosenchymatous cells may be described which enter into the composition of Woody Tissues; namely, the ordinary *Wood-cells*, *Disc-bearing Wood-cells* or *Cells with Bordered Pits*, and *Liber-cells*; these form respectively, by their combination, ordinary *Woody Tissue*, *Disc-bearing Woody Tissue*, and *Woody Tissue of the Liber*.

a. *Woody Tissue.*—This, the ordinary kind of woody tissue, is composed of prosenchymatous cells or *fibres* of moderate length and lignified (*fig.* 96). A transverse section of these cells shows the thickening matter of their walls to be arranged in concentric layers, which are often so numerous as to almost obliterate their cavities (*fig.* 97). This kind of tissue occurs in the wood of most trees, except that of the Coniferæ and most other Gymnospermous plants; and in the veins of some leaves, and those of certain parts of the flower. The peculiar manner in which these wood-cells are arranged with respect to one another, overlapping at their pointed extremities, and thus becoming firmly cemented, as it were, together, combined with the thickness of their walls, renders this tissue very strong and tough, and thus admirably adapted for those parts of plants in which it is found, and where such qualities are especially required.

b. *Disc-bearing Woody Tissue.*—This tissue is composed of those wood-cells called *cells with bordered pits*, which have been already described on page 43 (*figs.* 82–86). This tissue constitutes generally nearly the whole of the wood of the Coniferæ and most other Gymnospermous plants, as well as a portion of the wood of some other plants (see pages 44 and 83). These disc-bearing wood-cells are much larger than the other kinds of wood-cells, being often as much as $\frac{1}{300}$ or $\frac{1}{200}$ of an inch in diameter; while the latter are frequently not more than $\frac{1}{3000}$, or on an average about $\frac{1}{1500}$ of an inch in diameter.

c. *Woody Tissue of the Liber or Bast Tissue.*—This consists of cells much longer than ordinary wood-cells (*figs.* 99 and 157 *b*), with very thick walls (*fig.* 101), and owing to their not being lignified, or but partially so, they are softer, tougher and more flexible; hence these are regarded as a peculiar kind of cell, and have received the distinctive name of *Liber-cells*, from their common occurrence in the inner bark or liber of Dicotyledonous stems. Such cells are also termed *bast-fibres*, and the tissue formed of them *bast-tissue*, because the inner bark is also commonly termed *bast*. These cells are rarely branched (*fig.* 100). Besides the common occurrence of this tissue in the liber, it also occurs as a constituent of the *fibro-vascular bundles* of Monocotyledonous stems; and of the fibrous coats of fruits. The veins which form the framework of leaves are also in part composed of this kind of tissue.

These bast-fibres are called *bast-tubes* by some botanists, who regard them not as elongated cells, but as true vessels formed like them by the coalescence of rows of cells, the partition walls between them having become absorbed, so that their cavities communicate and form a continuous canal. These liber-cells, bast-fibres, or bast-tubes, must not be confounded with *sieve-vessels* or *sieve-tubes* (see page 55), which are also frequently termed *bast-vessels* from their common occurrence in the liber.

From the peculiar qualities of the *woody tissue of the liber* it is admirably adapted for various manufacturing purposes; thus Hemp, Flax, New Zealand Flax, Pita Flax, Sunn, Jute, China Grass, and many other fibres, are all composed of the liber tissue of different plants, and will afford good illustrations of the value of such fibres as textile materials. This liber tissue also when macerated so as to separate the cells from one another is made into a mash from which the best kinds of paper are made. Inferior sorts of paper are prepared from the ordinary woody tissue of many plants, but they lack the toughness of papers made from the liber, and are brittle and tear more easily.

The different kinds of woody tissue are commonly associated with other organs, which are also of an elongated tubular character, but larger than the prosenchymatous cells of which the woody tissues are composed. These constitute the vessels of plants, and must now be described.

3. Vessels.—These have also been frequently termed *ducts* by authors. The essential character of a vessel is that it is composed of several cells, which are united end to end, and the septa dividing them more or less completely absorbed. The component cells may be either very long and narrow, or they may be short and broad.

There are several varieties of these vessels, which are known as *pitted*, *spiral*, *annular*, *reticulated*, and *scalariform*, the characters of which depend upon the component cells out of which they have been formed, and which have already been described. They contain air or water.

But besides these vessels we have also other varieties, which are commonly distinguished under the names of *sieve-tubes* or *sieve-vessels*, *laticiferous vessels*, and *vesicular* or *utricular vessels*. These are closely related to one another from the nature of their contents, their chief function being to act as reservoirs of nutrient fluids or secretions, and also as carriers of the nutrient fluids to those parts of plants where they are required.

a. *Pitted or Dotted Vessels.*—A pitted vessel is formed from a row of cylindrical pitted cells placed end to end (*fig.* 102), the intervening partitions of which have become more or less absorbed, so that their cavities communicate and form a continuous canal (*fig.* 103). The origin of pitted vessels from a row of cells of a similar pitted nature is clearly shown in many instances by the contractions which their sides exhibit at various intervals, by which they acquire a beaded appearance (*fig.* 102); for these contractions evidently correspond to the points where the component cells come in contact, and in some cases even we find the intervening membrane not completely absorbed between the cavities, but remaining in the form of a network or sieve-like partition (*fig.* 103). Pitted vessels generally terminate obliquely (*fig.* 103), and when they combine with neighbouring vessels, the oblique extremities of the latter are so placed as accurately to correspond with the former. In some cases, however, where the pitted vessels are pointed at the ends, they overlap more or less by these points. Pitted vessels may be commonly found in the wood of Dicotyledons; they are mixed here with the ordinary wood-cells, but are much larger than these, as may be seen by making a transverse section of the wood of the Oak, Chestnut, and other trees, when the holes then visible to the naked eye are caused by their section (*fig.* 183, *v*, *v*, *v*). The pitted vessels are generally among the largest occurring in any tissue.

FIG. 102.

FIG. 103.

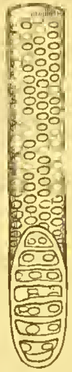


Fig. 102. Beaded pitted vessel.——*Fig.* 103. Pitted vessel terminating obliquely, and showing that the partition wall has been incompletely absorbed.

It sometimes happens that when a pitted or other vessel has lost its fluid contents, the neighbouring parenchymatous cells push bladder-like portions of their membrane through pores which are then formed in its wall, and then multiply by division and form a cellular mass which may completely fill it—to this intra-cellular tissue the name of *tyloses* or *thyloses* has been given. It may be well observed in the wood of the Oak, in that of *Robinia Pseud-acacia*, in *Periploca*, and in the stem of *Cucumis sativus*.

b. *Spiral Vessels.*—This name is applied to vessels with tapering extremities, having either one continuous spiral fibre running from end to end, as is commonly the case (*fig.* 104), or two or more fibres (*fig.* 105) running parallel to one another. Those with only one spiral fibre are sometimes termed *Simple Spiral Vessels*; those with more than one, *Compound Spiral Vessels*. The latter kind are well seen in the stem of the Banana and other allied plants, in the young shoots of the Asparagus, and in the Pitcher Plant. The fibre contained within the spiral vessel is generally so elastic as to admit of being uncoiled when the vessel is pulled asunder, in which case the wall is ruptured between the coils. This appearance may be commonly seen by the naked eye by partially breaking the young shoots, flower-stalks, or leaf-stalks of almost any plant; or the leaves of the

Hyacinth, Banana, and others, and gently pulling asunder the two ends, when the uncoiled fibres appear like a fine cobweb. In most cases the coils of the fibre are close together, so that the enclosing membrane cannot be observed between them ; but in other instances they are more or less separated by portions of membrane (*fig.* 104). The latter appearance is probably caused by the growth of the cell-wall after the thickening which forms the fibre has taken place, by which the coils become extended and separated from one another. The fibre is generally turned to the right as in the ordinary spiral cells, although instances occur in which it is wound in the opposite direction. When spiral vessels come in contact they overlap more or less at their ends (*fig.* 104), and frequently the membrane between their cavities then becomes absorbed so that they communicate with each other. Spiral vessels sometimes present a branched appearance ; this is generally occasioned by the union of separate vessels in a more or less

FIG. 104. FIG. 105. FIG. 106. FIG. 107.

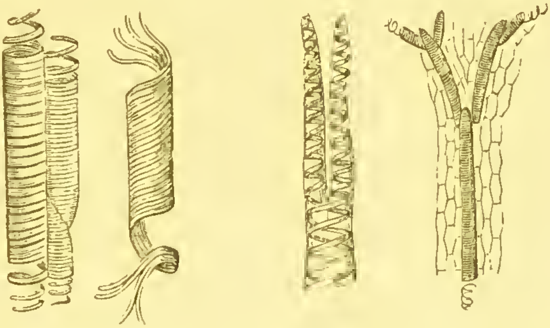


Fig. 104. Simple spiral vessels.——*Fig.* 105. Compound spiral vessel.——*Fig.* 106. Branched spiral vessel.——*Fig.* 107. Union of spiral vessels in an oblique manner.

oblique manner (*fig.* 107), or occasionally, it is said, as in the Gourd and some other plants, by a division of the fibres of distinct vessels (*fig.* 106).

Spiral vessels occur in the sheath surrounding the pith of Dicotyledons (*figs.* 179, *s*, *s′*, and 185 B, *d*), in the fibro-vascular bundles of Monocotyledons (*fig.* 181, *sv*), and in some of the Cormophytes, as the Lycopodiaceæ. They also exist in the petiole and veins of leaves, and in those of all other organs which are modifications of leaves, as bracts, sepals, petals, and other parts of the flower. They may be also frequently found in roots. In size they vary from the $\frac{1}{300}$ to $\frac{1}{3000}$ of an inch in diameter. The average size is about the $\frac{1}{1000}$. Spiral vessels are sometimes called *Tracheæ* or *Trachenchyma*, from their resemblance to the tracheæ or air-tubes of insects.

c. *Annular Vessels.*—In these vessels the fibre is arranged in the form of rings more or less regularly arranged upon their inner surface (*figs.* 108, *r*, 109, and 110). Sometimes the whole of the vessel presents this ringed appearance (*figs.* 109 and 110), while in other vessels we find two rings connected by one or more turns of a spiral, the two forms irregularly alternating with

FIG. 108.

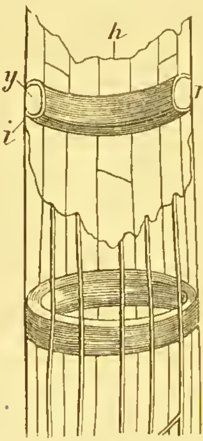


FIG. 109.

FIG. 110.

FIG. 111.

Fig. 108. Piece of an annular vessel from *Zea Mays*. *h*. The thin cell-wall; *r*, the annular thickening of the cell-wall; *r'*, vertical section of one of the rings, showing, *y*, the inner substance, and, *i*, the denser layer over the inner side of the ring projecting into the cavity of the cell. After Sachs.——*Figs.* 109, 110. Annular vessels.——*Fig.* 111. Vessel showing a combination of rings and spiral fibres.

each other (*fig.* 111). In size they vary from about $\frac{1}{400}$ to $\frac{1}{800}$ of an inch in diameter. Annular vessels occur especially in the fibro-vascular bundles of the stems of soft, rapidly growing herbaceous plants among Dicotyledons, also in those of Mono-

FIG. 112.

FIG. 113.

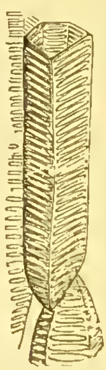


FIG. 114.

FIG. 115.

Fig. 112. Reticulated vessel.——*Fig.* 113. Prismatic scalariform vessels of a Fern.——*Fig.* 114. Cylindrical scalariform vessels of the Vine.——*Fig.* 115. Vessel showing a combination of spiral and reticulated fibres, and scalariform markings.

cotyledons, and in those of some Cormophytes. In the latter they exist especially, and of a very regular character, in the Equisetaceæ (*fig.* 109).

d. *Reticulated Vessels.*—In these vessels the convolutions are more or less irregular, and connected in various ways by cross or oblique fibres, so as to produce a branched or netted appearance (*fig.* 112). These vessels are generally larger than the annular, and of much more frequent occurrence. They are found in similar situations.

e. *Scalariform Vessels.*—The peculiar appearance of these vessels is owing to their walls being marked by elongated transverse pits or lines, arranged over one another like the steps of a ladder, whence their name (*figs.* 113 and 114). They are sometimes cylindrical tubes like the other vessels, as in the Vine (*fig.* 114), and in many other Dicotyledons, in which condition they are apparently but slight modifications of reticulated vessels ; but in their more perfect state, scalariform vessels assume a prismatic form, as in Ferns (*fig.* 113), of which they are then very characteristic, though sometimes they may be found elsewhere.

Fig. 116.

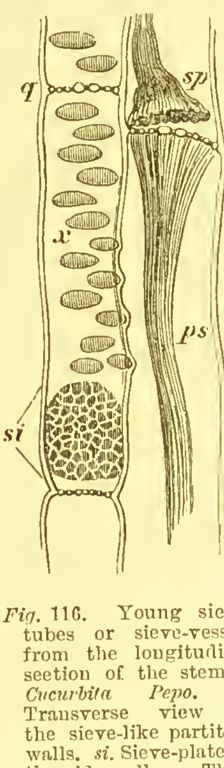


Fig. 116. Young sieve-tubes or sieve-vessels from the longitudinal section of the stem of *Cucurbita Pepo.* *q.* Transverse view of the sieve-like partition walls. *si.* Sieve-plate on the side-wall. *x.* Thinner parts of the side-wall. *ps.* Contracted protoplasmic contents, lifted off the transverse septum at *sp.* After Sachs.

The *annular*, *reticulated*, and *scalariform vessels* constitute the *spurious tracheæ* of some authors. These vessels have commonly tapering points like the true spiral vessels ; and thus overlap at their extremities when they come in contact (*fig.* 113). But in other instances they terminate more or less obliquely, or by flattened ends, like most pitted vessels. We frequently find in the same vessel one or more of the above forms combined with the spiral (*figs.* 111 and 115), and thus forming intermediate states of each other.

f. *Sieve-tubes or Sieve-vessels.*—These are vessels in which thickening of the cell-walls of their component cells does not take place uniformly over their whole surface, but only at the ends of the cells, that is, where they are in contact with others of a similar nature. At these ends it forms a kind of network, sculptured in relief as it were on the wall (*fig.* 116, *q*) ; and when in such cases, the unthickened part of the walls of contiguous cells becomes absorbed so that their cavities are continuous, we have formed what are commonly known as *sieve-tubes* or *sieve-vessels.* Some have also sieve-like openings through their side walls (*fig.* 116, *si*). These vessels are very constantly present in the inner bark or *phloëm* of Dicotyledons, and also in the fibro-vascular bundles of some Monocotyledons, and elsewhere. If the partition walls between the component cells are not really perforated, but only thickened in a sieve-like manner, the name of *sieve, lattice,* or *clathrate*, is applied to the component cells.

g. *Laticiferous Vessels.*—These constitute the *Milk-vessels* of the old authors. They consist usually of long-branched tubes lying in no definite position with regard to the other tissues (*figs.* 117 and 118), and anastomosing or uniting freely with one another like the veins of animals, from which peculiarity they may be at once distinguished from the other vessels of plants. When first formed these vessels are exceedingly minute and their walls are very thin; they become, however, large and

Fig. 117.

Fig. 118.

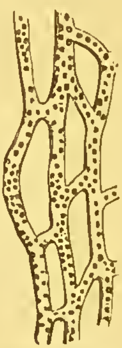
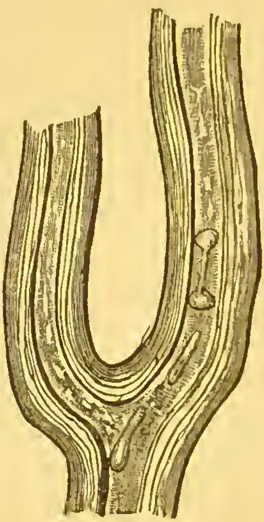


Fig. 119.



Figs. 117, 118. Laticiferous vessels. ——*Fig.* 119. Laticiferous vessel from *Euphorbia splendens*: the latex contains starch granules of a peculiar form. After Thomé.

thick-sided as they increase in age, but even then rarely present any pits or spiral deposits in their interior, as is the case in the thickened cells and vessels already described. A common size is the $\frac{1}{1100}$ of an inch in diameter. They derive their name from containing a fluid called *latex*, which when exposed to the air becomes milky, and is either white, as in the Dandelion, Spurge, Opium Poppy, Indiarubber, Lettuce, and many other plants; or coloured, as is well seen in the Celandine, where it is yellow; or it may be of other colours. The latex has a number of granules or globules floating in it, which are composed of caoutchouc or analogous gum-resinous matters, &c., and occasionally mixed with them may be observed peculiar-shaped starch granules (page 32), as in *Euphorbia splendens* (*fig.* 119); or it may be mucilaginous, or gummy, or contain active secretions, &c. Laticiferous vessels, from their containing some of the so-called secretions of the plant, are closely allied to the Receptacles of Secretion, and are frequently placed with them. (See page 72.) Laticiferous vessels occur especially in the inner bark of many Dicotyledons, in the pith, and in the petiole and veins of leaves; but they are also to be found in other plants.

They are formed, like other vessels, from rows of cells arranged in various directions with respect to one another, the partitions between their cavities being more or less absorbed so that they communicate freely together.

Besides the above more common characteristics of laticiferous vessels, there are numerous other varieties; indeed, from the very great variety in structure, contents, and position of these vessels, and the many and various transitions between them and vesicular vessels, now to be described, Sachs has proposed that these laticiferous and vesicular vessels should be included under the common name of *latex-sacs*.

h. *Vesicular or Utricular Vessels.*—These resemble laticiferous vessels in one particular, as they contain latex (which, however, is clear or milky, but always contains true raphides): while, on the other hand, they are unbranched and analogous to sieve-tubes in form, consisting as they do of long broad cells with sieve-like septa. They were first noticed by Hanstein in the scales of the bulb of *Allium*, and have since been observed in the leaves and other parts of Monocotyledons, and in some Dicotyledons.

We have now described all the different kinds of cells, and the modifications they undergo, and the combinations of them which take place so as to form vessels. The different kinds of vessels and woody tissues are more or less combined together, and have always a tendency to develop and arrange themselves in longitudinal or vertical bundles in the parts of the plant where they are found, and thus they may be readily distinguished from the parenchyma in which they are placed, both in their form and mode of elongation. We thus find it convenient to speak of the tissue formed of these bundles under the collective name of *Fibro-vascular Tissue*, or the *Fibro-vascular, Vertical*, or *Longitudinal System*, to distinguish it from the ordinary cellular tissue, which constitutes the *Parenchymatous, Cellular*, or *Horizontal System*.

4. Epidermal Tissue.—In Cormophytes and in all Flowering plants, the cells situated on the surface of their young parts and organs (see page 60) which are exposed to the air, vary in form and in the nature of their contents from those placed beneath them, and are so arranged as to constitute a firm layer which may commonly be readily separated as a distinct membrane. To this layer the term *Epidermal Tissue* is given. It

is generally described as consisting of two parts; namely, of an inner portion called the *Epidermis*, and of an outer thin pellicle to which the name *Cuticle* has been given.

a. *Epidermis.*—This consists of one (*figs.* 95, *e*, and 123, *a*), two (*fig.* 124, *a*, *a*), three (*fig.* 125, *a*), or more layers of cells, firmly united together by their sides, and forming a continuous structure, except at the points where it is perforated by the stomata, presently to be described (*figs.* 131, *s*, and 132, *s*). These cells are generally of a flattened tabular character (*figs.*

Fig. 120.

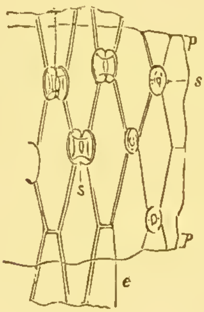


Fig. 121.

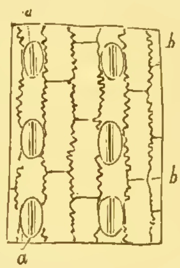


Fig. 122.

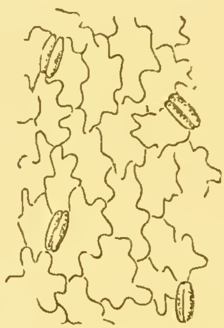


Fig. 120. Epidermal tissue from the leaf of the Iris (*Iris germanica*). *p*, *p*. Cuticle. *s*, *s*, *s*. Oval stomata. *e*, *e*. Epidermal cells. After Jussieu.——*Fig.* 121. Epidermis of the Maize. *a*, *a*. Oval stomata. *b*, *b*. Zigzag reticulations formed by the sides of the cells.——*Fig.* 122. Sinuous epidermis with stomata, from the garden Balsam.

123-127), the sides of which vary much in their outline; thus, in the epidermis of the *Iris*, and many other plants, they are elongated hexagons (*fig.* 120, *e*, *e*); in that of the Maize they are zigzag (*fig.* 121, *b*, *b*); while in the garden Balsam, Madder, and the common Polypody, they are very irregular or sinuous (*fig.* 122); and in the epidermis of other plants we find them square, rhomboid, &c.

Fig. 123.

Fig. 123. Vertical section of the leaf of the Maize, showing the epidermis, *a*, *a*, formed of one row of cells, with projecting hairs, *g*, *g*.

Ordinarily in European plants and in those generally of cold and temperate climates, the epidermis is formed of but one row of cells; but in tropical plants we frequently find two, three, or more rows of cells, by which provision such plants are admirably adapted, as will be afterwards explained, for growth in hot dry climates.

The upper walls of the epidermal cells are generally much thickened and chemically altered, or *cuticularised* as it is termed (see *Cuticle*), by which the cell-walls are rendered impervious to moisture, and thus adapted to protect the more tender cells beneath from an undue loss of moisture from the scorching heat

FIG. 124.

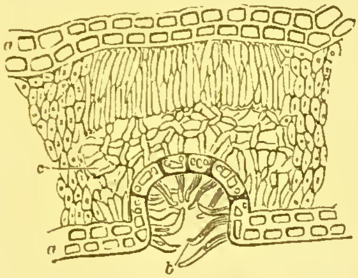


FIG. 125.

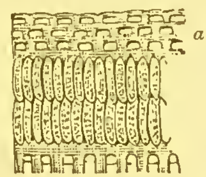


Fig. 124. Vertical section through the leaf of a Banksia. *a, a.* Epidermis with two rows of cells. *c.* Spongiform parenchyma. *b.* Hairs which are contained in little depressions on the under surface of the leaf, and at whose base peculiar stomata are found. After Schleiden.——*Fig.* 125. Vertical section through the leaf of Oleander, showing the epidermis, *a*, composed of three layers of thick-sided cells, and placed above a compact parenchyma of oblong cells. After Brongniart.

of the sun. This thickening of the upper walls of the epidermal cells may be especially observed in leaves of a leathery or hardened texture, as in those of the Oleander (*fig.* 125, *a*), Aloes, Hoya (*fig.* 126, *a*), Box, and Holly, and in the succulent green stems of the Cactaceæ (*fig.* 127, *a*).

FIG. 126.

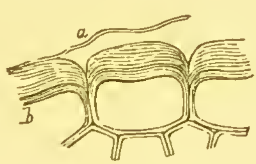


FIG. 127.

Fig. 126. Vertical section of the epidermis of *Hoya carnosa* treated with caustic potash. *a.* The detached cuticle. *b.* The thickened cuticularised layers of the outer walls of the epidermal cells. After Mohl.——*Fig.* 127. Vertical section through the epidermis of the stem of a Cactus. *a.* The thickened cuticularised upper walls of the epidermal cells.

The epidermal cells are generally colourless, but in some cases they contain coloured fluids, and very rarely chlorophyll; hence the green and other colours which leaves and other organs assume are due to colouring matters of various kinds which are contained in the cavities of the subjacent parenchymatous cells, and which show through the transparent epidermal cells. In the walls, however, of the epidermal cells of many plants, waxy matter is contained; in those of *Chara* and *Nitella*, carbonate of lime; and in those of the species of *Equisetum*, and of the Grasses generally, silica is met with in such abundance that, if the organic matter be removed by the agency of heat or acids, a perfect skeleton of the structure will be obtained.

The epidermis covers all the young parts of plants which are directly exposed to the air, except the stigma in Flowering Plants, and it is in all cases absent from those which live under water. No true epidermis is to be found in Thallophytes. The epidermis which at first covers the young stem and branches of trees is replaced at a subsequent period by the corky layer of the bark.

Fig. 128.

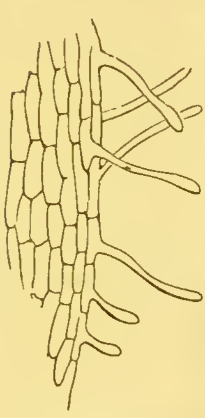


Fig. 128. Fibrils or root-hairs on the surface of a young root.

The roots of plants are invested by a modified epidermal tissue to which the term *Epiblema* has been given by Schleiden; this name is, however, now but rarely used. It consists of cells with thin walls, without stomata, but possessing cellular hair-like prolongations termed *fibrils* or *root-hairs* (*fig.* 128).

b. *Cuticle.*—This consists generally of a thin transparent pellicle, which covers the entire surface of the epidermal cells (*figs.* 120, *p*, *p*, and 126, *a*) with the exception of the openings called stomata (*fig.* 129); and it also forms a sheath over the hairs (*fig.* 129).

Not unfrequently the cuticle becomes of considerable thickness, as in the epidermis of the upper surface of the leaf of Cycas (*fig.* 130, *a*). The cuticle is formed on the outer walls of those cells which are exposed to the chemical influences of air and light.

Fig. 129.

Fig. 130.

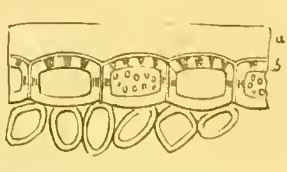


Fig. 129. Cuticle of the Cabbage, showing that it is perforated by the stomata, and forms sheaths over the hairs.——*Fig.* 130. Vertical section through the epidermis, *b*, of *Cycas revoluta*, showing that it is covered by a thickened cuticle, *a*. After Schleiden.

The cell-wall in such a position becomes greatly thickened and altered in its texture; so much so that the outer part is clearly defined from the inner cuticularised layers, and can be stripped off as a distinct layer or cuticle (*fig.* 126, *a*).

c. *Stomata or Stomates.*—These are orifices situated between the sides of some of the epidermal cells, and opening into the intercellular cavities beneath, so as to allow a free communication between the internal tissues and the external air (*figs.* 132, *s*, and 133, *s*). The orifices are surrounded by cells with thinner walls and of a different form from those of the epidermis; they also usually contain some chlorophyll grains. There are generally but two cells surrounding the orifice, and these are commonly of a more or less semilunar form (*fig.* 120), so that the whole has some faint resemblance to the lips and mouth of an animal, and hence the name of *stoma* applied to these structures, from στόμα, a mouth. These bordering cells are called '*stomatal cells*,' '*pore-cells*,' and '*guard-cells*,' and have the power of opening or closing the orifice which they surround according to circumstances, as will be explained hereafter when treating of the functions of stomata

FIG. 131.

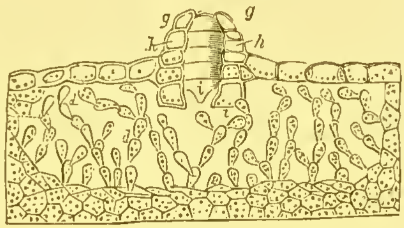
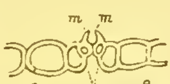


Fig. 131. Vertical section of a portion of the frond of *Marchantia polymorpha*. *g, g.* Stoma divided perpendicularly. *h, h.* Tiers of cells forming its walls. After Carpenter.

FIG. 132.



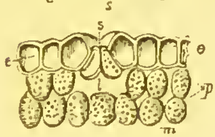


FIG. 133.

FIG. 134.

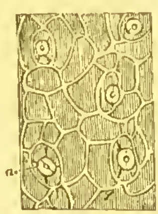


FIG. 135.

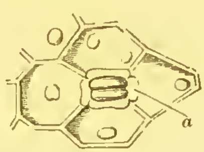


Fig. 132. Vertical section of the epidermis of *Leucadendron decorum*, showing, *e, e*, the epidermal cells, with the stomatal cells, *s*, with elevated margins, *m, m*.——*Fig.* 133. Vertical section of the epidermis of the Iris. *s.* The stoma. *e, e.* Epidermis. *p.* Parenchyma beneath the epidermis. *l.* Intercellular space into which the stoma opens.——*Fig.* 134. Epidermis of *Rumex acetosa*, with rounded stomata, *a.*——*Fig.* 135. Square stoma, *a*, of *Yucca gloriosa*.

in the part devoted to the Physiology of Plants. Instead of two stomatal cells, we sometimes, although but rarely, find four, or even more; thus, in some of the Liverworts, the stomata are rounded apertures between the epidermal cells, surrounded by three or more tiers of stomatal cells, each tier being itself composed of four or five cells, the whole forming a kind of funnel or chimney (*fig.* 131).

Upon making a vertical section through a stomate we usually find that the stomatal cells are placed nearly or quite on a level with those of the epidermis. In other cases, however, and especially when situated upon leaves of a leathery or hardened texture, the stomatal cells are below the epidermal ones, while in some rare instances, again, they are above them.

The stomata vary in form and position in different plants, and in different parts of the same plant, but they are always the same in any particular part of a plant. The more common form is the oval (*figs.* 120, *s*, *s*, and 121, *a*, *a*); but in other instances they are round (*fig.* 134, *a*); and in some cases square (*fig.* 135, *a*). They are either placed singly upon the epidermis, at regular (*fig.* 120) or irregular intervals (*fig.* 134); or in clusters, the intervening epidermis having none (*fig.* 136). The former is the more common arrangement. In the Banksia we find little cavities beneath the epidermis of the under surface of the leaves which contain a number of hairs (*fig.* 124, *b*), and between them, at their base, very small stomata.

FIG. 136.

Fig. 136. Epidermis of the leaf of a species of *Saxifraga*, showing clustered stomata, *s*, with intervening spaces, *e*, *e*, in which they are absent.

The number of stomata also varies considerably. The following table will give some idea of their abundance in leaves, and it will be observed that the number of stomata is usually greatest in those leaves where they are entirely absent from their upper surface.

Stomata in one square inch of surface.

	Upper surface	Lower surface
Mezereon . .	none	4,000
Pæony . . .	none	13,790
Vine . . .	none	13,600
Olive . . .	none	57,600
Holly . . .	none	63,600
Laurustinus . .	none	90,000
Cherry-Laurel .	none	90,000
Lilac . . .	none	160,000
Hydrangea . .	none	160,000
Mistletoe . .	200	200
Tradescantia . .	2,000	2,000
House Leek . .	10,710	6,000
Garden Flag . .	11,572	11,572

	Upper surface	Lower surface
Aloe . . .	25,000	20,000
Yucca . . .	40,000	40,000
Clove Pink . .	38,500	38,500

Stomata are not found upon all plants. Thus they are absent from all Thallophytes, but in the higher orders of Cormophytes, as the Ferns and their allies, they abound, while in the Liverworts and Mosses they are confined to certain parts. They exist more or less upon all Flowering Plants and their organs. But they are far more abundant upon those organs which are green ; thus they are found especially upon leaves, as we have seen, but more particularly on their under surface. On the floating leaves of water plants, as in the Water-lily, however, we find them only on the upper surface ; while in vertical leaves the stomata are equally distributed on the two surfaces. They occur also on the young green stem and branches of plants ; and on the parts of the flower. In those plants which have no foliage leaves, as the Cactaceæ, they abound upon the green succulent stems. They are commonly only found on those parts which are furnished with a true epidermis, and are accordingly absent, as a rule, from roots and all submersed parts of plants. Sachs and others have pointed out that there is a connexion between the distribution of stomata on leaves and their protection from wet by the wax-like coating commonly known as 'bloom;' and recently this has formed the subject of an interesting series of investigations by Francis Darwin (see *Journ. Linn. Soc.* (*Bot.*), vol. xxii. p. 99).

5. Appendages of the Epidermis.—Upon the surface of the epidermis, or in the sub-epidermal tissue, there are frequently to be found certain structures consisting of one or more cells of different forms, variously combined, and containing various substances. These are termed, collectively, *Appendages of the Epidermis*; and, as their name implies, they have no connexion with the fibro-vascular tissue of the leaves, branches, or stem. We shall treat of them under the two heads of *Hairs* and *Glands* ; although in many cases we can draw no distinct line of demarcation between these structures.

(1.) *Hairs or Trichomes.*—These are thread-like prolongations externally of the epidermal cells covered by cuticle (*figs.* 123, *g*, *g*, and 129). They may either consist of a single cell, when they are called *simple hairs* (*figs.* 137–141), or of several cells, when they are termed *compound* (*figs.* 144 and 145). *Simple hairs* may be undivided (*fig.* 137), or forked (*fig.* 138), or branched (*fig.* 139). A beautiful form of simple hair is that called stellate, as seen in *Deutzia scabra*, *Alyssum*, &c. (*figs.* 140 and 141) ; this is formed by a cell dividing horizontally into a number of parts which are arranged in a star-like form.

Compound hairs may be also undivided, as is more frequently the case (*figs.* 144 and 145), or branched (*figs.* 142 and 143). The component cells of compound hairs may be also variously arranged, and thus give a variety of forms to such hairs. Commonly their cells are placed end to end in a single row, so that the hairs assume a more or less cylindrical form; but when the component cells are contracted at the points where they come in contact, they become *moniliform* or *necklace-shaped* (*figs.* 144 and 145). When the cells below are larger than those above, so that the hairs gradually taper upwards to a point, they become *conical*; or when gradually larger from the base to the apex, the

Fig. 137.

Fig. 138.

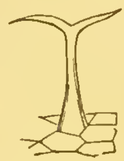


Fig. 139.

Fig. 140.

Fig. 141.

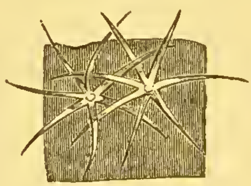


Fig. 142.

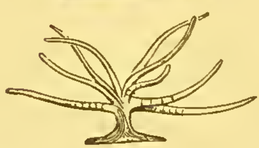


Fig. 143.

Fig. 137. Simple unbranched hair of the common Cabbage.——*Fig.* 138. Forked hair of Whitlow-grass (*Draba*).——*Figs.* 139, 140. Branched stellate hairs of *Alyssum*.——*Fig.* 141. Stellate hairs from *Althæa officinalis*.——*Fig.* 142. Branched hair of a species of *Marrubium*.——*Fig.* 143. Branched hair of *Alternanthera axillaris*. From Henfrey.

hairs are *clavate* or *club-shaped* (*fig.* 146); or when suddenly enlarged at their apex into a rounded head, *capitate* (*fig.* 147). When the terminal cell of a hair is terminated by a hook on one side pointing downwards, such hairs are termed *uncinate* or *hooked* (*fig.* 148); or if ending in two or more hooks at the apex, they are *glochidiate* or *barbed* (*fig.* 149). Hairs, again, instead of being erect, or placed obliquely upon the epidermis, may develop horizontally in a more or less circular manner, and form *stellate hairs*, as in the Ivy (*fig.* 150); or two of the component cells may develop in opposite directions from another cell raised above the level of the epidermis, so as to produce what is termed a *shield-like* or *peltate hair* (*fig.* 151). Many of the above forms occur equally in simple hairs as in compound ones, and the figures are taken indifferently from either kind. Many hairs have one or more spiral fibres in their interior, as those on the testa of the seeds of *Acanthodium*, and of the outer coat (*epicarp*) of the fruit of certain species of *Salvia*, as in that of *Salvia Horminum* (*fig.* 152).

When the divisions of stellate hairs are closely connected by cuticle or otherwise, they form *scales* or *scurf*; such epidermal appendages are, therefore, simply modifications of stellate hairs. A scale may be defined as a flattened membranous more or less rounded plate of parenchymatous tissue, attached by its centre,

Fig. 144. Fig. 146. Fig. 147. Fig. 148.

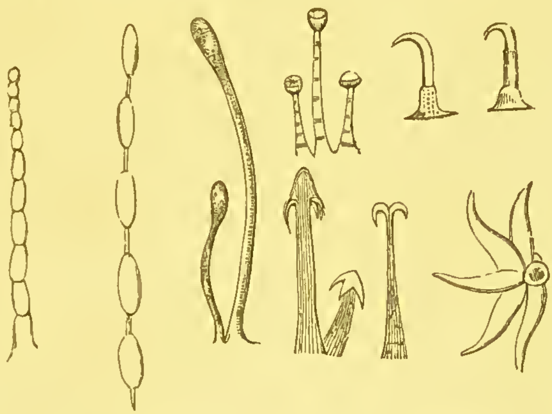


Fig. 145. Fig. 149. Fig. 150.

Fig. 151.

Fig. 144. Moniliform hair of the Virginian Spiderwort (*Tradescantia virginica*).——*Fig.* 145. Moniliform hair of the Marvel of Peru (*Mirabilis Jalapa*).——*Fig.* 146. Clavate hairs.——*Fig.* 147. Capitate hairs.——*Fig.* 148. Hooked hairs.——*Fig.* 149. Glochidiate or barbed hairs.——*Fig.* 150. Stellate hair from the Ivy.——*Fig.* 151. Peltate hair from *Malpighia urens*.

and presenting a more or less irregular margin from the unequal prolongation of its component cells (*fig.* 153). These scales are particularly abundant on the surface of some plants, to which they communicate a scurfy or silvery appearance, as in the *Elæagnus*. Such a surface is said to be *lepidote*, from *lepis*, the Greek term for a *scale*.

Other modifications of hairs which are allied to the above, are the *ramenta* or *ramentaceous hairs* so frequently found upon the stem and petioles of Ferns. These consist of a layer of cells (*fig.* 155) combined so as to form a brownish flattened scale attached by its base to the surface of the epidermis from whence it grows (*fig.* 154).

When the hairs are composed of cells which are short, and have their internal walls thickened so that they form stiffened processes, they are then called *setæ* or *bristles*, and the surface is termed *setose* or *setaceous*. These, slightly modified, form *prickles*, which may be defined as large multicellular hairs springing

FIG. 152.

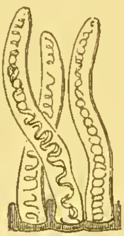


FIG. 153.

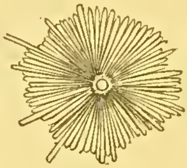


FIG. 155.

FIG. 154.

FIG. 156.

Fig. 152. Hairs, each having a spiral fibre in its interior, from the epicarp of the fruit of *Salvia Horminum*.——*Fig.* 153. Scale of the Oleaster (*Elæagnus*).——*Fig.* 154. Ramenta from the petiole of a Fern.——*Fig.* 155. Ramentaceous hair, showing its component cells.——*Fig.* 156. Prickles on a Rose-branch.

from the epidermis and layer of cells beneath, the walls of which are hardened by the deposition of lignin, and which terminate in a sharp point (*fig.* 156). They are especially abundant on the stems of the Rose and Bramble. Prickles and some other allied structures, as warts, &c., which arise from the sub-epidermal tissue as well as the epidermis, have been termed *Emergences*. They should be carefully distinguished from *spines*, to be hereafter alluded to when speaking of branches. (See page 107.)

The ordinary hairs above described are either empty, or they contain fluid of a watery nature, which may be colourless or coloured. Such have been therefore termed by some botanists *lymphatic hairs*, to distinguish them from other hair-like appendages which are filled with special secretions, and hence have been called *glandular hairs*. The latter will be again alluded to under *glands*, to which variety of epidermal appendage they properly belong.

Hairs occur upon various parts of plants, and, according to their abundance and nature, they give varying appearances to their surfaces, all of which are distinguished in practical Botany by special names. The more common position of hairs is upon

FIG. 157.

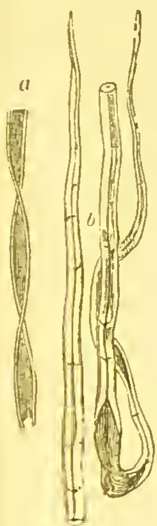


FIG. 158.

FIG. 159.

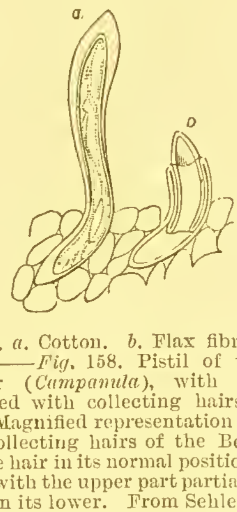


Fig. 157. *a.* Cotton. *b.* Flax fibres (*liber-cells*).——*Fig.* 158. Pistil of the Bell-flower (*Campanula*), with its style covered with collecting hairs.——*Fig.* 159. Magnified representation of two of the collecting hairs of the Bell-flower. *a.* The hair in its normal position. *b.* The hair with the upper part partially drawn within its lower. From Schleiden.

the leaves, stem, and young branches, but they may also be found on the flower-stalks, bracts, parts of the flower, the fruit, and the seed. The substance called cowhage consists of the hairs covering the legumes of *Mucuna pruriens*; while cotton is the hair covering the seeds of the species of *Gossypium*.

Cotton may be readily distinguished under the microscope from the liber-cells already described (page 50), from the cell of which it is formed, not possessing any stiff thickening layers, and thus collapsing when dry, so that it then resembles a more or less twisted band with thickened edges (*fig.* 157, *a*); while liber-cells, such as those forming flax fibres, from having thick walls, always maintain their original cylindrical form and tapering extremities (*fig.* 157, *b*).

On young roots we find also cells prolonged beyond the surface which are of the nature of hairs, and have therefore been termed *root-hairs* or *fibrils* (*fig.* 128) (see Roots). The hairs which occur on the parts of the flower frequently serve an indirect part in the process of fertilisation by collecting the pollen which falls from the anthers ; hence such are termed *collecting hairs* (*fig.* 158). The collecting hairs, which occur on the style of the species of *Campanula* (*fig.* 159, *a*) are peculiar from their upper end, *b*, retracting within their lower, at the period of fertilisation.

FIG. 160. FIG. 161. FIG. 162. FIG. 163.

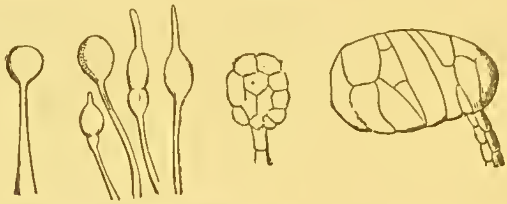


Fig. 160. Stalked unicellular gland of *Salvia*.——*Fig.* 161. Stalked unicellular glands of Snapdragon (*Antirrhinum majus*).——*Fig.* 162. Stalked many-celled gland of *Ailanthus glandulosa*. From Meyen.——*Fig.* 163. Stalked many-celled gland from *Begonia platanifolia*. From Meyen.

(2.) *Glands.*—This name properly applies only to cells which secrete a peculiar matter, but it is also vaguely given to some other epidermal and sub-epidermal appendages. Glands have been variously arranged by authors ; thus, by some, into *exter-*

FIG. 164. FIG. 165. FIG. 166. FIG. 167.

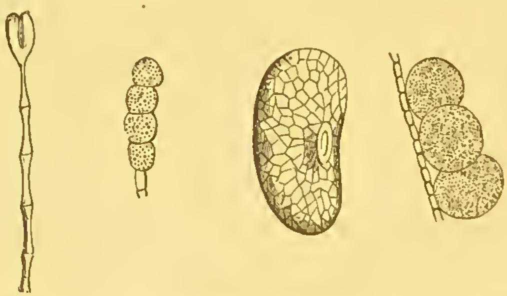


Fig. 164. Stalked gland of Snapdragon, terminated at its summit by two secreting cells.——*Fig.* 165. Stalked gland with four secreting cells at its apex. From Meyen.——*Fig.* 166. Sessile many-celled gland.——*Fig.* 167. One-celled sessile glands, termed *papulæ* or *papillæ*.

nal and *internal* ; by others, into *simple* and *compound* ; while others, again, have adopted different modes of arrangement. We divide them into *external* and *internal*.

a. *External Glands.*—These may be again divided into *stalked*, and *sessile* or *not stalked*. The *stalked glands* are those which are frequently called *glandular hairs* (see page 67). They are either formed of a single cell, dilated at its apex by the peculiar fluid it secretes (*figs.* 160 and 161), or of two (*fig.* 164), or more (*fig.* 165) secreting cells placed at the end of a hair; or they consist of a mass of secreting cells (*figs.* 162 and 163).

Sessile Glands present various appearances, and consist, like the former, of either one secreting cell (*fig.* 167), or of two, or more (*fig.* 166). Those with one secreting cell placed above the level of the epidermis are frequently termed *papillæ* (*fig.* 167); and it is to their presence upon the surface of the Ice-plant (*Mesembryanthemum crystallinum*) that the peculiar crystalline appearance of that plant is due. When sessile glands are composed of cells containing solid secretions so that they form hardened spherical or other shaped appendages upon the surface of the epidermis, they are termed *warts*; these are now, however, commonly placed among the Emergences (see page 66).

Fig. 168.

Fig. 169.

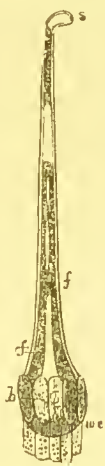


Fig. 168. Sting of a species of *Malpighia*. *e.* Epidermis. *b, b, g.* Glandular apparatus. *Fig.* 169. Sting of the common Nettle (*Urtica dioica*), consisting of a single cell with a bulbous expansion at its base, *b*, and terminated above by a swelling, *s*, and containing a granular irritating fluid, *f, f.* *we.* Epidermal cells surrounding its base.

When a sessile gland contains an irritating fluid, and is prolonged above into one or more hair-like processes, which are placed horizontally (*fig.* 168), or vertically (*fig.* 169), we have a *sting* formed. Stings are sometimes arranged under the head of stalked glands; we place them here because their secreting apparatus is at the base, and not at the apex, as in stalked glands.

In the Nettle (*fig.* 169), the sting consists of a single cell, enlarged at its base, *b*, by the irritating fluid *f, f*, which it contains, and tapering upwards to near the apex, when it again expands into a rounded head, *s*. The enlarged base is closely invested by a dense layer of epidermal cells, *w e*, which forms a kind of case to it. In touching a nettle lightly, the knob-like head, *s*, is broken off, and the sharp point of the sting then left enters the skin, while the irritating fluid is pushed up at the same time into the wound by the pressure occasioned by the elastic force of the surrounding epidermal cells, *we*. If a nettle, instead of being thus touched lightly, be grasped firmly, the sting becomes crushed, and as it cannot then penetrate the skin, no irritation is produced.

b. *Internal Glands.*—These are cavities containing secretions situated below the epidermis, and surrounded by a compact layer of secreting cells (*fig.* 170, *l*, *g*). They are closely allied in their nature to receptacles of secretion (see page 72), from

FIG. 170.

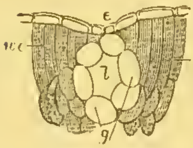


FIG. 171.

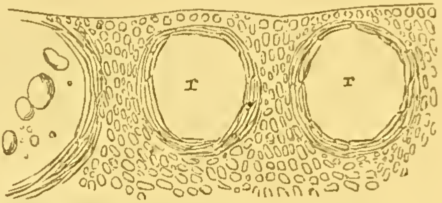


Fig. 170. Internal gland from the leaf of the common Rue (*Ruta graveolens*). *g*. Gland surrounding a cavity, *l*, and itself surrounded by the epidermis, *e*, and the ordinary cells of the leaf, *we*.——*Fig.* 171. *r*, *r*. Internal glands from the rind of the Orange.

which, in fact, in many cases, it is difficult to distinguish them, and amongst which, therefore, they are frequently placed. In some cases they are of small size, as those in the leaves of the Rue (*fig.* 170, *g*, *l*), Myrtle, Orange, and St. John's Wort. In these leaves they may be readily observed by holding them between the eye and the light, when they appear as little transparent spots; hence such leaves are termed *dotted*. This dotted

FIG. 172.

FIG. 173.

FIG. 174.

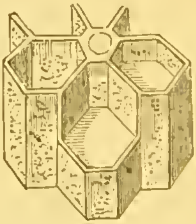


Fig. 172. Petal of a species of *Ranunculus* with a nectary at its base, covered by a scale.——*Fig.* 173. Petal of Crown Imperial (*Fritillaria imperialis*), with a nectariferous gland at its base.——*Fig.* 174. Air cavities from the stem of *Limnocharis Plumieri*.

transparent appearance is due to the oily matters they contain refracting the light in a different manner to that of the other parts of the leaf. In other instances these glands are of large size (*fig.* 171, *r*, *r*), and project more or less beyond the surface in the form of little excrescences, as those in the rind of the Orange, Lemon, and Citron. Internal glands are very common in many other plants besides those already mentioned: thus in all the Labiate Plants, as Mint, Marjoram, Thyme, Rosemary, Sage, &c.; and it is to the presence of the secretions they contain that such plants owe their value as articles of domestic economy, or as perfumes, or medicinal agents.

Holding a sort of intermediate position between the internal and external glands as above described, are the true nectaries of flowers, which being strictly of a glandular nature will be most properly alluded to here under the name of *nectariferous glands.* They are well seen at the base of the petals of the species of *Ranunculus* (*fig.* 172) and in the Crown Imperial (*fig.* 173). These glands consist of a pore or depression into which a honey-like fluid or nectar is secreted, or rather excreted, by the surrounding cells. The tissue of the stigma of Flowering Plants is also covered by a viscid secretion or excretion at certain periods, and may be considered therefore as of a glandular nature. The surface of the ovary and other parts are also sometimes more or less covered by a similar saccharine fluid, and are then described as *nectariferous.*

When glands or other receptacles containing peculiar secretions arise from the separation of uninjured cells from one another, they are termed *schizogenous*; when from the absorption of a mass of tissue, *lysigenous* (*fig.* 171, *r*, *r*).

6. Intercellular System. — Having now described the different kinds of cells, and the modifications which they undergo when combined so as to form the tissues, we have in the next place to allude to certain cavities which are placed between their walls, or produced by the destruction of some of their component cells. These constitute the *Intercellular System.*

a. *Intercellular Passages or Canals and Intercellular Spaces.*— The cells being, in the great majority of cases, bounded by rounded surfaces, or by more or less irregular outlines, it must necessarily happen that when they come in contact with one another they can only touch at certain points, and therefore interspaces will be left between them, the sizes of which will vary, according to the greater or less roundness or irregularity of their surfaces. When such spaces exist as small angular canals running round the edges of the cells and freely communicating with one another, as is especially evident in round or elliptical parenchyma (*fig.* 62), they are called *intercellular passages* or *canals*; but when they are of large size, as in stellate or spongiform tissue, they are termed *intercellular spaces* (*figs.* 93 and 124, *c*). In most cases these spaces and canals are filled with air, and when they occur in any organ exposed to the atmosphere in which stomata are found, they always communicate with them (*fig.* 132, *l*), by which means a free passage is kept up between the atmosphere and the air they themselves contain.

b. *Air Cavities.*—In water-plants the intercellular spaces are frequently of large size, and bounded by a number of small cells regularly arranged (*fig.* 174), by which they are prevented from communicating with one another, or with the external air; they are then commonly termed *air cavities.* In such plants these cavities fulfil the important services of enabling them to float, and of supplying their interior with air. In other instances we find large air cavities, as in the stems of Grasses and Umbelliferous plants, which have been formed by the destruction of their internal tissues by the more rapid growth of the outer portions; these large cavities are termed *lacunæ*, and appear to have no special functions to perform.

c. *Receptacles of Secretion.*—In many plants, again, the intercellular canals or spaces act as receptacles for the peculiar secretions of the plant; in which case they are termed *Receptacles of Secretion.* In many instances these are closely allied to the internal glands (*figs.* 170 and 171) already described, and are frequently confounded with them; indeed, some regard them as highly developed forms of internal glands. These receptacles vary much in form, but are usually more or less

Fig. 175.

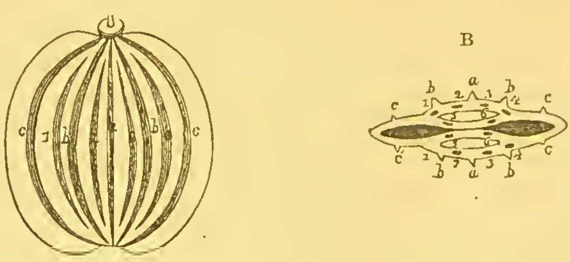


Fig. 175. Fruit of Parsnip (*Pastinaca sativa*). A. Dorsal surface. *a, b, b, c, c.* Primary ridges. 1, 2, 3, 4, Vittæ. B. Horizontal section of the fruit. The letters and figures refer to the same parts as in A. In *fig* A, the vittæ are readily seen by noticing that they are shorter than, and alternate with, the ridges, *a, b, b, c, c.*

elongated. They are formed by certain cells separating from each other as they are developed (*schizogenous*), by which means canals and spaces of various kinds are formed in the surrounding tissue. In the Coniferæ they contain turpentine, and have therefore been termed *turpentine vessels.* In the plants of this order they occur especially in the wood (*fig.* 186, *la*) and bark: those in the wood forming elongated tubular passages. In the pericarp of the fruit of Umbelliferous Plants they form the receptacles of oil, which are commonly termed *vittæ* (*fig.* 175, 1, 2, 3, 4, A and B). The receptacles of secretion are found especially in certain orders of plants, to which from the nature of their contents they communicate important properties. (See also Laticiferous Vessels, page 57).

d. *Intercellular Substance.*—A peculiar substance which was termed, from its position, *intercellular substance*, was formerly supposed to be universally distributed between the walls of the cells, glueing them together as it were ; and in some plants occurring in great abundance, as in many Algæ, the horny albumen or endosperm of some seeds, and in the collenchymatous cells of the common Beet, Begonia (*fig.* 95, *cl*, *cl*), &c. But in all these cases this appearance is due to alterations and changes which have taken place in the cellulose forming the cell-wall and in the contents of the cell. Thus, in the Sea Wrack, it is caused by the enormous imbibition of water, which makes the outer part of the cell-wall swell up, and eventually to be converted into mucilage. Hence this special intercellular substance does not exist in plants.

CHAPTER 3.

ORGANS OF NUTRITION.

Having now considered the elementary structures of plants, we proceed to describe in detail the various compound organs which they form by their combination. These, as already noticed (page 13), are arranged in two divisions, namely : 1. *Organs of Nutrition* ; and 2. *Organs of Reproduction.* The root, stem, and leaves form those of nutrition, and the flower and its parts those of reproduction. Upon the whole, it is most convenient to commence our notice of the organs of nutrition with the stem.

Section 1. The Stem or Caulome.

The stem may be defined as that part of the axis which at its first development in the embryo takes an opposite direction to the root, seeking the light and air, and hence termed the ascending axis, and bearing on its surface the leaves and other leafy appendages (*fig.* 20, *t*). This definition will, in numerous instances, only strictly apply to a stem at its earliest development, for it frequently happens that, soon after its first appearance, instead of continuing to take an upward direction into the air, it will grow along the ground, or even bury itself beneath the surface, and thus by withdrawing itself from the light and air it resembles, in such respects, the root, with which organ such stems are, therefore, ordinarily confounded. In these cases, however, a stem is at once distinguished from a root by bearing scales or cataphyllary leaves, each of which has also the power of forming a leaf-bud in its axil. The presence of leaves with leaf-buds in their axils is therefore the essential characteristic of a stem, in contradistinction to a root, in which such structures are always absent.

All Flowering plants, from the mode in which their axis is developed from the embryo in germination (page 13), must necessarily have a stem, although such stem may be very short. Those which have this organ clearly evident are called *caulescent*, while those in which it is very short or inconspicuous are termed *acaulescent* or *stemless.* In Flowerless plants the stem is not necessarily present; thus it is absent in all Thallophytes, as already noticed (page 7).

1. Internal Structure of the Stem in general.—A stem in its simplest condition consists merely of parenchymatous cells, with occasionally a central vertical cord of slightly elongated, somewhat thickened cells. Examples of such a stem may be commonly seen in Mosses (*figs.* 9 and 10). Such a structure however would be unsuited to plants except those of low organisation, and we accordingly find, as a rule, that in all plants above the Mosses the stem is made up partly of parenchymatous cells, and partly of woody tissue and vessels of different kinds, by which the requisite strength and toughness are produced. In such stems therefore we distinguish two systems as already noticed (page 57), namely, a *Parenchymatous* or *Cellular*, and a *Fibro-vascular*; and as the fibro-vascular tissue is arranged in longitudinal bundles in the midst of the parenchymatous, it has also been termed the *Vertical* or *Longitudinal System*, while the parenchymatous has been called the *Horizontal System*.

In their internal structure the stems of plants are subject to numerous modifications, all of which may be, however, in their essential particulars, reduced to three great divisions, two of which are found in the Phanerogamia, and one in the Cryptogamia. As illustrations of the two former, we may take an Oak and a Palm stem; of the latter, that of a Tree-fern.

Upon making a transverse section of an Oak (*fig.* 176), we observe that the two systems of which the stem is composed are so arranged as to exhibit a distinct separation of parts. Thus we have a central one, *m*, called the *pith*; an external one, *c e*, or *bark*; an intermediate *wood*, *r*, arranged in concentric layers or annual rings; and little rays, *b*, connecting the pith and the bark, termed *medullary rays.* Such a stem grows essentially in diameter by annual additions of new wood on the outside of the previous wood, and hence it is called Exogenous (from two Greek words signifying *outside growers*).

In a Palm stem no such distinction of parts can be noticed (*fig.* 177), but upon making a transverse section we observe a mass of parenchyma, *m*, distributed throughout it, and the fibro-vascular system arranged vertically in this in the form of separate bundles, *f*, which have no tendency to form concentric

FIG. 176.

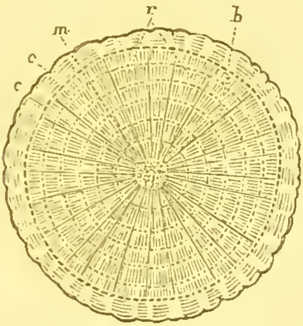


FIG. 177.

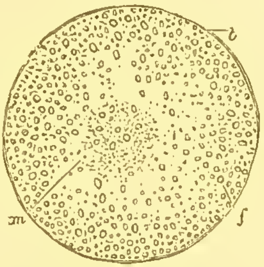


Fig. 176. Transverse section of an Oak-branch six years old. *m.* The medulla or pith. *c, c.* The bark. *r.* The wood, arranged in concentric layers. *b.* Medullary rays.—*Fig.* 177. Transverse section of the stem of a Palm. *m.* The parenchyma. *f.* The fibro-vascular bundles. *b.* The rind or false bark.

layers of wood ; the whole being covered externally by a fibrous and parenchymatous layer, *b*, which, as will be hereafter seen, is formed essentially by the ends of the fibro-vascular bundles, and which is termed the *false bark* or *rind.* This structure is called Endogenous (from two Greek words signifying *inside growers*), as such stems grow by the addition of new fibro-vascular bundles which are at first directed towards their interior. These two structures, the Exogenous and Endogenous, are characteristic of Flowering plants.

FIG. 178.

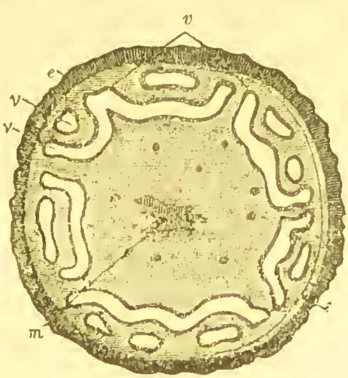


Fig. 178. Transverse section of the stem of a Tree-fern. *m.* Parenchymatous cells, which are wanting in the centre. *v, v, v.* Fibro-vascular bundles. *e.* Rind.

If we now turn our attention to the Cryptogamia, and make a transverse section of a Tree-fern (*fig.* 178), we observe the centre, *m*, to be either hollow or filled with parenchyma, the fibro-vascular bundles being arranged in irregular sinuous plates around it, *v, v, v*, and forming a continuous or interrupted circle near the circumference, which consists of a rind, *e*, inseparable from the wood beneath. This structure is termed Acrogenous (from two Greek words signifying *summit growers*), because the fibro-vascular bundles of such a stem grow only by additions to their apex.

The characteristic peculiarities thus found to exist in the internal appearance and growth of these three kinds of stem are due to corresponding differences in their component parts, or, as they are commonly called, their *fibro-vascular* or *vascular bundles.* Thus, the *fibro-vascular bundle* of an Exogenous stem (*fig.* 179) consists in the first year of growth of a layer of spiral vessels (*s*, *s′*, and *fig.* 180, *s v*), surrounding the pith (*p′*, and *fig.* 180, *p*); on the outside of this layer there are subsequently developed, in perennial plants, pitted vessels (*p*, *p*, and *fig.* 180, *d*) and wood-cells (*w′*, *w*, and *fig.* 180, *w*), which together form the wood. But in herbaceous plants annular and reticulated vessels are also found

Fig. 179.

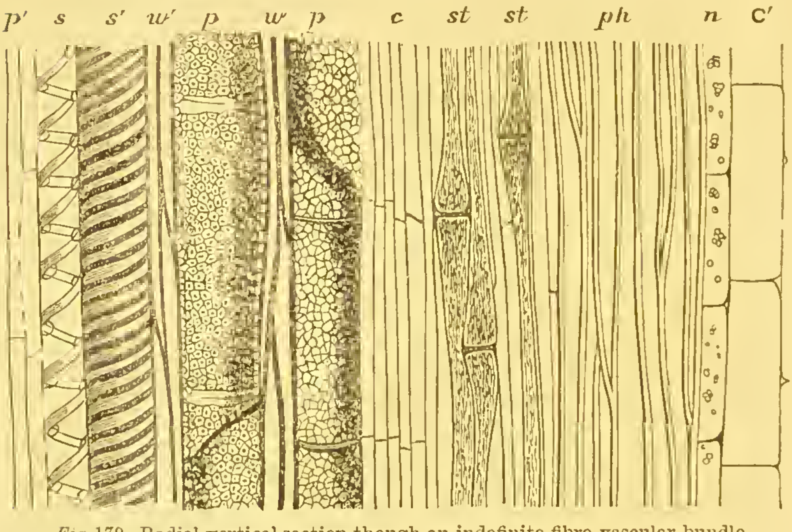


Fig. 179. Radial vertical section though an indefinite fibro-vascular bundle from the stem of the Sunflower. *p′*. Pith. *s, s′*. Spiral vessels. *w′, w*. Wood-cells. *p, p*. Pitted vessels. *c*. Cambium. *st, st*. Sieve tubes. *ph*. Liber-cells. *n*. Bundle-sheath. C′. Cellular layers of the bark. After Prantl.

intermixed with the wood-cells. The wood is covered externally by a layer of vitally active or generating cells (*figs.* 179, *c*, and 180, *c*), called the *cambium* (see page 88), on the outside of which are the liber (*figs.* 179, *st*, *ph*, and 180, *l*), the cellular parts of the bark (*figs.* 179, C′, and 180, *c e*), and the epidermis (*fig.* 180, *e*). The different kinds of tissue which are placed within the cambium, or cambium layer as it is frequently termed, form what has been called the *xylem* or *woody portion* of the bundle, and those outside the cambium forming the liber, that portion which has been termed the *phloëm*; so that the fibro-vascular bundle has the pith (*fig.* 180, *p*), on its inner surface, and is covered externally by the cellular layers, *ce*, of the bark. In the stem of some plants, as in the above, a single special layer of cells, termed the *bundle-sheath* (*fig.* 179, *n*), forms the innermost layer of the cellular portions of the bark, and thus investing the fibro-vascular bundle. In these bundles the growth of the different parts is *progressive*, the inner part of each being first formed, and growth gradually proceeding to the outside, and as they always contain a cambium layer they are capable of further growth, and thus form periodically new layers of xylem and phloëm, and are therefore called *indefinite* or *open fibro-vascular bundles.* It also necessarily follows from the cambium layer

FIG. 180.

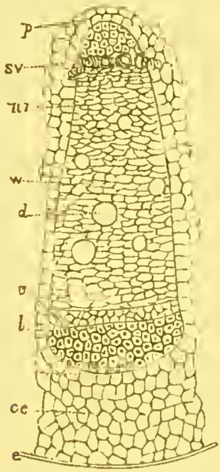


FIG. 181.

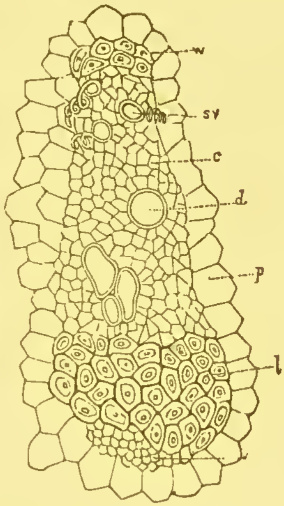


Fig. 180. Transverse section of an indefinite fibro-vascular bundle of an Exogenous stem (Melon). *p.* Pith. *sv.* Spiral vessels. *mr.* Medullary ray. *w.* Wood-cells. *d.* Pitted vessels. *c.* Cambium layer. *l.* Liber or phloëm. *ce.* Cellular portions of the bark. *e.* Epidermal tissue.——*Fig.* 181. Transverse section of a definite fibro-vascular bundle of an Endogenous stem (Palm), the upper portion being directed to the centre. *w.* Wood-cells. *sv.* Spiral vessels. *c.* Cambium-like cells. *d.* Pitted vessels. *p.* Parenchyma (ground tissue), surrounding the bundle. *l.* Liber-cells.

being placed between the xylem and the phloëm, that the layers of increase to these parts of the bundle are in continuity with the previous ones.

In Endogenous stems the *fibro-vascular bundles* (*fig.* 181) consist internally of wood-cells, *w*, and spiral vessels, *s v*; on the outside of which other spiral vessels are formed, as well as pitted, *d*, and other vessels; these are succeeded by a number of delicate parenchymatous cells, *c*, corresponding to cambium cells, which are gradually converted into thick-walled prosenchymatous cells, *l*, resembling those of the liber of Exogenous stems, together with some sieve-tubes; and the whole bundle is surrounded by parenchyma, *p*. In this case the development of the fibro-vascular bundles, like those of Exogenous stems, is gradual, the inner part of each being first formed, and growth proceeding progressively to the outside: hence these also are progressive bundles; but, as such bundles have no special layer of generating cells resembling the cambium layer, no additions to them can be made in successive seasons, as is the case in the indefinite fibro-vascular bundles of Exogenous stems. Hence the new bundles are not developed in continuity with the old, but remain distinct and of limited size, and are therefore named *definite* or *closed fibro-vascular bundles.*

In Acrogenous stems the *fibro-vascular* bundles are chiefly made up of vessels of the scalariform, annular, or spiral type, according to the different orders of Cormophytes from whence they have been derived; these are surrounded by delicate tubular cells, and the whole is enclosed by a firm layer of parenchymatous cells the walls of which have undergone a thickening and hardening process, and to which the name of *sclerenchyma* has been given, and forming what has been called the *bundle-sheath.* Such bundles only grow by additions to their summit; and as these bundles, like those of Endogenous stems, have no special layer of cambium cells, they are also said to be *closed* or *definite.*

The distinctive appearances and modes of growth which we have thus seen to occur in the stems of the two Flowering Plants above noticed are also accompanied by certain differences in the structure of their embryo. Thus plants with Exogenous stems have an embryo with two cotyledons (*figs.* 16, *c*, *c*, and 18, *c*, *c*); those with Endogenous stems have but one cotyledon in their embryo (*fig.* 19, *c*). Hence Exogenous stems are also termed *Dicotyledonous*; and Endogenous stems *Monocotyledonous.* For reasons which we shall describe hereafter, the latter terms are in some cases to be preferred to the former. In the succeeding pages we shall use them indiscriminately. Acrogenous stems are also sometimes termed *Cryptogamous*, because they are only found in Flowerless plants. With these general remarks on the internal structure of the three kinds of stems we now proceed to describe them respectively in detail.

A. Exogenous or Dicotyledonous Stem.—All the trees and large shrubs of this country, and with rare exceptions those of temperate and cold climates, are exogenous in their growth. In warm and tropical climates such plants occur associated with those possessing endogenous and acrogenous structure; but Dicotyledonous plants are far the most abundant even in these parts of the world.

In the embryo state, the Exogenous stem is entirely composed of parenchyma. But as soon as growth commences, some of its parenchymatous cells become developed into vessels and wood-cells, so as to form the indefinite fibro-vascular bundles which are characteristic of such a stem. These woody portions (*fig.* 182, *t*) are at first separated from each other by large intervening spaces of parenchyma, but as growth proceeds they continue to enlarge, while at the same time new fibro-vascular elements are developed between them, so that they ultimately form at the end of the first year's growth a ring of vessels and wood-cells round the central mass of parenchyma, *m*, interrupted only at certain points by projections of this parenchyma in the form of radiating lines, *r*. This ring is also surrounded by an external layer, *b*, of parenchymatous and liber tissues, which is connected with the central parenchyma by the radiating lines, *r*, already alluded to. The stem then presents the following parts (*fig.* 182): 1. A central mass of parenchyma, *m*, which is called the *Medulla* or *Pith*; 2. An interrupted sheath of spiral vessels, *t*, called the *Medullary sheath*; 3. An interrupted ring of wood-cells and vessels, forming the *Wood*; 4. A layer of very delicate thin-walled cells, the *Cambium* or *Cambium layer*; 5. Radiating lines, *r*, connecting the pith with the cambium layer and bark, the *Medullary rays*; and 6. The *Bark*, *b*, a mass of parenchyma surrounding the whole stem,

FIG. 182.

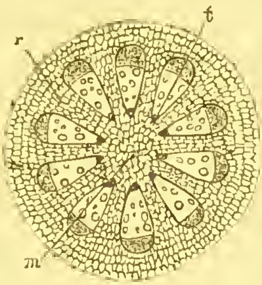


Fig. 182. Transverse section of the first year's stem of an Exogenous or Dicotyledonous stem. *m*. Pith. *r*. Medullary rays. *t*. Spiral vessels forming the medullary sheath on the outside of which are the other elements of the wood and the liber. *b*. Cellular layers of the bark.

FIG. 183.

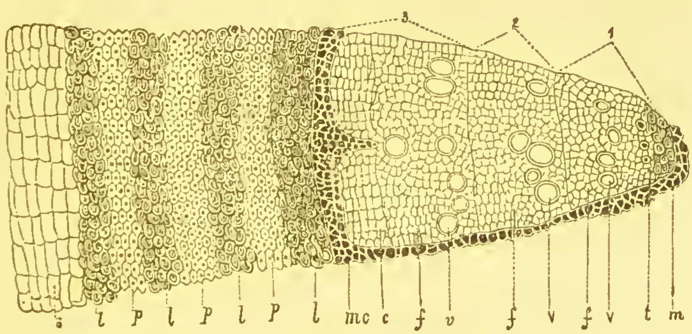


Fig. 183. Transverse section from the centre to the circumference of the stem of the Maple, three years old. *m*. Pith. *t*. Spiral vessels. *v*, *v*, *v*. Pitted vessels. *f*, *f*, *f*. Wood-cells. *c*. Cambium or cambium layer. *s*. Corky layer; within which may be observed the other cortical layers, marked *l p l*, *p l*, *p l*. *mc*. Newly forming bark. The figures 1, 2, 3, refer to the three successive years' growth of the wood.

and containing in its interior liber-cells, &c., and invested on its outer surface by the *Epidermis*.

The stems of plants which live more than one year, as those of trees and shrubs, at first resemble those which are herbaceous or die yearly, except that the wood in such plants is generally firmer and in larger proportion. As growth proceeds in the second year, a new ring of wood is formed on the outside of the one of the previous year (*fig.* 183, 2), while at the same time a new fibrous layer is added to the inside of the bark, *l*. These layers are developed out of the cells of the cambium layer, already alluded to as being situated between the xylem and the phloëm of the indefinite fibro-vascular bundles which form the stems of Exogenous plants (*figs.* 179, *c*, and 180, *c*). The medullary rays (*fig.* 185, A, *i*, *i*), at the same time increase by addition to their outside, and thus continue to keep up the connexion between the pith and the bark. In succeeding years we have in like manner new layers of wood and liber, one of each, as a rule, for every year's growth (*fig.* 183, 3), while the medullary rays also continue to grow from within outwards. Each succeeding year's growth is therefore essentially a repetition of that of the first year, except as regards the pith and spiral vessels; the former of which does not increase in size after the first year, and the latter are never repeated, so that in old stems we have no more distinct regions than in those of the first year. We have consequently in all Exogenous stems the following parts, namely, *pith*, *medullary sheath*, *wood*, *medullary rays*, *cambium layer*, and *bark*—which we shall now describe in the order in which they are placed.

Fig. 184.

Fig. 184. Young branch of Walnut (*Juglans regia*) cut vertically to show the *discoid* pith.

1. *Pith or Medulla* (*figs.* 182, *m*, and 185, B, *a*, *a*).—This consists essentially of parenchyma, and it forms a more or less cylindrical or angular column which is situated commonly at, or towards, the centre of the stem. As a general rule the pith is not continued into the root, but it is always in connexion directly with the terminal bud of the stem, and also at first indirectly by the medullary rays with all the lateral leaf-buds; as the latter, however, continue to develop, their connexion with the central pith is cut off, as will be explained hereafter in speaking of their structure and origin. The parenchyma of which the pith is composed is generally that kind which is known as *regular* (*fig.* 65), so that when a section is made of it, and examined microscopically, it presents an hexagonal (*figs.* 66 and 185, B, *a*, *a*) or polyhedral appearance.

In the earliest stages of the plant's existence the whole of it consists of parenchyma; and out of this tissue, by the differentiation of special cells, the more elaborate spiral and other vessels, and wood-cells are developed. As, however, these elements of the fibro-vascular bundles increase in number, they encroach upon the parenchyma, and thus circumscribing the central portion till it assumes the appearance of a central continuous column or pith (*fig.* 182, *m*), filling the interior of the stem, and giving off the medullary rays, *r*, as flattened plate-like processes which connect the pith with the cellular layers of the bark, *b*. That portion of the parenchyma which thus remains, including the pith, medullary rays, and cellular layers of the bark, is called the *fundamental* or *ground tissue*.

Instead of continuing to form an uninterrupted column, the pith, in after years, owing to the external parts growing rapidly, becomes more or less broken up; and even in many herbaceous plants, such as the Hemlock and others, which grow with great rapidity, it is almost entirely destroyed, at an early period of the plant's life, merely remaining in the form of ragged portions attached to the interior of the stem; and thus large central air-cavities or lacunæ are formed. In some plants, such as the Walnut (*fig.* 184) and Jessamine, the pith is broken up regularly into horizontal cavities separated only by thin discs of its substance. It is then termed *discoid*.

The diameter of the pith varies much in different plants. Thus it is generally very small in hard-wooded plants, as in the Ebony and Guaiacum; while in soft-wooded plants, as the Elder and Ricepaper Plant (*Tetrapanax* (*Aralia*) *papyrifera*), it is large. The diameter not only varies in different plants, but also in different branches of the same plant; but when once the ring of wood of the first year is fully perfected, the pith which it surrounds can no longer increase, and it accordingly remains of the same diameter throughout the life of the plant.

The pith, as we have just seen, is essentially composed of parenchyma. It also frequently contains laticiferous vessels, as may be readily observed by breaking asunder a young branch of the Fig-tree, when a quantity of milky juice at once oozes out from their laceration.

2. *The Medullary Sheath* (*fig.* 185, B, *d*) consists of spiral vessels which are situated on the innermost part of the wedge of wood which forms the first year's growth. These vessels do not form a continuous sheath to the pith, but spaces are left between them, through which the medullary rays pass outwards (*fig.* 182, *t*). As the spiral vessels are never repeated after the first year's growth, the medullary sheath is consequently the only part of the stem in which they normally occur.

3. *The Wood or Xylem.*—This is situated between the pith on its inside, and the bark on its outer surface (*fig.* 176, *r*), and it is separated into wedge-shaped bundles by the passage through it of the medullary rays, *b*. We have seen that in the first year's growth of an exogenous stem the wood is deposited

in the form of an interrupted ring immediately surrounding the pith (*fig.* 182, *t*). That portion of the ring which is first developed consists, as we have also seen, chiefly of spiral vessels (*figs.* 182, *t*, 183, *t*, and 185, B, *d*), which form the *medullary sheath*.

On the outside of the medullary sheath, the ring of wood forming the first year's growth (*fig.* 185, B, 1) consists of woody tissue, *c*, among which are distributed, more or less abundantly, some vessels, *b*, chiefly of the kind called pitted in perennial plants; although in herbaceous plants we have also annular and

Fig. 185.

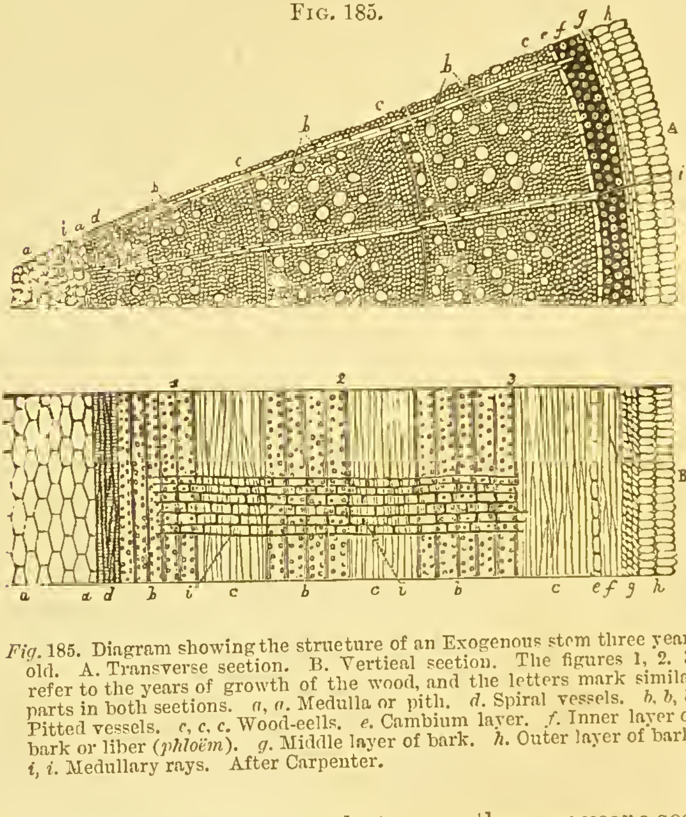


Fig. 185. Diagram showing the structure of an Exogenous stem three years old. A. Transverse section. B. Vertical section. The figures 1, 2, 3, refer to the years of growth of the wood, and the letters mark similar parts in both sections. *a*, *a*. Medulla or pith. *d*. Spiral vessels. *b*, *b*, *b*. Pitted vessels. *c*, *c*, *c*. Wood-cells. *e*. Cambium layer. *f*. Inner layer of bark or liber (*phloëm*). *g*. Middle layer of bark. *h*. Outer layer of bark. *i*, *i*. Medullary rays. After Carpenter.

other vessels. When the stem lasts more than one year a second ring of wood is formed, as we have seen, from the cells of the cambium layer which are placed on the outside of the first ring. This second ring (*fig.* 185, 2) resembles in every respect that of the first year, except that no medullary sheath is formed; it consists therefore entirely of woody tissue and pitted vessels, *c*, *b*. In the third year of growth another zone of wood is produced precisely resembling the second (*fig.* 185, 3), and the same is the case with each succeeding annual ring as long as the plant continues to live. It is in consequence of each succeeding layer of wood being thus deposited on the outside of those of the previous years, that these stems are called *exogenous*. In the stems of the Coniferæ and most other Gymnosperms, as those of the Fir, Yew, and Cypress, the annual rings of wood which are well marked (*fig.* 186), instead of being formed of ordinary woody tissue, and pitted vessels, consist essentially of wood-cells, with large bordered pits (see pages 44 and 50).

The pitted vessels, which as we have seen form an essential portion of the annual layers of the wood of all exogenous stems, except those of the Gymnospermia, as mentioned above, are so large in the Oak, Ash, and other plants, that they may readily be seen by the naked eye upon making a transverse section of the wood of such trees ; and in all cases, upon examining under the microscope a transverse slice of any common exogenous stem, the pitted vessels may be at once distinguished from the

FIG. 186.

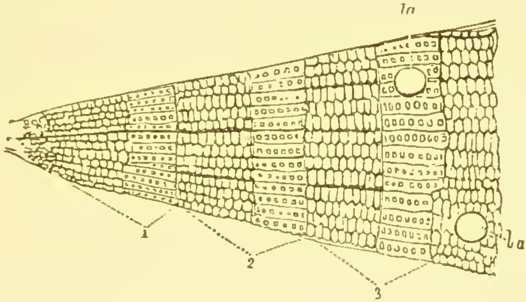


Fig. 186. Transverse section of the stem of a Fir three years old. The figures 1, 2, 3, refer to the annual layers of wood. *la*, *la*. Cavities containing oleo-resinous secretions (*receptacles of secretion*).

wood-cells by the larger size of their openings (*figs.* 183, *v*, *v*, *v*, and 185, A, *b*, *b*, *b*).

But in those Gymnosperms where the wood is made up, as just noticed, of disc-bearing woody tissue, or cells with large bordered pits, though the openings of the cells are larger than those of ordinary woody tissue, they will be observed to be nearly of the same size, but at the same time those formed earliest in the year in each ring are larger and have thinner walls than those which have been formed at the end of the year (*fig.* 186). The pitted vessels in ordinary trees are also commonly more abundant on the inner part of each annual ring, the wood-cells forming a compact layer on the outside (*fig.* 185, A, *c*, *c*, *c*). In such cases the limits of each ring are accurately defined. In those trees which have the pitted vessels more or less diffused throughout the wood-cells or woody tissue, as in the Lime and Maple, the rings are by no means so evident, and can then only be distinguished by the smaller size of the wood-cells on the outside of each, which appearance is caused by their diminished growth towards the end of the season.

The distinction between the annual rings is always most evident in trees growing in temperate and cold climates, where there is a more or less lengthened winter in which no growth takes place, followed by rapid vegetation afterwards in the spring and other seasons. In the trees of tropical climates the rings are not so clearly defined, because there is no complete season of repose in such regions, although to a certain extent the dry season here leads to a cessation of growth, but the alternation of the growing season and that of rest is not so well marked as in colder climates. As alternations of growth and seasons of repose may thus be shown to produce the appearance of annual rings, we can readily understand that if a plant were submitted to such influences several times in a single year it would produce a corresponding number of rings ; and this does really occur in some plants of temperate climates, particularly in those which are herbaceous, where growth is more rapid than in hard-wooded perennial plants, so that the influence of such alternations is more evident. In tropical climates the production of two or more rings in a year is probably even more frequent than in temperate regions. In other trees, again, we have only one ring produced as the growth of several years, as in the *Cycas* ; and lastly, there are instances occurring in which no annual rings are formed, but the wood forms a uniform mass whatever be the age of the plant, as in certain species of *Cacti*. Such appearances as the two latter are, however, totally independent of climate, but are the characteristic peculiarities of certain plants, and even of entire natural orders.

The annual layers of different trees vary much in thickness, thus they are much broader in soft woods which grow rapidly, than in those which are harder and of slower growth. The influence of different seasons, again, will cause even the same tree to vary in this respect, the rings being broader in warm seasons than in cold ones, and hence we find the trees as we approach the poles have very narrow annual rings. The influence of soil and other circumstances will also materially affect the thickness of the annual rings in the same tree. We find also that the same ring will vary in diameter at different parts, so that the pith, instead of being in the centre of the wood, is more or less eccentric, owing to the rings being thicker on one side than on the other. This irregular thickness of the different parts of the annual rings is owing to several causes, but the greater growth on one side is chiefly due to the fact of its being more exposed to light and air than the other.

The annual rings also vary in thickness in the same tree, according to the age of that tree. Thus when a tree is in full vigour it will form larger rings than when that period is past, and it begins to get old. The age in which trees are in full vigour varies according to the species ; thus the Oak, it is said, will form most timber from the age of twenty to thirty, and that after sixty years of age the amount formed will be much less considerable. Again, in the Larch, the vigour of growth appears to diminish after it is forty years of age ; in the Elm after fifty years ; in the Beech after thirty years ; in the Spruce Fir after forty ; and in the Yew after sixty years.

Duramen and Alburnum.—When the annual rings are first formed, the walls of their component wood-cells and vessels are pervious to fluids, and very thin, and their cavities gorged with *sap*, which they transmit upwards from the root to the leaves. As they increase in age, however, their walls become so thickened by various deposits from the contained sap, that their cavities are ultimately almost or entirely obliterated, and they are thus rendered nearly or entirely impervious to fluids. This change is especially evident in the wood of those trees in which the thickening layers are coloured, as in the Ebony, Mahogany, Rosewood, and Guaiacum. Such coloured deposits are generally most evident in tropical trees, although they also occur more or less in most of the trees of cold and temperate regions. In some of the latter, however, as the Poplar and the Willow, the whole of the wood is nearly colourless, and exhibits no difference in this respect in the appearance of the internal and external rings. The value of wood as timber depends chiefly upon the nature of this incrusting matter, and is commonly in proportion to its colour ; hence those woods, as Ebony, Ironwood, and Mahogany, which are deeply coloured, are far harder and more durable than white woods, such as the Poplar and the Willow.

From the above characters presented by the wood according to its age, we distinguish in it two parts : namely, an internal portion, in which the wood-cells and vessels have thickened walls, are impervious to fluids, hard in texture, of a dry nature, and commonly more or less coloured, which is called the *Duramen* or *Heart-wood* ; and an outer portion, in which the wood-cells and vessels have thin sides, are pervious to, and full of sap, soft in texture, and pale or colourless, to which the name of *Alburnum* or *Sap-wood* is given.

Age of Dicotyledonous Trees.—As each ring of wood in an Exogenous stem is produced annually, it should follow that by counting the number of rings in a transverse section of a tree presenting this structure, we ought to be able to ascertain its age, and this is true with a few exceptions, when such trees are natives of cold climates, because in these, as we have seen, the annual rings are usually distinctly marked. In Dicotyledonous trees, however, of warm climates it is generally difficult, and frequently impossible, to ascertain their age in this manner, in consequence of several disturbing causes : thus, in the first place, the rings are by no means so well defined ; secondly, more than one ring may be formed in a year ; thirdly, some trees, as already noticed (page 84), such as *Zamias* and the species of *Cycas*, only produce one ring as the growth of several years ; fourthly, some plants, as certain species of *Cacti*, never form annual rings, but the wood, whatever its age, only appears as a uniform mass ; while lastly, in some, such as *Guaiacum*, the rings are not only indistinct, but very irregular in their growth.

It is commonly stated that the age of a Dicotyledonous tree may not only be ascertained by counting the annual rings in a transverse section of its wood, but that the mere inspection of a fragment of the wood of such a tree of which the diameter is known, will also afford data by which the age may be ascertained. The manner of proceeding in such a case is as follows :—Divide half the diameter of the tree divested of its bark by the diameter of the fragment, and then, having ascertained the number of rings in that fragment, multiply this number by the quotient previously obtained. Thus, suppose the diameter of the fragment to be two inches, and that of half the diameter of the wood twenty inches ; then, if there are eight rings in the fragment, by multiplying this number by ten, the quotient resulting from the division of half the diameter of the tree by that of the fragment, we shall get eighty years as the supposed age. Now, if the thickness of the rings was the same on both sides of the tree, and the pith consequently central, such a result would be perfectly accurate, but it happens from various causes, as already noticed (page 84), that the rings are frequently much thicker on one side than on the other, and the taking therefore of a piece from either side indifferently would lead to very varying results. A better way therefore to calculate the age of a tree by the inspection of a fragment, is to make two notches, or remove two pieces from its two opposite sides, and then, having ascertained the number of rings in each, take the mean of that number, and proceed as in the former case. Thus, suppose two inches, as before, removed from the two opposite sides of a tree, and that in one we have eight rings, and in the other twelve ; we have ten rings as the mean of the two. If we now divide, as before, half the diameter, twenty inches, by two, and multiply the quotient ten which results, by ten, the mean of the number of rings in the two notches, we get one hundred years as the age of the tree under consideration. Such a rule in many cases will no doubt furnish a result tolerably correct, but even this will frequently lead to error, from the varying thickness of the annual rings produced by a tree at different periods of its age.

It is probable that De Candolle and others, in calculating the ages of different trees, have been led into error by not sufficiently taking into account the variations in the growth of the annual rings at different periods of their age, and their varying thickness on the two sides of the tree ; and, when we consider that some trees were estimated by De Candolle to be more than 5,000 years of age, we cannot but believe that such calculations give an exaggerated result. But, however erroneous they may have been, still there can be no doubt but that Dicotyledonous trees do live to a great age ; in fact, when we consider that the new rings of wood are developed from the cambium cells which are placed on the outside of the previous rings, and that it is in these new annual rings that all the active functions of the plant are carried on, there can be, under ordinary circumstances, no real limit to their age. Mohl believes that there is a limit to the age of all such trees, arising from the increasing difficulty of conveying the proper amount of nourishment to the growing point, as the stem elongates from year to year. We cannot, however, attach much importance to this opinion, because some trees, as the *Sequoia* (*Wellingtonia*) *gigantea*, exist in California as much as 450 feet in height, and species of *Eucalyptus* may also be found in Australia which have reached nearly or quite the same height.

The following table is given by Lindley of the age of some trees, all of which, he states, can be proved historically :—

An Ivy near Montpellier	433 years.
Lime trees near Freiburg	1230
,, ,, Neustadt	800
Larch	576
Cedars, on Mount Lebanon . .	600—800
Oaks	at least 1000

There can be no doubt, therefore, but that such trees will live beyond the above periods. Other trees, such as the *Sequoia*, Yew, and Olive, may be added to the above list ; thus, it is probable that the former will live at least 3,000 years ; and it seems certain that the Yew will attain the age of 1,200 years, and the Olive at least 800 years.

Size of Dicotyledonous Trees.—As there is no assignable limit to the age of Dicotyledonous trees in consequence of their mode of growth, so in like manner the same circumstance leads, in many cases, to their attaining a great size. Thus the *Sequoia gigantea* has been measured 116 feet in circumference at the base ; the Chestnut tree (*Castanea vesca*) of Mount Etna is 180 feet in circumference ; a Plane tree (*Platanus orientalis*) near Constantinople is 150 feet in circumference ; the Ceiba tree (*Bombax pentandrum*) is said to be sometimes so large that it takes fifteen men with their arms extended to embrace it ; even Oaks in this country have been known to measure more than 50 feet in circumference ; and many other remarkable examples might be given of such trees attaining to an enormous size, which circumstance is of itself also an evidence of their great age.

4. *Cambium-layer or Cambium* (*figs.* 179, *c*, and 185, A, and B, *e*).—On the outside of each annual ring of wood, as we have already

seen, a layer of vitally active cells is placed, to which the name of *cambium-layer* or *cambium* has been given. It is from these cambium cells that the new layers of wood and phloëm are formed, and from the fact of the cambium-layer being situated between the xylem and the phloëm of the indefinite fibro-vascular bundles of which Exogenous stems are composed, it follows that the layers of increase to these parts of the bundle are in continuity with the previous layers. The cells composing the cambium-layer are of a very delicate nature, and consist of a thin wall of cellulose, containing a nucleus, protoplasm, and watery cell-sap ; in fact, they contain all the substances which are present in young growing cells. These cells, from their becoming changed into the matured woody tissues and phloëm, were called *cambium-cells*, hence the origin of the names *cambium* and *cambium-layer* applied to this portion of the stem. This layer is dormant during the winter, at which time the bark is firmly attached to the wood beneath, but it is in full activity in the spring, when it becomes charged with the materials necessary for the development of new structures, and then the bark may be readily separated from the wood beneath, but such separation can only be effected by the rupture of the cells of which it is composed. The cambium layer is called a *formative* or *generating tissue*, or *meristem*, because its component cells are capable of dividing and forming *permanent tissue*, or that in which the cells have ceased to divide, and have assumed their definite form.

5. *Medullary Rays.*—We have already seen that at first the stem consists entirely of parenchyma, but that in a short time fibro-vascular portions are developed, so that at the end of the first year's growth, in consequence of the development of the wood and phloëm, this parenchyma becomes separated into two regions—an internal or pith, and an external forming the cellular layers of the bark ; the separation, however, not being complete, but the two being connected by tissue of the same nature as themselves, to which the name of *medullary rays* has been applied (*figs.* 176, *b*, and 182, *r*).

The cells forming these medullary rays, like those of the pith, are part of the fundamental tissue of the stem (page 81) ; but, unlike the cells of the pith, which remain of a more or less rounded form, they differ from them in form, and become much flattened in a radial direction (*figs.* 94, and 185, B, *i*, *i*), owing to the pressure which the neighbouring wedges of the wood have exerted upon them. As new rings of wood are formed in successive years, fresh additions are made to the ends of the medullary rays from the cambium, so that, however large the space between the pith and the cellular layers of the bark ultimately becomes, the two are always kept in connexion by their means. Besides the medullary rays which thus extend throughout the entire thickness of the wood, others are also commonly developed between them in each succeeding year, which extend from the rings of those years respectively to the bark; these are called *secondary medullary rays.* In the Cork-oak both kinds may be well seen in a transverse section (*fig.* 187, 1, 2, 3, 4).

The medullary rays are composed of flattened six-sided cells, which are placed one above the other in one or more rows, like the bricks in a wall, hence the tissue which they form is termed *muriform parenchyma* (*figs.* 185, B, *i*, *i*, and 94). It is a variety of *tabular parenchyma*, as already noticed (page 48). The tissue formed by the medullary rays is not continuous from one end of the wood to the other, but the rays are more or less interrupted by the passage between them of the fibro-vascular tissue forming the wood, so that they are

FIG. 187.

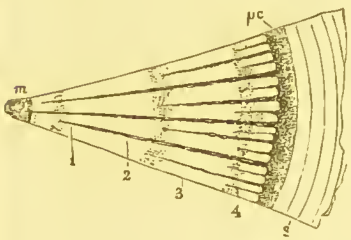


FIG. 188.

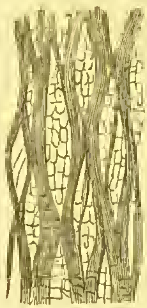


FIG. 189.

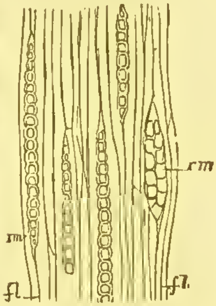


Fig. 187. Transverse section of a portion of the stem of the Cork-oak (*Quercus Suber*), four years old. *m*. Pith. 1. Medullary ray of the first year's growth. 2, 3, 4. Medullary rays of successive years. *pc*. Liber and cellular envelope. *s*. Cork layers.——*Fig.* 188. Surface of the stem of a Dicotyledonous tree from which the bark has been removed.——*Fig.* 189. Vertical section of a branch of the common Maple, perpendicular to the medullary rays. *fl*, *fl*. Fibro-vascular tissue forming the wood. *rm*, *rm*. Medullary rays.

split up vertically into a number of distinct portions (*figs.* 188 and 189, *rm*). This arrangement may be observed by examining the surface of a stem from which the bark has been removed (*fig.* 188), or still better by making thin sections of the wood perpendicular to the rays,—that is, tangential to the circumference of the stem (*fig.* 189). In some stems, such as those of the species of *Aristolochia,* and also in many plants of the natural order Menispermaceæ, and in other orders, the medullary rays are very conspicuous, forming large plates between the wedges of wood. In other plants, such as the Yew and Birch, they are comparatively small. The medullary rays constitute the *silver grain* of cabinet-makers and carpenters, as it is to their presence that many woods, such as the Plane and Sycamore, owe their peculiar lustre.

6. *The Bark or Cortex.*—The bark is situated on the outside of the stem, surrounding the wood, to which it is

organically connected by means of the medullary rays and cambium-layer (*fig.* 176, *c*, *c*). When the stem is first formed the bark is entirely composed, like the pith, of parenchyma; but as soon as the wood begins to be developed on the outside of the pith, certain cells which lie nearer the surface of the stem make their appearance, which develop into liber-cells and certain vessels (*fig.* 190, *d*). Externally to these lie other parenchymatous cells, the inner ones of which form the green layer of the bark, *c*, whilst the outer cells become developed into the cork tissue, *b*, and these again are invested by colourless cells forming the epidermis, *a*, so that the bark, when fully formed, consists of two distinct systems; namely, an *internal* or *fibro-vascular*, and an *external* or *parenchymatous*. Further, the parenchymatous system, as just noticed, also exhibits, in all plants which are destined to live for any period, a separation into two portions; and the whole is covered externally by the epidermis already described (*fig.* 190, *a*). The fully developed bark accordingly presents three distinct layers, in addition to the epidermis, which is common to it and the other external parts of plants. The three layers proper to the bark are called, proceeding from within outwards: 1. *Liber*, *Inner Bark*, or *Phloëm* (*figs.* 190, *d*, and 185, A, and B, *f*, *f*); 2. *Cellular Envelope*, *Green Layer*, or *Phelloderm* (*figs.* 190, *c*, and 185, *g*, *g*); and 3. *Corky Layer*, *Suberous Layer*, or *Outer Bark* (*figs.* 190, *b*, and 185, *h*, *h*).

Fig. 190.

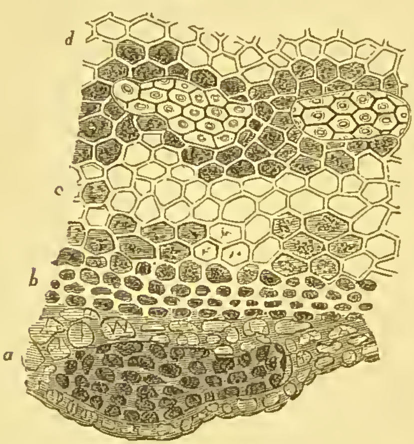


Fig. 190. Transverse section of a portion of the bark of an Exogenous stem. *a*. Epidermis. *b*. Corky layer. *c*. Cellular envelope. *d*. Liber or Phloëm.

a. *The Liber, Inner Bark, or Phloëm* (*figs.* 190, *d*, and 185, A, and B, *f*, *f*).—This is composed of *true bast tissue*, or, as it is also called, *woody tissue of the liber*, as it consists of narrow elongated cells with thickened and flexible walls; mixed with parenchymatous (*cambiform*) tissue and sieve-tubes filled with albuminous matters, and frequently laticiferous vessels. The phloëm therefore belongs to the fibro-vascular system, and forms the portion of the indefinite fibro-vascular bundles outside the cambium (page 76). The portion formed of bast tissue is sometimes termed *hard bast*, and the cambiform parenchyma and sieve tubes together constitute what is then called the *soft bast*.

The liber-cells of which it is essentially composed are either placed side by side in a parallel direction, and thus form by their union a continuous layer, as in the Horsechestnut tree; or far more frequently they present a wavy outline, and only touch each other at certain points, so that numerous interspaces are left between their sides, in which the medullary rays connecting the cellular layers of bark and the pith may be observed. From this circumstance the inner bark when macerated in water commonly presents a netted appearance, as may be especially seen in that of the Lace-bark tree (*Lagetta lintearia*) of Jamaica, and of other plants belonging to the same natural order.

b. *The Cellular Envelope, Green Layer, or Phelloderm* (*fig.* 190, *e*, and 185, *g*, *g*).—This layer lies between the *liber* and corky layer, and hence the name *middle layer* which is also applied to it. It is connected on its inner surface with the medullary rays. It consists of thin-sided, usually angular or prismatic, parenchymatous cells (*fig.* 190, *e*), which are loosely connected, and thus leave between their walls a number of interspaces. The cells of which it is composed contain an abundance of chlorophyll, which gives the green colour to young bark, and hence the name of *green layer*, by which it is also commonly distinguished. It is also sometimes known under the name of *phelloderm*. This layer and the next belong to the fundamental tissue, and form together the parenchymatous system of the bark.

c. *Corky or Suberous Layer* (*figs.* 190, *b*, and 185, *h*, *h*).—This is the *outer layer* of the bark, and is invested by the epidermis (*fig.* 190, *a*). It has also received the name of *periderm*; this term is, however, sometimes used in a general sense to indicate the dead portion of the bark, or that which has ceased to perform any active part in the life of the plant; which is commonly the case, as we shall presently see, in a few years with the two outer layers (see page 92). In this sense the periderm may consist of the corky layer alone, or of phelloderm chiefly, or of portions of both, or even in some cases of a portion of the phloëm also. Those botanists who adopt this nomenclature commonly apply the term *derm* to the inner living portion of the bark. Other botanists also use the term *periderm* to indicate the inner portion of the corky layer, and which consists of cells with thicker walls and less elastic than true cork cells.

FIG. 191.

Fig. 191. Branch of a species of Willow—*l*, *l*. Lenticels. *c*, *c*. Buds.

The corky layer consists of one or more layers of tabular cells (*fig.* 190, *b*), elongated more or less in a horizontal direction, and which in most cases ultimately become dried up and filled with air, and form by their union a compact tissue, or one without interspaces. It is this layer which gives to the young bark of trees and shrubs their peculiar hues, which are generally brownish or some colour approaching to this; or sometimes it possesses more vivid tints. In some plants, as in the Cork-oak (*fig.* 187, *s*), this layer becomes excessively developed and forms the substance called *cork*, and hence the name *corky layer* which is commonly applied to it. Large developments of cork also occur on some other trees, as various species of Elm.

On the young bark of most plants may be observed little circular or somewhat oval brownish or whitish specks, which have been called *lenticels* (*fig.* 191, *l*, *l*). They are formed of loosely aggregated cork-cells, separated by intercellular spaces, and serving, like stomata, to admit air to the living cortical tissues beneath.

Growth of the Bark.—The bark, except the middle layer, develops in an opposite direction to that of the wood, for while the latter increases by additions to its outer surface, the former increases by additions to its inner. The bark is therefore strictly endogenous in its growth; while the wood is exogenous. Each layer of the bark also grows separately; thus the liber by the addition of new matter from the cambium-layer on its inside; and the phelloderm and corky layer from a special meristem, which is termed the *cork-cambium* or *phellogen.* This phellogen is placed between the phelloderm and corky layer, so that it develops cork-cells on its outside and the cells of the phelloderm on its inner surface. The formation of cork-cells, however, is not always of the same character, and in some cases it is very complex. When the soft tissues of a plant are wounded, a *callus* of cork-cells is also commonly produced, and thus forms a protection to the wounded tissues. But when wood is well developed, and the plant wounded so deep as the cambium, cork is not directly formed, but a *callus* of parenchymatous tissue is produced from all the living cells bordering on the wound.

The two outer layers which together constitute the parenchymatous or cellular system of the bark generally cease growing after a few years, and become dead structures on the surface of the tree; but the inner bark continues to grow throughout the life of the individual, by the addition of a new layer annually on its inner surface from the cambium. They are commonly so thin when separated that they appear like the leaves of a book, and hence the supposed origin of the term *liber* applied to the inner bark. The name liber is, however, sometimes considered to be derived from the inner bark of trees having been formerly used for writing upon. In some trees, as in the Oak, these layers may be readily observed up to a certain age; but this distinction of the liber into layers is generally soon lost, in consequence of the pressure to which it is subjected from the growth of the wood beneath.

The outer cellular layers of the bark, after a certain period in their life, which varies in different plants, generally become cracked in various directions in consequence of the pressure which is exerted upon them by the growth of the wood and liber beneath, and thus assume a rugged appearance, as in the Elm and Cork-oak. In some trees, as the Beech, the bark, however, always retains its smoothness, which circumstance arises, partly from the small development of the parenchymatous layers, and partly from their great distensibility. Other smooth-barked stems, such as those of the Holly and Ivy, owe their peculiarities in this respect to similar causes. When the bark has thus become cracked and rugged, it is commonly thrown off in large pieces, or in plates or layers of various sizes and appearance. The epidermis in all cases separates early, and is replaced by cork-cells. By this separation and peeling off of portions of the bark, its thickness is continually diminished. This decaying and falling away of the outer layers of the old bark does not in any way injure the tree; hence, it is evident that the old cellular layers of the bark, like the pith and inner rings of the wood, have nothing to do with its life and growth after a certain period. The new rings of wood, the cambium-layer, and the recently formed liber, are the parts of an exogenous stem which are alone concerned in its active development and life.

Having now described the different parts which enter into the structure of an Exogenous or Dicotyledonous stem, we will, in conclusion, recapitulate them, and place them in a tabular form :—

1. *Pith* or *Medulla*, belonging to the parenchymatous system.

2. *Medullary Sheath*, consisting of spiral vessels. 3. *Wood*, composed of interrupted rings, one of which is developed annually on the outside of the previous rings, and consisting ordinarily in perennial plants of wood-cells and pitted vessels.	These belong to the fibro-vascular system, and together form the wood (*xylem*) properly so called.

4. *Medullary Rays*, composed of muriform parenchyma connecting the pith and the parenchymatous layers of the bark.

5. *Cambium-layer*, consisting of vitally active or generating cells containing protoplasm, &c., from which additions are made annually to the wood and liber.

6. *The Bark*, composed of two systems—

   1. *Inner Bark*, *Phloëm*, or *Liber*, formed essentially of liber-cells and sieve-tubes, and thus belonging to the fibro-vascular system; and increasing by the annual addition of a new layer on its inner surface.

2. *Outer Bark*, composed of parenchyma, and hence belonging to the parenchymatous system, and consisting of—
   - a. *Cellular Envelope* or *Phelloderm*, composed of more or less angular cells, with interspaces, and giving the green colour to bark.
   - b. *Corky Layer* or *Suberous Layer*, composed of tabular cells, forming a compact tissue, and giving the peculiar hues to the young bark.

7. The *Epidermis*, investing the bark of young stems, and replaced after a certain age by the corky layer.

FIG. 192.

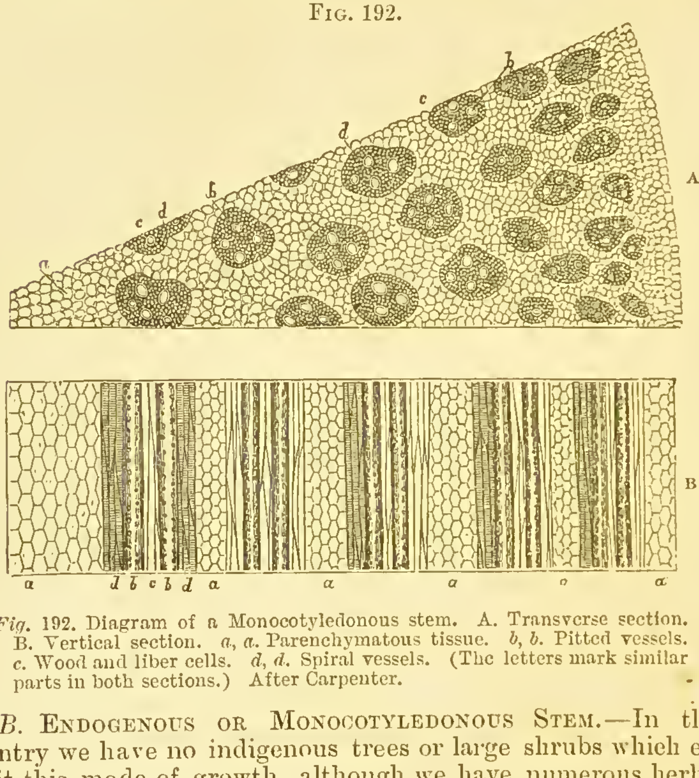


Fig. 192. Diagram of a Monocotyledonous stem. A. Transverse section. B. Vertical section. *a*, *a*. Parenchymatous tissue. *b*, *b*. Pitted vessels. *c*. Wood and liber cells. *d*, *d*. Spiral vessels. (The letters mark similar parts in both sections.) After Carpenter.

B. ENDOGENOUS OR MONOCOTYLEDONOUS STEM.—In this country we have no indigenous trees or large shrubs which exhibit this mode of growth, although we have numerous herbaceous plants, such as Grasses, Rushes, and Sedges, which are illustrations of endogenous structure. In our gardens, again, we have various kinds of Lilies, Hyacinths, Tulips, and other bulbous plants, which are also endogenous in their growth. But it is in the warmer regions of the globe, and especially in the tropics, where we find the most striking and characteristic illustrations of such stems, and of all such the Palms are by far the most remarkable.

Internal Structure.—When we make a transverse section of a Palm stem, it presents, as we have seen (page 75), no such separation of parts into pith, wood, medullary rays, and bark, as we have described as existing in an exogenous stem; but the fibro-vascular system is seen to consist of bundles (*figs.* 177, *f*, and 192, A, *b*, *c*, *d*), which have no tendency to collect together so as to form rings of wood as in exogenous stems, but are arranged separately from one another in the mass of parenchymatous cells (*figs.* 177, *m*, and 192, A, *a*, *a*), of which the ground substance or fundamental tissue is composed. The whole is covered externally by a fibrous and parenchymatous layer, which is called the *false bark* or *rind* (*fig.* 177, *b*); because this is not a distinct and parallel formation to the wood, as is the case with the bark of exogenous stems, but is formed essentially by the ends of the fibro-vascular bundles, as will be presently noticed, and cannot therefore be separated from the mass beneath (see page 96).

FIG. 193.

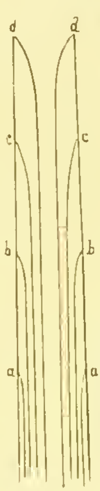


FIG. 194.

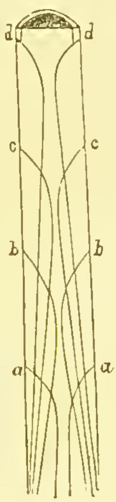
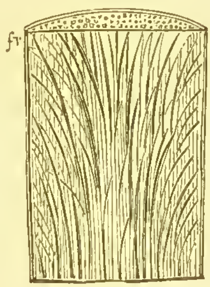


FIG. 195.



Figs. 193 and 194. Diagrams showing the course of the fibro-vascular bundles in a monocotyledonous stem. *a*, *b*, *c*, *d*. Fibro-vascular bundles. *Fig.* 193. Exhibits the course of the bundles as formerly supposed. *Fig.* 194. According to Mohl's view, as now proved to be correct.—*Fig.* 195. Vertical section of the stem of a Palm, showing (*fv*) the fibro-vascular bundles intersecting each other as they pass downwards.

In annual or herbaceous monocotyledonous stems the parenchyma between the fibro-vascular bundles is soft and delicate; but in trees which grow to any height, as Palms, the cell-walls become thickened and hardened, and thus form the tissue termed *sclerenchyma*, which ultimately binds the original separate bundles into a solid hardened mass resembling wood.

Origin and Growth of the Fibro-vascular Bundles. — The structure of the fibro-vascular bundles thus distributed in the parenchymatous system has been already referred to under the name of *definite* or *closed* (page 77); but we have still to describe their origin and direction through the stem. It was formerly supposed that these bundles, as they were successively developed, were at first directed towards the centre of the stem, and continued their course in the same direction down to its base as seen in *fig.* 193, *a*, *b*, *c*, *d*, the last-formed bundles being the most internal, and gradually pushing towards the circumference those which had previously been developed. Hence the origin of the name *endogenous* or *inside growers*, applied to these stems. The researches of Mohl first showed that the above mode of growth was not correct, but that the following is that which really takes place:—the fibro-vascular bundles have their origin in the *punctum vegetationis* of the stem, and are fully developed with its growth upwards and outwards into the leaves, and downwards and outwards towards the circumference of the stem. In other words, to render it more simple, the bundles may be traced to the leaves, from which organs they are at first directed towards the interior of the stem (*fig.* 194, *a*, *b*, *c*, *d*), along which they descend generally for some distance, and then gradually curve outwards again and terminate close to the circumference, where they anastomose and thus form a net-work with the ends of other bundles. When we make a vertical section therefore of an endogenous stem, we find these fibro-vascular bundles intersecting each other in various ways as shown in *fig.* 195.

When the fibro-vascular bundles thus pass from the stem into the leaves at their upper ends, they are termed *common bundles*, namely, common to both leaf and stem—those portions coming from, or continuous with, the leaves, being called *leaf-traces*. The fibro-vascular bundles in their course down the stem generally become more attenuated, which circumstance arises from certain differences which take place in their structure as they descend. Thus when they first originate they consist, as we have seen (see page 77), of spiral, pitted, and other vessels, mixed with parenchymatous and woody tissues (*fig.* 192, B, *b*, *c*, *d*). In their descent they gradually lose their spiral and other vessels, so that when they terminate close to the circumference they consist chiefly of a net-work of liber-cells bound together and covered by a more or less developed cortical parenchyma. The *rind* or *false bark* (*fig.* 177, *b*) of endogenous stems is thus chiefly formed of the ends of the fibro-vascular bundles which originate in the leaves, and hence we see the principal reason why this rind cannot be separated, as the bark of exogenous stems, from the tissues beneath.

It follows from the mode of growth of the fibro-vascular bundles, as indicated above, that the term *endogenous*, commonly applied to such stems, is not altogether correct, as the bundles are only endogenous for a portion of their course, terminating as they do ultimately close to the circumference. On this account the name endogenous has been generally discarded of late years by botanists, who use instead that of *monocotyledonous*, a term, as already noticed (page 78), which is derived from the fact that the embryo of plants which possess such stems has but one cotyledon. In this volume we have employed both terms, and so long as that of endogenous is properly understood, it can lead to no confusion in its application.

As the fibro-vascular bundles of an endogenous stem, in the course of their successive development, are always directed at first towards the centre, it must necessarily follow that those previously formed will be gradually pushed outwards, for which reason the outer part of a transverse section will always exhibit a closer aggregation of bundles than the inside (*figs.* 177, *f*, and 192, A, *b*, *c*, *d*). In such stems, therefore, the hardest part is on the outside, and the softest inside, directly the reverse of what occurs in those of exogenous growth. The lower portion of such stems also, in consequence of the descent of the fibro-vascular bundles, the constituents of which become, moreover, more or less thickened in their interior, will be harder than the

Fig. 196.

Fig. 197.

Fig. 198.

Fig 197 is WRONG WA

Fig. 196. The Dragon Tree of Teneriffe (*Dracæna Draco*), now destroyed. ——*Fig.* 197. Dicotyledonous stem, with a woody twining plant around it. ——*Fig.* 198. Monocotyledonous stem encircled by a woody twiner.

upper. The rind in like manner, at the lower part, will become harder, from the greater number of liber-cells which terminate in it. As endogenous stems increase in diameter, partly by the formation of fibro-vascular bundles in their interior, and partly by the general development of the parenchymatous tissue in which they are placed, it follows that as soon as the rind has become thus hardened by the liber-cells and other causes, it is not capable of further distension, and the stem will consequently become at length choked up by the bundles which continue to descend, and further growth is then impossible. It is evident, therefore, that endogenous stems, unlike those of exogenous growth, cannot increase in diameter beyond a certain limit, and that from the same causes also they cannot live beyond a certain age.

Although, as a general rule, the stems of Palms and most other Monocotyledons are thus limited in size and life, there are some remarkable exceptions to this, as for instance in *Yuccas,* and the *Dracænas* or *Dragon-trees* (*fig.* 196); in these the rind is always soft and capable of distension, and the fibro-vascular bundles, after having reached it, are continued downwards as fibrous layers between it and the original fibro-vascular bundles, and thus form a sort of wood beneath, in successive layers, somewhat after the manner that layers of wood are produced by the cambium layer of an exogenous stem. Such endogenous stems, like those of exogenous growth, have necessarily no limit either to their size or age.

Fig. 199.

Fig. 199. 1. Unbranched stem of the Cocoa-nut Palm (*Cocos nucifera*), with a tuft of leaves at the summit. 2. Branched stem of *Pandanus odoratissimus,* with a number of aerial roots arising from its lower part, and each branch terminated by a tuft of leaves. The figures are placed at the base to give some idea of the height of the trees.

It is in consequence of the comparatively small increase in diameter which most endogenous stems undergo after they have arrived at a certain age, that twining plants which encircle them after that period has arrived, do them no injury, frequently not even producing the slightest swelling on their surface; thus proving incontestably that such stems do not increase in diameter after a certain age. The effect of such twining plants is well seen in *fig.* 198. If we compare this figure with that of an exogenous stem (*fig.* 197), with a woody twiner encircling it, we find a striking difference;

for here we observe extensive swellings produced, which show the increase in the diameter of the stem after the twiner has encircled it. Such a comparison shows, in a very striking and conclusive manner, the characteristic peculiarities of the growth of exogenous and endogenous stems.

Growth by Terminal Buds.—In Palms (*fig.* 199, 1), and most commonly in other Monocotyledons, there are no branches, the stems of such plants having no power of forming lateral buds, from which branches can alone be produced (see page 106). These plants, which frequently rise to the height of 150 feet or more, therefore grow simply by the development of a terminal bud, which when it unfolds crowns the summit with a tuft of leaves, which are commonly of great size. Monocotyledonous stems are consequently exposed throughout their whole length to, as far as possible, the same influences as regards their increase in diameter, and we find accordingly, that, as a rule, such stems are almost uniformly cylindrical from below upwards, being of the same diameter throughout (*fig.* 199, 1), instead of conical, as in trees of exogenous growth. In such plants, therefore, the destruction of the terminal bud necessarily leads to their death, as they are then deprived of all further mode of increase. In some monocotyledonous trees, however, more than one bud is developed; thus in the Doum Palm of Egypt two buds are formed, so that the stem is forked above (*fig.* 200); each branch again develops two other buds at its apex in like manner, and this mode of growth is continued with the successive branches, which are therefore also forked (*false dichotomy*). In other Monocotyledons we have lateral buds formed as in those of Dicotyledons; this is the case in the Asparagus, the Screw Pine (*fig.* 199, 2), and the Dracænas (*fig.* 196); and as the lower part of such stems receives more fibro-vascular bundles than the upper, they are necessarily larger in their diameter at their base, and thus these stems are conical or taper upwards like those of Dicotyledons.

Fig. 200.

Fig. 200. The Doum Palm of Egypt (*Hyphæne thebaica*), showing forked stem and branches.

Anomalous Structure of Monocotyledonous Stems.—Some monocotyledonous stems present an anomalous structure; thus, in most Grasses the stem is hollow (*fig.* 201, *a*), except at the *nodes*, *b*, where the leaves arise, at which parts solid partitions are formed across the cavity, by which it is divided into a number of separate portions. Such stems when examined at their first development present the usual endogenous structure, but in consequence of their growth in diameter taking place more rapidly than new matter can be deposited in their interior, the central tissue becomes ruptured, and they soon become hollow.

In the stems of some other Monocotyledons we have a more striking deviation from the ordinary structure. Thus the species of Sarsaparilla and some allied plants have aerial stems which are strictly endogenous in structure, and underground stems which have the fibro-vascular bundles arranged in a ring

Fig. 201.

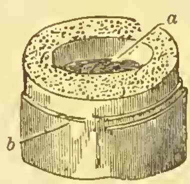


Fig. 202.

Fig. 201. Transverse section of the stem of the common Reed. *a*. Cavity closed at the bottom by a partition. *b*. Annular scar indicating the point (*node*) where the leaf was attached——*Fig.* 202. Half of a transverse section of the underground stem of a species of Sarsaparilla. *a*. Epidermal tissue. *b*, *c*, *d*. The cortical portion. *e*. Woody ring. *f*. Central parenchyma.

(*fig.* 202, *e*), around a central parenchyma, *f*, like the wood about the pith of an exogenous stem : such fibro-vascular bundles have, however, no cambium layer like that which forms the rings of wood of an exogenous stem, and have consequently no power of indefinite increase like them.

Age of Monocotyledonous Trees.—There is nothing in the internal structure of endogenous stems by which we can ascertain the age of monocotyledonous trees as in those of exogenous structure. It is supposed that the age of a Palm tree is indicated by the annular scars (*fig.* 199, 1) which are produced on the external surface of its stem by the fall of the terminal tufts of leaves ; for, as one tuft only is commonly produced annually, each ring marks a year's growth, and hence the number of annular scars corresponds to the number of years the tree has lived. Although it is true that in some few cases such a rule may enable us to ascertain the age of a Palm, and probably also that of some other monocotyledonous trees, not the slightest dependence can be placed upon it in any particular instance, for there are frequently several rings produced on the stems of monocotyledonous plants in one year, and these again often disappear after having existed for a certain period. The best means of ascertaining the age of Palms is by noting their increase in height in any one year's growth, and then, as such stems grow almost uniformly in successive years, by knowing their height we can determine their age. This mode, however, of calculating their age is very liable to error, and can be moreover but of limited application from the absence of data to work upon; hence we must come to the conclusion that at present we possess no trustworthy means of determining the age of Monocotyledons.

C. Acrogenous Stem, or the Stem of Cormophytes.—The simplest form of stem presented by Cryptogamous plants is that seen in Liverworts (*fig.* 8), and in Mosses (*figs.* 9 and 10). In such a stem we have no vessels, but the whole is composed of ordinary parenchyma, with occasionally a central cord of slightly elongated cells with somewhat thickened walls. In the stems of Club-mosses (*Lycopodiaceæ*) (*fig.* 12), Selaginellas (*Selaginellaceæ*), Pepperworts (*Marsileaceæ*), and Horsetails (*Equisetaceæ*) (*fig.* 13), we have the simplest forms of acrogenous stems, and the composition of the fibro-vascular bundles, of which they are composed, and their mode of growth, have been already described (see page 78). The vessels found in the fibro-vascular bundles of the Lycopodiaceæ are commonly *spiral*, and in those of the Equisetaceæ *annular*; and as these bundles grow by additions to their apex, the stems of Cormophytes are termed *acrogenous*.

In the Ferns (*Filices*) we have the acrogenous stem in the highest state of development. The Ferns of this country are comparatively but insignificant specimens of such plants, for in them the stem merely runs along the surface of the ground, or burrows beneath it, sending up its leaves, or *fronds* as they are commonly called, into the air, which die down yearly (*fig.* 14). In warm regions, and more especially in the tropics, we find such plants much more highly developed. Here the stem rises into the air to the height of sometimes as much as forty feet (*fig.* 15), and bears on its summit a tuft of fronds. In their general appearance externally these Tree-ferns have great resemblance to monocotyledonous trees, not only in bearing their foliage like them at the summit, but also in producing no lateral branches, and being of uniform diameter from near their base to their apex. The outside of the stem of a Fern is marked with a number of *scars*, which have a more or less rhomboidal outline (*fig.* 203). The surface of these scars presents little hardened projections, *c*, or darker-coloured spots, which appearance is produced by the rupture of some of the elements of the fibro-vascular bundles proceeding to the leaves, by the fall of which organs the scars have been produced.

Internal Structure of Fern Stems.—Upon making a transverse section of a Tree-fern it presents, as we have already briefly noticed (see page 75), the following parts :—Thus in the centre, when young, a parenchyma (*fig.* 178, *m*), the cells of which have thin walls; but in old stems this central parenchyma is destroyed, so that the stem becomes hollow. Towards the outside of this parenchyma, and just within the rind, we find the so-called wood (*fibro-vascular bundles*), arranged in the form of irregular, sinuous, or wavy plates, *v*, *v*, *v*. These masses of wood have generally openings between them, by means of which the parenchyma beneath the rind and that of the centre of the stem communicate; but in other cases these woody masses or plates touch each other at their margins, and thus form a continuous circle within the rind. These masses, as already noticed, consist

Fig. 203.

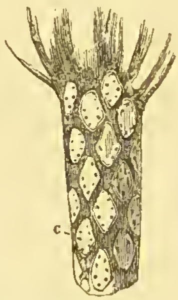


Fig. 204.

Fig. 203. Rhizome of Male Fern (*Aspidium Filix-mas*), marked externally by rhomboidal scars, which present dark-coloured projections, *c*.——*Fig.* 204. Vertical section of the dichotomous or forked stem of a Tree-fern.

of *closed fibro-vascular bundles*, the vessels of which are chiefly scalariform in their character; these are situated in the centre of the bundles, where they may be readily distinguished by their pale colour (*fig.* 178, *v*, *v*, *v*). External to them are usually a few layers of parenchymatous cells, which contain starch in the winter, and amongst which are situated some wide sieve or lattice-cells. The whole is surrounded by a single layer of cells, the walls of which are usually more or less lignified and dark-coloured, thus constituting the tissue termed *sclerenchyma*, and forming what has been called the *bundle-sheath*. The tissues external to the fibro-vascular bundles constitute collectively what has been termed the *rind* (*fig.* 178, *c*).

Growth by Terminal Buds.—We have already stated that Tree-ferns have no branches (*fig.* 15). This absence of branches arises from their having, like Palms, no provision for lateral buds: hence the cylindrical form of stem which is common to them as with the stems generally of Monocotyledons. For the same reason, also, they are rarely of great diameter. Some Ferns, however, become forked at their apex (*fig.* 204); which forking is produced by the division of the terminal bud into two (*true dichotomy*), from each of which a branch is formed (see page 109). But such branches are very different from those of dicotyledonous stems, which are produced from lateral buds, for, as they arise simply from the splitting of one bud into two, the diameter of the two branches combined is only equal to that of the trunk, and in all cases where acrogenous stems branch, the diameter of the branches combined is only equal to that of the axis from whence they are derived. As acrogenous stems only grow by the development of a terminal bud, the destruction of that bud necessarily leads to their death (page 106). There is nothing in the internal structure or external appearance of such stems by which we can ascertain their age.

2. Buds and Ramification.—We have already stated (page 14) that the presence of leaves and leaf-buds is the essential characteristic by which a stem may be distinguished from a root. The leaves will be treated of hereafter, but we have now to allude to the parts of the stem from whence they arise, and to describe the nature of leaf-buds, and the mode in which branches are formed.

Leaves are always developed at regular points upon the surface of the stem, which are called *nodes* (*fig.* 208, *c*, *c*, *c*), and the intervals between them are termed *internodes*, *d*, *d*. Generally the arrangement of the tissue of the stem at the nodes is somewhat different to that in the internodes; thus at a node it exhibits a more or less contracted or interrupted appearance, which arises from a portion of its fibro-vascular tissue being given off to enter into the structure of the leaf. This appearance is most evident in those cases where the internodes are clearly developed and especially if under such circumstances the leaf or leaves which arise encircle the stem, as in the Bamboo and other Grasses; in such plants each leaf causes the formation of a hardened ring externally (*fig.* 201, *b*), and thus produces the appearance of a joint or articulation, and indeed, in some cases, the stem does readily separate into distinct portions at these joints, as in the common Pink, in which case it is said to be *jointed* or *articulated*.

A. Leaf-buds or Buds.—Under ordinary circumstances we have developed in the axil of every leaf a little more or less conical body called a leaf-bud, or simply a bud (*fig.* 205, *a*, *a*). In like manner, the apex of a stem, as well as of all its main branches and twigs which are capable of further elongation, is also terminated by a similar bud (*fig.* 207). In a Dicotyledonous plant each bud, whether lateral or terminal, is produced by an elongation of the parenchymatous system of the stem or one of its divisions, and consists at first of a minute conical central parenchymatous mass (*fig.* 206, *i*), which is connected with the pith, *a*; around this spiral and other vessels and wood cells are soon developed, also in connexion with similar parts of the wood, *b, b*; and on the outside of these, in a parenchymatous mass which ultimately becomes the bark, we have little cellular projections developed, which are the rudimentary leaves. As growth proceeds these parts become more evident, and a little more or less conical body is ultimately produced at the apex of the stem or branch (*fig.* 207); or laterally in the axil of the leaves, *c*, and the formation of the bud is completed. In like manner the buds of Monocotyledonous and Acrogenous plants are connected

FIG. 205.

FIG. 206.

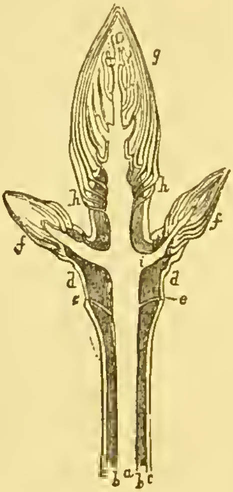


Fig. 205. Branch of Oak with alternate leaves and leaf-buds in their axils. *a, a.* Buds. *b, b.* Leaves.——*Fig.* 206. Vertical section through the end of a twig of the Horsechestnut (*Æsculus Hippocastanum*), before the bursting of the bud. After Schleiden. *a.* The pith. *b, b.* The wood. *c, c.* The bark. *d, d.* Scars of leaves of former years. *e, e.* The fibro-vascular bundles of those leaves. *f, f.* The axillary buds of those leaves, with their scales and fibro-vascular bundles. *g.* Terminal bud of the twig ending in a rudimentary flowering panicle. *h, h.* Scars formed by the falling off of the lowest scales of the bud, and above these may be seen the closed scales with their fibro-vascular bundles. *i.* Medullary mass leading from the pith, *a*, into the axillary bud, *s, f, f.*

with both the parenchymatous and fibro-vascular systems of their stems; but in these plants, as we have seen, there are, as a general rule, no lateral buds.

The buds of temperate and cold climates, which remain dormant during the winter, and which are accordingly exposed to all its rigours, have generally certain protective organs developed on their outer surface in the form of modified leaves (*cataphyllary*), which are commonly called *scales* (page 140). These are usually of a hardened texture, and are sometimes covered with a resinous secretion, as in the Horsechestnut and several species of Poplars; or with a dense coating of soft hairs or down, as in some Willows. Such scales, therefore, by interposing between the tender rudimentary leaves of the bud and the air a thick coating of matter which is a bad conductor of heat and insoluble in water, protect them from the influence of external circumstances, by which they would be otherwise injured, or even destroyed. Buds thus protected are sometimes termed *scaly*. In the buds of tropical regions, and those of herbaceous plants growing in temperate climates which are not thus exposed to the influence of a winter, such protective organs would be unnecessary, and are accordingly absent, and hence all

Fig. 207.

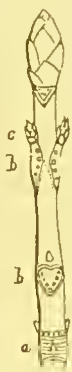


Fig. 208.

Fig. 209.

Fig. 207. A shoot one year old of the Horsechestnut, with terminal bud. *a.* Scar produced by the falling off of the bud-scales of the previous year. *b, b.* Scars caused by the falling off of the petioles of the leaves of the present year, with buds, *c*, in their axils.——*Fig.* 208. Diagram to illustrate the growth of the shoot from the bud. *c, c, c.* The nodes where the leaves are situated. *d, d.* The internodes developed between them.——*Fig.* 209. Shoot of the Lilac (*Syringa vulgaris*), showing suppression of the terminal bud, and two lateral buds in its place (*false dichotomy*).

the leaves of these buds are nearly of the same character. Such buds are called *naked*. In a few instances we find even that the buds of perennial plants growing in cold climates, and which are exposed during the winter, are naked like those of tropical and herbaceous plants. Such is the case, for instance, with the Alder Buckthorn (*Rhamnus Frangula*), and those of some species of *Viburnum*.

These protective organs of the bud are commonly, as we have just mentioned, termed *scales*, but they have also received the name of *tegmenta*. That such scales are really only modified leaves adapted for a special purpose, is proved not only by their position with regard to the true leaves, but also from the gradual transitional states, which may be frequently traced from them to the ordinary leaves of the bud. These scales have only a temporary duration, falling off as soon as the growth of the bud commences in the spring.

The bud thus contains all the elements of a stem or branch; in fact it is really the first stage in the development of these parts, the axis being here so short that the rudimentary leaves are closely packed together, and thus overlap one another. When growth commences in the spring, or whenever vegetation is reanimated, the internodes between the leaves become developed (*fig.* 208, *d*, *d*, *d*), and these therefore become separated from one another, *c*, *c*, *c*, and thus the stem or branch increases in length, or a new branch is formed. In other words, the leaves, which in a bud state overlap one another and surround a growing point or axis, by the elongation of the internodes of that axis become separated and dispersed over a branch or an elongation of the stem, much in the same way as the joints of a telescope become separated from one another by lengths of tube when it is drawn out. The branch, therefore, like the bud from which it is formed, necessarily contains the same parts as the axis upon which it is placed, and these parts are also continuous with that axis, with the exception of the pith, which, although originally continuous in the bud state, ultimately becomes separated by the development of tissue at the point where the branch springs from the axis. But when a branch becomes broken off close to the wood, and there are no buds upon it to continue its growth, it becomes ultimately enclosed by the successive annual layers of wood, and thus a *knot* is formed.

From the above circumstances it follows that a bud resembles in its functions the embryo from which growth first commenced, and it has accordingly been termed a *fixed embryo*. There is this difference, however, between them :—a bud continues the individual, while the embryo continues the species. A stem is therefore really made up of a number of similar parts or buds, called *phytons*, which are developed in succession, one upon the summit of the other. Hence, by the development of a terminal bud, the stem increases in height; and by those situated laterally branches are produced. A tree may thus be considered as a compound body, formed of a series of individuals which mutually assist one another, and benefit the whole mass to which they belong. In Dicotyledonous trees, which form lateral or axillary buds, the destruction of a few branches is of no consequence, as they are soon replaced; but in Palms, and most other monocotyledonous trees, and also in those of Cormophytes, which develop only from terminal buds, the destruction of these under ordinary circumstances, as we have seen (pages 99 and 103), leads to their death.

The buds or similar parts, of which a tree, or other Dicotyledonous plant, may thus be shown to be made up, being thus distinct individuals, as it were, in themselves, are also capable of being separated from their parents and attached to other individuals of the same, or even of nearly allied species; or a branch with one or more buds upon it may be bent down into the earth (*fig.* 230). The operations of Budding, Grafting, and Layering depend for their success upon this circumstance; and in some plants buds naturally separate from their parents, and produce new individuals. These operations are of great importance in horticulture, because all plants raised by such means propagate the *individual peculiarities* of their parents, which is not the case with those raised from seed, which have merely a *specific identity.*

It sometimes happens that a leaf-bud, instead of developing as usual, so as to form a symmetrical leaf-bearing branch, be-

FIG. 210. FIG. 211. FIG. 212.

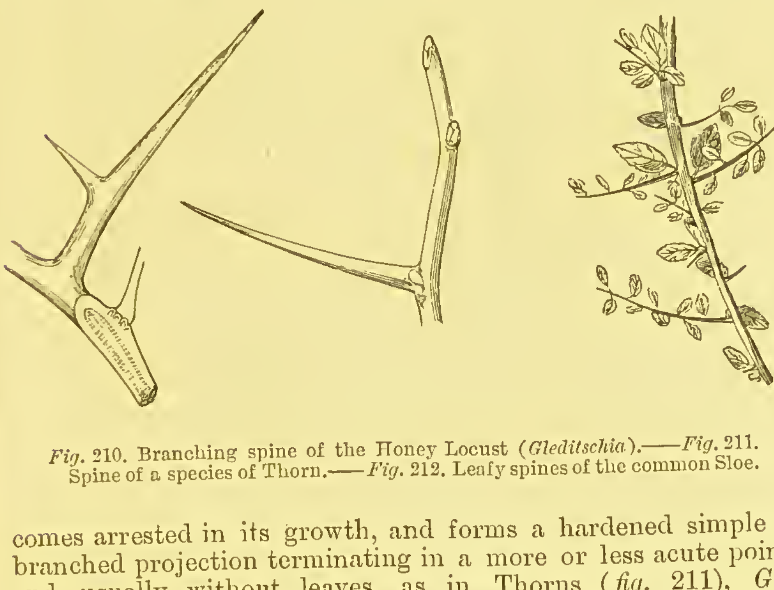


Fig. 210. Branching spine of the Honey Locust (*Gleditschia*).——*Fig.* 211. Spine of a species of Thorn.——*Fig.* 212. Leafy spines of the common Sloe.

comes arrested in its growth, and forms a hardened simple or branched projection terminating in a more or less acute point, and usually without leaves, as in Thorns (*fig.* 211), *Gleditschia* (*fig.* 210), and many other plants. Such an irregularly-developed branch is called a *spine* or *thorn.* That the spines are really modified branches is proved not only by their structure, which is exactly the same as the stem or branch upon which they are placed, but also by their position in the axil of leaves; by their sometimes bearing leaves, as in the Sloe (*fig.* 212) and Spiny Rest-harrow; and by their being frequently changed into ordinary leaf-bearing branches by cultivation, as in the Apple and Pear. Spines are sometimes confounded with prickles, already described (page 66), but they are readily distinguished from these by their structure and connexion with the internal parts of the stem; the prickles being merely formed of hardened parenchyma, arising immediately from, and in connexion only with, the epidermal tissue and layer of cells beneath.

Another irregularly developed branch is the *tendril* or *cirrhus* : this term is applied to a thread-like leafless branch, which is twisted in a spiral direction, as in the Passion-flower (*fig.* 213, *v*, *v*). It is one of those contrivances of nature by means of which weak plants are enabled to rise into the air by attaching themselves to neighbouring bodies for support. Tendrils may be also observed in the Vine (*fig.* 214, *v*, *v*, *v*), where they are regarded by many botanists as the terminations of separate axes, or as transformed terminal buds.

Fig. 213.

Fig. 214.

Fig. 213. A portion of the stem of *Passiflora quadrangularis.* *v*, *v*. Tendrils. ——*Fig.* 214. Part of the stem of the Vine. *v*, *v*, *v*. Tendrils.

Both spines and tendrils are occasionally produced from leaves and some other organs of the plant ; these peculiarities will be referred to hereafter, in the description of those organs of which they are respectively modifications.

B. Ramification or Branching.—In the same way as branches are produced from buds placed on the main axis or stem, so in like manner from the axils of the leaves of these branches other buds and branches are formed ; these again will form a third series, to which will succeed a fourth, fifth, and so on. The main divisions of the stem are called *branches*, while the smaller divisions of these are commonly termed *twigs*. The general arrangement and modifications to which these are liable are commonly described under the name of *ramification* or *branching*, which may be defined as the lateral development of similar parts. Thus the divisions of a stem or root are branches; but the lateral development from a stem or branch of leaves, or other dissimilar parts, such as hairs, is not branching.

There are two principal types of branching, the *monopodial* and the *dichotomous*. Thus, when the axis continues to develop in an upward direction by a terminal bud or growing point, so as to form a common *foot* or *podium* for the branches, which are produced from below upwards, or *acropetally* from lateral buds (*fig.* 205, *a*, *a*), the branchingis called *monopodial*. This is, probably, the universal system of branching in the Angiospermia, although there are some apparent exceptions. But when the terminal bud or growing point bifurcates, and thus produces

Fig. 215.

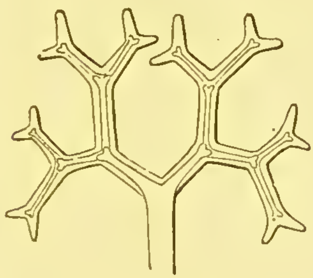


Fig. 216.

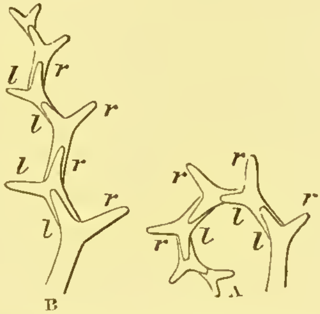


Fig. 215. Diagram of normal or true dichotomous branching, showing the two branches equally developed in a forked manner, and each branch dividing in succession in a similar way.——*Fig.* 216. Diagrams of sympodial dichotomous branching. A. Bostrycoid or Helicoid dichotomy. B. Cicinal or Scorpioid dichotomy. In A, the left-hand branches, *l*, *l*, *l*, of successive dichotomies are much more developed than the right, *r*, *r*, *r*, *r*. In B, the left-hand branches, *l*, *l*, and those of the right-hand, *r*, *r*, are alternately more vigorous in their growth. After Sachs.

two shoots, so that the foot or podium bears two branches arranged in a forked manner (*fig.* 215), the branching is termed *dichotomous*. This form is common in many of the Cryptogamia (*fig.* 204).

In dichotomous branching we have also two forms: one which is termed *true* or *normal dichotomy*, in which the two branches continue to develop equally in a forked manner—that is, each becomes the podium of a new dichotomy (*fig.* 215); and a second, in which one branch grows much more vigorously than the other, when it is called *sympodial* (*fig.* 216, A and B). In this latter case, owing to the unequal growth of the branches, the podia of successive bifurcations form an axis which is termed the *pseud-axis* or *sympodium*, on which the weaker fork-branches or bifurcations appear as lateral branches (*fig.* 216, A, *r*, *r*, *r*, *r*, and B, *r*, *l*, *r*, *l*, *r*). This branching might at first sight be confounded with the monopodial form, where we have a continuous axis giving off lateral branches; but it differs in the fact that here the apparent primary axis consists of a succession of secondary axes.

In sympodial branching, again, the sympodium may be either formed of the fork-branches of the same side (left or right) of successive dichotomies (*fig.* 216, A, *l*, *l*, *l*); or it may consist alternately of the left and right fork-branches or bifurcations (*fig.* 216, B, *l*, *r*, *l*, *r*). In the former case it is called *helicoid* or *bostrycoid dichotomy*; in the latter, *scorpioid* or *cicinal dichotomy*.

Of the monopodial branching there are also two forms, the *racemose* and the *cymose*. In the first the primary axis continues to develop upwards and gives off acropetally lateral branches from axillary buds; which also give off lateral branches in a similar manner; but in the second form the lateral axes at an early age develop much more vigorously than the primary axis and become more branched than it. It is in this way—that in some plants, by the suppression of the terminal bud, and the subsequent vigorous growth of the closely arranged lateral buds forming two shoots apparently radiating from a common point, as if caused by the division of the terminal bud, as in true dichotomous branching—an apparent but false dichotomy is produced, which is called a *dichasium* or *false cyme*. This suppression of the terminal bud may occur naturally, as in the Lilac (*fig.* 209), or accidentally from frost or other injury.

These modes of branching will be again alluded to under the head of Inflorescence, in which their more practical application arises.

All lateral or axillary buds are called *regular* or *normal*, and their arrangement in such cases is necessarily the same as that of the leaves. Again, as branches are formed from buds thus placed, it should follow that their arrangement should also correspond to that of the leaves. This corresponding symmetry, however, between the arrangement of the branches and that of the leaves is interfered with from various causes. Thus, in the first place, by many of *the regular buds not being developed*. Secondly, by the development of other buds which arise irregularly at various other points than the axils of leaves: these are called, from their abnormal origin, *adventitious*. And, thirdly, by the formation of *accessory buds*.

1. *Non-development of the Regular Buds.*—This frequently takes place irregularly, and is then altogether owing to local or special causes; thus, want of light, too much crowding, or bad soil, may cause many buds to become abortive, or to perish after having acquired a slight development. In other instances, however, this non-development of the buds takes place in the most regular manner; thus, in Firs, where the leaves are very closely arranged in a spiral manner, the branches, instead of presenting a similar arrangement, are placed in circles around the axis, at distant intervals. This arises from the non-deve-

lopment of many of the buds of the leaves forming a spire, which is followed by the development of the buds in the axils of other leaves successively; and as such leaves are thickly placed, we are unable, after the development of the branches, to trace clearly the turns of the spire, so that they appear to grow in a circle.

2. *Adventitious Buds.*—These have been found on various parts of the plant, as on the root, the woody part of the stem, the leaves, and other organs. Thus, when a tree is *pollarded*, that is, when the main branches and the apex of the trunk are

FIG. 217.

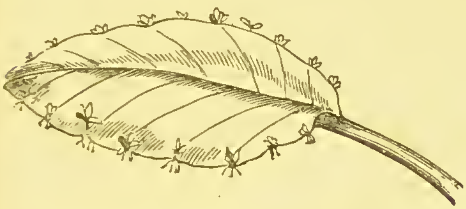


FIG. 218.

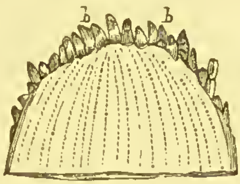


Fig. 217. Leaf of *Bryophyllum calycinum* with buds on its margins.——*Fig.* 218. End of the leaf of *Malaxis paludosa*, with buds, *b*, *b*, on its margins.

cut off, the latter becomes so gorged with sap that a multitude of adventitious buds are formed from which branches are developed. The branches thus produced by pollarding are, however, to a certain extent, also caused by the development of regular buds which had become latent from some cause having hitherto interfered with their growth.

In every instance the adventitious buds, like the normal ones, take their origin from parenchymatous tissue. Thus, if produced on the stem or branches, they come from the ends of the medullary rays; or when developed upon leaves, they may arise from their margins, as in *Malaxis paludosa* (*fig.* 218, *b*, *b*), and *Bryophyllum calycinum* (*fig.* 217); or from their surface, as in *Ornithogalum thyrsoideum* (*fig.* 219, *b*, *b*, *b*). Leaves thus bearing buds are called *proliferous*. Such buds are naturally formed on the leaves of the above-named plants, and occasionally on others; but they may also be produced artificially on various leaves, such as those of species of *Gesnera*, *Gloxinia*, and *Achimenes*, by the infliction of wounds, and then afterwards placing them in a moist soil, and exposing them to the other influences which are favourable for the growth of buds. The buds developed on the leaves, in such cases, ultimately form independent plants, and this process is therefore constantly resorted to by gardeners as a means of propagation. These adventitious

FIG. 219.

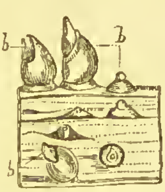


Fig. 219. A portion of the leaf of *Ornithogalum thyrsoideum*, showing buds, *b*, *b*, *b*, on its surface.

buds differ from those commonly produced in the axils of leaves, or at least from those which remain dormant during the winter, in being smaller, and having no external protective organs or scales.

Embryo-Buds.—In some trees the adventitious buds, instead of being developed on the outside of the stem or branch, are enclosed in the bark; such have been called *embryo-buds* or *embryo-nodules.* They may be readily observed in the bark of certain trees, such as the Cork-oak, the Beech, and the Cedar of Lebanon, in which they produce externally little swellings, which, when examined, are found to be owing to the presence of these nodules, which have a more or less irregular ovoid (*fig.* 220) or spheroidal form, and woody texture. Upon making a transverse or vertical section of one of them (*fig.* 221), we observe a central pith surrounded by a variable number of concentric rings of wood according to its age, as in the wood of ordinary trees, and traversed by medullary rays; in fact, it has all the structural parts found in the branch or trunk

FIG. 220.

FIG. 221.

Fig. 220. Embryo-bud or embryo-nodule of the Cedar.——*Fig.* 221. A vertical section of the same surrounded by the bark.

of a Dicotyledonous tree. In the course of their development, these embryo-buds frequently reach the wood, with the growth of which they then become confounded, and thus form what are called *knobs.* In other cases a number of nodules meeting together on the surface form an *excrescence.* That such nodules are analogous to buds is further proved by the fact of their sometimes producing a short branch from their summit, as in the Cedar of Lebanon and Olive. Those of the latter plant, under the name of *Uovili*, are really employed for its propagation.

3. *Accessory Buds.*—The third cause of irregularity in the distribution and appearance of branches arises from the multiplication of buds in the axils of leaves. Thus instead of one bud, we have in rare cases two, three, or more, thus situated (*figs.* 222–224); such are called *accessory buds.* These buds may be either placed one above the other, or side by side. Thus, in certain Willows, Poplars, and Maples, we have three buds placed side by side (*fig.* 222, *a*), which frequently give rise

to a corresponding number of branches. In some Aristolochias, in Walnuts (*fig.* 223, *b*), in the Tartarian Honeysuckle (*fig.* 224, *b*), and other plants, the accessory buds are arranged one above the other. Sometimes the uppermost bud alone develops (*fig.* 223, *b*), as in the Walnut, and thus the branch which is formed arises above the axil of the leaf, in which caso it is said to be *extra-axillary*. In the Tartarian Honeysuckle (*fig.* 224, *b*), the axillary or lowest bud is that which forms the strongest branch, over which a number of smaller branches are placed, arising from the development of the accessory buds. In some trees, as the Larch, and Ash, and frequently in herbaceous plants, these accessory buds, instead of forming separate branches, become more or less united, and the branches thus

FIG. 222.

FIG. 223.

FIG. 224.

Fig. 222. Branch of a species of Maple with three buds, *a*, placed side by side.——*Fig.* 223. A piece of a branch of the Walnut-tree. *p*. The petiole having in its axil a number of buds placed one above the other, the uppermost, *b*, most developed.——*Fig.* 224. A piece of a branch of the Tartarian Honeysuckle (*Lonicera tartarica*), bearing a leaf, *f*, with numerous buds, *b*, in its axil, placed above one another, the lowermost being the most developed.

produced then assume a more or less flattened or thickened appearance. Such abnormal branches are commonly called *fasciated*. These branches may, however, be produced by a single bud developing in an irregular manner.

Besides the above three principal sources of abnormal or irregular development of the branches, some minor ones also arise from the formation of *extra-axillary* branches in other ways than those just alluded to. Thus the stem may adhere to the lower part of the branch, which then appears to arise from above the axil of the leaf; or to the petiole, when it appears to arise from below it. Other irregularities also occur, but they are of little importance compared with those already mentioned.

3. Of the Forms and Kinds of Stem and Branches.—In form the stem is usually more or less cylindrical, while in other

cases it becomes angular, and in some plants, particularly in those of certain natural orders, as the Cactaceæ, Orchidaceæ, Euphorbiaceæ, &c., it assumes a variety of anomalous forms. Thus in many epiphytical Orchids it becomes more or less oval or rounded, and has received the name of *Pseudobulb* (*fig.* 256, *b*, *b*) ; in the Melon-cactus it is globular ; and in other Cacti it is columnar, more or less flattened, or jointed. In the Tortoise or Elephant's-foot Plant (*Testudinaria elephantipes*), it forms a large rough irregular mass.

FIG. 225.

Fig. 225. Climbing stem of the Ivy. *a*, *a*. Aerial roots.

FIG. 226.

Fig. 226. Twining stem of Honeysuckle.

FIG. 227.

Fig. 227. Twining stem of a species of *Convolvulus*.

In general, stems possess a firm texture, and can therefore readily sustain themselves in an upright position ; but at other times they are too weak to support themselves, and then either trail along the ground, or attach themselves to some other plant or neighbouring object. In such cases, if they trail on the ground, they are said to be *procumbent* or *prostrate* ; or if when thus reclining they rise towards their extremity, they are *decumbent* ; or if they rise obliquely from near the base, *ascending*. But if, instead of resting on the ground, they take an erect position and cling to neighbouring plants or other objects for support, they are called *climbing* if they proceed in a more or less rectilineal direction, as in the Passion-flower (*fig.* 213), where they adhere to other bodies by means of little twisted ramifications called tendrils, *v*, *v*; or in the Ivy, where they emit little aerial roots from their sides, by which they cling to neighbouring bodies (*fig.* 225, *a*, *a*). Or if such stems twist round other bodies in a spiral manner they are said to be *twining*; and this twining may take place either from right to left, as in some Convolvuli (*fig.* 227), French Bean, and Dodder; or from left to right, as in the Honeysuckle (*fig.* 226), Hop, and Black Bryony; or first in one direction and then in another, irregularly, as in the White Bryony. The climbing and twining stems of cold and temperate regions are generally herbaceous or die annually, although we have exceptions in those of the Ivy, Clematis, and Honeysuckle, which are woody. In tropical climates these woody climbing and twining stems often occur; these are called *lianas* or *lianes*, and they frequently ascend to the tops of the loftiest trees, and then either descend to the ground again, or pass to the branches of neighbouring trees.

The stem has received many names according to its nature. Thus it is called a *caulis* in plants which are herbaceous, or die down annually to the surface of the ground; a *trunk*, as in trees, where it is woody and perennial; a *culm*, as in most Grasses and Sedges, where it presents a jointed appearance; and a *caudex* or *stipe*, as in Tree-ferns and Palms.

Herbs, Shrubs, and Trees.—From the nature, duration, and mode of branching of stems, plants have been arranged from the earliest periods in three divisions, called, respectively, *Herbs*, *Shrubs*, and *Trees*. Thus, those plants which have stems that die down annually to the surface of the ground are called *herbs*; while those with perennial aerial woody stems are denominated *trees* or *shrubs* according to circumstances, as described below. Herbs are also further characterised as *annual*, *biennial*, and *perennial*. Thus they are *annual* when they only live through one season, that is, between the spring and winter; *biennial*, when they spring from seed in one season, and die in the second, after producing flowers, fruit, and seed; and *perennial*, when they germinate from seed in one season, and continue to live through a succession of years, and annually send up an herbaceous stem. The term *tree* is applied if the branches are perennial and arise from a trunk. When the branches are perennial and proceed directly from. or near to, the surface of the ground, without any trunk, or where this is very short, a *shrub* is formed; this when low and branched very much at the base, is denominated a *bush*. The term *undershrub* is also applied to a small shrub which is intermediate in its characters between an ordinary shrub and an herb; thus, when some of its branches generally perish annually, while others are more or less permanent. All the above kinds of stems are connected by intermediate links, so that in many cases they are by no means well defined.

If the terminal bud of a stem is continually developed, the axis upon which it is placed is prolonged upwards from the earth to its summit, giving off branches from its side, as in most Firs ; such a stem has been termed *excurrent*. When the main stem is arrested in its growth by the process of flowering, or some other cause, and the lateral buds become the more vigorously developed, so that the stem appears to divide into a number of irregular branches, it is said to be *deliquescent*. These different kinds of growth influence materially the general form of trees. Thus, those with excurrent stems are usually more or less conical or pyramidal ; while those with deliquescent stems are rounded or spreading. The general appearance of trees also depends upon the nature of the lateral branches, and upon the angle which they make with the stem from which they arise. Thus, if the branches are firm, and spring at an acute angle to the stem, as in the Cypress and Lombardy Poplar, they are erect, and the tree is more or less narrowed ; if they come off at a right angle, the branches are *spreading*, as in the Oak and Cedar ; if the angle is very obtuse, or if the branches bend downwards from their origin, as in the Weeping Ash and Weeping Elm, they are termed *weeping* or *pendulous* ; or in other cases this weeping appearance arises from the weakness and flexibility of the branches, as in the Weeping Willow and Weeping Birch. The relative length also of the upper and lower branches will give rise to corresponding differences in the general appearance of trees. Thus, if the lower branches are the longest and become shorter as they approach the top, the whole will take the form of a cone or pyramid, as in the Spruce Fir ; if the middle branches are longer than those of the base and apex, the general appearance will be rounded or oval, as in the Horsechestnut ; if those of the top are the most developed, the form will be umbrella-like, as in the Italian Pine.

Kinds of Stem and Branches.—We have seen that the stem (page 73), when first developed, always passes upwards, while the root at the same time passes downwards. In many instances this original direction of the stem is continued more or less throughout its life, but in other plants the terminal bud either acquires an irregular development, and the stem runs along, or remains under, the surface of the ground ; or it perishes altogether at a very early period, and an axillary branch takes its place, which also, by developing laterally, will likewise continue near the surface of the ground, or burrow beneath it. From these peculiarities in the direction and growth of stems and branches, we have a number of modifications which we now proceed to describe. These are best treated of, in a practical point of view, under two heads, namely, those which are *aerial*, and those which are *subterranean*. We can, however, by no means draw a distinct line between the modifications of stem which these two divisions respectively contain, as certain forms occasionally pass from one into the other, thus being both subterranean and aerial at different points, or at different periods of their course.

1. *Aerial Modifications of the Stem and Branches.*—Of these the more important are the *runner*, the *offset*, the *stolon*, the *sucker*, and the *rhizome.*

a. *The Runner or Flagellum* (*fig.* 228).—This is an elon-

FIG. 228.

FIG. 229.

FIG. 230.

Fig. 228. A portion of the common Strawberry plant. *a'*. An axis producing a tuft of leaves at its extremity, the upper of which, *r*, are well developed and green, and the lower rudimentary. From the axil of one of the latter a second axis or runner, *a''*, arises, bearing a rudimentary leaf, *f'*, near the middle, and a cluster of leaves, *r*, at its end. *a'''*. A third axis produced in a similar manner to the former. *f*, *f*. Roots or rootlets.——*Fig.* 229. Offset of *Sempervivum.*——*Fig.* 230. Plant showing the process of *layering.*

gated, slender, prostrate branch, *a'*, sent off from the base of the stem, and giving off at its extremity leaves, *r*, and roots, *f*, and thus producing a new plant, which extends itself in a similar manner. This is well seen in the common Strawberry.

b. *The Offset* (*fig.* 229).—This is a short, prostrate, more or less thickened branch, which produces at its apex small roots and a tuft of leaves, and thus forms an independent plant, which is capable of producing other offsets in a like manner. It is well seen in the Houseleek. This differs very little from the ordinary runner, except in being shorter, somewhat thicker, and its leaves distinctly tufted.

e. *The Stolon.*—This is a branch given off above the surface of the earth, but which curves or proceeds downwards towards it, and when it reaches a moist spot it sends rootlets into the ground, and a stem upwards into the air, and being thus capable of acquiring food independently of its parent, it ultimately forms a new individual. The Currant, Gooseberry, and other plants, multiply in this way. All such plants are said to be *stoloniferous.* Gardeners imitate this natural formation of new individuals when they lay down a branch into the earth, from which a new plant is ultimately formed; this process is technically called *layering* (*fig.* 230).

FIG. 231.

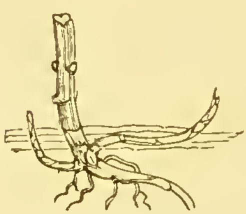
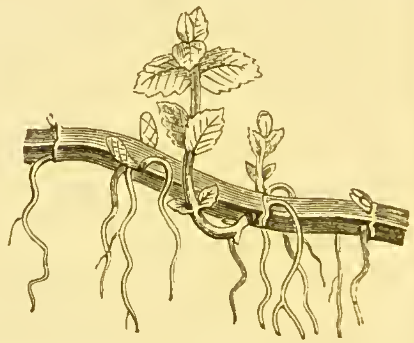


FIG. 232.



Figs. 231 and 232. Suckers of species of *Mentha.*

d. *The Sucker* (*figs.* 231 and 232).—This is a branch which arises from the stem below the surface of the earth, and which, after proceeding in a horizontal direction for a certain distance, and giving off little roots or rootlets in its course, turns upwards into the air, and ultimately forms an independent plant. Plants thus producing suckers are said to be *surculose.* Good examples of this kind of stem are seen in the Rose, the Raspberry, and the Mint. The sucker can scarcely be said to differ in any essential particulars from the stolon, except that it is originally subterranean, and ultimately aerial; whereas the stolon is first aerial, and then subterranean.

e. *The Rhizome or Rootstock* (*figs.* 233 and 234).—This is a prostrate thickened stem or branch running along the surface of the ground, or more generally partly beneath it, and giving off small roots or rootlets from its lower side, and leaves and buds from its upper. These stems sometimes creep for a long distance in this way, and have their upper surface then marked by scars (*fig.* 234, *c*, *c*), which are caused by the falling off of former leaves, or of aerial herbaceous branches or flower-stalks, by which character they may be commonly distinguished, even when in a dried state, from true roots. Such stems are found in the Iris, Sweet-flag, Ginger, Turmeric, Solomon's Seal, Fern, and many other plants. In some cases these rhizomes are placed in a vertical direction in the earth (*erect rhizomes*), and they then bear a great resemblance to roots, as in the Devil's-bit Scabious (*Scabiosa succisa*), where such a rhizome is commonly known as a *præmorse root* (*fig.* 272). The rhizome being generally, as we have seen, partly beneath the surface of the ground, forms therefore a natural transition to the description of subterranean stems.

Fig. 233.

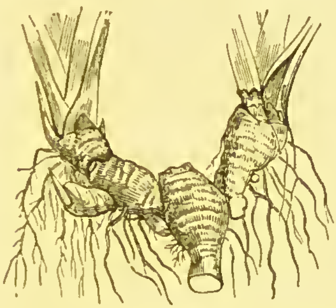


Fig. 234.

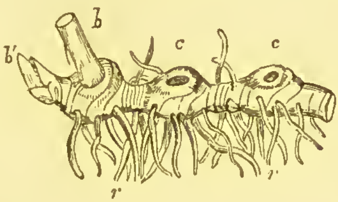


Fig. 233. A portion of the rhizome of a species of *Iris*.——*Fig.* 234. A portion of the rhizome of the Solomon's Seal (*Polygonatum multiflorum*). *b*. Remains of the flowering stem of the present year. *b'*. Terminal bud. *c*, *c*. Scars produced by the decay of the flowering stems of the two preceding years. *r*, *r*. Rootlets.

2. *Subterranean Modifications of the Stem and Branches.*—All these modifications of the stem and branches were formerly confounded with roots, and they are still thus designated in common language. They are distinguished, however, from roots, either by the presence of buds, or by scales (*cataphyllary leaves*), or by the presence of scars on their surface which are produced by the falling off of former leaves or buds. The different kinds of aerial stems described above, when partially subterranean, may be also distinguished in a similar manner from roots.

a. *The Creeping Stem* (*fig.* 235).—This kind of stem is called in common language a *creeping root.* It is a slender branch which runs along beneath the surface of the earth, emitting small roots from its lower side, and buds from its upper, in the same manner as the rhizome, and it is considered by many botanists as a variety of that stem. The only differences existing between the creeping stem as defined above and the rhizome, are its more slender form, its commonly greater length, and its entirely subterranean course. The Sand Sedge (*Carex arenaria*) (*fig.* 235), and the Couch Grass (*Triticum repens*), afford good examples of this stem. In some instances such stems serve important purposes in nature; thus those of the Sand Sedge or Carex, by spreading through the sand of the sea-shore, and in this way binding it together, prevent it from being washed away by the receding waves. Others, like those of the Couch Grass, are the pest of the agriculturist, who finds it very difficult to destroy such stems by cutting them into pieces, for as every node is capable of developing a leaf-bud and roots, each of the pieces into which they will then be divided may become an independent individual; and therefore such a

FIG. 235.

Fig. 235. Creeping stem of the Sand Carex (*Carex arenaria*). 1. Terminal bud by which the stem continues to elongate. 2, 3, 4. Shoots produced from former buds.

process, instead of destroying such plants, only serves the purpose of still further multiplying them by placing the separated parts under more favourable circumstances for development.

b. *The Tuber* (*figs.* 236 and 237).—This is a subterranean stem or branch, arrested in its growth, and excessively enlarged by the deposition of starch or other nutritious substance in its tissue. It has upon its surface a variable number of little buds, or eyes as they are sometimes called, from which new plants are ultimately formed. The presence of these buds indicates its nature as a kind of stem. This stem-like nature of the tuber is also clearly proved by the practice commonly adopted for propagating potatoes, the tuber being cut into pieces, each piece containing one or more buds. When these pieces are placed under favourable circumstances for development, the buds are at first nourished by the matter which surrounds them, and are thus enabled to put forth roots and obtain nourishment for themselves, and in this manner to form independent plants. The Potato (*fig.* 236), and Jerusalem Artichoke (*fig.* 237), are good illustrations of tubers. A case was reported in the *Gardener's Chronicle* of a Potato plant in which the buds in the axils of the true leaves above ground

FIG. 236.

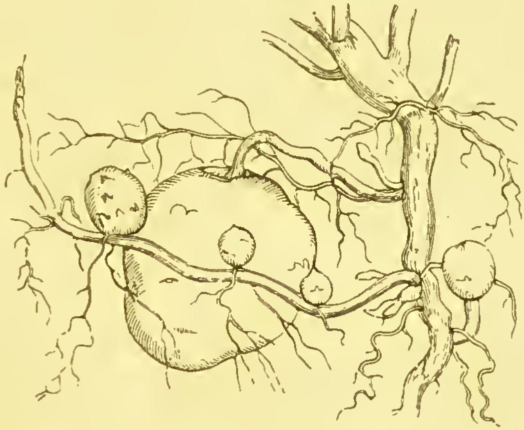


Fig. 236. Tubers of the common Potato (*Solanum tuberosum*).

showed a tendency to form tubers (*fig.* 238), by which their analogy to stems was also clearly indicated. The stem-like nature of the tuber is likewise corroborated by the common experience of gardeners, who, by surrounding the lower part

FIG. 237.

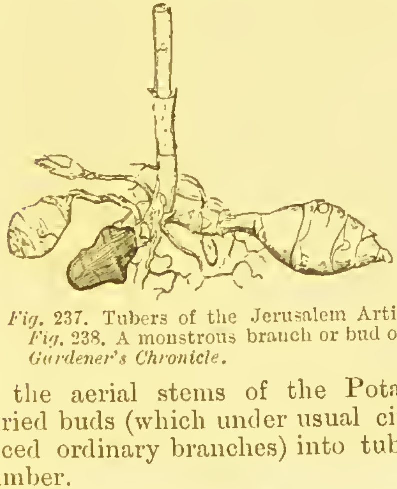


FIG. 238.

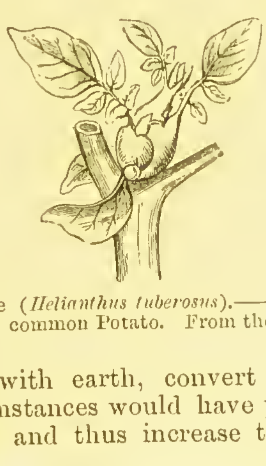


Fig. 237. Tubers of the Jerusalem Artichoke (*Helianthus tuberosus*).——*Fig.* 238. A monstrous branch or bud of the common Potato. From the *Gardener's Chronicle*.

of the aerial stems of the Potato with earth, convert the buried buds (which under usual circumstances would have produced ordinary branches) into tubers, and thus increase their number.

The tubercules of certain terrestrial Orchids and other plants (*figs.* 261–263), which are described by us as enlarged roots, are considered by some botanists as tubers. The tuber, however, as defined above, is well characterised, and, in practice at least, should be distinguished from them.

e. *The Bulb.*—This is a shortened, usually subterranean stem or branch, generally in the form of a rounded or flattened plate or disc (*figs.* 239–241, *a*), which bears on its surface a number of fleshy scales or cataphyllary leaves ; or it may be considered as a subterranean bud of a scaly nature which sends off roots or rootlets from below (*fig.* 241, *b*), and a flowering stem upwards (*fig.* 239, *p*, and *figs.* 240 and 241, *d*). The scales are generally more or less thickened by deposition of nutritive matters ; these, therefore, serve as reservoirs of nutriment for the future use of the plant, just as in other cases the enlarged stems and roots serve a similar purpose. The true bulb is only

Fig. 239.

Fig. 240.

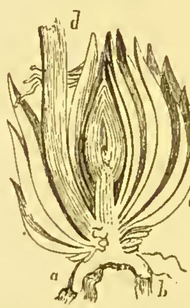


Fig. 241.

Fig. 239. Vertical section of the scaly bulb of the Lily. *a.* Shortened axis or stem. *b.* Lateral bulb or clove. *p.* Flowering stem. *c.* Scales.——*Fig.* 240. Vertical section of the scaly bulb of the Lily.——*Fig.* 241. Scaly bulb of the Lily. *a.* Shortened axis or stem. *b.* Fibrous roots. *c.* Scales. *d.* Flowering stem. The letters refer to the same parts in the two latter figures.

found in Monocotyledons, as in the Lily (*figs.* 240 and 241), Onion (*fig.* 242), and Tulip. The scales of a bulb, like the leaves of a branch, have the power of developing in their axils new bulbs (*fig.* 239, *b*) ; these are called by gardeners *cloves*, and their presence is an additional proof of the analogy of a bulb to a branch or bud.

There are two kinds of bulbs commonly distinguished by botanists, namely, the *tunicated* (*fig.* 242), and the *scaly* (*figs.* 240 and 241). The *tunicated bulb* is well seen in the Onion (*fig.* 242) and Squill. In this kind of bulb the inner scales, which are thick and fleshy, enclose each other in a concentric manner, and are covered externally by thin and membranous ones, which form a covering or *tunic* to them, and hence the name *tunicated* or *coated*, which is applied to it. In the *scaly*, or *naked* bulb, as it is also called (*figs.* 240 and 241), there are no outer dry scales ; but it is entirely composed of thick, fleshy, more or less flattened ones, which simply overlap one another.

The young bulbs (*cloves*) (*fig.* 239, *b*), which are developed in the axils of the scales of bulbs, either remain attached to their parent, which they then commonly destroy by absorbing all its stored-up nutriment ; or more commonly they become separated in the course of growth, and form independent plants.

In the axils of the leaves of certain plants, such as some species of Lily (*fig.* 243, *a*, *a*), the Coralwort (*Dentaria bulbifera*), and Pilewort (*Ranunculus Ficaria*), small conical or rounded fleshy bodies are produced, which are of the nature of bulbs, and are hence called *aerial bulbs* from their position, or from their smaller size *bulbils* or *bulblets.* They differ from ordinary buds in their fleshy nature, and by spontaneously separating

FIG. 242.

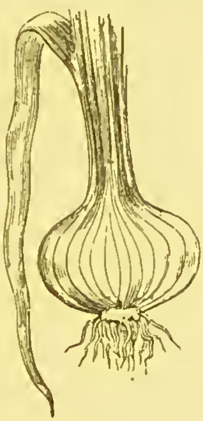


FIG. 243.

Fig. 242. Tunicated bulb of the Onion.——*Fig.* 243. Stem of a species of Lily (*Lilium bulbiferum*) bearing bulbils or bulblets, *a*, *a*, in the axils of its leaves.

from their parent, and producing new individuals when placed under favourable circumstances ; and from true bulbs from their small size and aerial position. These aerial bulbs are not confined, as is the case with true bulbs, to Monocotyledons, as may be seen by the examples given.

d. *The Corm.*—This form of stem, like the true bulb, is only found in Monocotyledons, as, for example, the Colchicum (*fig.* 246), and Crocus (*figs.* 244 and 245). It is an enlarged solid subterranean stem, of a more or less rounded or oval figure, and commonly covered externally by a few thin membranous scales or cataphyllary leaves. By some botanists it is considered as a kind of bulb, in which the stem is much enlarged, and the scales reduced to thin membranes. Practically a corm may be distinguished from a bulb by its solid nature (*fig.* 245, *a*, *b*), the bulb being formed of flattened imbricated or concentrically

Fig. 244.

Fig. 245.

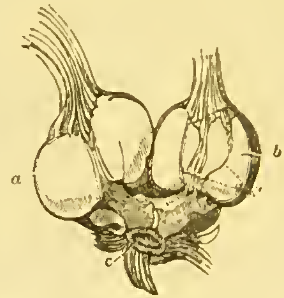


Fig. 244. Corms of *Crocus sativus.* *a*, *b*. The new corms, arising from *c*, the apex of the old or parent corm.——*Fig.* 245. Vertical section of the former. The letters refer to the same parts.

arranged scales. The corm is known to be a kind of stem by producing from its surface one or more buds, in the form of young corms, as in the Crocus (*fig.* 244, *a*, *b*), where they proceed from the apex, *c*, and ultimately destroy their parent by feeding upon its accumulated nutriment. These new corms, in a future year, also produce others near their apex, and these by developing at the expense of their parents also destroy them in like manner, and these again form other corms by which they are themselves destroyed. In this manner the new corms, as they are successively developed from the apex of the old corms, come gradually nearer and nearer to the surface of the earth.

Fig. 246.

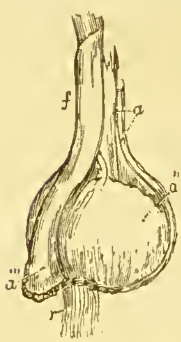


Fig. 246. Colchicum. *r*. Roots or rootlets. *f*. Leaf. *a*. Shrivelled remains of last year's corm. *a''*. Corm of the present year. *a'''*. Commencement of the corm of next year.

In the Colchicum (*fig.* 246), the new corm *a'''* is developed on one side of the old corm near its base, instead of from the apex, as in the Crocus. This also feeds upon its parent, and ultimately destroys it, and is in like manner destroyed the next year by its own progeny. Thus, in taking up such a corm carefully, we find (*fig.* 246), *a*, the shrivelled corm of last year; and *a''*, that of the present season, which, if cut vertically, shows *a'''*, the corm in a young condition for the next year. All corms, like bulbs, contain starch or other nutritious matters, which are stored up for the future use of their offspring.

Section 2. THE ROOT OR DESCENDING AXIS.

THE root is defined as that part of the axis which at its first development in the embryo takes an opposite direction to the stem, avoiding the light and air, and hence called the descending axis, and fixing the plant to the soil or to the substance upon which it grows, or suspended in the water when the plant is placed on the surface of, or in, that medium. That part of the root which joins the stem is called the *base*, and the opposite extremity the *apex*.

We distinguish two varieties of roots, namely, the *True* or *Primary*, and the *Adventitious* or *Secondary*.

FIG. 247.

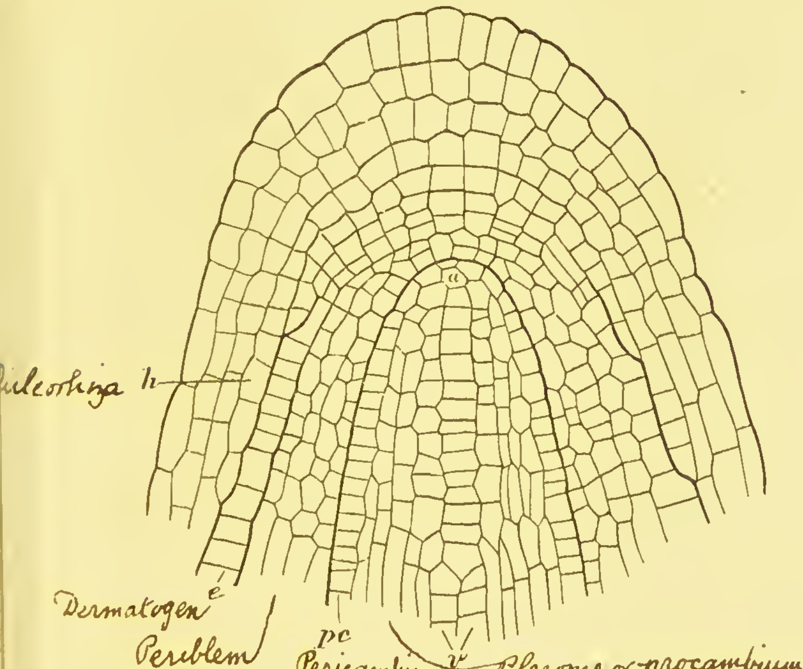


Fig. 247. Root apex (*Polygonum Fagopyrum*), median longitudinal section. *v*. Rudiment of a vessel. *pc*. Pericambium—the outside boundary of the plerome or procambium. *e*. Dermatogen, between which and *pc* is the periblem. *h*. Root-cap or pileorhiza. *a*. Apical cells. After De Bary.

1. TRUE OR PRIMARY ROOT.—The true root, which, except in rare cases, can only exist in Dicotyledons (page 134), is formed at first by additions made within the extremity of the radicle (*fig.* 248, *a*) of the embryo; and the mode in which it takes place may be thus stated:—Growth commences by the multiplication of cells by division just within the apex of the radicle; the mass of cells thus formed becomes gradually differentiated into three layers, an outer, inner, and intermediate. From the *inner layer*,

which is termed the *plerome* or *procambium* (*fig.* 247), is subsequently developed the fibro-vascular portion of the root, *v*, the cortical layers being formed from the *intermediate layer* or *periblem*, whilst the *outer single layer* of cells, known as the *dermatogen*, *e*, in addition to giving rise to the epidermis, forms the cap-shaped mass of tissue called the *root-cap* or *pileorhiza*, *h*, by which the growing apex of the root is always clothed. All roots (*fig.* 248, *a*) and the branches of a root grow in length in a similar manner to the radicle as above described; hence roots do not grow throughout their entire length like stems, but only within their extremities, which are continually pushed forward and renewed. Thus the apex of the root is always clothed by a layer of denser tissue which is commonly known

FIG. 248.

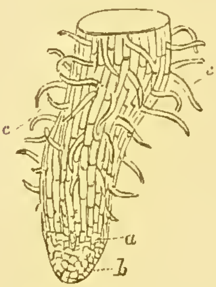


FIG. 249.

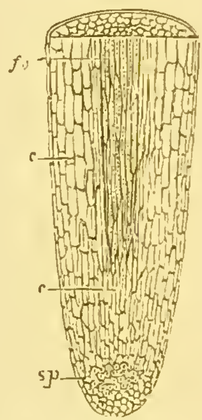


Fig. 248. Young root of the Maple, magnified. *a*. The part where growth is taking place. *b*. The original extremity. *c*, *c*. Fibrils or root-hairs. After Gray.——*Fig.* 249. Highly magnified vertical section of an Orchis root. *sp*. The so-called spongiole. *c*, *c*. Parenchymatous cells. *fv*. Wood-cells and vessels.

as the root-cap (*fig.* 248, *b*). All the branches of a root are likewise terminated by a similar cap (*fig.* 250, *h*, *h*). This cap forms in fact a sort of protecting shield to the young extremities of the root; and its external cells are commonly thrown off as new cells are formed within them. (See also Development of Roots, in Physiological Botany.) These cap-like coverings at the extremities of the root were formerly regarded as special organs, and called *spongioles* or *spongelets* (*fig.* 249, *sp*), under the idea that they absorbed fluid for the use of the plant, in the same manner as a sponge sucks up water. But it will be seen from the above description of the growth of roots that such structures have no existence. Roots increase in diameter by the formation of annual layers of wood, much in the same manner as stems.

At first the elongating growing extremities of the root consist entirely of parenchymatous cells (*figs.* 248, *a*, and 249, *c*); wood-cells and vessels (*fig.* 249, *fv*), however, soon make their appearance, and are constantly added to below by the new tissue formed as the root continues to lengthen. When the root is fully developed, these vessels and wood-cells generally form a central mass of wood (*figs.* 249, *fv*, and 250, *f*), in which there is commonly no pith, and no medullary sheath, but the medullary rays exist as in the stem. Roots, however, differ from stems in the arrangement of the parts of their fibro-vascular bundles. Thus in roots, the phloëm or liber portions alternate with the xylem or woody portions, instead of being placed external to them as in stems; and some other minor differences also occur. Externally there is a true bark or cortex (*fig.* 250, *r*, *r*), which is also covered when young by a modified epidermis without stomata (*fig.* 128), and which, as we have seen, is sometimes called *epiblema* (page 60). This epidermis is also furnished with hair-like prolongations, which are termed *root-hairs* or *fibrils* (*figs.* 128, and 248, *c*, *c*). The latter are especially evident upon young growing roots, and as these advance in age they perish, while the tissue from which they were prolonged becomes at the same time harder and firmer, and is converted gradually into cork-tissue.

Fig. 250.

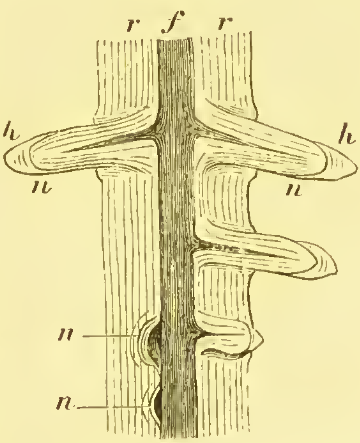


Fig. 250. Longitudinal section of the root of the common Bean (*Faba vulgaris*), magnified five times. *r*, *r*. Cortex of the main root. *f*. Fibro-vascular bundles. *n*, *n*, *n*, *n*. Lateral roots in different stages, developing from the pericambium and ultimately bursting through the cortex. *h*, *h*. Root-cap, or pileorhiza, of the lateral roots. After Prantl.

Roots have no leaves, and normally no buds, hence they have no provision for regular ramification; but they appear to divide and subdivide according to circumstances without any definite order; hence while the branches of the stem have a more or less symmetrical arrangement, as already described, those of the root are unsymmetrical. The branches of the root are also always developed endogenously (*fig.* 250, *n*, *n*), that is, they are deep-seated, being derived from the pericambium (*fig.* 247, *pc*) or outer layer of the plerome or procambium. As they increase in length they ultimately push through the tissues which are superficial to them, namely, the cortical layers and epidermis of the main root, which are therefore not continuous with the similar tissues of the branches (*fig.* 250, *r*, *r*). The branches are thus merely repetitions of the original axis from which they are developed, and grow, as already noticed, in a similar manner, and, like it, have commonly neither buds nor leaves. To this latter character, however, there are many exceptions, for although the root has no power of forming regular buds, yet adventitious buds may be developed, in the same manner as we have seen that under certain circumstances they may be produced from any parenchymatous tissue (page 111). The power which the root thus possesses of producing adventitious buds may be observed in the Plum-tree, the Moutan Pæony, the Japan Anemone, and many other plants. The latter plant especially exhibits this tendency in a remarkable degree.

Distinctive Characters of Stems and Roots.—From the above general description which has been given of the growth, structure, and characteristics of the true or primary root, we find that the chief distinctive characters between it and the stem in Dicotyledons may be summed up as follows:—1st. The tendency of the root at its first formation to develop in an opposite direction to the stem, and thus withdraw from the light and air. 2nd. By not growing throughout the entire length of its newly formed parts like a stem, but only by additions just within its apex, which is covered by a *root-cap* or *pileorhiza*. 3rd. The root under ordinary circumstances, when fully developed, has no pith or medullary sheath. 4th. It has no true epidermis with stomata, but in place of this an integument composed of cells without stomata, to which the name of *epiblema* has been given. 5th. It has no foliage leaves, or scales (*cataphyllary leaves*). 6th. It has no regular buds, and has consequently no provision for a regular ramification.

2. Adventitious or Secondary Roots.—This name is applied to all roots which are not produced by the direct elongation of the radicle of the embryo; because such roots, instead of proceeding from a definite point as is the case with the true or primary root, are, to a certain extent at least, accidental in their origin, and dependent upon favourable external circumstances for their development. All branches of a true root, except those originally produced from its apex, are of this nature, as are also those of the different modifications of the stem, such as the rhizome, runner, sucker, stolon, corm, bulb, &c.; those of slips and cuttings of plants, &c.; and those of nearly all Monocotyledons and of Acrogens or Cormophytes. In some plants roots are also developed from the stem or branches of plants in the air, and are hence called *Aerial Roots.* Such roots are likewise necessarily of an adventitious nature.

The adventitious roots of Monocotyledons make their first appearance as little more or less conical bodies formed by division and subsequent growth of the cells constituting the pericambium or outer layer of the plerome or procambium; these soon break through the tissue which envelops them, and appear externally, at first as parenchymatous elongations, but ultimately having a similar structure to that of a monocotyledonous stem. Where they break through they are surrounded at the base by a kind of sheath or collar called a *coleorhiza* (*fig.* 251, *co*). They also grow by additions within their extremities like true roots, and are terminated like them by a root-cap or pileorhiza. In the adventitious aerial roots of the Screw-pine (*fig.* 199, 2), and some other plants, the pileorhiza may be well seen in the form of a cap-like covering at the extremity of each root or branch of a root. The pileorhiza of a monocotyledonous root, like that of a true root, is commonly thrown off as development takes place behind it; but in certain aquatic plants, as in the Duckweed (*fig.* 252), it is persistent, and appears in the form of a long sheath over the end of the root; and is continually pushed onwards by the development of the cells within the apex.

FIG. 251.

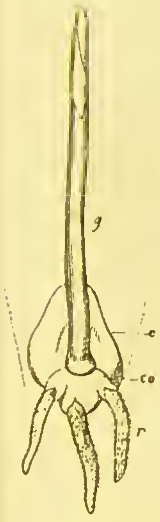


FIG. 252.

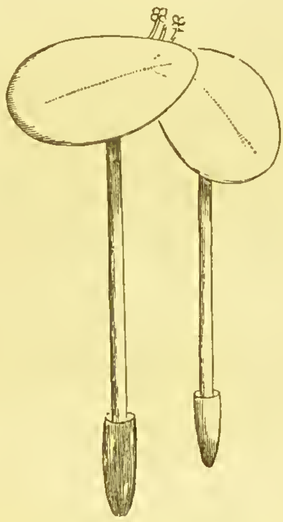


FIG. 253.

Fig. 251. Germinating embryo of the Oat. *r*. Rootlets, each with a sheath (coleorhiza), *co*, at its base. *c*. Cotyledon. *g*. Young stem.——*Fig.* 252. Magnified plants of the Lesser Duckweed (*Lemna minor*), with the roots covered by a long root-cap (*pileorhiza*).——*Fig.* 253. Lower part of the stem and root of the common Stock. *r*. The tap-root with its branches. *c*. The base of the root or point of union between the stem and root which was formerly termed the neck. *t*. The stem. *f*, *f*. Leaves. *b*, *b*. Buds in process of development into branches.

The adventitious roots of Dicotyledons arise in a somewhat similar manner to those of Monocotyledons, making their first appearance as little conical bodies formed from the substance of the pericambium, and ultimately breaking through the bark and appearing on the surface. They also grow by additions within their extremities, and each is protected by a pilcorhiza, and has at its base a coleorhiza. They have under ordinary circumstances a similar structure to that of true roots.

Adventitious roots generally, like true roots, have no leaves or buds, and when subterranean have no epidermis furnished with stomata; hence when derived from Dicotyledons, they are distinguished from the stem by the same characters as that of the true root. The adventitious roots of Monocotyledons and of Cormophytes have a similar structure to their respective stems, as will be afterwards noticed. Aerial roots are, however, from their exceptional position, frequently furnished with a true epidermis and stomata, and are sometimes of a green colour; but in other respects they resemble ordinary adventitious roots.

The true or primary root, from its being formed by direct elongation from the radicle, by additions made within its extremity, generally continues to grow downwards for some

Fig. 254.

Fig. 254. The Banyan-tree (*Ficus indica*).

time at least, and hence forms a main trunk or axis from which the branches are given off (*fig.* 253, *r*). Such a root is termed a *tap-root*, and may be commonly observed in Dicotyledons. On the contrary, the roots of Monocotyledons and Cormophytes, which are adventitious, are usually of nearly equal size, and given off in variable numbers from the radicle (*fig.* 251, *r*). Some adventitious roots, such as those called aerial, require a more particular notice.

Aerial Roots.—The simplest forms of aerial roots are seen in the Ivy (*fig.* 225, *a*, *a*), and some other climbing plants. In these plants they are essentially intended for mechanical support, and not to obtain food: this they obtain by their ordinary roots fixed in the soil. It is probable, however, that in the Ivy and other climbing plants some food may be taken up by these roots. In many other plants the aerial roots which are given off by the stem or branches descend to the ground, and fixing themselves there, not only act as mechanical supports, but also assist the true root in obtaining food. Such roots are well seen in the Screw-pine (*fig.* 199, 2), in the Banyan or Indian Fig-tree (*fig.* 254), and in the Mangrove-tree (*fig.* 255). In the latter tree these aerial roots frequently form the entire support of the stem, both mechanically and otherwise, in consequence of this decaying at its lower part.

Fig. 255.

Fig. 255. The Mangrove-tree (*Rhizophora Mangle*).

Epiphytes or Air-plants.—In these plants none but aerial roots are produced (*fig.* 256, *a*, *a*), and as these never reach the soil they cannot obtain any food from it, but must draw their food entirely from the air in which they are developed; hence the name of *air-plants* which is applied to them. They are also called *epiphytes*, because they commonly grow upon other plants. Most Orchids (*fig.* 256) and Tillandsias afford us illustrations of epiphytical plants. The roots of such plants are commonly green, and possess a true epidermis and stomata; in which particulars, there-

Fig. 256.

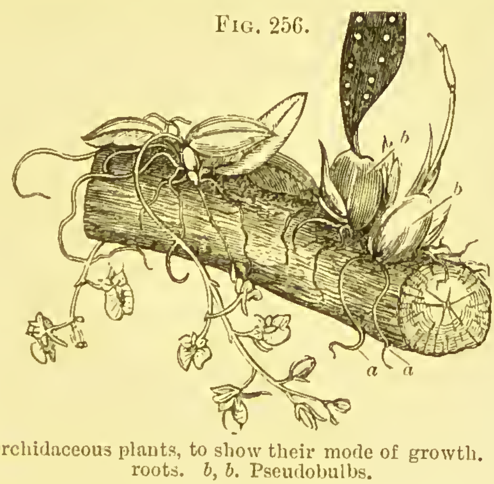


Fig. 256. Orchidaceous plants, to show their mode of growth. *a*, *a*. Aerial roots. *b*, *b*. Pseudobulbs.

fore, these aerial roots present exceptions, as already noticed, to what is commonly observed in other roots. The aerial roots of Orchids have also a layer of usually very delicate fibrous cells (page 45), placed over the true epidermis, to which the name of *root-sheath* (*velamen radicum*) has been applied by Schleiden, who also calls such roots *coated roots.*

Besides these epiphytes, there is another very interesting class of plants which are called *parasites* : these we must now notice.

Parasites.—These are plants which not only grow upon others, but which, instead of sending their roots into the air and deriving their food from it, as is the case with the epiphytes, send them into the tissues of the plants upon which they grow, and obtain nutriment from them. The plant which they thus penetrate and feed upon is termed their *host* ; and their sucking roots are termed *haustoria.* The Mistletoe (*Viscum album*), Broom-rapes (*Orobanche*), Dodders (*Cuscuta*) (*fig.*

FIG. 257.

FIG. 258.

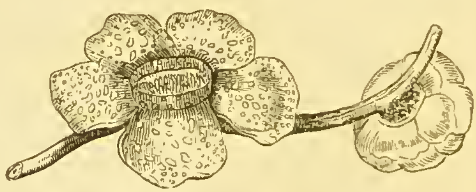


Fig. 257. Cuscuta or Dodder-plant. ——*Fig.* 258. Flower and flower-bud of *Rafflesia Arnoldi*, a parasitic plant of Sumatra.

257), and *Rafflesia Arnoldi* (*fig.*258), may be cited as examples of such plants. These parasites are of various natures : thus some have green foliage, as the Mistletoe ; while many others are pale, or brownish, or possess other tints than green, as the Broom-rapes and Rafflesia. The latter plant is especially interesting from its producing the largest flowers of any known plant : thus the first flower which was discovered measured nine feet in circumference, and weighed fifteen pounds.

Parasitical plants also vary in the degree of their parasitism ; thus the Mistletoe and the greater number of parasites are, so far as their roots are concerned, entirely dependent upon the plants on which they grow for their food. Others, as the Dodders, obtain their food at first, like other plants, by means of the ordinary roots contained in the soil ; but after having arrived at a certain age, these perish, and they then derive their food entirely from roots which penetrate the plants upon which they grow; others, again, continue throughout their life to derive a portion of their food by means of roots imbedded in the soil.

It will thus be seen that parasites differ from other plants in the fact that they do not live like them entirely on inorganic matters, but derive at least some of their food in an assimilated state from the plants on which they grow. Thus, when green like the Mistletoe, they obtain a portion of their food, like ordinary plants, from the air; but if of other colours than green, all their food is derived by their roots from the plants on which they grow. It must also necessarily happen that parasites, by living partially or entirely upon those plants on which they are placed, frequently injure, and even destroy them, and in this way great damage is done to Clover, Flax, and other crops in this country and elsewhere.

Besides the parasites just described, there is also another class of plants called *saprophytes*, which, whilst agreeing with ordinary parasites in deriving their food from already formed organic material, differ from this latter class in growing on dead organic substances, and therefore assimilating such matter which is in a state of decomposition or decay. Such plants as *Monotropa Hypopithys*, *Corallorhiza innata*, *Epipogium Gmelini*, and *Neottia Nidus-avis*, together with the greater number of Fungi, are examples of Saprophytes.

Duration of Roots.—Having now described the general characters and structure of the *true* or *primary root*, and of the *adventitious* or *secondary root*, we have in the next place to allude to certain differences which roots present depending upon their duration. Roots are thus divided into *annual*, *biennial*, and *perennial*.

1. *Annual Roots.*—These are produced by plants which grow from seed, flower, and die the same year in which they are developed. In such plants the roots are always of small size, and either all spring from a common point as in annual Grasses (*fig.* 259), or the true root is small, and gives off from its sides a number of small branches. Such plants, in the process of flowering and ripening their fruits and seeds, exhaust all the nutriment they contain, and thus necessarily perish.

2. *Biennial Roots.*—These are produced by plants which spring from seed one year, but which do not flower and ripen their seeds till the second year, when they perish. Such roots are commonly enlarged in various ways at the close of the first season, in consequence of their tissues becoming gorged with nutritious matters stored up for the support of the plant during its flowering and fruiting the succeeding season. The Carrot (*fig.* 267), and Turnip (*fig.* 269), afford us good examples of biennial roots.

3. *Perennial Roots.*—These are the roots of plants which live for many years. In some such plants, as the Dahlia (*fig.* 263), and Orchis (*figs.* 261 and 262), the roots are the only portions

of the plant which are thus perennial, their stems dying down to the ground yearly. Perennial roots are either of woody consistence, or more or less fleshy as in those of biennial plants. In the case of fleshy roots such as the Dahlia and Orchis, the individual roots are not in themselves perennial, but usually perish annually ; but before doing so, they produce other roots from some point or points of their substance ; hence, while the root as a whole is perennial, any particular portion may perish. Woody roots are commonly perennial in themselves, and are not renewed.

Roots of Dicotyledons, Monocotyledons, and Acrogens.—We have already seen that the stem of Dicotyledons, Monocotyledons, and Cormophytes, possesses certain characteristic differences in its internal structure. The roots of such plants in like manner possess similar distinctive structural characters, and also some others, which, although generally referred to previously, had better be briefly summed up here.

1. *The Root of Dicotyledons.*—The root of these plants is formed, as we have seen (page 125), by the direct elongation of the radicle of the embryo from the formation of new tissue just within its apex. Such a mode of root-development has been called *exorhizal*, and a root thus formed is called a *true root.*

It follows from this mode of development that Dicotyledons have generally a tap-root (page 130) or descending axis (*fig.* 253, *r*), from which branches are given off in various directions, in the same manner as such plants have also an ascending axis or stem, *t*, from which its branches arise. These tap-roots do not, however, commonly descend far into the ground, but their branches become much developed laterally ; in some cases even more so than those of the stem ; while in others, as in plants of the Gourd tribe, and commonly in succulent plants, to a less extent.

In its internal structure the fully developed root essentially resembles the stem, except that, as already noticed (page 127), it has no pith or medullary sheath : hence the fibro-vascular tissue forms a central axis. This absence of pith and medullary sheath is general in herbaceous Dicotyledons ; but there are some trees, as, for instance, the Walnut and Horsechestnut, where the pith is prolonged downwards for some distance into the root.

2. *The Root of Monocotyledons.*—In these plants the radicle does not itself, except in rare cases, become prolonged to form the root, but it generally gives off above its base one or more branches of equal size, which separately pierce the radicular extremity of the embryo, and become the roots (*fig.* 251, *r*) ; and each of these roots is surrounded at its base, where it pierces the integuments, with a kind of cellular collar, termed

the *coleorhiza*, *co.* Such a mode of root-development has been termed *endorhizal.* The roots of Monocotyledons are therefore to be regarded as *adventitious* or *secondary.*

From their mode of development it rarely happens that the plants of this class have tap-roots, but they have instead a variable number of roots of nearly equal size (*fig.* 259), which are accordingly often termed *compound.* There are, however, exceptions to this, as for instance in the Dragon-tree (*fig.* 196), which has a descending axis resembling the ordinary tap-root of Dicotyledons.

Aerial roots are much more common in Monocotyledons than in Dicotyledons. We have already referred to them in the Screw-pine (*fig.* 199, 2), and other plants of this class. In many Palms they are developed in great abundance towards the base of the stem, by which this portion assumes a conical appearance, which is at once evident by the contrast it presents to the otherwise cylindrical stem of such trees. In its internal struc-

FIG. 259.

FIG. 260.

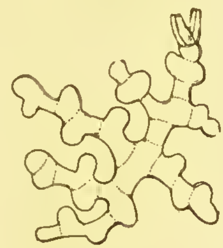


Fig. 259. Fibrous roots of a Grass.——*Fig.* 260. Coralline root.

ture the root of a Monocotyledon corresponds to that of the stem in the same class of plants.

3. *The Root of Cormophytes or Acrogens.*—Such plants, as we have seen (page 11), have no true seeds containing an embryo, but are propagated by spores, from which roots are developed in a very irregular manner ; and hence this mode of root-development has been called *heterorhizal.* Such roots are therefore all adventitious ; and resemble those of Monocotyledons in being *compound.* When the stem has become developed it soon also gives origin to other aerial adventitious roots, by which such plants are often chiefly supported. Hence aerial roots are very common in Acrogenous plants, as they are in Monocotyledons ; indeed, in Tree-ferns, as in many Palms, these roots are so abundant at the base of the stem, that they sometimes double, triple, or still further increase its normal thickness (*fig.* 15, *ra*), and hence give to the lower part of such stems a conical form.

The internal structure of the root of Acrogenous plants in all essential characters resembles that of the stem in the same class of plants.

FORMS OF ROOTS.—When a root divides at once into a

FIG. 261.

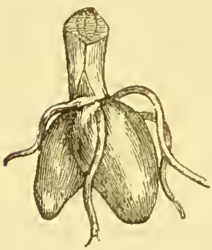


FIG. 262.

Fig. 261. Tubercular roots of an Orchis.—— *Fig.* 262. Palmated tubercules of an Orchis.

FIG. 263.

FIG. 264.

Fig. 263. Fasciculated roots of the Dahlia.——*Fig.* 264. Nodulose root of the common Dropwort (*Spiræa Filipendula*).

number of slender branches or rootlets, or if the primary root is but little enlarged, and gives off from its sides a multitude of similar branches, it is called *fibrous*. Such roots occur commonly in annual plants, and may be well seen in annual Grasses (*fig.* 259), and in bulbous plants (*figs.* 241 and 242). *Coralline Root.*—This name is applied to a root which consists of a number of succulent branches of nearly equal size, and arranged like a piece of coral (*fig.* 260), as in *Corallorhiza innata.* *Tuberculated Root.*—When some of the divisions of a root become enlarged so as to form more or less rounded, oval, or ovoid expansions (*fig.* 261), the root is said to be *tuberculated*, and each enlargement is called a *tubercule.* Such a root occurs in various terrestrial Orchids, the Jalap plant, &c. These tubercules should not be confounded with tubers (page 120), which have been already described as subterranean modifi-

FIG. 265.

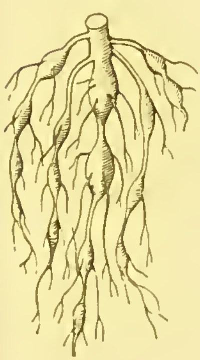


FIG. 266.

FIG. 267.

Fig. 265. Moniliform or beaded root.——*Fig.* 266. Annulated root of Ipecacuanha (*Cephaëlis Ipecacuanha*).——*Fig.* 267. Conical root of the common Carrot (*Daucus Carota*).

cations of the stem. The presence of buds on the latter at once distinguishes them. In many Orchids, as for instance *Orchis maculata*, the tubercules are divided at their extremities, so that the whole somewhat resembles the human hand (*fig.* 262); they are then said to be *palmated*, and the root is also thus termed. Or when a number of tubercules arise from a common point, as in the Dahlia (*fig.* 263), and Bird's-nest Orchis (*Neottia Nidus-avis*), the root is said to be *fasciculated* or *tufted.*

When the branches of a root are expanded only at certain points, other terms are applied. Thus, when the branches are enlarged irregularly towards the ends, as in the Common Dropwort, the root is *nodulose* (*fig.* 264); when the branches have alternate contractions and expansions, so as to present a beaded appearance, as in *Pelargonium triste*, the root is *moniliform*, *necklace-shaped*, or *beaded* (*fig.* 265); and when the root has a number of ring-like expansions on its surface, as in Ipecacuanha, it is *annulated* (*fig.* 266).

The above forms of roots, with few exceptions, are those which are commonly observed in plants which have no true tap-root. Those which have now to be described owe their special forms to modifications of the latter kind of root.

FIG. 268.

FIG. 269.

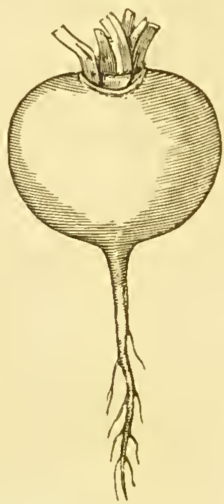


FIG. 270.

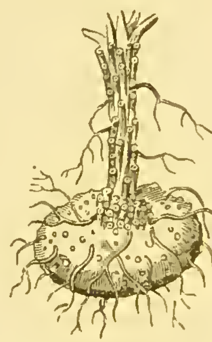


Fig. 268. Fusiform root of the common Radish (*Raphanus sativus*).——*Fig.* 269. Napiform root of the Turnip (*Brassica Rapa*). ——*Fig.* 270. Placentiform root of the Sow-bread (*Cyclamen europæum*).

Conical Root.—When a tap-root is broad at its base, and tapers towards the apex, it is termed *conical*. The roots of Monkshood (*Aconitum Napellus*), Parsnip (*Pastinaca sativa*), and Carrot (*Daucus Carota*) (*fig.* 267), are familiar examples of this form of root. *Fusiform Root.*—This term is applied to a tap-root which swells out a little below its base, and then tapers upwards and downwards (*fig.* 268). The common Radish, and Beet (*Beta vulgaris*), may be taken as examples. *Napiform Root.*—This name is given to a root which is much swollen at its base, and tapers below into a long point, the upper part being of a somewhat globular form (*fig.* 269). It occurs in a variety of the common Radish—which is hence called the Turnip-radish, in the common Turnip, and in some other plants. When what would be otherwise a napiform root becomes compressed both at its base and apex so that it has no tapering extremity, it is sometimes termed *placentiform* (*fig.* 270). It occurs in the Sow-bread (*Cyclamen europæum*).

Some botanists regard the roots of the Radish, the Turnip, the Cyclamen, and others, as really enlarged stems. We have, however, placed them here, in accordance with the more commonly accepted views of their nature, and on account of their importance in Practical Botany. The two next described forms of roots are also more properly rhizomes, but it is convenient to notice them here, and so long as their nature is understood no confusion can arise.

FIG. 271.

FIG. 272.

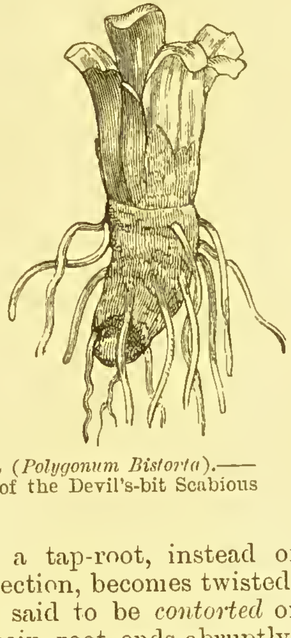


Fig. 271. Contorted root or rhizome of Bistort (*Polygonum Bistorta*).—— *Fig.* 272. Præmorse root or vertical rhizome of the Devil's-bit Scabious (*Scabiosa succisa*).

Contorted or Twisted Root.—When a tap-root, instead of proceeding in a more or less straight direction, becomes twisted, as in the Bistort (*fig.* 271), the root is said to be *contorted* or *twisted*. *Præmorse Root.*—When the main root ends abruptly, so as to present the appearance of having been bitten off, it is called *abrupt*, *truncated*, or *præmorse* (*fig.* 272). We have a good example of this form of root in the Devil's-bit Scabious, which plant has received its common name from a superstitious opinion connected with this peculiar bitten-off appearance of its root.

Section 3. The Leaf or Phyllome.

1. GENERAL DESCRIPTION AND PARTS OF THE LEAF.

The leaf may be defined as a lateral development of the stem or branch. In the lowest leaf-bearing plants, as Mosses, it consists entirely of parenchyma ; but in the higher classes of plants the leaf usually contains, in addition to the parenchyma, a framework or skeleton, consisting of wood-cells or liber-cells, or both, and vessels of different kinds, all of which structures are in direct connexion with similar parts of the stem or branch. We distinguish therefore, in such leaves, as in the stem and branch, both a parenchymatous and a fibro-vascular system—the former constituting the soft parts, and the latter the hard parts, which act as a mechanical support to the leaf, and, by their ramification, form what are called *veins* or *nerves*. The leaf is therefore an appendicular organ of the stem, but it differs from the latter organ in the order of its development ; for while in the stem or branch the apex is the youngest part, the reverse is the case in the leaf, where the apex is first formed and consequently the oldest, and is gradually pushed outwards by the formation of the other parts between it and the stem.

The leaves are usually of a green colour and of a more or less flattened nature ; but in the Stonecrop, Aloes, and many other plants, they are thick and fleshy, when they are said to be *succulent*. In other cases, as in the scales of the bud, the thin membranous coverings of tunicated bulbs and corms, the fleshy scales of bulbs, and the leaves of Broom-rapes, &c., they are colourless, or of a yellowish or brownish colour, and of simple structure ; they are then termed *scales* or *cataphyllary leaves*, the ordinary leaves being called *foliage leaves*.

The part of the stem or branch from which a leaf arises is called a *node*, and the space between two nodes an *internode*. The portion of the leaf next the stem is termed its *base*, the opposite extremity the *apex*, and the lines connecting the base and apex the *margins*. The leaf being commonly of a flattened nature, has only two surfaces ; but when *succulent* it has frequently more than two surfaces. The terms upper and lower are applied to the two surfaces of ordinary leaves, because in by far the greater number of plants such leaves are placed horizontally, so that one surface is turned upwards, and the other downwards. There are certain leaves, however, which are placed vertically, as those of some species of *Acacia* and *Eucalyptus*, in which case the margins are turned upwards and downwards instead of the surfaces. The angle formed by the union of the upper surface of the leaf with the stem is called the *axil*, and everything which arises out of that point is said to be *axillary* to the leaf; or, if from the stem above, or below the axil, it is *extra-axillary*; or, as more generally described when above, *supra-axillary*; if below, *infra-axillary*.

Duration and Fall of the Leaf.—The leaf varies as regards its duration, and receives different names accordingly. Thus, when it falls off soon after its appearance, it is said to be *fugacious* or *caducous*; if it lasts throughout the season in which it is developed, it is *deciduous* or *annual*; or if beyond a single season, or until new leaves are developed, so that the plant is never without leaves, it is *persistent*, *evergreen*, or *perennial*.

When a leaf separates from the stem or branch, it either does so by decaying upon it, when it is said to be *non-articulated*; or by an articulation, in which case it is *articulated*. The remains of a non-articulated leaf, as they decay upon the stem, or branch, are

FIG. 273.

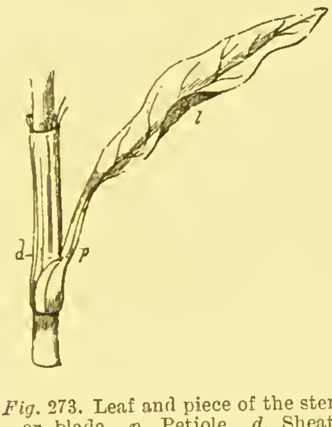


FIG. 274.

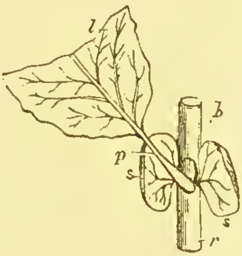


Fig. 273. Leaf and piece of the stem of *Polygonum Hydropiper*. *l*. Lamina or blade. *p*. Petiole. *d*. Sheath.——*Fig.* 274. Leaf and portion of a branch of *Salix aurita*. *r*. Branch. *b*. Bud. *l*. Lamina with the upper portion removed, and attached by a petiole, *p*, to the stem. *s*, *s*. Caulinary stipules.

sometimes called *reliquiæ* or *induviæ*, and the stem or branch is said to be *induviate*. When a leaf separates by an articulation, it leaves a *scar* or *cicatrix* (*fig.* 207, *b*, *b*).

Parts of the Leaf.—The leaf in the highest state of development consists of three distinct parts; namely, of an expanded portion, which is usually more or less flattened (*figs.* 273 and 274, *l*), called the *lamina*, or *blade*; of a narrower portion, by which the lamina is connected with the stem, termed the *petiole* or *leaf-stalk* (*p*); and of a third or *stipular portion*, which is situated at the base of the petiole, and which either exists in the form of a *sheath* (*fig.* 273, *d*), encircling the stem, or as two little leaf-like appendages on each side, which are called *stipules* (*fig.* 274, *s*, *s*).

These three portions are by no means always present, though such is frequently the ease. Thus, the leaves of the Water Pepper (*fig.* 273), and of the Trailing Sallow (*fig.* 274), may be taken as illustrations of the most highly developed leaves, namely, those in which all the parts are found ; but in many plants one of these parts is absent, and in some two, so that the leaf is in such cases reduced to but two, or one of its portions only. The petiole and the sheath or stipules are those parts which are more commonly absent. When the petiole is absent, the leaf is said to be *sessile* (*fig.* 286); when the stipules are absent, it is *exstipulate* (*fig.* 290). The lamina or blade is that part which is most generally present. The leaf is called *simple* if there is but one blade (*figs.* 273 and 274), or *compound* if this is divided into two or more separate parts (*fig.* 275). The lamina of the leaf is usually that part also which is most developed, which performs the most important functions of the leaf, and which is also in ordinary language known under the name of leaf. It is the part, therefore, which will come more particularly under our notice ; but before we proceed to describe it and the other parts of the leaf separately, it will be necessary for us to treat of the internal structure of leaves, and of their insertion and arrangement.

Fig. 275.

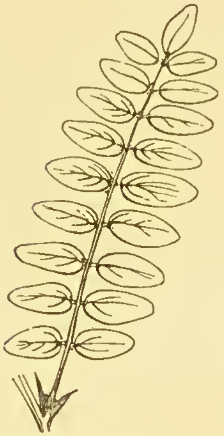


Fig. 275. Compound leaf of *Robinia Pseud-acacia*, with spiny stipules at its base.

2. THE INTERNAL STRUCTURE OF LEAVES.

Leaves with reference to their structure are divided into *aerial* and *submersed* ; by the former is to be understood those that are developed and live entirely or partially in the air ; by the latter, those that are formed and dwell wholly immersed in water.

1. Aerial Leaves.—In the lowest leaf-bearing plants, such as Mosses, the leaves consist, as we have seen, simply of parenchymatous tissue, formed by the growing outwards of the parenchyma of the circumference of the stem or branch ; while in the majority of the higher plants they contain, in addition to this parenchyma, a framework or skeleton formed of wood-cells or liber-cells, or of both, and vessels of different kinds, all of which are in direct connexion with corresponding parts of the fibro-vascular system of the stem or branch. We distinguish therefore, in such leaves, as in the stem and branch, both a parenchymatous and a fibro-vascular system, the former constituting the soft parts or the *parenchyma* of the leaf ; the latter

the hard parts, which by their ramification form what are called the *veins* or *nerves*.

A. The Petiole.—This when present consists of fibro-vascular tissue (*fig.* 276), surrounded by parenchyma, and the whole covered by epidermis, which commonly contains a variable number of stomata, and is frequently furnished with hairs and other epidermal appendages. The parenchyma immediately below the epidermis is sometimes specially modified and forms the tissue known as collenchyma (*fig.* 95), which is one form of what has been termed the *hypoderma* (see pages 48 and 145). The fibro-vascular tissue varies in its nature in the leaves of the different classes of plants, being merely prolongations of that of the three kinds of stems already fully described. Thus in Dicotyledons the fibro-vascular tissue (*fig.* 276) commonly consists of spiral, and pitted, annular, or some other vessels, and also of sieve-tubes, and wood and liber-cells, that is, of the same elements essentially as the wood and liber—the spiral vessels and the other structures belonging to the xylem being placed above those of the phloëm or liber.

Fig. 276.

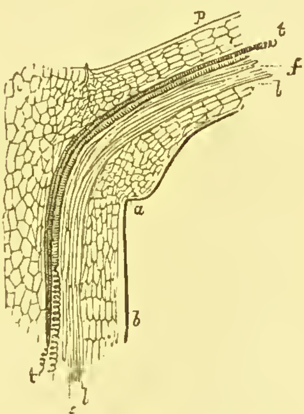


Fig. 276. Fibro-vascular tissue passing from a branch, *b*, of an herbaceous Dicotyledon into the petiole, *p*, surrounded by parenchyma. *a*. Articulation between the petiole and the branch from which it arises. *t*, *t*. Spiral and annular vessels. *f*, *f*. Wood-cells. *l*, *l*. Liber cells.

B. The Lamina.—The whole of the *lamina* is covered by the epidermis, which is furnished with stomata in the manner already described. The stomata are, however, almost confined to that portion of the epidermis which corresponds to the parenchyma of the leaf. The epidermis is also frequently furnished with various appendages, as Hairs, Glands, and their several modifications. The epidermis with its stomata and appendages having been already fully described under their respective heads, it now remains only to allude to the fibro-vascular and parenchymatous systems of the lamina which are situated between the epidermis of its upper and lower surfaces.

1. *Fibro-vascular System.*—This is in direct connexion with that of the stem or branch in the three great divisions of plants respectively. We shall direct our attention more especially to that of the leaves of Dicotyledons. The fibro-vascular system of such plants in by far the majority of cases consists of an upper layer which is in connexion with the fibro-vascular system of the wood and petiole when present (*fig.* 276, *t*, *f*) ; and of a lower which is continuous with the liber (*l*). The upper layer

therefore corresponds in its structure to the wood, and the lower to the liber; hence the former is composed of spiral and pitted vessels in perennial plants, and of spiral and annular or some other vessels in herbaceous plants (*fig.* 276, *t*, *t*), and also in all cases, of wood-cells, *f*, besides the above-named vessels; while the latter consists essentially of liber-cells, *l*, *l*, and sieve-tubes. The ramifications of the fibro-vascular elements in the lamina of the leaf form the *veins* or *nerves*, and will be described presently under the head of *venation* (see page 157). The number and size of the elements of the bundle diminish however as they continue to ramify, so that the ultimate degrees of ramification commonly consist of spiral vessels alone. The two layers of the fibro-vascular system are usually readily seen in what are called *skeleton leaves*. Thus the leaves lying in a damp ditch in the winter will afford us good illustrations of these, and those which have been artificially prepared by maceration for a sufficient time in acidulated water, or in other ways.

FIG. 277.

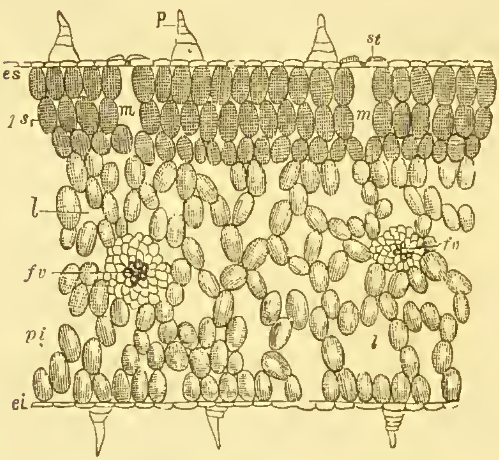


FIG. 278.

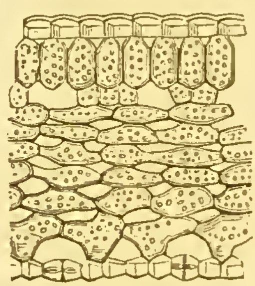


Fig. 277. Vertical section of a leaf of the Melon, highly magnified. *es.* Epidermal tissue of the upper surface furnished with hairs, *p*, and stomata, *st*. *ei.* Epidermal tissue of the lower surface, with the hairs arising from it. *ps.* Three layers of parenchymatous cells below the epidermis of the upper surface. *pi.* Parenchymatous cells below the epidermal tissue of the lower surface. *fv, fv.* Fibro-vascular tissue forming the veins. *m, m.* Cavities connected with the stomata. *l, l.* Cavities between the loose spongiform parenchyma.——*Fig.* 278. Vertical section of a leaf of the White Lily highly magnified, showing the epidermis of both the upper and lower surfaces, with the intervening parenchyma.

2. *Parenchyma or Mesophyll.*—By this we understand the parenchymatous tissue which is situated between the epidermis of the upper and lower surfaces of the lamina (*fig.* 277, *ps*, *pi*), and which surrounds the ramification of the fibro-vascular system or veins, *fv*, *fv*. The parenchymatous tissue which is

immediately beneath the epidermis of the upper surface of the leaf is sometimes specially modified, as in the leaves of the Coniferæ, where its cells become elongated and sclerenchymatous, when it constitutes a form of the *hypoderma* (see pages 48 and 143). The parenchyma varies in amount in different leaves; thus, in ordinary leaves it is moderately developed, and the leaves are then thin and flattened; while in other leaves it is formed in large quantities, when they become thick and fleshy, and are termed *succulent*. In ordinary flat leaves all the cells composing the parenchyma are commonly green from containing chlorophyll granules; but in succulent leaves the cells in the centre of the parenchyma are usually colourless.

The parenchyma also varies in the form and arrangement of its component cells in different parts of the same leaf: thus in ordinary flat leaves we find beneath the epidermis of the upper surface one (*fig.* 278), two, or three layers of closely packed oblong or somewhat elongated cells (*fig.* 277, *ps*), and forming the tissue which has been termed *palisade parenchyma*. The form and arrangement of the cells beneath the epidermis of the lower surface are commonly entirely different; thus, here the cells (*fig.* 278) are loosely connected and have numerous large spaces between them; they are also frequently very irregular in form, presenting commonly two or more projecting rays, which become united with similar projections of the cells next them, and thus leave numerous interspaces which communicate freely with each other, and form a spongiform parenchyma (*fig.* 124, *c*). These interspaces are also connected with the stomata, which, as we have already seen, are generally most abundant on the epidermis of the lower surface, and thus a free communication is kept up between the interior of the leaf and the external air, which is essential to the due performance of its functions.

Such is the general arrangement of the parenchyma in the blades of aerial leaves, but it is subject to various modifications in those of different plants. Thus in blades which have their margins turned upwards and downwards instead of their surfaces, the arrangement of the parenchyma is similar beneath the epidermis of both the surfaces; while in succulent blades the parenchyma is composed of cells which are usually larger than those in the blades of ordinary leaves, and closely compacted, or with but few interspaces. In the floating leaves of aquatic plants, again, the spongiform parenchyma is beneath the epidermis of the upper surface of the blades, and the compactly arranged cells next that of the under surface, the position of the parts being here therefore completely reversed.

2. Submersed Leaves.—The petiole when present in these leaves is solely formed of parenchymatous cells, which are, however, frequently elongated; and the blades are therefore also necessarily entirely formed of parenchyma, the so-called

veins being composed simply of more or less elongated parenchymatous cells. The blades of such leaves are generally very thin, only containing two or three layers of cells, so that all the cells are nearly in contact with the water in which they are placed. The cells are disposed very regularly and have no interspaces, but all contain chlorophyll granules. In submersed leaves, however, which are thickened, we find large cavities

FIG. 279.

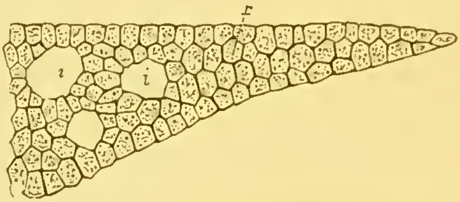


Fig. 279. Vertical section of a leaf of a *Potamogeton*, highly magnified. *i i*. Air cavities. *r*. Parenchymatous cells containing chlorophyll granules.

which are very regular in their form and arrangement (*fig.* 279, *i*, *i*); these contain air, by which the specific gravity of the leaf is diminished, and it is thus enabled to float in the water. Submersed leaves have no true epidermal layer, and no stomata, both of which would be useless from their being always exposed to similar hygrometric conditions.

3. INSERTION AND ARRANGEMENT OF LEAVES.

1. INSERTION.—The point by which a leaf is attached to the stem or branch is called its *insertion*. Leaves are inserted on various parts of the stem and branches, and receive different names accordingly. Thus the first leaves which are developed are called *cotyledons* (*fig.* 18, *c*, *c*) or *nursing leaves*. The cotyledons are usually very different in their appearance from the ordinary leaves which succeed them. The first leaves which appear after the cotyledons are termed *primordial* (*fig.* 18, *d*, *d*); these, and the cotyledons, generally perish as soon as, or shortly after, the development of the other ordinary leaves. Leaves are called *radical* when they arise at, or below, the surface of the ground, and thus apparently from the root, but really from a shortened stem, or *crown of the root* as it is commonly called. Leaves are thus situated in what are termed acaulescent plants, such as the Dandelion and Primrose. The leaves which arise from the main stem are called *cauline*; those from the branches *ramal*; and the modified leaves arising from the base of, or upon the flower-stalks, *bracts* or *hypsophyllary leaves* (*figs.* 23 and 24, *b*, *b*).

When a leaf arises from the stem by means of a petiole it is said to be *stalked* or *petiolate* (*fig.* 274, *p*); when the blade of a leaf is fixed to the petiole by a point more or less within its margins, as in the Indian Cress (*fig.* 280), and Castor-oil plant (*fig.* 332), the leaf is termed *peltate*; when the petiole is absent,

FIG. 280.

FIG. 281.

Fig. 280. Peltate leaf of the Indian Cress (*Tropæolum*).——*Fig.* 281. Amplexicaul petiole of *Angelica*.

so that the blade arises directly from the stem, it is said to be *sessile* (*fig.* 286); when a leaf is enlarged at its base and clasps the stem from which it springs, it is *amplexicaul*, *clasping*, or *em-*

FIG. 282.

FIG. 283.

FIG. 284.

FIG. 285.

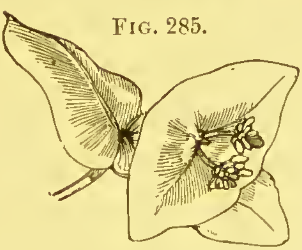


Fig. 282. Sheathing leaf of a Grass.——*Fig.* 283. Decurrent leaf of a species of Thistle.——*Fig.* 284. Perfoliate leaf of a species of Hare's-ear (*Bupleurum rotundifolium*).——*Fig.* 285. Connate leaves of a species of Honeysuckle (*Lonicera Caprifolium*).

bracing (*fig.* 281), as in Fool's Parsley; or if it forms a complete sheath around it, as in Grasses generally (*figs.* 282 and 374, *g*), it is said to be *sheathing*. When a leaf is prolonged from its base, so as to form a winged or leafy appendage, down the stem, as in

Thistles, it is *decurrent* (*fig.* 283); when the two sides of the base of a leaf project beyond the stem, and unite, as in the Hare's-ear (*fig.* 284), it is said to be *perfoliate*, because the stem then appears to pass through the blade; or when two leaves placed at the same level on opposite sides of the stem unite more or less by their bases, they are said to be *connate*, as in the Teasels and some species of Honeysuckle (*fig.* 285).

2. Arrangement of Leaves on the Stem or Phyllotaxis.—The term *phyllotaxis* is used in a general sense to indicate the various modes in which leaves are arranged on the stem or branches. The following are the more important varieties. Thus, when only one leaf arises from a node, the leaves as they succeed each other are placed alternately on different sides of the stem, and are then said to be *alternate* (*fig.* 289). When two leaves are produced at a node, they are usually situated on opposite sides of the stem, in which case

Fig. 286.

Fig. 287.

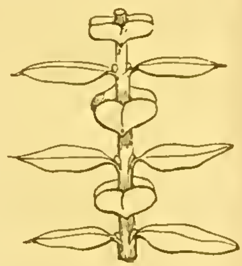


Fig. 286. Whorled leaves of a species of *Galium*.——*Fig.* 287. Decussate leaves of *Pimelea decussata*.

they are described as *opposite* (*fig.* 287); or when three or more leaves arise from the stem so as to be arranged around it at the same level in the form of a circle, they are called *verticillate* or *whorled* (*fig.* 286), and each circle is termed a *verticil* or *whorl*. When leaves are opposite, the pairs as they succeed each other usually cross at right angles, in which case they are said to *decussate* (*fig.* 287), and the arrangement is called *decussation*. When different whorls succeed each other it also frequently happens that a somewhat similar arrangement occurs; thus the leaves of one whorl correspond to the intervals of the whorl below it. There are, however, commonly great irregularities in this respect, and in some cases the number of leaves in the successive whorls vary, by which their arrangement becomes still more complicated. This is the case, for instance, in *Lysimachia vulgaris*.

Only one leaf can arise from the same point, but it sometimes happens that, by the non-development of the internodes of an axillary branch, all the leaves of that branch are brought close together, in which case they form a *tuft* or *fascicle* (*fig.* Coniferæ 288), and the leaves are then said to be *tufted* or *fascicled*. Such an arrangement is well seen in the Barberry and Larch. That fascicled leaves are thus produced is rendered evident by the fact that in the young branches of the Larch the internodes become elongated and the leaves are then separated from each other.

The laws which regulate the arrangement of leaves upon the stem have of late years been carefully investigated; and when we consider that all the organs of the plant which succeed the leaves are formed on the same plan, and follow similar laws, the determination of these laws must be considered to be a matter of much importance. It has been supposed by some that the

Fig. 288.

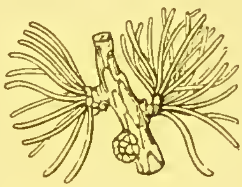


Fig. 289.

Fig. 288. Fascicled or tufted leaves of the Larch.——*Fig.* 289. A portion of a branch of the Cherry-tree with six leaves, the sixth of which is placed vertically over the first. The right-hand figure is the same branch magnified, the leaves having been removed, and numbers placed to indicate the points of their insertion.

arrangement of the leaves varies in the different classes of plants: thus, that in Dicotyledons where the cotyledons or first leaves which are developed are opposite, the regular arrangements of the leaves in such plants is to be *opposite* or *whorled* also; and that when they become alternate, this arises from the prolongation or extension of the nodes; while in Monocotyledons, on the contrary, which have normally but one cotyledon, that the regular position of the leaves is *alternate*, and that when they become opposite or whorled, this arises from the non-development or shortening of the successive internodes. The investigations, however, of Bonnet, nearly a century ago, tended to prove that all leaves and their modifications have normally a spiral arrangement on the stem; and he was led to this belief by observing that if a line be drawn from the bottom to the top of a stem or branch, so as to touch in succession the base of the different leaves upon its surface, it would describe a spiral around it. He found also, that the relation of the leaves to one another was constant, each being separated from the other by an equal distance, so that if we started with any particular leaf and waited until another leaf was reached which corresponded vertically with it, and then proceeded to the leaf beyond this, we should find that this would also correspond vertically with the one next above that which we started from, and so on, each successive leaf would be placed vertically over one of the leaves below, but that in all cases in the same plant, the number of leaves between the one started from, and that which corresponded vertically with it, would be always the same. Thus if we take a branch of the Apple or Cherry-tree (*fig.* 289), and commence with any particular leaf which we will mark 1, and then proceed upwards, connecting in our course the base of each succeeding leaf by a line or piece of string, we shall find that we shall pass the leaves marked 2, 3, 4, and 5, but that when we reach the one marked 6, that this will correspond vertically with the 1st; and then proceeding further, that the 7th will be directly over the 2nd, the 8th over the 3rd, the 9th over the 4th, the 10th over the 5th, and the 11th over the 6th and 1st; so that in all cases when the sixth leaf is reached, including the one started from, a straight line might be drawn from below upwards to it, and that consequently there were five leaves thus necessary to complete the arrangement. Bonnet also discovered other more complicated arrangements in which more leaves were necessary for the purpose. His ideas were little attended to at the time; but of late years by the researches of Schimper, Braun, Bravais, and others, his views have been confirmed and considerably extended, and it has been shown that the spiral arrangement is not only universal, but that the laws which regulate it may be reduced to mathematical precision, the formulæ representing the relative position of leaves in different plants varying, although always constant for the same species. The examination of these laws further than to show that the regular arrangement of leaves and their modifications is in the form of a spiral around the stem, having at present no very practical bearing in Botany, however interesting they may be in a mathematical point of view, would be out of place here; we shall confine ourselves to the general discussion of the subject, and as alternate leaves are those which will enable us to do so with most facility, we shall allude to them first.

1. *Alternate Leaves.*—If we refer again to the arrangement of the leaves in the Cherry or Apple, we shall find that before we arrive at the sixth leaf (*fig.* 289), which is over the first, the string or line used to connect the base of the leaves will have passed twice round the circumference of the branch. The point where a leaf is thus found, which is placed in a straight line, or perpendicularly over the first, shows the completion of a *series*

or *cycle*, and thus in the Cherry and Apple the cycle consists of five leaves. As the five leaves are equidistant from each other, and as the line which connects them passes twice round the stem, the distance of one leaf from the other will be $\frac{2}{5}$ of its circumference. The fraction $\frac{2}{5}$, therefore, is the *angular divergence*, or size of the arc interposed between the insertion of two successive leaves, or their distance from each other expressed in parts of the circumference of the circle, that is $\frac{2}{5}$ of $360° = 144°$; the numerator indicates the number of turns made in completing the cycle, and the denominator the number of leaves contained in it. The successive leaves as they are produced on the stem, as we have seen, are also arranged in similar cycles. This arrange-

FIG. 290.

FIG. 291.

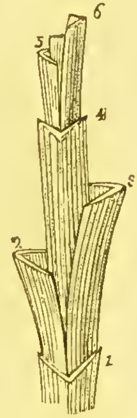


Fig. 290. Portion of a branch of the Lime-tree, with four leaves arranged in a distichous or two-ranked manner.——*Fig.* 291. Portion of a branch with the base of the leaves of a species of *Carex*, showing the tristichous or three-ranked arrangement. The numbers indicate the successive bases of the leaves.

ment in cycles of five is by far the most common in Dicotyledons. It is termed the *quincuncial*, *pentastichous*, or *five-ranked arrangement*.

A second variety of arrangement in alternate leaves is that which is called *distichous* or *two-ranked*. Here the second leaf is above and directly opposite to the first (*fig.* 290), and the third being in like manner opposite to the second, it is placed vertically over the first, and thus completes the cycle, which here consists of but two leaves; the fourth leaf again is over the second, and the fifth over the third and first, thus completing a second cycle; and so on with the successive leaves. Here one turn completes the spiral, so that the angular divergence is $\frac{1}{2}$ the circumference of a circle, or $\frac{1}{2}$ of $360° = 180°$. This arrangement is the normal one in all Grasses, and many other Monocotyledons; and the Lime-tree (*fig.* 290), and other Dicotyledons, exhibit a similar arrangement.

A third variety of arrangement in alternate leaves is the *tristichous* or *three-ranked* (*fig.* 291). Thus, if we start with any leaf, and mark it No. 1, and then pass to 2, 3, and 4, we shall find that we shall make one turn round the stem, and that the fourth leaf is vertically over the first, and thus completes a cycle composed of three leaves. In like manner, the fifth leaf will be over the second, the sixth over the third, and the seventh over the fourth and first, thus completing a second cycle ; and so on with the succeeding leaves. Here the angular divergence is $\frac{1}{3}$, or one turn and three leaves, that is, $\frac{1}{3}$ of $360° = 120°$. This arrangement is by far the more common one among Monocotyledons, and may be considered as the most characteristic of that class of plants, just as the pentastichous arrangement is of Dicotyledons.

FIG. 292.

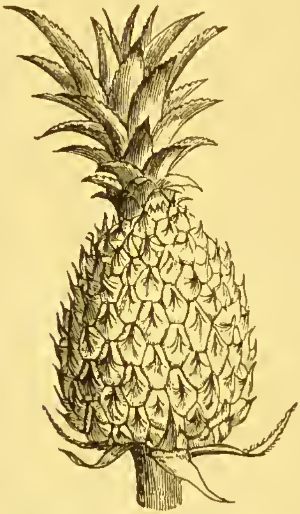


FIG. 293.

Fig. 292. Pineapple fruit (*Sorosis*), surmounted by a crown of empty bracts. *Fig.* 293. Cone or fruit of the Scotch Fir.

A fourth variety of Phyllotaxis in alternate leaves is the *octastichous* or *eight-ranked*. Examples of this variety occur in the Holly and Aconite. In this the ninth leaf is over the first, the tenth over the second, the eleventh over the third, and so on ; thus taking eight leaves to complete the cycle : and, as the spiral line here makes three turns round the stem, the angular divergence will be $\frac{3}{8}$ of the circumference, that is, $\frac{3}{8}$ of $360° = 135°$.

The above are the more common varieties of Phyllotaxis ; but a number of others also frequently occur, as $\frac{5}{13}$, $\frac{8}{21}$, $\frac{13}{34}$, $\frac{21}{55}$, &c. Other varieties met with are $\frac{1}{4}$, $\frac{1}{5}$, $\frac{2}{9}$, $\frac{3}{14}$, $\frac{5}{23}$, $\frac{8}{37}$, &c. ; also $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{5}$, $\frac{5}{8}$, $\frac{8}{13}$, $\frac{13}{21}$, &c. ; as also others of a rarer occurrence.

These become more complicated as the number of leaves, &c., in the spire is increased; but in those cases where the leaves, &c., are so numerous as to be close to each other, as in the Screw-pine, the Pineapple (*fig.* 292), and in the fruit of Coniferous plants (*fig.* 293), the spiral arrangement is at once evident.

By placing the fractions representing the angular divergence in the different varieties of Phyllotaxis side by side in a line, thus:—$\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, $\frac{8}{21}$, $\frac{13}{34}$, $\frac{21}{55}$, &c.; $\frac{1}{4}$, $\frac{1}{5}$, $\frac{2}{9}$, $\frac{3}{14}$, $\frac{5}{23}$, $\frac{8}{37}$, &c., we see at once that a certain relation exists between them; for the numerator of each fraction is composed of the sum of the numerators, and the denominator of the sum of the denominators of the two preceding fractions; also in the first series, that the numerator of each fraction is the denominator of the next but one preceding. By applying this simple law therefore we may continue the series of fractions representing the angular divergence, &c., thus: $\frac{34}{89}$, $\frac{55}{144}$, $\frac{89}{233}$, &c. It should be mentioned with respect to the laws of Phyllotaxy, that they are frequently interfered with by accidental causes which produce corresponding interruptions of growth, so that it is then difficult, or altogether impossible, to discover the regular condition.

All the above varieties of Phyllotaxis in which the angular divergence is such that by it we may divide the circumference into an exact number of equal parts, so that the leaves completing the cycles must be necessarily directly over those commencing them, are called *rectiserial*; while those in which the divergence is such that the circumference cannot be divided by it into an exact number of equal parts, and thus no leaf can be placed precisely in a straight line over any preceding leaf, but disposed in an infinite curve, are termed *curviserial.* The first forms of arrangement are looked upon as the normal ones; the latter will show the impossibility of bringing organic forms and arrangements, in all cases, under exact mathematical laws.

We have thus endeavoured to show that when leaves are alternate, the successive leaves form a spiral round the axis. The spire may either turn from right to left, or from left to right. In the majority of cases, the direction in both the stem and branches is the same, and it is then said to be *homodromous*; but instances also occasionally occur in which the direction is different, when it is called *heterodromous.*

2. *Opposite and Whorled Leaves.*—We have already observed with regard to these modifications of arrangement, that the successive pairs, or whorls, of leaves, as they succeed each other (page 148), are not commonly inserted immediately over the preceding, but that the second pair (*fig.* 287), or whorl, is placed over the intervals of the first, the third over those of the second, and so on. Here, therefore, the third pair of leaves will be directly over the first, the fourth over the second, the fifth over

the third, and so on. This arrangement occurs in plants of the Labiate and Olive orders, and is called decussation, as previously noticed. In some cases the succeeding pairs, or whorls, are not thus placed directly over the intervals of those below, but a little on one side, so that we shall have to pass to some higher pair or whorl than the third, before we arrive at one which is placed directly over the first. Such arrangements, therefore, clearly show that the successive pairs and whorls of leaves are arranged in a spiral manner with regard to each other. Opposite leaves may be thus looked upon as produced by two spirals proceeding up the stem simultaneously in two opposite directions; and the whorl as formed of as many spirals as there are component leaves.

3. *Phyllotaxis in different Natural Orders, &c.*—The alternation or opposition of leaves is generally constant in the same species, and even in some cases throughout entire natural orders. Thus, the Borage order (*Boraginaceæ*) have alternate leaves; the Pink order (*Caryophyllaceæ*), opposite; the Labiate order (*Labiatæ*), opposite and decussate; the Leguminous order (*Leguminosæ*), alternate; the Rose order (*Rosaceæ*), alternate, &c. While the opposition or alternation of leaves may be thus shown to be constant throughout entire natural orders, yet the change from one arrangement to another may be sometimes seen upon the same stem, as in the common Myrtle and Snapdragon. Other opposite-leaved plants also often exhibit an alternate arrangement at the extremities of their young branches when these grow very rapidly. In other cases alternate leaves may become opposite, or whorled, by the non-development of the successive internodes by interruptions of growth; or, if the whole of the internodes of a branch become non-developed, the leaves become tufted or fascicled (*fig.* 288), as already noticed. Generally, however, the relative position of leaves is so constant in the same species that it forms one of its characteristic distinctions.

The arrangement of leaves probably influences, in some degree at least, the form of the stem and branches. Thus, a certain amount of alternation commonly leads to a rounded form of stem or branch; an opposite or whorled arrangement, to an angular stem or branch: for instance, the Labiate order of plants, in which the leaves are opposite and decussate, have commonly square stems and branches; in the *Nerium Oleander*, where the leaves on the young branches are placed in whorls of three, the stem has three angles; and in the species of *Galium* and *Rubia*, which have whorled leaves, the stems and branches are always angular. M. Cagnat and others have also endeavoured to show that the arrangement of the leaves has a direct influence upon the forms of the wood, bark, and pith; either upon one of these parts only, or sometimes upon them all; but, although some curious relations have been found to exist between the arrangement of the leaves and the form of certain parts of the stem, yet it is not possible at present to deduce any general laws regulating the relations between them.

3. Arrangement of the Leaves in the Bud, or Vernation.—Having now described the general arrangement of leaves when in a fully formed and expanded state upon the stem or branch, we have in the next place to allude to the different modes in which they are disposed while in a rudimentary and unexpanded condition in the bud. To these modifications the general name of *Vernation* (the spring state), or *Præfoliation* has been applied. Under this head we include :—1st, The modes in which each of the leaves considered independently of the others is disposed ; and, 2nd, The relation of the several leaves of the same bud taken as a whole to one another. In the *first place* we shall consider the modes in which each of the leaves considered separately is disposed. We arrange these again in two divi-

Fig 294.

Fig. 295.

Fig. 296.

Fig. 297.

Fig. 298.

Fig. 299.

Fig. 300.

Fig. 294. Vertical section of a reclinate leaf.——*Fig.* 295. Transverse section of a conduplicate leaf.——*Fig.* 296. Transverse section of a plaited or plicate leaf.——*Fig.* 297. Vertical section of a circinate leaf.——*Fig.* 298. Transverse section of a convolute leaf.——*Fig.* 299. Transverse section of a revolute leaf.——*Fig.* 300. Transverse section of an involute leaf.

sions :—1st, Those in which the leaf is simply *bent* or *folded* ; and 2nd, Those where it is *rolled*. Of the first modification we have three varieties :—Thus, 1st, the upper half of the leaf may be bent upon the lower, so that the apex approaches the base (*fig.* 294), as in the Tulip-tree, it is then said to be *reclinate* or *inflexed* ; 2nd, the right half may be folded upon the left, the ends and midrib or axis of the leaf remaining immovable (*fig.* 295), as in the Oak and Magnolia, when it is called *conduplicate* ; or, 3rd, each leaf may be folded up a number of times like a fan (*fig.* 296), as in the Sycamore, Currant, and Vine, when it is *plaited* or *plicate*. Of the second modification we have four varieties :—1st, the apex may be rolled up on the axis of the leaf towards the base, like a crosier (*fig.* 297), as in the Sundew and Ferns, when it is *circinate* ; 2nd, the whole leaf may be rolled up from one margin into a single coil, with the other margin exterior (*fig.* 298), as in the Apricot and Banana, in which case it is *convolute*; 3rd, the two margins of the leaf may both be rolled inwards on the upper surface of the leaf, towards the midrib, which remains immovable (*fig.* 300), as in the Violet and Water-lily, when it is *involute*; or, 4th, the two margins may be rolled outwards or towards the midrib on the lower surface of the leaf (*fig.* 299), as in the Dock and Azalea, in which case it is *revolute.*

We pass now to consider, *secondly*, the relation of the several leaves of the same bud taken as a whole to one another. Of this we have several varieties which may also be treated of in two divisions :—1st, those in which the component leaves are *flat* or *slightly convex*; and 2nd, where they are *bent* or *rolled.* Of the first division we shall describe three varieties :—1st, that

Fig. 301.

Fig. 302.

Fig. 303.

Fig. 304.

Fig. 305.

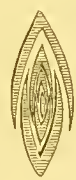


Fig. 306.

Fig. 307.

Fig. 301. Transverse section of a bud to show the leaves arranged in a valvate manner.——*Fig.* 302. Transverse section of a bud to show imbricate vernation.——*Fig.* 303. Transverse section of a bud to show twisted or spiral vernation.——*Fig.* 304. Transverse section of a bud to show induplicate vernation.——*Fig.* 305. Transverse section of a bud showing equitant vernation.——*Fig.* 306 Transverse section of a bud showing obvolute vernation.——*Fig.* 307. Transverse section of a bud showing supervolute vernation.

in which the leaves are placed nearly in a circle or at the same level, and in contact by their margins only, without overlapping each other (*fig.* 301), when they are *valvate*; 2nd, that in which the leaves are placed at different levels, and the outer successively overlap the inner to a greater or less extent by their margins (*fig.* 302), as in the Lilac, and in the outer scales of the Sycamore, when they are said to be *imbricate*; and 3rd, if when leaves are placed as in imbricate vernation, the margin of one leaf overlaps that of another, while it, in its turn, is overlapped by a third (*fig.* 303), the vernation is *twisted* or *spiral.* Of the second division, viz. where the component leaves of the bud are *bent* or *rolled*, we shall describe four varieties :—1st, when involute leaves are applied together in a circle without overlapping (*fig.* 304), they are said to be *induplicate* ; 2nd, if the leaves are conduplicate, and the outer successively embrace and sit astride of those next within them as if on a saddle (*fig.* 305), as in the Privet, and the leaves of the Iris at their base, they are *equitant* ; 3rd, if the half of one conduplicate leaf receives in its fold the half of another folded in the same manner (*fig.* 306), as in the Sage, the vernation is *half-equitant* or *obvolute* ; and 4th, when a convolute leaf encloses another which is rolled up in a like manner (*fig.* 307), as in the Apricot, the vernation is *supervolute.*

The terms thus used in describing the different kinds of vernation are also applied in like manner to the component parts of the flower-bud, that is, so far as the floral envelopes are concerned, under the collective name of *æstivation* or *præfloration.* We shall have therefore to refer to some of them again, together with others, not found in the leaf-bud, when speaking of the flower-bud.

4. LAMINA OR BLADE.

We have already seen that the leaf (*figs.* 273 and 274) in its most highly developed state consists of three parts ; namely, of a *lamina* or *blade*, a *petiole* or *stalk*, and of a *stipular* portion. We have now to describe each of these portions in detail, commencing with the *lamina* or *blade.*

VENATION OR NERVATION.—The term *venation* is applied generally to indicate the various modes in which the veins are distributed throughout the lamina. These veins have also been called *nerves*, and their distribution *nervation* ; but the latter terms, by indicating an analogy which does not exist between them and the nerves of animals, are better avoided ; hence we shall in future always use the terms *veins* and *venation.*

In some plants, as Mosses, and those living under water, &c., the leaves have no fibro-vascular skeleton, and consequently no true veins, and are hence said to be *veinless* ; while in succulent plants the veins are hidden more or less from view, in consequence of the great development of parenchyma, in which case the leaves are termed *hidden-veined.*

In those leaves where the veins are well marked, they are subject to various modifications of arrangement, the more important of which need only be mentioned here. Thus, when there is but one large central vein, proceeding from the base to the apex of the lamina, and from which all the other veins proceed, such a vein is called the *midrib* or *costa* (*fig.* 308) ; or when there are three or more large veins, which thus proceed from the base to the apex (*fig.* 309), or to the margins (*fig.* 310), of the lamina, the separate veins are then termed *ribs.* The divisions or primary branches of the midrib, or of the separate ribs, are commonly called *veins*; and their smaller ramifications *veinlets*.

There are two marked modifications of venation. In the

Fig. 308.

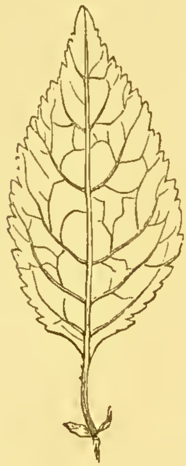


Fig. 310.

Fig. 309.

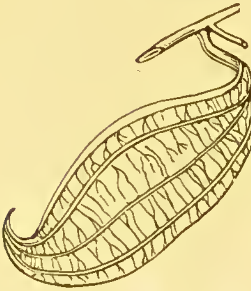


Fig. 311.

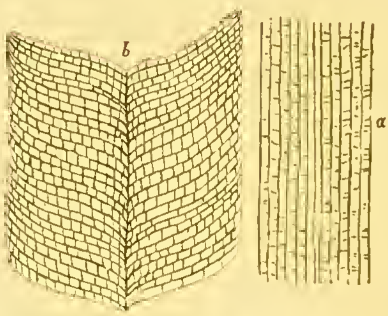


Fig. 308. Leaf of the Cherry with lamina, petiole, and stipules. The lamina has serrate margins, and a large central vein or midrib is seen to proceed from the petiole to the apex of the leaf, and to give off from its sides the other veins (*pinnately-veined*).——*Fig.* 309. Ribbed leaf of Cinnamon with entire margins.——*Fig.* 310. Leaf of the Melon with dentate margins. The venation is said to be radiated or palmately-veined.——*Fig.* 311. *a.* Parallel venation of a grass; this variety of venation is commonly called straight-veined. *b.* A variety of parallel venation sometimes termed curve-veined, as seen in the Banana.

first modification the fibro-vascular tissue as it enters the lamina is either continued as the midrib (*fig.* 308), or it divides into two or more ribs (*figs.* 309 and 310); and from this midrib or ribs other veins are given off; and from them, in like manner, smaller ramifications or veinlets arise, which unite with one another so as to form a kind of network. Or, in the *second modification*, the fibro-vascular tissue is either continued as a midrib from the base to the apex of the lamina, giving off from its sides other veins, which run parallel to the margins, and which are simply connected by unbranched veinlets (*figs.* 311, *b*, and 318); or it divides at once into several veins or ribs, which proceed from the base to the apex (*fig.* 316), or margins (*fig.* 317) of the blade, more or less parallel to one another, and are in like manner connected only by simple parallel unbranched veinlets (*fig.* 311, *a*). The leaves which exhibit the first modification of venation are called *reticulated* or *netted-veined* leaves, and occur universally in Dicotyledons; and those which present the second modification are termed *parallel-veined* leaves, and are characteristic with some few exceptions of Monocotyledons.

These two modifications are also subject to certain variations, some of which must now be noticed.

1. *Varieties of Reticulated or Netted Venation.*

There are two principal varieties of this kind of venation, namely, the *feather-veined* or *pinnately-veined*, and the *radiated* or *palmately-veined*.

FIG. 312.

FIG. 313.

FIG. 314.

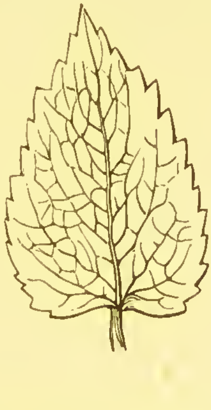


FIG. 315.

Fig. 312. Feather-veined leaf of the Spanish Chestnut.——*Fig.* 313. Feather-veined leaf of the Oak. Its lobes are arranged in a pinnatifid manner.——*Fig.* 314. Leaf of the Dead-nettle. The venation is the true netted, and its margins are serrate.——*Fig.* 315. *a*. Linear leaf. *b*. Triple-ribbed leaf of the common Sunflower.

A. *Feather-veined or Pinnately-veined.*—In this variety the midrib either gives off lateral veins which proceed at once to the margins (*figs.* 312 and 313), and are connected by numerous branching veinlets, as in the leaves of the Beech, Spanish Chestnut, Holly, Oak ; or the midrib gives off branches from its sides, which proceed at first towards the margins, and then curve towards the apex, terminating finally within the margins, with which they are connected by small veins, as in the Dead-nettle (*fig.* 314), and Lilac. The latter modification of arrangement is sometimes termed *true netted venation.*

B. *Radiated or Palmately-veined.*—This name is applied to a leaf which possesses two or more ribs that arise from at or near the base of the lamina, and diverge from one another towards its margins, and are connected by branching veins, as in the Melon (*fig.* 310) and Castor-oil plant (*fig.* 332). The *ribbed venation*, as seen in the Cinnamon (*fig.* 309), is but a modification of this variety, in which the ribs, instead of diverging from one another, run in a curved manner from at or near the base of the blade to the apex, towards which they converge, such ribs being connected together by branching veins. If a ribbed leaf has three ribs proceeding from the base, it is said to be *three-ribbed* or *tricostate* ; if five, *five-ribbed* or *quinquecostate* ; if more than five, *many-ribbed* or *multicostate.* If the midrib of such a leaf gives off on each side, a little above its base, another rib, it is said to be *triple-ribbed* or *triplicostate*, as in the common Sunflower (*fig.* 315, *b*) ; or if two such ribs arise on each side of the midrib, it is termed *quintuple-ribbed* or *quintuplicostate.* These ribbed leaves have frequently a great resemblance to parallel-veined leaves, from which, however, they may be at once distinguished by their ribs being connected by branching veins.

2. *Varieties of Parallel Venation.*

The term parallel-veined is not strictly applicable in all cases, for it frequently happens that the veins are radiated ; but from the difficulty of finding a name which will comprise all the modifications to which such leaves are liable, it must be understood that we apply the term parallel-veined to all leaves in which the main veins of the lamina are more or less parallel and only connected by unbranched parallel veinlets.

There are certain characteristic variations of parallel venation. Thus, the main veins may either proceed in a somewhat parallel direction from the base to the apex of the lamina, to which point they converge more or less (*fig.* 316), as in the ordinary ribbed variety of reticulated leaves already noticed, and are connected by simple unbranched transverse veinlets ; or they diverge from one another towards the circumference of the blade (*fig.* 317), as in the radiated-veined variety of reticulated leaves, and are likewise united by cross-veinlets. The leaves of Grasses, Lilies, and the common Flag, may be taken as examples of the first variety; and those of many Palms (*fig.* 317) of the second.

Or, the leaves may have a prominent midrib, as in the feather-veined variety of reticulated venation, giving off from its sides along its whole length other veins, which proceed parallel to each other in a straight or curved direction towards, and lose themselves in, the margins (*figs.* 318 and 311, *b*); and are connected, as in the last variety, by unbranched veinlets.

FIG. 317.

FIG. 318.

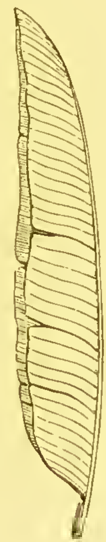


FIG. 316.

FIG. 319.

Fig. 316. Leaf showing the variety of parallel venation usually called straight-veined; the margins are entire.——*Fig.* 317. Straight-veined variety of parallel venation, as seen in the leaf of the Fan Palm (*Chamærops*).——*Fig.* 318. Curve-veined variety of parallel venation, as seen in the Banana.——*Fig.* 319. Forked venation of a Fern leaf (*frond*); the margins are crenate.

The Banana, the Plantain, and allied plants, furnish us with examples of this variety. This latter variety is sometimes distinguished as the *curve-veined*, the former being commonly known as the *straight-veined* or *parallel-veined*.

Venation of the Leaves of Cormophytes.—Besides the above varieties of reticulated and parallel venation as found in Dicotyledons and Monocotyledons, the leaves (*fronds*) of Ferns, and those of other Cormophytes which have veins, present us with a third variety; thus, in these the primary venation may be feather-veined or radiated-veined, but the whole of their principal veins either divide afterwards in a forked manner (*fig.* 319), or their terminal ramifications are thus divided. Such a variety of venation has therefore been called *Furcate* or *forked.*

The leaves of these three great divisions of plants present us, therefore, with three different varieties of venation : thus, those of Dicotyledons are *reticulated* ; those of Monocotyledons *parallel* ; and those of Cormophytes *forked.* But the venation of Cormophytes is not so generally characteristic as that of Dicotyledons and Monocotyledons.

COMPOSITION.—Leaves are divided into *simple* and *compound.* Thus a leaf is called *simple* if it has only one blade (*figs.* 308 and 309), however much this may be divided, so that the divisions do not extend to the midrib (*fig.* 325), or petiole (*figs.* 331 and 332) ; or in some cases the divisions may even extend to the midrib, or petiole, but the leaf is still called simple when the parts into which the lamina is divided are attached by a broad base, as in *fig.* 326. (See Incision, page 165.) A leaf is termed *compound,* when the petiole divides so as to separate the blade into two or more portions, each of which bears the same relation to the petiole as the petiole itself does to the stem or branch from whence it arises (*fig.* 275). The separated portions of a compound leaf are then called *leaflets* or *folioles* ; and these may be either sessile (*figs.* 364–366), or have stalks (*fig.* 378), each of which is then termed a *petiolule*, *stalklet*, or *partial petiole*, and the main axis which supports them, the *rachis* or *common petiole.*

FIG. 320.

Fig. 320. Leaf of Orange (*Citrus Aurantium*). *p.* Winged petiole articulated to the lamina, *l.*

The leaflets of a compound leaf may be generally at once distinguished from the separate leaves of a branch, from the fact of their being all situated in the same plane ; there are, however, to this character many exceptions. Another mode of distinguishing a simple from a compound leaf arises from the fact that a simple leaf has never more than one articulation, which is placed at the point where it joins the stem ; but a compound leaf frequently presents two or more articulations : thus, besides the common articulation to the stem, each of the separate leaflets may be also articulated to the common petiole. (See also page 180.) This character frequently forms a good mark of distinction between simple and compound leaves, for although it is quite true that many compound leaves only present one articulation, and can then only be distinguished from those simple leaves which are divided to their midribs or petioles by the greater breadth of attachment of the divisions in the latter instances ; yet, if such leaflets are articulated to the common petiole, their compound nature is
articulated

at once evident. The presence of more than one articulation is, therefore, positive proof as to the compound nature of a leaf, but the absence of such articulation does not necessarily prove it to be simple, as is sometimes stated. We thus look upon the leaf of the common Orange, which consists of only a single blade (*fig.* 320, *l*), as compound, because its petiole, *p*, is not only articulated to the stem, but the blade is also articulated to the petiole. There are, however, numerous instances of leaves in a transitional state between simple and compound, so that it is impossible in all cases to draw a distinct line of demarcation between them. We shall now treat in detail of simple and compound leaves.

1. Simple Leaves.—The modifications which simple leaves present as regards their margins, figure or shape, form, and other variations of their blades, are extremely numerous; hence we require a corresponding number of terms to define them. These terms are also applied in a similar sense to describe like modifications of the other compound organs of the plant which possess a definite figure and form, as the parts of the calyx, corolla, &c.; and also to those of the stipules, and the leaflets of a compound leaf. It is absolutely necessary therefore that the student should become thoroughly acquainted at once with the more important modifications to which the blades of leaves are subject. It was thought by De Candolle that the figure of the lamina depended upon the distribution and length of the veins, and the extent of parenchyma which is developed between them; the general outline or figure being determined by the former, and the condition of the margins by the latter. But although these views have been proved to be incorrect in a scientific point of view, still, if this be borne in mind, it is convenient, to say the least, to study the almost infinite modifications of the lamina of leaves with reference to his views, as it is always found that there is a mutual adaptation between the venation of the leaf and its general outline. We shall therefore describe the various modifications of the lamina to some extent after this manner, and in doing so we shall divide our subject into five heads as follows:—1. *Margins*; 2. *Incision*; 3. *Apex*; 4. *General Outline*; 5. *Form*.

1. *Margins.*—We have already stated that the condition of the margins is dependent upon the extent to which the parenchyma is developed between the veins of the lamina. Thus, if the parenchyma completely fills up the interstices between the veins, so that the margins are perfectly even, or free from every kind of irregularity, the leaf is *entire* (*figs.* 316 and 320), as in those of the Orchis order. But when the parenchyma does not reach the margins, but terminates at a short distance within them, so that the margins are uneven, we have several modifications, which are distinguished by characteristic terms. Thus, if the margins present sharp indentations like the teeth of a saw, and

all point to the apex, the leaf is *serrate* (*figs.* 314 and 348), as in the common Dead-nettle; or, if similar teeth point towards the base, the leaf is described as *retroserrate*; if these teeth are themselves serrate, it is *biserrate* (*figs.* 321, *b*, and 337), as in the Elm, and Nettle-leaved Bell-flower; or when the margins are minutely serrate they are termed *serrulate*, as in *Barosma serratifolia.* When the teeth are sharp, but do not point in any particular direction, and are separated by concavities, the leaf is *dentate* or *toothed* (*figs.* 310 and 343), as in the Melon, and the lower leaves of the Corn Bluebottle; or when the teeth are themselves divided in a similar manner, it is *duplicato-dentate* (*fig.* 321, *c*). When the teeth are rounded (*figs.* 319 and 349) the leaf is *crenate*, as in the Horseradish, and Ground Ivy; or if these teeth are themselves crenate it is *bicrenate* (*fig.* 321, *a*); or when the leaf is minutely crenate it is said to be *crenulated.* When the margins present alternately deep concavities and convexities it is *sinuated*, as in some Oaks (*fig.* 322). This kind of leaf is sometimes placed under the head of Incision; it may be regarded as an intermediate condition between a toothed leaf and one that is pinnatifid (*fig.* 313). When the margins are slightly sinuous or wavy, as in the Holly (*fig.* 323), they are said to be *wavy* or *undulated*; or when the margins are very irregular, being twisted and curled, as in the Garden Endive, Curled

FIG. 321.

a *b* *c*

Fig. 321. Diagram of the margins of leaves. *a.* Bicrenate. *b.* Biserrate. *c.* Duplicato-dentate.

FIG. 322.

FIG. 323.

Fig. 322. Sinuated leaf of the Oak.——*Fig.* 323. Spiny leaf of the Holly (*Ilex Aquifolium*), with wavy margins.

Dock, and Curled Mint, they are called *crisped* or *curled* (*fig.* 324).

2. *Incision.*—This term is employed when the margins of the blades are more deeply divided than in the above instances, so that the parenchyma only extends about midway or a less distance between them and the midrib, or petiole. The divisions are then commonly called *lobes*. It is usual, however, to give different names to these lobes, according to the depth of the incisions by which they are produced ; thus, if they reach to about midway between the margins and midrib (*fig.* 313), or petiole (*fig.* 331), they are properly called *lobes*, and the inter-

FIG. 324.

FIG. 325.

FIG. 326.

Fig. 324. Crisped or curled leaf of a species of Mallow (*Malva*).——*Fig.* 325. Pinnatipartite leaf of a species of Valerian (*Valeriana dioica*).——*Fig.* 326. Pinnatisected leaf of a species of Poppy (*Papaver Argemone*).

vals between them *fissures*, or in composition the term *-fid* is used, and the leaf is also said to be *-cleft* : if nearly to the base, or midrib (*fig.* 325), they are termed *partitions*, and the leaf is *-partite* ; if quite down to the base, or midrib, they are called *segments* (*fig.* 326), and the leaf is *dissected*, or in composition *-sected*. The segments of the latter differ from the leaflets of compound leaves, as already noticed (see page 162), in not being articulated ; and also in being united to the midrib, or petiole, by a broad base.

In describing the above incised leaves we say that they are *bifid* or *two-cleft*, *trifid* or *three-cleft*, *quinquefid* or *five-cleft*, *septemfid* or *seven-cleft*, and *multifid* or *many-cleft*, according to the number of their fissures ; or *two-lobed*, *three-lobed*, *four-lobed*, &c., from the number of their lobes. Or, a leaf is also said to be *tripartite* or *trisected*, &c., in the same manner, according to the number of partitions, or segments. The above terms are more especially used with palmately-veined simple leaves.

The divisions of the lamina are, however, always arranged in the direction of the principal veins. Thus, those of feather-veined or pinnately-veined leaves are directed towards the midrib (*figs.* 313, 325, and 326); while those of palmately or radiated-veined leaves are directed towards the base of the lamina (*figs.* 331 and 332). Hence, instead of using terms indicating the number of lobes, partitions, and segments of the lamina, others are generally employed that define the leaf more

Fig. 327.

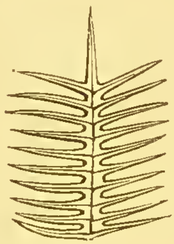


Fig. 328.

Fig 329.

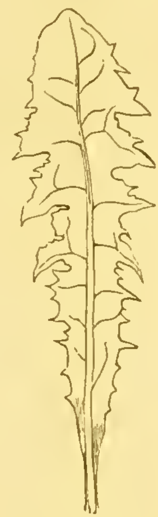


Fig. 330.

Fig. 327. Pectinate or comb-shaped leaf.——*Fig.* 328. Lyrate leaf of the common Turnip (*Brassica Rapa*).——*Fig.* 329. Runcinate leaf of the Dandelion (*Taraxacum officinale*). —— *Fig.* 330. Fiddle-shaped leaf of *Rumex pulcher*.

accurately, which are derived from the mode of venation combined with that of incision. Thus, if the lamina is feather-veined, and the divisions consequently arranged in that manner, the leaf is said to be *pinnatifid* (*fig.* 313), as in the common Oak; or *pinnatipartite* (*fig.* 325), as in *Valeriana dioica*; or *pinnatisected* (*fig.* 326), as in *Papaver Argemone*, according to their depth, as already described. If the divisions are themselves incised in a similar manner to the original divisions of the lamina itself, the leaf is said to be *bipinnatifid*, *bipinnatipartite*, or *bipinnatisected*. Or, if the sub-divisions of these are again divided in a similar manner, *tripinnatifid*, *tripinnatipartite*, or *tripinnatisected*. Or, if the lamina is still further divided, the leaf is said to be *decomposed* or *laciniated*.

Certain modifications of these varieties have also received special names; thus, when a pinnately-veined leaf is deeply divided, and the divisions are very close and narrow like the teeth of a comb (*fig.* 327), it is said to be *pectinate*, as in the Water Milfoil; when the terminal lobe of a pinnately-veined leaf is large and rounded, and the lateral lobes which are also more or less rounded become gradually smaller towards the base, it is *lyrate* or *lyre-shaped*, as in the common Turnip (*fig.* 328); when the terminal lobe is triangular, and the other lobes which are also more or less of the same shape have their points directed downwards towards the base of the lamina, as in the

FIG. 331.

FIG. 332.

Fig. 331. Palmate leaf of a species of Passion-flower (*Passiflora*).
Fig. 332. Palmatifid leaf of the Castor-oil Plant (*Ricinus communis*).

Dandelion (*fig.* 329), the leaf is said to be *runcinate*; or when a lyrate leaf has but one deep recess on each side, so that it resembles a violin in shape, it is termed *panduriform* or *fiddle-shaped*, as in the Fiddle Dock (*fig.* 330).

The above terms are those which are employed to define incised feather-veined leaves; but when the blades are palmately-veined and incised, other terms are used according to the degree of division. In describing such leaves, the terms *bifid*, *trifid*, *quinquefid*, &c., *bipartite*, *tripartite*, &c., *bisected*, *trisected*, &c., are employed according to the number of their lobes, partitions, or segments, as already noticed; or the terms *palmatifid*, *palmatipartite*, *palmatisected*, derived from the direction of the veins, combined with that of incision, are used. Special names are also applied to certain modifications of these palmately-veined leaves as with those which are pinnately-veined. Thus, when the blade of such a leaf has five spreading lobes united at their base by a more or less broad expansion of parenchyma, so that the whole has a resemblance to the palm of the hand with spreading fingers, the leaf is termed *palmate*, as in some species of Passion-flower (*fig.* 331); or when there are more than five lobes, the leaf is described as *palmatifid* or *palmately-cleft*, as in the Castor-oil Plant (*fig.* 332). Some writers, however, use

FIG. 333.

Fig. 333. Dissected leaf of the Water Crowfoot (*Ranunculus aquatilis*).

the terms palmate and palmatifid indifferently to describe either of the above modifications of incised leaves, but the sense in which they are defined above is more precise, and should alone be used. When the lobes are less spreading, narrower, and somewhat deeper than in a true palmate leaf, the leaf is *digitate*; or when there are more than five lobes of a similar character, as in the Bitter Cassava, it is sometimes termed *digitipartite*, or even *digitate* (though improperly so), by some authors. When the lamina is divided nearly to its base into numerous narrow thread-like divisions, as in the submersed leaves of the Water Crowfoot (*fig.* 333), the leaf is said to be *dissected*. When the lateral lobes, partitions, or segments, of what would be otherwise a palmate leaf are themselves divided into two or more divisions (*fig.* 334), as in the Stinking Hellebore and *Sauromatum guttatum*, so that the whole bears some resemblance to a bird's foot, the leaf is termed *pedatifid*, *pedatipartite*, or *pedatisected*, according to the depth of the divisions. The term *pedate* is by some botanists applied generally to these modifications of the palmate leaf, but

FIG. 334.

Fig. 334. Pedatipartite leaf.

such a term ought properly to be reserved for a compound leaf when the leaflets are arranged in a pedate manner (page 178).

Besides the above modifications of palmately-veined leaves, other variations also occur, in consequence of the lobes, partitions, or segments of the lamina becoming themselves divided, either in a pinnately-veined or palmately-veined manner, and terms are used accordingly, the application of which will be at once evident from what has been already stated.

3. *Apex.*—This varies much in the blades of different leaves. Thus the apex is *obtuse* or *blunt*, when it is rounded (*figs.* 344 and 346), as in the Primrose; it is *retuse* when it is obtuse, with a broad shallow notch in the middle, as in the Red Whortleberry (*Vaccinium Vitis-idæa*) and the leaflets of Logwood; or when under the same circumstances the notch is sharp, or nearly triangular, it is *emarginate*, as in some species

Fig. 335.

Fig. 336.

Fig. 335. Leaflet of a species of *Cassia*. It is obovate in figure or outline, somewhat oblique at the base, and emarginate at its apex.——*Fig.* 336. Branch of the Tulip-tree (*Liriodendron tulipifera*) with flower and leaves. The latter terminate abruptly, hence they are said to be *truncate*.

of *Cassia* (*fig.* 335), and in the common Box (*Buxus sempervirens*). When the lamina terminates very abruptly, as if it had been cut across in a straight line, the apex is *truncate*, as in the leaf of the Tulip-tree (*fig.* 336); or if under the same circumstances the termination is ragged and irregular, as if it had been bitten off, it is *præmorse*, as in the leaf of *Caryota urens*. When the apex is sharp, so that the two margins form an acute angle with each other (*figs.* 338 and 345), it is *acute* or *sharp-pointed*; when the point is very long, and tapering (*fig.* 343), it is *acuminate* or *taper-pointed*, as in the leaf of the White Willow and common Reed; or when it tapers gradually into a rigid point, it is *cuspidate*, as in many *Rubi*. When the apex, which is then commonly rounded, has a short hard or softened point standing on it, it is *mucronate* (*fig.* 342), as in the leaf of *Statice mucronata* and *Lathyrus pratensis*.

4. *General Outline or Figure.*—By the general outline or

shape of the lamina we mean the superficial aspect or figure which is described by its margins. The development of veins and parenchyma is usually nearly equal on the two sides of the midrib or petiole, so that the lamina of the leaf is in most instances nearly symmetrical and of some regular figure; in which case the leaf is said to be *equal* (*figs.* 343–346). When,

FIG. 337. FIG. 338. FIG. 339. FIG. 340.

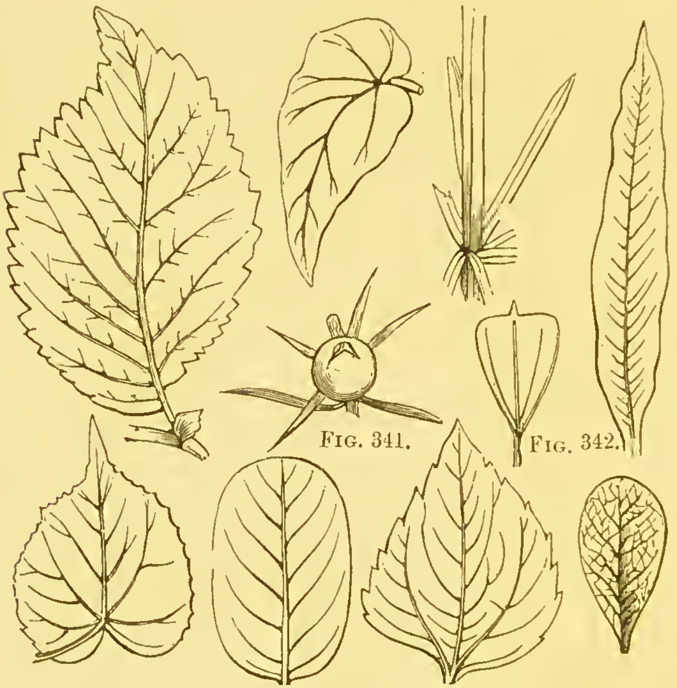


FIG. 343. FIG. 344. FIG. 345. FIG. 346.

Fig. 337. Leaf of Elm, with its margins biserrate, and the lamina unequal at its base.——*Fig.* 338. Unequal or oblique leaf of a species of *Begonia*.——*Fig.* 339. Linear leaf of Goose-grass (*Galium Aparine*).——*Fig.* 340. Lanceolate leaf.——*Fig.* 341. Acerose or needle-shaped leaves of Juniper (*Juniperus communis*).——*Fig.* 342. A cuneate and mucronate-pointed leaf.——*Fig.* 343. Cordate and acuminate leaf, with its margins dentate.——*Fig.* 344. Oblong leaf of Bladder-Senna (*Colutea arborescens*).——*Fig.* 345. Ovate leaf, with its margins serrate.——*Fig.* 346. Obovate leaf.

as occasionally happens, the lamina of the leaf is more developed on one side than on the other, the leaf is termed *unequal* or *oblique* (*figs.* 335 and 337); this is remarkably the case in the species of *Begonia* (*fig.* 338). Generally speaking, the leaves with ribbed, parallel, or feather-veined venation, are longer than broad; while those which are radiated or palmately-veined are more or less rounded, or broader than long.

When the lamina of a leaf is nearly of the same breadth at the base as near the apex, narrow, and with the two margins parallel (*figs.* 315, *a*, and 339), the leaf is called *linear*, as in the Marsh Gentian (*Gentiana Pneumonanthe*) and most Grasses; when a linear leaf terminates in a sharp rigid point like a needle, as in the common Juniper (*fig.* 341), and many of our Firs and Larches, it is *acerose* or *needle-shaped*. When the blade of a leaf is very narrow and tapers from the base to a very fine point, so that it resembles an awl in shape, as in the common Furze (*Ulex europæus*), the leaf is *subulate* or *awl-shaped*. When the blade of a leaf is broadest at the centre, three or more times as long as broad, and tapers perceptibly

Fig. 348.

Fig. 349.

Fig. 347.

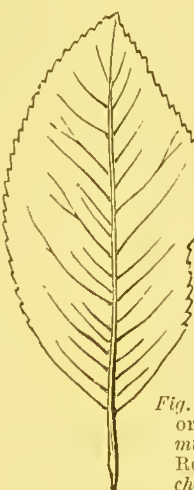


Fig. 350.

Fig. 347. Spathulate leaf.——*Fig.* 348. Oval or elliptical leaf of Pear-tree (*Pyrus communis*), with serrate margins.——*Fig.* 349. Reniform leaf of Ground Ivy (*Nepeta Glechoma*), with crenate margins.——*Fig.* 350. Trifoliate leaf with obcordate leaflets.

from the centre to both base and apex, as in the White Willow (*Salix alba*), the leaf is *lanceolate* (*fig.* 340); when it is longer than broad, of about the same breadth at its base and apex, and slightly acute at these points, it is *oval* or *elliptical* (*fig.* 348), as in the Lily of the Valley (*Convallaria majalis*); or if under the same circumstances it is obtuse or rounded at each end (*fig.* 344), it is *oblong*. By many botanists, however, the term *oval* is applied to a leaf which is only two or three times, and *oblong*, to one which is four or more times, as long as broad; and in both cases either rounded or acute at the two extremities. If the lamina of a leaf is more or less rounded at the base and broader at this part than at the apex, so that the whole is of the shape of an egg cut lengthwise, the leaf is *ovate* or *egg-shaped* (*fig.* 345), as in the Lilac; or if of the same figure, but with the apex broader than the base (*fig.* 346), it is *obovate* or *inversely egg-shaped.* When the lamina is broad at the apex, and abrupt-pointed, and tapers towards the base (*fig.* 342), as in some Saxifrages, the leaf is *cuneate* or *wedge-shaped* ; or if

Fig. 351.

Fig. 352.

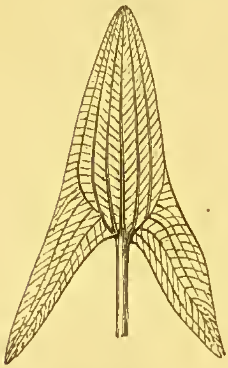


Fig. 354.

Fig. 353.

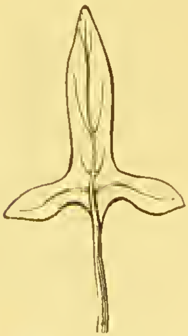


Fig. 355.

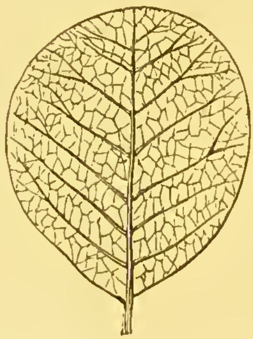


Fig. 356.

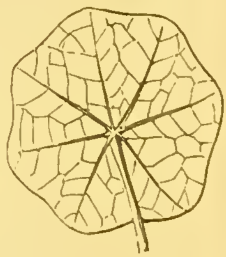


Fig. 351. Lunate or crescent-shaped leaf.——*Fig.* 352. Sagittate leaf.——*Fig.* 353. Hastate leaf.——*Fig.* 354. A portion of the stem of the Woody Nightshade (*Solanum Dulcamara*), bearing flowering stalk and an auriculate leaf.——*Fig.* 355. A sub-rotund or rounded leaf, with entire margins.——*Fig.* 356. Orbicular peltate leaf.

the apex is broad and rounded, and tapers down to the base (*fig.* 347), it is *spathulate*, as in the Daisy. When the lamina is broad and hollowed out at its base into two rounded lobes, and more or less pointed at the apex, so that it somewhat resembles in shape the heart in a pack of cards, the leaf is *cordate* or *heart-shaped* (*fig.* 343), as in the Black Bryony (*Tamus communis*); or if of the same shape, but with the apex broader than the base, and hollowed out into two rounded lobes, it is *obcordate* or *inversely heart-shaped* (*fig.* 350). When a leaf resembles a cordate one generally in shape, but with its apex rounded, and the whole blade usually shorter and broader (*fig.* 349), it is *reniform* or *kidney-shaped*, as in the Asarabacca (*Asarum europæum*); when a leaf is reniform but with the lobes at the base of the lamina pointed, so that it resembles the form of a crescent (*fig.* 351), it is *lunate* or *crescent-shaped*, as in *Passiflora lunata*. When the blade is broad and hollowed out at its base into two acute lobes, and pointed at the apex, so that it resembles the head of an arrow (*fig.* 352), the leaf is *sagittate* or *arrow-shaped*, as in the Arrowhead (*Sagittaria sagittifolia*); when the lobes of such a leaf are placed horizontally, instead of passing downwards, it is *hastate* or *halbert-shaped* (*fig.* 353), as in Sheep's Sorrel (*Rumex Acetosella*); or when the lobes are entirely separated from the blade, as in the upper leaves of the Woody Nightshade (*Solanum Dulcamara*), it is *auriculate* or *hastate-auricled* (*fig.* 354). When the blade is perfectly round, the leaf is *orbicular* (*fig.* 356), a figure which is scarcely or ever found; but when it approaches to orbicular, as in *Pyrola rotundifolia*, the leaf is *subrotund* or *rounded* (*fig.* 355).

It frequently happens, that a leaf does not distinctly present any of the above-described figures, but exhibits a combination of two of them, in which case we use such terms as *ovate-lanceolate, linear-lanceolate, cordate-ovate, cordate-lanceolate, elliptico-lanceolate, roundish-ovate*, &c., the application of which will be at once evident.

In many cases we find leaves of different figures on the same plant; under which circumstance the plant is said to be *heterophyllous*. Thus, in the Hairbell (*Campanula rotundifolia*), the radical leaves are *cordate* or *reniform*, and the cauline leaves *linear*; and this difference of outline between the radical and stem leaves is by no means uncommon. In water plants, again, where some of the leaves are submersed, while others float on the water, or rise above it into the air, as in the Water Crowfoot (*Ranunculus aquatilis*), and Arrowhead (*Sagittaria sagittifolia*), the leaves thus differently situated frequently vary in shape.

5. *Form.*—By this term we understand the solid configuration of the lamina, that is, including its length, breadth, and thickness. The terms used in defining the various forms are therefore especially applicable to thick or succulent leaves—namely, those which are produced when the veins are connected by a large development of parenchyma. Such leaves either assume

some regular geometrical forms, as *cylindrical*, *pyramidal*, *conical*, *prismatic*, &c., and receive corresponding names; or they approach in form to some well-known objects, and are hence termed *acicular*, *ensiform*, *acinaciform*, *dolabriform*, *clavate*, *linguiform*, &c. The above terms need no further description. In other instances, the lamina, instead of having its veins entirely connected by parenchyma, is more or less hollowed out in its centre, when the leaf is said to be *tubular*, *hood-shaped*, *urn-shaped*, &c. Various other singular forms are also found, some of which will be hereafter alluded to under the head of Anomalous Forms of Leaves (page 185).

Besides the above described modifications which the blades of leaves present in reference to their *Margins*, *Incision*, *Apex*, *Outline*, and *Form*, they also present numerous other variations as regards their *surface*, *texture*, *colour*, &c. For an explanation of these we must refer to the contents generally of this Manual; and more especially to that part which treats of the Appendages of the Epidermis.

2. COMPOUND LEAVES.—We have already defined a compound leaf (page 162). Its separate leaflets are subject to similar modifications of their margins, incision, apex, outline, form, texture, surface, colour, &c., as the blades of simple leaves, and the same terms are accordingly used in describing

FIG. 357.

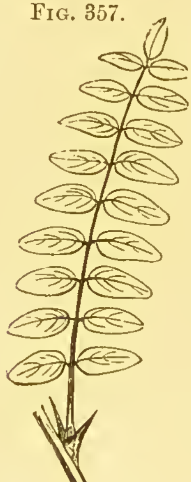


FIG. 358.

Fig. 357. Imparipinnate or unequally pinnate leaf of *Robinia*, with spiny stipules.——*Fig.* 358. Equally or abruptly pinnate leaf.

them. We have therefore only now to speak of compound leaves as a whole, and the terms which are employed in describing their special modifications. We divide them into two heads, namely: 1. *Pinnately* or *feather-veined Compound Leaves*; and 2. *Palmately* or *radiated-veined Compound Leaves*.

1. *Pinnately-veined Compound Leaves.*—When a leaf present-

ing this kind of venation is separated into distinct portions or leaflets, it is termed *pinnate* (*figs.* 357–360) ; and the leaflets are then termed *pinnæ*. The leaflets are arranged either in an opposite or alternate manner along the sides of the rachis or

Fig. 359.

Fig. 360.

Fig. 361.

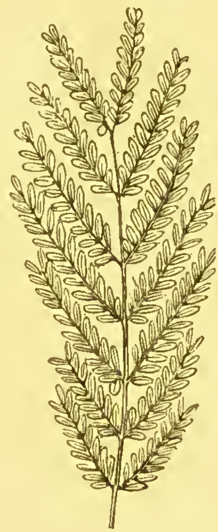


Fig. 362.

Fig. 359. Interruptedly pinnate leaf of the Potato (*Solanum tuberosum*).——*Fig.* 360. Lyrately pinnate leaf.——*Fig.* 361. Bipinnate leaf of a species of *Gleditschia*.——*Fig.* 362. A tripinnate leaf. Some of the leaflets are, however, only bipinnate.

common petiole in pairs, and according to their number the leaf is said to be *unijugate* or *one-paired*, as in several species of *Lathyrus* (*fig.* 385); *bijugate* or *two-paired* ; *trijugate* or *three-*

paired; and *multijugate* or *many-paired* (*fig.* 357). Several kinds of pinnate leaves have also been distinguished by special names. Thus, when a pinnate leaf ends in a solitary leaflet (*fig.* 357), as in the Rose and Elder, it is *imparipinnate* or *unequally-pinnate*, or *pinnate with an odd leaflet*; it is *equally* or *abruptly pinnate*, or *paripinnate*, when it ends in a pair of leaflets or pinnæ (*fig.* 358), as in some species of *Cassia*, the Mastich plant (*Pistacia Lentiscus*), Logwood (*Hæmatoxylon campechianum*), and *Orobus tuberosus*; and it is *interruptedly pinnate* (*fig.* 359) when the leaflets are of different sizes, so that small pinnæ are regularly or irregularly intermixed with larger ones, as in the Potato (*Solanum tuberosum*) and Silver Weed (*Potentilla anserina*). Or, when the terminal leaflet of a pinnate leaf is the largest, and the rest gradually smaller as they approach the base (*fig.* 360), it is *lyrately pinnate*, as in the common Turnip. This leaf and the true lyrate (page 167 and *fig.* 328) are frequently confounded together by botanists, and the two kinds often run into one another, so that it is by no means uncommon to find both varieties of leaf on the same plant, as in the common Turnip and Yellow Rocket.

Fig. 363.

Fig. 363. A decompound leaf.

When the leaflets of a pinnate leaf become themselves pinnate, or, in other words, when the partial petioles which are arranged on the common petiole exhibit the characters of an ordinary pinnate leaf, it is said to be *bipinnate* (*fig.* 361); the leaflets borne by the partial or secondary petioles are then commonly termed *pinnules*. When the pinnules of a bipinnate leaf become themselves pinnate, it is *tripinnate* (*fig.* 362), as in the Meadow Rue (*Thalictrum minus*), and the common Parsley; it commonly happens, however, that in these leaves the upper leaflets are less divided, as in *fig.* 362. If the division extends beyond this, the leaf is *decompound* (*fig.* 363), as in many Umbelliferous plants.

2. *Palmately-veined Compound Leaves.*—Such a leaf is formed when the ribs of a palmately-veined leaf bear separate leaflets; and hence these leaves are readily distinguished from those of the pinnate kind by their leaflets coming off from the same point, instead of, as in them, along the sides of a common petiole. We distinguish several kinds of such leaves; thus, a leaf is said to be *binate*, *bifoliate*, or *unijugate*, if it consists of only two leaflets springing from a common point (*fig.* 364), as

in *Zygophyllum* ; it is *ternate* or *trifoliate* if it consists of three leaflets arranged in a similar manner (*figs.* 350 and 365), as in the genus *Trifolium*, which receives its name from this circumstance ; it is *quadrinate* or *quadrifoliate* if there are four leaflets

FIG. 364.

FIG. 365.

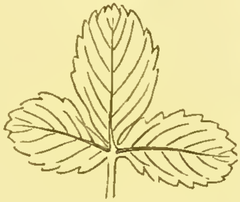


FIG. 366.

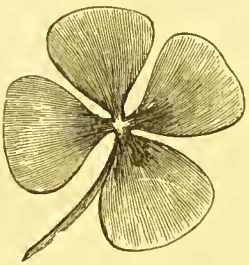


FIG. 367.

FIG. 368.

FIG. 369.

FIG. 370.

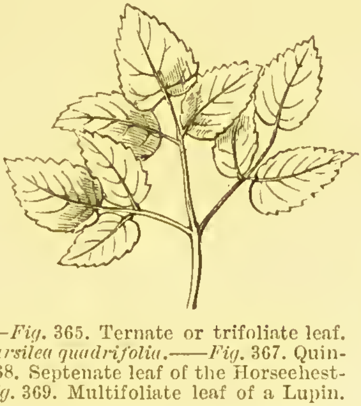


Fig. 364. A binate or bifoliate leaf.——*Fig.* 365. Ternate or trifoliate leaf. ——*Fig.* 366. Quadrifoliate leaf of *Marsilea quadrifolia.*——*Fig.* 367. Quinate or quinquefoliate leaf.——*Fig.* 368. Septenate leaf of the Horsechestnut (*Æsculus Hippocastanum*).——*Fig.* 369. Multifoliate leaf of a Lupin. ——*Fig.* 370. A biternate leaf.

(*fig.* 366) ; it is *quinate* or *quinquefoliate* if there are five (*fig.* 367), as in *Potentilla argentea* and *P. alba* ; it is *septenate* or *septemfoliate*, if there are seven (*fig.* 368), as in the Horsechestnut and some Potentillas ; and it is *multifoliate* if there are more than seven (*fig.* 369), as in many species of the Lupin. The term *digitate* is sometimes employed to characterise a compound leaf of five leaflets, but this name should be confined to a simple leaf, and used in the sense already noticed (page 168). In speaking of palmately-veined compound leaves in a general

FIG. 371.

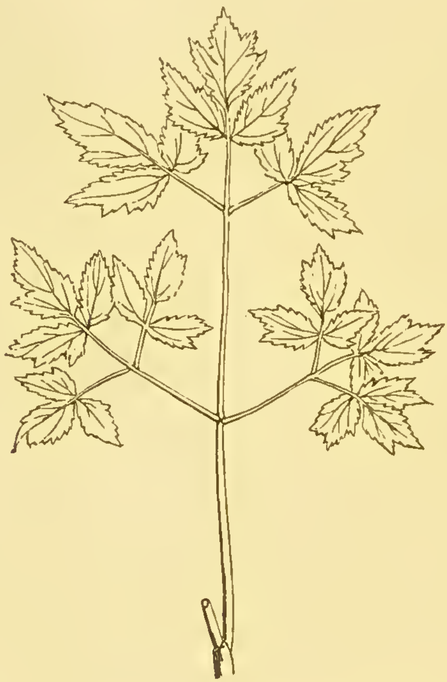


Fig. 371. Triternate leaf of Baneberry (*Actæa*).

sense, they are also commonly, although improperly, termed *palmate* or *digitate* ; but when the leaflets of a palmately-veined leaf are arranged in a pedate manner, the leaf is properly termed *pedate* (page 168).

Palmately-veined compound leaves may become still more divided. Thus, if the common petiole divides at its apex into three partial ones, each of which bears three leaflets (*fig.* 370), as in the Masterwort (*Imperatoria Ostruthium*), the leaf is termed *biternate* ; or when the common petiole divides at its apex into three partial ones, and these again divide into three others, each of which bears three leaflets, as in the Yellow Fumitory (*Corydalis lutea*) and *Epimedium*, the leaf is *triternate* (*fig.* 371) ; or when such a leaf is still further divided, it is said to be *decompound*.

5. PETIOLE OR LEAF-STALK.

The petiole or leaf-stalk is that part which connects the blade of the leaf with the stem or branch (*figs.* 273, *p*, and 274, *p*). It is frequently absent, and the leaf is then said to be *sessile* (*fig.* 236). It consists, as already described (page 143), of fibro-vascular tissue (*fig.* 372, *fv*), surrounded by parenchmya *pc*, and the whole covered by epidermis, which contains a variable number of stomata, and is frequently furnished with hairs and other epidermal appendages. The fibro-vascular tissue varies in its nature in the leaves of Dicotyledons, Monocotyledons, and Cormophytes, being in structure essentially the same in each case as that of the

Fig. 372.

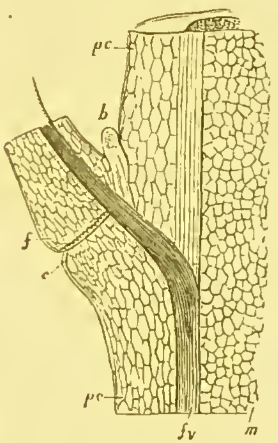


Fig. 373.

Fig. 374.

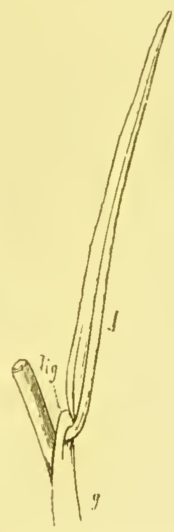


Fig. 372. Vertical section of a portion of the stem and the base of a leaf, showing the passage of the fibro-vascular tissue, *fv*, into the petiole. *pc, pc.* Parenchymatous tissue of the stem and petiole. *c.* Pulvinus. *f.* Articulation between the leaf and stem. *b.* Leaf-bud in the axil of the petiole. *m.* Pith.——*Fig.* 373. A portion of a branch and leaf of the Sensitive Plant, showing pulvinus at the base of the petiole.——*Fig.* 374. A portion of the stem of a Grass with a leaf attached. *l.* Blade. *g.* Sheathing petiole. *lig.* Ligule.

three kinds of stem already fully described; thus, in Dicotyledons, the fibro-vascular tissue (*fig.* 276), consists of spiral, pitted, annular, or some other vessels (see page 143), and sieve tubes, and wood and liber cells, that is, of the same elements essentially as the wood and liber. The distribution of this fibro-vascular tissue in the lamina forms the veins, which have been already described under the head of Venation (page 157).

The petiole is either *simple* or undivided, as in all simple leaves, and in those of a compound character in which the leaflets are sessile; or it is *compound*, as in the Rose, when it divides into two or more portions, each of which bears a leaflet (*fig.* 378), or it is still more compound when the blade is further divided. The branches of the petiole or the stalks of the leaflets are then called *petiolules*, *stalklets*, or *partial petioles*; while the main petiole is termed the *rachis* or *common petiole*.

The petiole is frequently more or less contracted at the base where it joins the stem owing to the presence of an *articulation* or *joint* (*fig.* 372, *f*). Leaves thus furnished with an articulated petiole fall away from the stem after they have performed their functions; and in doing so they leave a *scar* or *cicatrix* (*fig.* 207, *b*, *b*). This cicatrix commonly exhibits on its surface several little points, which are produced by the rupture of the fibro-vascular tissue of the petiole. The outline of the cicatrix and the arrangement of its ruptured fibro-vascular tissue vary much in different species of plants, and thus frequently form characters by which we may distinguish one plant from another after the leaves have fallen; thus the varying appearance of these scars may be well seen by comparing a branch of the Ash with that of the Horsechestnut.

In compound leaves the petiole is not only generally articulated to the stem, but the partial petioles are also frequently jointed to the common petiole, so that each leaflet becomes detached separately when the leaf begins to decay, as in the Sensitive Plant. By many botanists, indeed, no leaf is considered truly compound unless it presents this characteristic; consequently all leaves however much divided, and apparently compound, but which have not their separate portions articulated, are considered simple. Such a distinctive character cannot, however, be well carried out in practice, and when we consider that the presence of an articulation is by no means constant even in simple leaves, we can see no sufficient grounds for insisting upon this character in the separate portions of a leaf as evidence of its compound nature. The distinctive characters of simple and compound leaves as adopted in this Manual have been already fully treated of under the head of Composition of Leaves. (See page 162.)

The presence of an articulation is to some extent a character of distinction between the three great divisions of plants. Thus the leaves of Dicotyledons are in the majority of instances articulated; while those of Monocotyledons and of Cormophytes are non-articulated. Hence the leaves of the two latter, when they have performed their functions, instead of falling away and leaving a cicatrix as the former, decay gradually upon their respective plants, to the stems and branches of which they thus give a ragged appearance. There are many instances, however, in which the leaves of Dicotyledons are not articulated, as in the Oak. In such cases, the leaves, although dead, remain attached to their respective plants frequently for months, which thus form a striking contrast in their appearance to the surrounding trees, which have lost their leaves in consequence of these being articulated.

On the lower surface of the petiole at its base, the parenchyma commonly forms a more or less evident swelling (*figs.* 372, *c*, and 373), to which the name of pulvinus has been given. A somewhat similar swelling may be also seen in many compound leaves at the base of each partial petiole; each of which is then termed a *struma.* The compound pinnate leaves of the Sensitive Plant afford a good illustration of the presence of both pulvinus and strumæ.

Forms of the Petiole.—The form of the petiole varies in different leaves. It is usually rounded below, and flattened, or more or less grooved above; but in other cases it is cylindrical,

FIG. 375.

FIG. 376.

Fig. 375. A portion of the stem with some leaves of Venus's Fly-trap (*Dionæa muscipula*). *l.* Lamina fringed with hairs, and hence said to be ciliated. *p.* Winged petiole.——*Fig.* 376. Decurrent leaves of the Comfrey (*Symphytum officinale*).

especially in the leaves of Monocotyledons; while in other plants of the same class, as in Grasses, it becomes widened at its base, and surrounds the stem in the form of a *sheath* (*fig.* 374, *g*). This sheath in all true Grasses terminates above in a membranous appendage (*fig.* 374, *lig*), which is entire, or divided into two symmetrical portions, or incised in various ways; to this the name of ligule has been given, and is now supposed by most authorities to be analogous to the stipules. In the Aspen (*Populus tremula*), the petiole is flattened in a line at right angles to the blade, and is thus one of the causes of the peculiar mobility of such leaves; while in other plants it is flattened in a horizontal direction. In Water Plants the petiole is frequently more or less dilated from the presence of a number of air cavities, as in *Pontederia*; such petioles by diminishing the specific gravity of the plants in which they are found, enable them to float readily in the water. At other times the petiole becomes flattened at its base, and embraces the stem, in which case the leaf is said to be *amplexicaul* or *clasping* (*fig.* 281); this commonly occurs in Umbelliferous Plants. Frequently the petiole presents at its two edges a leaf-like border called a *wing*, when it is said to be *winged*; as in the Orange (*fig.* 320, *p*), Venus's Flytrap (*fig.* 375, *p*), Sweet Pea (*fig.* 385), and many other plants. In some plants the winged expansion does not terminate at the base of the petiole, but it is continued downwards along the stem; in which case the stem is also termed winged, and the leaf is said to be *decurrent* (*figs.* 283 and 376). Besides the above forms of petiole, others still more remarkable occur, which will be alluded to hereafter, under the head of Anomalous Forms of Leaves (page 185).

Fig. 377.

Fig. 377. A portion of the flowering stem of the common Pea, with a pinnate leaf terminated by a tendril, and having two large stipules at its base, the lower margins of which are dentate.

Generally speaking, the petiole is less developed than the lamina; it is also commonly shorter than it, and is of sufficient thickness to support it without bending. When the petiole is very long or thin, or when the lamina is very heavy, and in other cases, it becomes more or less bent downwards towards the earth, and no longer supports the blade in a horizontal direction.

6. STIPULES.

Stipules are small leafy bodies situated at the base, and usually on each side of the petiole of simple (*fig.* 274, *s*, *s*), or compound (*fig.* 377), leaves. They have the same structure as the blades of leaves, and are liable to similar modifications as regards venation, apex, incision, outline, margins, surface, &c. The stipules are often wanting, and the leaves are then said to be *exstipulate*; when present the leaves are *stipulate*. They are often overlooked from their small size; while in other cases they are very large, as in the Pansy (*fig.* 379), and in the common

Pea (*fig.* 377). In the leaves of *Lathyrus Aphaca*, again (*fig.* 380), there are no true blades, or leaflets, but the stipules, *s*, *s*, are here very large and perform all their functions. It sometimes happens that the leaflets of a compound leaf possess little stipules of their own, as in the Bean and Bladder Nut; to these the name of *stipels* has been given, and the leaf is then termed *stipellate.*

Stipules either remain attached as long as the lamina, when they are said to be *persistent*; or they fall off soon after its expansion, in which case they are *deciduous.* In the Beech, the Fig, the Magnolia, &c., they form the *tegmenta* or protective coverings of the buds, and fall off as these open (page 105).

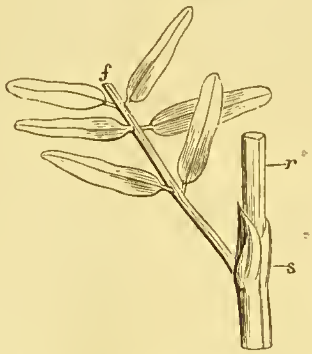
FIG. 378.

FIG. 379.

Fig. 378. A portion of a branch, *r*, of the common Rose (*Rosa canina*). *a.* A prickle. *b.* Bud in the axil of a compound leaf, *f*, with stalked leaflets. *p.* Petiole. *s*, *s*. Adnate or adherent stipules.——*Fig.* 379. Petiolate leaf of Pansy (*Viola tricolor*) with large caulinary stipules at its base.

Kinds of Stipules.—The stipules vary in their position with regard to the petiole and to each other, and have received different names accordingly. Thus, when they adhere to each side of the base of the petiole, as in the Rose (*fig.* 378, *s*, *s*), they are said to be *adnate*, *adherent*, or *petiolar.* When they remain as little leafy expansions on each side of the base of the petiole, but quite distinct from it, as in many Willows (*fig.* 274, *s*, *s*), and the Pansy (*fig.* 379), they are called *caulinary.* When the stipules are large, it sometimes happens that they meet on the opposite side of the stem or branch from which the leaf grows, and become united more or less by their outer margins, and thus form one stipule, as in the *Astragalus*, they are then said to be *synochreate* or *opposite* (*fig.* 380, *s*); if under similar circumstances they cohere by their inner margins, as in *Melianthus annuus* and *Houttuynia cordata* (*fig.* 381, *s*), they form a solitary stipule which is placed in the axil of the leaf, and is accordingly termed *axillary*; and if such stipules cohere by both outer and inner

Fig. 380. Fig. 381.



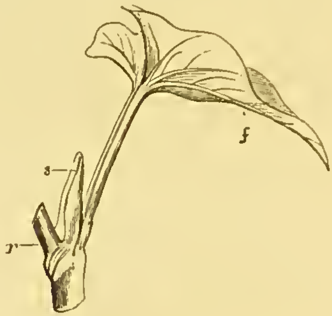


Fig. 380. A portion of the stem, *r*, and leaf, *f*, of the *Astragalus Onobrychis*. *s*. Synochreate or opposite stipule.——*Fig.* 381. A portion of the stem, *r*, and leaf, *f*, of *Houttuynia cordata*. *s*. Axillary stipule.

margins so as to form a sheath which encircles the stem above the insertion of the leaf (*fig.* 273, *d*), as in the Rhubarb, and most other plants of the order Polygonaceæ, they form what is termed an *ochrea* or *intrafoliaceous stipule*.

All the above kinds of stipules occur in plants with alternate leaves, in which such appendages are far more common than in

Fig. 382.

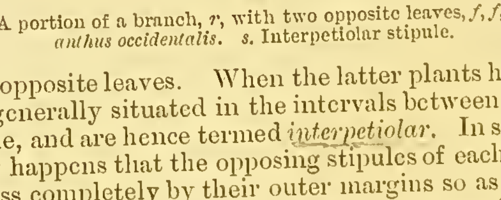


Fig. 382. A portion of a branch, *r*, with two opposite leaves, *f*, *f*, of *Cephalanthus occidentalis*. *s*. Interpetiolar stipule.

those with opposite leaves. When the latter plants have stipules these are generally situated in the intervals between the petioles on each side, and are hence termed *interpetiolar*. In such cases, it frequently happens that the opposing stipules of each leaf cohere more or less completely by their outer margins so as to form but one interpetiolar stipule on each side of the stem (*fig.* 382, *s*), as is the case in the Cinchonas, the Coffee, and most other plants of the natural order Rubiaceæ to which they belong.

Stipules, as we have already noticed, are not always present in plants, but their presence or absence in any particular plant is always constant, and although the appearance and arrangement of them also vary in different plants, they are always uniform in those of the same species, and even, in some cases, throughout entire natural orders, and thus they frequently supply important distinctive characters in such plants and orders. Thus the plants of the Loganiaceæ are distinguished from those of the allied order Apocynaceæ by possessing interpetiolar stipules; and the plants of the Polygonaceæ usually from those of allied orders by intrafoliaceous stipules.

Stipules are very rare in Monocotyledons, except the ligule is to be considered as analogous to them. The only orders of Monocotyledons in which they undoubtedly occur are the Naiadaceæ and Araceæ. They are altogether absent in Cormophytes.

7. ANOMALOUS FORMS OF LEAVES.

We have already seen that the branches of a stem sometimes acquire an irregular development, and take the form of Spines or Tendrils (pages 107 and 108). In the same manner the parts of a leaf may assume similar modifications, as well as some others still more remarkable, which we now proceed to describe.

FIG. 383.

FIG. 384.

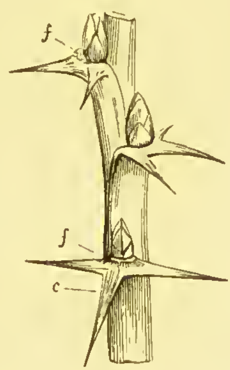


Fig. 383. A portion of a branch of the Barberry (*Berberis vulgaris*), bearing spiny leaves. The upper leaf is composed entirely of hardened veins, without any parenchyma between them. *Fig.* 384. A portion of a branch of the Gooseberry (*Ribes Grossularia*). *f, f.* Scars of former leaves, with buds in their axils. *c.* Spine produced from the pulvinus.

Spines of Leaves.—Any part of the leaf may exhibit a spiny character owing to the non-development or diminution of parenchyma, and the hardening of the veins. Thus,—1st, in the Holly (*fig.* 323) and many Thistles (*fig.* 283), the veins project beyond the blade, and become hard and spiny; in some species of *Solanum* the spines are situated on the surface of the lamina; while in the Barberry (*fig.* 383) the blade has little or no parenchyma produced between its veins, which are of a spiny character, so that the whole lamina becomes spinous. Spines of leaves may be readily distinguished from those already described (page 107), which are modified branches, because in the latter case they always arise from the axil of the leaf, instead of from the leaf itself. Spines may be also readily distinguished from prickles by their internal structure and the other characters alluded to when speaking of the spines of branches (p. 107). 2nd. The petiole may assume a spiny character, either at its apex, as in some species of *Astragalus*; or at its base from the pulvinus (*fig.* 384, *c*), as in the Gooseberry. And, 3rd. The stipules may become transformed into spines, as in *Robinia Pseud-acacia* (*fig.* 275).

Tendrils of Leaves.—Any part of the leaf may also become

Fig. 385.

Fig. 387.

Fig. 386.

Fig. 385. Leaf of a species of *Lathyrus*, showing a winged petiole, with two half-sagittate stipules at its base, and terminated by a tendril.——*Fig.* 386. A portion of the stem of *Lathyrus Aphaca*, with stipules, *s*, *s*, and cirrhose petiole, *v*.——*Fig.* 387. A portion of the stem of *Smilax*, bearing a petiolate leaf, and two tendrils in place of stipules.

cirrhose or transformed into a tendril. Thus,—1st. The midrib of the blade of a simple leaf may project beyond the apex, and form a tendril, as in *Gloriosa superba*; or some of the leaflets of a compound leaf may become transformed into branched tendrils (*figs.* 377 and 385), as in certain species of *Lathyrus*, and many other Leguminosæ. 2nd. The petiole may become cirrhose, as in *Lathyrus Aphaca* (*fig.* 386, *v*), and numerous other plants of the Leguminosæ. And, 3rd. The stipules may assume the form of tendrils ; thus in many species of *Smilax* there are two tendrils, one on each side of the base of the petiole (*fig.* 387), in place of the ordinary stipules.

Phyllodes or Phyllodia.—In the leaves of certain plants, as in some Australian Acacias (*figs.* 388 and 389), certain species of *Eucalyptus*, and of other plants, the parts forming the fibro-vascular tissue of the petiole, instead of remaining till they reach the blade before separating, begin to diverge as soon as they leave the stem or branch and become connected by paren-

FIG. 388.

FIG. 389.

Fig. 388. A phyllode of an Australian Acacia.——*Fig.* 389. Leaf of an Acacia (*Acacia heterophylla*), the petiole of which assumes the character of a phyllode, and is terminated by a bipinnate lamina. The venation of the phyllode may be seen to be parallel.

chyma as in the ordinary blade of a leaf ; the petiole thus assumes the appearance of a lamina and then performs all its functions. To such a petiole the name of *phyllode* has been applied. In some cases, as in *Acacia heterophylla*, the phyllode is terminated by a true compound blade (*fig.* 389), and its nature is thus clearly ascertained, but in most instances no such blade is produced (*fig.* 388). These phyllodes may be distinguished from true blades, not only by the occasional production of a lamina as just mentioned, but also by other circumstances. Thus,—1st. By their venation, which is more or less parallel (*figs.* 388 and 389) instead of reticulated, as is the case generally in Dicotyledons, in which class of plants they alone occur. 2nd. By their being placed nearly or quite in a vertical direction—that is, turning their margins upwards and downwards instead of their surfaces. And 3rd. By their two surfaces resembling each other, whereas in true blades a manifest difference is commonly observable between their upper and lower surfaces.

Besides the true phyllodes thus described, there are some others, as in certain species of *Ranunculus*, which do not present such well-marked distinctive characters. In these phyllodes the direction of the surfaces is horizontal as in true blades, and in some other respects they resemble them; they have, however, more or less parallel venation instead of reticulated, and, belonging to Dicotyledons, this character will suffice to distinguish them, as it is now become the rule with most botanists to consider all organs occupying the place of leaves among Dicotyledons, which are not reticulated, as phyllodes.

Ascidia or Pitchers.—These are the most remarkable of all the anomalous forms presented by leaves. They may be seen

FIG. 390.

FIG. 391.

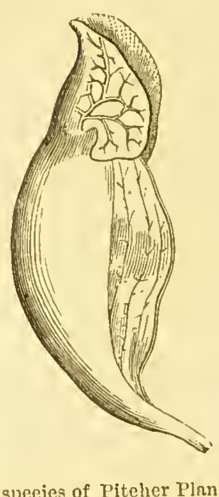


FIG. 392.

Fig. 390. Pitcher of a species of Pitcher Plant (*Nepenthes distillatoria*). *p.* Pitcher closed by the lid, *l.*——*Fig.* 391. Pitcher of the Side-saddle Plant (*Sarracenia purpurea*).——*Fig.* 392. Pitchers of *Heliamphora*.

in the species of *Nepenthes* or Pitcher Plants (*fig.* 390), in the species of *Sarracenia* or Side-saddle Plants (*fig.* 391), and in many others. These curious organs may be either formed from the petiole, or the blade of the leaf. Thus in the *Sarracenia* (*fig.* 391), the pitcher appears to be produced by the folding inwards of the two margins of a phyllode, which unite below, and form a hollow body or pitcher; but they are still separate above, and thus indicate its origin. The origin of the pitcher from the phyllode is, however, probably best seen in a species of *Heliamphora* (*fig.* 392), in which the union of the margins of the phyllode is even less evident than in the *Sarracenia*. In the *Nepenthes* (*fig.* 390) again, the petiole first expands into a phyllode, then assumes the appearance of a tendril, and ultimately forms a pitcher, *p*; this is closed above by a lid, *l*, called an operculum, which is united to it by an articulation. The lid is here commonly regarded as a remarkable transformation of the blade; but some consider that the pitcher is formed out of the lamina, and that the operculum is the terminal lobe. This kind of pitcher is also looked upon by others as a modification of such leaves as the Orange (*fig.* 320), and Venus's Fly-trap (*fig.* 375), in which the petiole, *p*, is articulated to the blade; thus, if we suppose the winged petiole of such plants to fold inwards and unite by its margins, a pitcher would be formed resembling that of *Nepenthes*, and the jointed blade would then be seen to be clearly analogous to the operculum or lid of that plant. In another of these plants, the *Dischidia*, the pitchers are considered to be formed by the folding inwards and union of the margins of the blades.

General View of the

8. LEAVES OF DICOTYLEDONS, MONOCOTYLEDONS, AND CORMOPHYTES.

We have already seen, in describing the structure and general characters of stems and roots, that these organs present well-marked distinctive characters in the above divisions of plants. The leaves of plants in the corresponding divisions, as we have noticed generally in their description, also present certain marked differences, which may be summed up as follows:—

1. Leaves of Dicotyledons.—In these the venation is reticulated in consequence of the veins branching in various directions and the divisions becoming united with one another, so as to form a more or less angular network (*fig.* 314). But in some plants, as *Ranunculus Lingua* and *R. Flammula*, the so-called blades have parallel veins, and have been therefore considered by some botanists as representing exceptions to the ordinary reticulated venation of Dicotyledons; but these, as we have just seen (page 188), are not usually regarded as true blades, but as phyllodes or transformed petioles, from which they only essentially differ in being placed horizontally.

The leaves of Dicotyledons are also very commonly articulated to the stem or branch, often compound, and variously indented or incised at their margins. Stipules are also frequently present.

2. Leaves of Monocotyledons.—In these the venation is

commonly more or less parallel: either from base to apex (*fig.* 311, *a*); or they present one large central vein from which veins are given off on each side, which proceed in a parallel direction to the margins, as in the Banana (*figs.* 311, *b*, and 318). But the leaves generally of plants of the Natural Orders Smilaceæ (*fig.* 387), Dioscoreaceæ, Trilliaceæ, Roxburghiaceæ, and Philesiaceæ, as well as some in the order Araceæ, present exceptions to this character, for in them the veins branch in various directions and form a network, as in the leaves of Dicotyledons. Some of these plants, as the Smilaceæ and allied orders, were therefore separated from other Monocotyledons by Lindley, and placed in a class by themselves, called Dictyogens, from the Greek word signifying a net. But this class has not been accepted by botanists, and is not therefore adopted in this Manual. We have already noticed (page 100) that such plants also present certain differences in the structure of their subterranean stems from those of other Monocotyledons.

In Monocotyledons the leaves are also commonly not articulated; and the margins of their blades are usually entire or free from toothings and incisions of every kind. They are also commonly simple, often sheathing at the base, and seldom have stipules, unless the ligule (page 181) is to be considered as the analogue of these organs.

3. Leaves of Cormophytes.—In these plants, when the leaves have veins, these may be arranged, at first, in a pinnate or palmate manner, but the whole of their principal veins either divide afterwards in a forked manner, or their terminal ramifications are thus divided (*fig.* 319). The leaves of Ferns are usually called *fronds*; this term being commonly applied to leaves or leaf-like structures which, like those of Ferns, bear the fructification.

Such leaves are usually not articulated; either sessile or stalked; frequently toothed or incised in various ways; often highly compound; but never have stipules.

CHAPTER 4.

ORGANS OF REPRODUCTION IN THE PHANEROGAMIA.

Under the head of Organs of Reproduction we include the Flower and its Appendages. They are called reproductive organs because they have for their office the reproduction of plants by the formation of seed. Plants with conspicuous organs of reproduction, as already noticed (page 11), are called *Phanerogamous* or *Flowering*; while those in which these parts are concealed or obscure, are termed *Cryptogamous* or *Flowerless*.

The parts of a flower (as will be particularly shown hereafter), are only leaves in a modified condition, or rather the *analogues* of these organs, or, more properly, *homologous formations* adapted for special purposes ; and hence a flower-bud is analogous to a leaf-bud, and the flower itself to a branch the internodes of which are but slightly developed, so that all its parts are situated in nearly the same plane. As flower-buds are thus analogous to leaf-buds, they are subject to similar laws of arrangement and development.

Section 1. Inflorescence or Anthotaxis.

The term *inflorescence* or *anthotaxis* is applied generally to indicate the floral axis and its ramification, or the arrangement of the flowers upon that axis. Under this head we have to examine—1st, the Leaf from the axil of which the flower-bud arises ; 2nd, the Stalk upon which the flower or flowers are situated ; and 3rd, the Kinds of Inflorescence.

Fig. 393.

Fig. 393. Flowering stalk of the White Dead-nettle (*Lamium album*), with leafy bracts and verticillasters in their axils.

1. The Bract.

We have just stated that flower-buds are analogous to leaf-buds ; and this analogy is still further proved by their occupying similar situations to them ; thus they are placed either at the apex of the floral axis or branch, or laterally, and then commonly in the axil of modified leaves. Flower-buds, therefore, like leaf-buds, are terminal or axillary. In the latter case the modified leaves from which they arise are called *bracts* or *hypsophyllary leaves.* In strict language the term bract should be only applied to the leaf from the axil of which a solitary flower or a floral axis arises; while all other leafy structures which are found upon that axis between the bract and the flower properly so called, should be termed *bractlets* or *bracteoles* (*fig.* 404, *b*, *b*). These two kinds of bracts are, however, but rarely distinguished in practice, the term bract being generally alone used for either variety, and in this sense we shall hereafter, as a general rule, apply it.

Bracts vary much in appearance, some of them being large, of a green colour, and in other respects resembling the ordinary foliage leaves of the plant upon which they are placed, as in the

Fig. 394.

Fig. 395.

Fig. 396.

Fig. 394. Flowering stalk of the Pimpernel (*Anagallis arvensis*). *b*, *b*. Solitary flowers arising from the axil of the leafy bracts, *a*, *a*.——*Fig.* 395. Calyx of the Marsh-mallow (*Althœa officinalis*) surrounded by an epicalyx or involucre.——*Fig.* 396. Flower of the Strawberry (*Fragaria vesca*), surrounded by an epicalyx or involucre.

White Dead-nettle (*fig.* 393); and in the Pimpernel (*fig.* 394, *a*, *a*); in which case they are called *leafy bracts.* Such bracts can only be distinguished from the true leaves by their position with regard to the flower-stalk or flower. In most cases, however, bracts, although very commonly of a greenish colour, are smaller than the foliage leaves; and in many plants they may be known from the ordinary leaves not only by their position, but also by differences of colour, outline, texture, and other peculiarities. Thus the bracts forming the cupule of the Oak are hard and woody; in the Hop they are membranous; in certain plants of the Araceæ and Euphorbiaceæ coloured; in the flower-heads of the Compositæ scaly; and other modifications also occur.

Sometimes when the bracts are situated in a whorl immediately below the calyx, it is difficult to determine whether they should be considered as a part of the calyx or as true bracts; thus, in most flowers of the Mallow order (*fig.* 395), and many of the Pink (*fig.* 474, *b*) and Rose orders (*fig.* 396), we have a circle of leafy organs placed just below the calyx, to which the term of *epicalyx* has been given by many botanists, but which properly comes under the denomination of *involucre* (page 194).

Almost all inflorescences are furnished with bracts of some kind or other; it frequently happens, however, that some of the bracts do not develop axillary flower-buds, just in the same manner as it occasionally happens that the leaves do not produce leaf-buds in their axils. In some cases the non-development of flower-buds in the axil of bracts appears to arise simply from accidental causes; but in others it occurs as a regular law, thus in the Purple Clary (*Salvia Horminum*), and the common Pineapple (*fig.* 292), there are a number of bracts without flower-buds placed at the apex of the inflorescence. Such bracts are called *empty*. When bracts are absent altogether, as is usually the case in the plants of the natural order Cruciferæ, and those of the Boraginaceæ, such plants are termed *ebracteated*; when bracts are present the inflorescence is said to be *bracteated*.

Arrangement and Duration of Bracts.—Bracts follow the same laws of arrangement as true leaves, being opposite, alternate, or whorled, in different plants. The bracts of the Pineapple fruit (*fig.* 292), and those of Fir cones (*figs.* 293 and 420), show in a marked manner a spiral arrangement.

Bracts vary in their duration; thus when they fall immediately, or soon after the flower-bud expands, they are said to be *deciduous*; or when they remain long united to the floral axis, they are *persistent*. In some plants they persist and constitute a part of the fruit; thus, in the Hazel-nut and Filbert they form the husk (*fig.* 401), in the Acorn they constitute the cup (*fig.* 400), and in the Hop-fruit (*fig.* 421), in the Fir-cones (*figs.* 293 and 420), and Pineapple (*fig.* 292), they persist as membranous, woody, fleshy, or scaly appendages.

Varieties of Bracts.—Bracts have received special names according to their arrangement and other characters. Thus the bracts of that kind of inflorescence called an Amentum or Catkin (see page 202), as seen in the Willow (*fig.* 416), Oak, Hazel (*fig.* 397), Birch, and other plants, are usually of a scaly nature, and are termed *squamæ* or *scales*; or the bracts are described as *squamous* or *scaly*. The bracts of the pistillate flowers of the Hop (*fig.* 421) are of like character.

When a circle or whorl of bracts is placed around one flower, as in the Marsh Mallow (*fig.* 395) and Strawberry (*fig.* 396); or around a number of flowers, as in the Carrot (*fig.* 398) and most other Umbelliferous plants, they form what is termed an *involucre*. In some Umbelliferous plants, as for instance the Carrot, (*fig.* 398), there are two involucres, one at the base of the primary divisions of the floral axis or general umbel, *a*; and another at

FIG. 397.

FIG. 398.

Fig. 397. Staminate or male catkin of the Hazel (*Corylus Avellana*), showing a number of scaly bracts between the flowers.——*Fig.* 398. Compound umbel of the Carrot (*Daucus Carota*). *a*. General involucre. *b*, *b*. Partial involucres or involucels.

FIG. 399.

Fig. 399. Capitulum of Marygold (*Calendula*), showing the flowers enclosed in an involucre.

the base of each of the partial umbels or umbellules, *b*, *b*; the former is then called the *general involucre*; and each of the latter an *involucel* or *partial involucre* (see page 208). In plants of the natural order Compositæ, such as the Marigold (*fig.* 399), Artichoke, Chamomile, and Daisy; and of some of the allied orders, a somewhat similar arrangement of bracts takes place, and the name of *involucre* is also applied in these cases. In the involucres of the Compositæ there are frequently two or three rows of bracts thus overlapping one another; the constituent bracts of these latter involucres have been termed *phyllaries*. Sometimes the bracts of an involucre grow together at their bases, and form ultimately a sort of cup-shaped body surrounding the fruit, as the cup of the Acorn (*fig.* 400), and the husk of the

Filbert or Hazel-nut (*fig.* 401); they then form what is called a *cupule.* also Sweet chestnut + Beech-nut

FIG. 400.

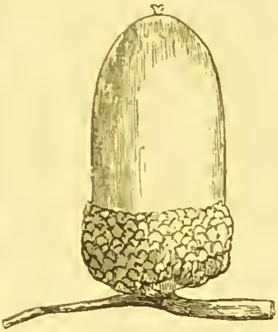


FIG. 401.

Fig. 400. Fruit of the Oak (*Quercus Robur*), surrounded by a cupule.——*Fig.* 401. Fruit of the Hazel (*Corylus Avellana*), with a cupule at its base.

FIG. 402.

FIG. 403.

Fig. 402. Flower of the Spring Snowflake (*Leucojum vernum*), arising from the axil of a spathaceous bract or spathe.——*Fig.* 403. Spadix of Cuckoo-pint (*Arum maculatum*) enclosed in a spathe, a portion of which has been removed to show the flowers within.

When a bract is of large size and sheathing, and surrounds one, or a number of flowers, so as to completely enclose them when in a young state, as in the Iris, Narcissus, Snowflake (*fig.* 402), the common Arum or Cuckoo-pint (*fig.* 403), and Palms (*fig.* 417), it is called a *spathe.* The spathe is generally found surrounding the kind of inflorescence called a spadix (page 203), as in the Arum (*fig.* 402), and Palm (*fig.* 417); and it is also very common in other Monocotyledons. The spathe may be either green like an ordinary leaf, as in the Cuckoo-pint; or coloured, as in *Richardia æthiopica.* In some Palms these spathes are of great length, sometimes even as much as twenty feet; and as many as 200,000 flowers have been counted in them. Sometimes the spadix of a Palm branches (*fig.* 417), and then we frequently find smaller spathes surrounding its divisions, which have been named *spathellæ.* Many

Arum or Calla

Fig. 405.

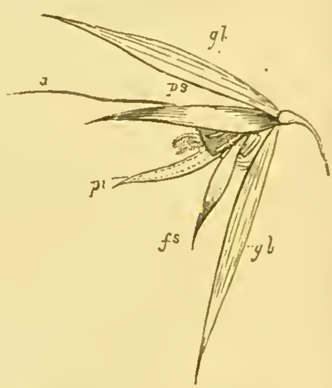


Fig. 404.

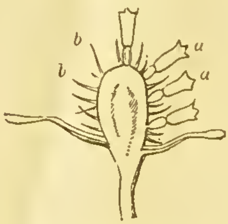


Fig. 404. Receptacle of the Chamomile (*Anthemis nobilis*), bearing tubular flowers (*florets*), *a*, *a*, and bracteoles, *b*, *b*: the latter are sometimes termed *Pales.* (The receptacle is here drawn much too large at the apex, it should be conical in form.) *Fig.* 405. Locusta or spikelet of the Oat (*Avena sativa*). *gl*, *gl*. Glumes. *ps*, *pi*. *Paleæ* or *Pales*. *a*. Awn arising from the dorsum of the outer pale, *ps*. *fs*. An abortive flower.

botanists restrict the term spathe to the large enveloping bract of the spadix, and call the other bracts of a like character, which enclose only one or at most a few flowers, as frequently found in Monocotyledons, *spathaceous bracts.*

Besides the bracts which surround the head of flowers of the Compositæ and form an involucre, it frequently happens that the individual flowers or florets (*fig.* 404, *a*, *a*) are also provided with little bracts or bracteoles, *b*, *b*, which are then generally of a membranous nature, and colourless, as in the Chamomile. These have received the name of *paleæ*, but as this term is applied to certain special bracts found in Grasses (see below), they are better named *scales*, or by some other term which expresses their texture and character.

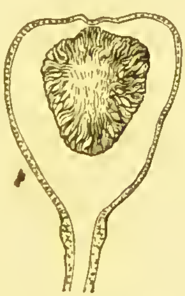
The only other bracts which have received special names are those found in plants of the Grass and Sedge orders. Thus the partial inflorescence of a Grass, which is termed a *locusta* or *spikelet* (page 203), has at its base one or two bracts, which are called glumes (*fig.* 405, *gl*, *gl*); while in the Cyperaceæ each flower arises from the axil of one or two similar bracts. In the Grasses we also find that each flower has two other bracts (*fig.* 405, *ps*, *pi*), which are commonly called *pales* or *paleæ*; and also frequently at the base of the ovary there are two or more little scales, also of the nature of bracts, which are usually termed *squamulæ*, *glumellules*, or *lodiculæ* (*fig.* 601, *sp*).

2. THE PEDUNCLE OR FLOWER STALK.

The term peduncle is applied to the stalk of a solitary flower, whether axillary (*fig.* 394, *b*, *b*), or terminal (*fig.* 402), or to a floral axis which bears a number of sessile flowers (*figs.* 413 and 414); or if the floral axis branches and each branch bears a flower (*figs.* 422 and 423), the main axis is still called a *peduncle*, and the stalk of each flower a *pedicel*; or if the axis be still further subdivided, the general name of peduncle (*fig.* 424) is applied to the whole, with the exception of the stalks immediately supporting the flowers, which are in all cases called pedicels. When the floral axis is thus branched, it is better to speak of the main axis as the *primary* axis (*fig.* 424, *a'*), its divisions as the *secondary* axes *a''*, and their divisions as the *tertiary* axes *a'''*, &c.

Kinds of Peduncle.—Under certain circumstances peduncles and pedicels have received special names. Thus, when a

Fig. 406. Fig. 407.



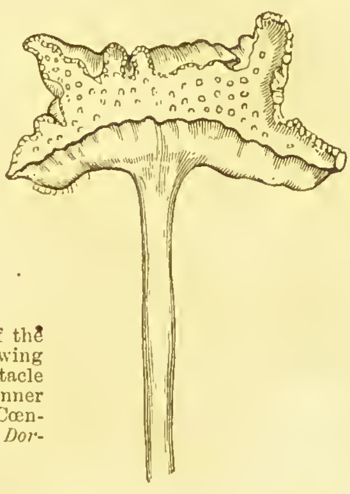


Fig. 406. Hypanthodium of the Fig (*Ficus Carica*), showing pear-shaped fleshy receptacle bearing flowers on its inner surface. —— *Fig.* 407. Cœnanthium of a species of *Dorstenia*.

peduncle is elongated, and gives off from its sides sessile flowers (*figs.* 413 and 414), or branches bearing flowers (*figs.* 422-424), it is called the *rachis* or *axis*; but if, instead of being elongated, it becomes more or less dilated, and usually bearing numerous flowers, it is termed the *receptacle*. This receptacle varies very much in form; thus, it is flattened in the Cotton Thistle (*fig.* 427), conical in the Chamomile, concave and fleshy in the Dorstenia (*fig.* 407), pear-shaped and hollowed out in the Fig (*fig.* 406); or it assumes a variety of other intermediate forms. The peculiar receptacle of the Dorstenia is sometimes termed a *cœnanthium*; and that of the Fig a *hypanthodium*; or both kinds are sometimes characterised by the latter name.

It should be observed, that the term receptacle is also applied by some botanists to the extremity of the peduncle or pedicel, upon which the parts of the flower are placed, whether enlarged or not, and whether bearing one or a number of flowers (see Thalamus).

When plants which have no aerial stem bear flowers, the peduncle necessarily arises at, or under, the ground, in which case it is called a *scape* or *radical peduncle* (*fig.* 402), as in the Spring Snowflake, Tulip, Hyacinth, Primrose, and Cowslip. The scape may either bear one flower as in the Tulip, or several flowers as in the Hyacinth.

Forms of Peduncle.—In form the peduncle is generally more or less cylindrical, but besides the departure from this ordinary

Fig. 408.

Fig. 409.

Fig. 408. Female plant of *Vallisneria spiralis*, with its flowers arranged on spiral peduncles.——*Fig.* 409. Portion of a branch of the Butcher's Broom (*Ruscus aculeatus*), with phylloid pedicels (*cladodes*), bearing flowers, *a*.

appearance as exhibited by the receptacle just described, and its modifications, it frequently assumes other forms. Thus, it may become more or less compressed, or grooved in various ways, or excessively enlarged during the ripening of the fruit, as in the Cashew-nut; or it may assume a spiral character, as in the *Vallisneria* (*fig.* 408); or become spiny, or transformed into a tendril; or it may be hollowed out at its apex, so as to form a cup-shaped body, to which the lower part of the calyx is attached, as in *Eschscholtzia*; or other modifications may occur.

In some cases the peduncle or pedicel becomes flattened and assumes the form of a phyllode, in which case it is termed *foliaceous* or *phylloid*; or it is called a *phylloclade* or *cladode*. Examples of this occur in the Butcher's Broom (*fig.* 409), where the flowers arise from its surface; and in *Xylophylla*, in which the flowers are attached to its margins. Sometimes the peduncle, or several peduncles united, assume an irregular flattened appearance, somewhat resembling the fasciated branch

FIG. 410.

FIG. 411.

Fig. 410. Peduncle of the Lime-tree (*Tilia europæa*) attached to the bract, *b*.——*Fig.* 411. Branch of Woody Nightshade (*Solanum Dulcamara*), with extra-axillary peduncle, and auriculate leaf.

already described (page 113), and bear numerous flowers in a sort of crest at their extremities, as in the Cockscomb; and in the Cauliflower, where the united fleshy branches of the peduncle form a rounded mass bearing on its upper part abortive flowers.

Insertion.—In speaking of the branches of a stem, we found that in some cases, instead of arising in the axil of leaves, they became *extra-axillary* (page 113) in consequence of adhesions of various kinds taking place between them and the stem and other parts. In like manner the peduncle may become *extra-axillary* by contracting adhesions. Thus, in the Lime-tree (*fig.* 410), the peduncle adheres to the midrib of the bract, *b*, for some distance, and then becomes free ; while in many Solanaceæ, as in the Woody Nightshade (*fig.* 411), the peduncle also becomes extra-axillary by forming adhesions to the stem or branch in various ways.

Duration.—With respect to their duration the peduncle and pedicel vary. Thus they are said to be *caducous*, when they fall off soon after the opening of the flower, as in the staminate or male flowers of a catkin ; they are *deciduous*, when they fall off after the fruit has ripened, as in the Cherry ; they are *persistent*, if they remain after the ripening of the fruit and dispersion of the seed, as in the Dandelion ; and they are said to be *excrescent*, if they enlarge or continue to grow during the ripening of the fruit, as in the Cashew-nut.

3. KINDS OF INFLORESCENCE.

The term *inflorescence* or *anthotaxis* is used in a general sense to indicate the arrangement of the flowers upon the floral axis or peduncle, in the same way as the term *phyllotaxis* is used in a general sense to indicate the various modes in which the leaves are arranged on the stem or branches, and that of *vernation* for the arrangement of the component rudimentary leaves of leaf-buds. As flowers are variously arranged upon the floral axis, we have a number of different kinds of inflorescence, and to each mode of arrangement a particular name is applied. These modifications are always the same for the same species of plant, and frequently for entire genera, and even natural orders, and hence their discrimination is of much practical importance. All the regular kinds may be arranged in two divisions : and if the general characters upon which they depend are understood, their several modifications will be readily intelligible. These two are usually called *Indefinite* or *Indeterminate*, and *Definite* or *Determinate Inflorescence.* The former is also sometimes termed *Botryoid* or *Botryose* ; and the latter *Terminal* or *Cymose Inflorescence.* In the former, the primary floral axis is terminated by a growing point, analogous to the terminal leaf-bud of a stem or branch ; hence such an axis has the power of either growing in an upward direction, in the same manner as the terminal leaf-bud of a stem or branch has the power of elongating, and thus adding to its length ; or of dilating more or less horizontally. There is consequently no necessary limit to the growth of such an axis, and hence the name of Indeterminate or Indefinite which is applied to it. Such an axis as it continues to grow upwards develops on its sides other flower-buds, from which flowers are produced, and these, like the buds of a stem or branch, are commonly situated in the axil of leaves which are here called bracts, as we have seen. All the flowers therefore of an Indefinite Inflorescence must be necessarily *lateral* or *axillary*, and hence this inflorescence is also termed *axillary*. The general characters of *Indefinite*, *Indeterminate*, or *Axillary Inflorescence*, depend therefore upon the indefinite growth of the primary axis ; while the secondary, tertiary, and other axes which are developed from it, are terminated by flower-buds. In the *Definite* or *Determinate Inflorescence*, on the contrary, the primary axis is terminated at an early period by the production of a flower-bud ; such an axis has therefore a limit at once put to its growth in an upward direction, and hence the names of *Definite*, *Determinate*, or *Terminal*, applied to it. Each of these primary divisions presents us with several modifications, which we now proceed to describe.

1. Indefinite, Indeterminate, or Axillary Inflorescence.—The simplest kind of inflorescence in this class is that presented by such plants as the Pimpernel (*fig.* 394), in which solitary flowers, *b*, *b*, are developed in the axils of what are commonly regarded as the ordinary foliage leaves of the plant, *a*, *a*, although properly leafy bracts, the primary axis continuing to elongate in an upward direction and bearing other leaves and flowers ; the flowers are then said to be *solitary* and *axillary*. When such flowers are arranged in whorls round the stem, as in the common Mare's Tail, each flower being axillary to a leafy bract (*fig.* 412), they are said to be *whorled*.

Fig. 412.

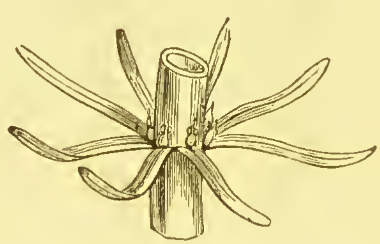


Fig. 412. Whorled leafy bracts and solitary axillary flowers of Mare's Tail (*Hippuris vulgaris*).

When a number of flowers instead of a single one are developed upon an elongated, shortened, or dilated, peduncle placed at the extremity of a branch, or in the axil of a bract, a number of kinds of inflorescence arise. All these depend upon the extent to which the floral axis branches, the mode in which the branching takes place, the comparative lengths of the flower-stalks, and other subordinate circumstances. It will be convenient to describe these various modifications under two heads—1st, those kinds of Indefinite Inflorescence with an Elongated Primary Axis ; and 2nd, those with a Shortened or Dilated Primary Axis.

In all kinds of indefinite inflorescence it will be found that the flower-buds always open in succession from the base to the apex if the axis is elongated (*figs.* 414 and 422), hence these inflorescences have been also called *acropetal* or *ascending* ; or from the circumference towards the centre if the axis is shortened or dilated (*fig.* 428), therefore such forms are also called *centripetal*. This acropetal or centripetal order of expansion necessarily arises from the mode of development of such kinds of inflorescence ; thus, the flower-buds situated at the base of an elongated axis are those that are first formed and consequently the oldest; for as the axis elongates upwards it is continually producing other flower-buds, the age of which continues to decrease as we approach the growing point or apex; and as flower-buds are necessarily most developed in the order of their age, it follows that those at the base will open first, and that the order of expansion will proceed gradually upwards towards the apex, or *acropetally*. In the same way the flower-buds situated at the circumference of a shortened or dilated axis are first formed, and those nearest the centre or growing point last, and therefore their expansion will proceed from the circumference to the centre, or *centripetally*.

FIG. 413.

FIG. 414.

Fig. 413. Spike of a species of Rib-grass (*Plantago*).——*Fig.* 414. Spike of Vervain (*Verbena*).

A. *Kinds of Indefinite or Indeterminate Inflorescence with an Elongated Primary Axis.*—These are as follows:—

a. *The Spike.*—This is a kind of inflorescence in which the peduncle is elongated and bears sessile flowers, or flowers in which the pedicels are very short, so as not to be clearly distinguishable. Examples of it may be seen in the Rib-grass (*fig.* 413), and Vervain (*fig.* 414). In this kind of inflorescence it will be observed that the flowers at the lower part of the spike have passed into fruit (*fig.* 414), while those near the middle are in full flower, and those at the top are still undeveloped. Such an inflorescence exhibits therefore, in a marked degree, the acropetal order of expansion.

There are five other kinds of indefinite inflorescence which are simply modifications of the spike. These are the Amentum or Catkin, the Spadix, the Locusta, the Cone, and the Strobile.

b. *The Amentum or Catkin.*—This is a kind of spike which usually bears barren flowers—that is, only staminate (*fig.* 415), or only pistillate (*fig.* 416) ones. The flowers of an amentum are also usually separated from one another by scaly bracts, and the whole inflorescence (at least as regards the staminate catkins) commonly falls off in one piece, soon after the process of flowering. The bracts have sometimes *one*, or at other times *several* flowers in their axils. All plants with this kind of inflorescence are called *amentaceous* or *amentiferous*. Our trees afford numerous examples, as the Oak, Willow, Birch, and Poplar.

c. *The Spadix* is a spike with a succulent peduncle, in which the individual flowers have no special bracts, but the whole inflorescence enclosed in that variety of bract which is called a spathe. This is well seen in the Cuckoo-pint (*fig.* 403). Sometimes the spadix branches, as in Palms (*fig.* 417), in which case it is called *compound* or *branching*. The term spadix is also usually applied to a succulent spike, whether enveloped in a spathe or not, as in the Sweet Flag (*Acorus Calamus*).

FIG. 415.

FIG. 416.

Fig. 415. Staminate amentum or catkin of a species of Willow (*Salix*).——*Fig.* 416. Pistillate or carpellary amentum of a species of Willow, with bracts between the carpels.

d. *The Locusta or Spikelet.*—This name is given to the partial inflorescence of Grasses (*fig.* 405), and of plants of the Sedge Order. In grasses it is a spike with a few flowers, and these destitute of a true calyx and corolla, their place being occupied by *paleæ* or *pales* (*fig.* 405, *ps*, *pi*), and the whole inflorescence surrounded at the base by one or two empty bracts (*glumes*), *gl*, *gl*. These spikelets may be either arranged sessile on the elongated peduncle or rachis (*fig.* 418), as in Wheat, or they may be placed on a more or less branched axis, as in the Oat (*fig.* 419). The spikelets of plants of the Sedge Order present certain peculiarities, but they are essentially of the same nature as those of Grasses.

e. *The Cone.*—This is a kind of spike, found in plants of the order Coniferæ, as the Larch, Pine, and Fir (*figs.* 293 and 420). It is composed of a collection of imbricated scales or open carpels arising from the axils of bracts, and bearing two or more naked ovules at their base (*fig.* 17, *ov*).

The cone is sometimes regarded as the fruit or *pseudocarp* of a single flower, and not an inflorescence or collection of flowers as here described. Some, again, do not distinguish between a cone and a strobile, but put the two inflorescences together under the common name of *cone* or *strobilus*, which they define as a collection of persistent woody or membranous scales or bracts, each of which bears a pistillate flower at its base.

Fig. 417.

Fig. 418.

Fig. 419.

Fig. 417. Branched spadix of a Palm (*Chamærops*), enveloped in a spathe.——*Fig.* 418. Inflorescence of Wheat (*Triticum vulgare*), consisting of numerous sessile spikelets arranged on an elongated peduncle (*rachis*).——*Fig.* 419. Branched or panicled arrangement of the spikelets of the Oat (*Avena sativa*).

f. *The Strobile.*—This is a kind of spike formed of persistent membranous bracts or scales, each of which bears at its base a pistillate flower. It is seen in the Hop (*fig.* 421).

All the kinds of indefinite inflorescence at present described owe their essential characters to the flowers being *sessile* upon an elongated axis. We now pass to describe others, in which the axis is more or less branched, and the flowers consequently situated upon stalks. The simplest of these is the Raceme.

g. *The Raceme.*—This name is applied to that form of inflorescence in which the elongated peduncle or rachis bears flowers placed on pedicels of nearly equal length (*fig.* 422). It only differs from the spike in the flowers being distinctly stalked instead of sessile or nearly so. Examples occur in the Currant, Mignonette, Hyacinth, Laburnum, Barberry, and Fumitory.

Fig. 420.

Fig. 422.

Fig. 421.

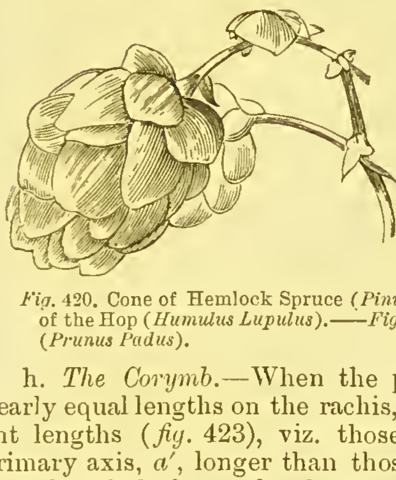


Fig. 420. Cone of Hemlock Spruce (*Pinus canadensis*).——*Fig.* 421. Strobile of the Hop (*Humulus Lupulus*).——*Fig.* 422. Raceme of a species of Cherry (*Prunus Padus*).

h. *The Corymb.*—When the pedicels, instead of being of nearly equal lengths on the rachis, as in the raceme, are of different lengths (*fig.* 423), viz. those, a'' a'', at the base of the primary axis, a', longer than those towards and at the apex, so that the whole form a level, or nearly level top, the inflorescence is termed a *corymb*. Examples may be seen in some species of *Prunus* (*fig.* 423). When the stalks or secondary axes of a corymb (*fig.* 424, a'') instead of bearing flowers immediately, divide and form tertiary, a''' a''', or other axes, upon which the flowers are then placed, it is termed *compound* or *branching*, as in some species of *Pyrus*. This may also be called a *panicled corymb* (see Panicle), to distinguish it from the former or *simple* corymb, which is then termed a *racemose corymb*. It sometimes happens that when the flowers are first developed they form a corymb, but as the primary axis elongates a raceme is produced; this may be seen in many Cruciferous plants.

In several species of *Juncus* and *Luzula*, the pedicels of the lower flowers are so long that they are elevated above the upper ones, in which case the inflorescence is sometimes distinguished by the term *anthela*.

i. *The Panicle.*—This is a sort of compound raceme, that is to say, a raceme in which the secondary axes, instead of pro-

FIG. 423.

FIG. 424.

Fig. 423. Simple corymb of a species of *Prunus* (*Cerasus*). a'. Primary axis, bearing bracts, b, b, from the axis of which pedicels, a'', a'', arise. ——*Fig.* 424. Compound or branching corymb of the Wild Service tree (*Pyrus torminalis*). a'. Primary axis. a'', a''. Secondary axes. a''', a'''. Tertiary axes. b, b, b. Bracts.

FIG. 425.

Fig. 425. Panicle.

ducing flowers directly, branch, and form tertiary axes, &c., the ultimate subdivisions of which bear the flowers (*fig.* 425). Examples occur in the *Yucca gloriosa*, and in the general arrangement of the partial inflorescences of the Oat (*fig.* 419). When the panicle is much branched and the flowers placed on short pedicels, so that the whole inflorescence forms a compact cluster of a somewhat pyramidal form, as in the Lilac and Vine, it is sometimes termed a *thyrsus* or *thyrse* (*fig.* 426).

B. *Kinds of Indefinite Inflorescence with a Shortened or Dilated Primary Axis.*—Of these we distinguish two varieties :—the Capitulum or Anthodium, and the Umbel.

a. *The Capitulum, Anthodium, or Head.*—This inflorescence was formerly called a *Compound Flower* ; and its involucre a *Common Calyx.* Its constituent flowers from their small size are commonly termed *florets.* This inflorescence is usually formed

FIG. 426.

FIG. 427.

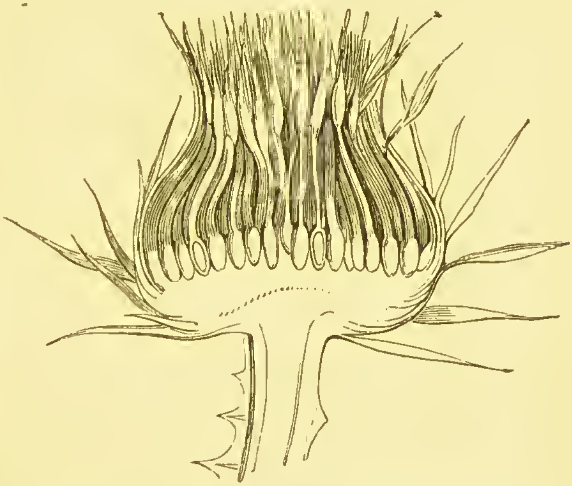


Fig. 426. Thyrsus of Vine (*Vitis vinifera*).——*Fig.* 427. Capitulum of Cotton Thistle (*Onopordum Acanthium*).

[illegible] Horsechestnut

by a number of sessile florets crowded together on a receptacle, and the whole surrounded by an involucre (*fig.* 399) ; but in some cases the florets are but few in number, and in other capitula the involucre is absent. The receptacle, as we have seen (page 198), may be either flattened, as in the Cotton Thistle (*fig.* 427) ; or slightly convex, as in the Dandelion ; or conical, as in the Chamomile ; or globular, as in the American Button-bush ; or elliptical, &c., by which a variety of forms is given to the different capitula.

This kind of indefinite inflorescence, as well as all others in this division with shortened or dilated primary axes, also exhibit a centripetal order of expansion. This may be well seen in the capitulum of the Scabious (*fig.* 428), where the outer florets are fully expanded, those within them less so, and those in the centre in an unexpanded condition. Here therefore the order of expansion is towards the centre—that is, *centripetally*. The capitulum is the universal form of inflorescence in plants of the natural orders Compositæ and Dipsacaceæ ; and is also found, more or less, in some orders allied to these. Capitula of a less marked character are also to be seen in other orders ; as in the species of Clover (*Trifolium*), and many Proteaceous plants ; in these, however, the involucre is always absent.

The arrangement of the flowers in the Fig (*fig.* 406) and Dorstenia (*fig.* 407) also closely resembles that of an ordinary capitulum, and such arrangements are sometimes regarded as special varieties of the capitulum ; but the involucre is in these

Fig. 428.

Fig. 429.

Fig. 428. Capitulum of Scabious (*Scabiosa*). The outermost florets may be observed to be more expanded than the inner.——*Fig.* 429. Simple umbel of a species of *Allium*.

inflorescences always absent, and the flowers are developed centrifugally, as in the *glomerule* (page 216), to which kind of inflorescence they therefore more properly belong.

b. *The Umbel.*—When the primary axis is shortened, and gives off from its apex a number of secondary axes or pedicels of nearly equal length, each bearing a flower, and the whole arranged like the ribs of an umbrella, an *umbel* is formed (*fig.* 429), as in the Onion and Cowslip. When the secondary axes themselves divide, and form tertiary axes, which are also arranged in an umbellate manner, a *compound umbel* is produced. This is seen in the Carrot (*fig.* 398), the Fennel (*fig.* 430), and other allied plants, which are hence called *umbelliferous*, and give the name to the natural order Umbelliferæ. In the compound umbel (*fig.* 430), the primary umbel *a* is called the *general umbel*, and the other umbels, *b*, *b*, *b*, formed by the divisions of this, *partial umbels* or *umbellules.* When the base of the general umbel is surrounded by a whorl of bracts (*fig.* 398, *a*) they constitute a *general involucre* ; and if other bracts, *b*, *b*, are arranged in a similar manner around the partial umbels, each of these whorls of bracts forms an *involucel* or *partial involucre.* These varieties of arrangement have been already alluded to when speaking of bracts (page 195).

Fig. 430.

Fig. 431.

Fig. 430. Compound umbel of Fennel. *a*. General umbel. *b*, *b*, *b*. Partial umbels or umbellules.——*Fig.* 431. Portion of the floral axis of a species of Gentian (*Gentiana acaulis*), terminated by a solitary flower, below which are two bracts.

2. Definite, Determinate, or Terminal Inflorescence. In all kinds of definite inflorescence the primary axis, as we have seen, page 201, is arrested in its growth at an early age by the development of a terminal flower-bud, and if the axis bears no other flower this is called a *solitary terminal* flower, and is the simplest form of this variety of inflorescence. Examples of this may be seen in the Stemless Gentian (*fig.* 431), and in the Wood Anemone (*Anemone nemorosa*). When other flowers are produced on such an axis, they must necessarily arise from axillary flower-buds placed below the terminal flower-bud ; and if these form secondary axes (*fig.* 432, a''), each axis will in like manner be arrested in its growth by a terminal flower-bud f'' ; and if other axes a''' are developed from the secondary ones, these also must be axillary, and will be arrested in a similar manner by flowers f''', and these axes may also form other axes of a like character, and so on. Hence this mode of inflorescence is *definite*, *determinate*, or *terminal*, in contradistinction to the former or indefinite mode of inflorescence already described, where the primary axis elongates indefinitely unless stopped by some extraneous cause. Definite inflorescences are most common and regular in plants with opposite or whorled leaves, but they also

occur in those which have alternate leaves, as for instance in the species of *Ranunculus* (*fig.* 432). In definite inflorescences the flower-buds necessarily follow a different order of expansion from those of indefinite inflorescences, because in them the terminal flower is the first developed and consequently the oldest (*fig.* 432, f'), and other flower-buds are produced in succession from the apex to the base, if the axis be elongated, f'' f'''; or if shortened or dilated, from the centre to the circumference. The uppermost flower-bud of the elongated primary axis (*fig.* 432, f'), and the central one of the shortened or dilated axis will accordingly open first; and the expansion of the other flower-buds will proceed in succession downwards, or towards the circumference, according to the character of the primary axis. Such an order of expansion is called *centrifugal* or *regressive*. Hence while the indefinite kinds of inflorescences are characterised by an *acropetal*, *progressive*, or *centripetal* order of expansion; those of definite inflorescences are *regressive* or *centrifugal*.

FIG. 432.

Fig. 432. A plant of *Ranunculus bulbosus*. a', a'. Primary axis terminated by a fully expanded flower, f'. a''. Secondary axis, which is also terminated by a flower, f'', not so fully developed as f'. a'''. Tertiary axis terminated by a flower-bud, f''', which is less developed than f' and f''.

Kinds of Definite or Determinate Inflorescence. — The kinds of definite inflorescence are also termed *cymose*, as the general name of cyme is applied to all such inflorescences. But some are also distinguished by special names :—

a. *The Cyme.*—This term is applied generally to a definite inflorescence which is more or less branched, the whole being developed in a corymbose or somewhat umbellate manner, so as to assume either a flattened head, as in the Laurustinus (*fig.* 433), Dogwood, and Elder; or a rounded one, as in the Hydrangea; or more or less spreading, as in the Chickweed (*fig.* 434) and Centaury (*fig.* 435). In the more perfect and compact form of cyme, as found in the Laurustinus and Elder, the flower-buds are all nearly perfect before any of them open, and then the flowering takes place rapidly, commencing in the centre of the cyme, and then in the centre of each of its divisions, and thence proceeding in an outward direction ; and as the central flower of

FIG. 433.

Fig. 433. Cyme of Laurustinus (*Viburnum Tinus*).

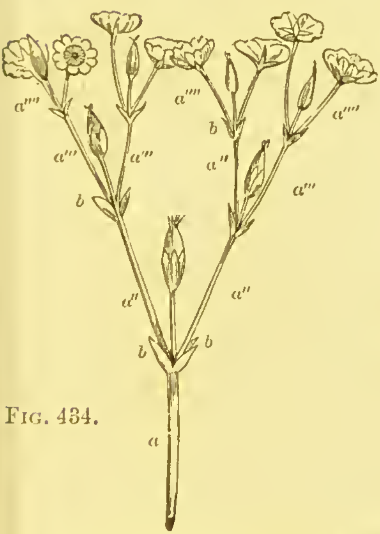


FIG. 434.

FIG. 435.

Fig. 434. Dichasial cyme or Dichasium of a species of Chickweed (*Cerastium*). a'. Primary axis terminated by a flower. a'', a''. Secondary axes, two in number, arising from the axils of opposite bracts, b, b, and terminated also by flowers. a''', a''', a''', a'''. Tertiary axes, four in number, arising from bracts, b, and bearing other bracts, b, from which the quaternary axes, eight in number, arise, a'''', a'''', a''''. The flowers are more developed on the primary axis than on the other axes ; thus the one terminating that axis is in the state of fruit ; the flowers of the axes of a'' and a''' are also in fruit, but less developed than that of a', while in the axes a'''' the flowers only are expanded.——*Fig.* 435. Dichasial cyme or Dichasium of the Centaury (*Erythræa Centaurium*). a', a'', a''', a''''. Floral axes. f', f'', f''', f''''. Flowers terminating those axes respectively. The flowers will be observed to be most developed in proportion to their age ; thus f' is in the state of fruit, f'', f'', expanded, f''', f''', f''', and the others still in bud.

each cluster corresponds to the apex of a branch, the expansion of the whole is centrifugal. By attention to this order of expansion such cymes may be always distinguished from indefinite kinds of inflorescence, such as the umbel or corymb, to which otherwise they bear in many cases a great resemblance. In the Chickweed (*fig.* 434), and many other plants, the formation of the secondary, tertiary, and other axes a'', a''', a'''', goes on throughout the growing season, and in such cymes, which are usually of a more or less spreading nature, the centrifugal order of expansion may be well observed.

Fig. 436.

Fig. 437.

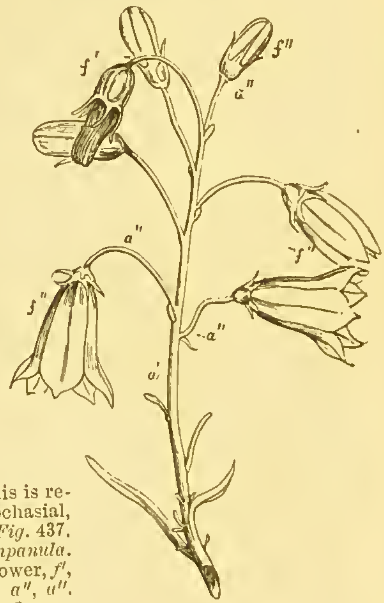


Fig. 436. Spiked cyme of *Sedum*. This is regarded by Sachs as a form of monochasial, uniparous, or unilateral cyme.——*Fig.* 437. Racemose cyme of a species of *Campanula*. a'. Primary axis terminated by a flower, f', which is already withering. a'', a'', a''. Secondary axes, each ending in a flower, f'', f'', f''.

The above cymes are sometimes characterised according to the number of their branches : thus they are *dichotomous*, as in the common Centaury (*fig.* 435), when the primary axis a' is terminated by a flower f', at the base of which are two bracts, each of which develops in its axil secondary axes a'', a'', ending in single flowers, f'', f'' ; and at the base of each of these flowers there are also two other bracts, from which tertiary axes a''', a''', are developed, also terminated by flowers f''', f''', and so on, and as the division in this case always takes place into two branches, the cyme is said to be *dichotomous*. The cyme of the Chickweed (*fig.* 434) is also *dichotomous*. The dichotomous cyme is also called a *biparous cyme* or *dichasium*. This is not a true dichotomous branching (see page

110), but only apparently so, in consequence of the greater development of the lateral branches as compared with that of the terminal one.

Such cymes are also frequently characterised as corymbose, or umbellate, from their resemblance, except in the order of the expansion of their flowers, to the true corymb, or umbel; or as globose, linear, &c., according to their general form.

Again, when a definite inflorescence does not assume a more or less corymbose or umbellate form, as in the ordinary cyme just described, it is also best characterised by terms derived from the kind of indefinite inflorescence to which it bears a resemblance. Thus, when a cyme has sessile flowers, or nearly so, as in the *Sedum* (*fig.* 436), it may be described as a *spiked cyme*; when it has its flowers on pedicels of nearly equal length, as in the *Campanula* (*fig.* 437), as a *racemose cyme*; or when it assumes the form of a panicle, as in the Privet (*fig.* 438), as a *panicled cyme.* These latter terms, however, although in many cases very characteristic, are but little employed. These forms of cymes are readily distinguished from the true racemes and other kinds of indefinite inflorescence, by the terminal flowers opening first, and the others expanding in succession towards the base, or in a centrifugal manner: while in the true raceme, and the other kinds of indefinite inflorescence, the flowers open first at the base and last at the apex, or centripetally.

Besides the ordinary cyme and its varieties now mentioned, other kinds of cymose inflorescences have also received particular names, as the *Helicoid* or *Scorpioid Cyme*, the *Fascicle*, the *Glomerule*, and the *Verticillaster*: these we must now briefly describe.

b. *Helicoid or Scorpioid Cyme.*—This is a kind of cyme in which the flowers are only developed on one side, and in which the upper extremity is more or less coiled up in a circinate manner, so as frequently to resemble a snail, or the tail of a scorpion; hence the names *helicoid* and *scorpioid* by which such a cyme is distinguished. This kind of cyme is especially developed in plants of the Boraginaceæ, as the Forget-me-not (*fig.* 439), and the Comfrey (*fig.* 440). In these plants the bracts are alternate; but such a cyme may also occur in plants with opposite bracts, and the manner in which it is most commonly believed to be formed in the two cases, is as follows:—Thus, in plants in which the bracts are opposite, it arises by the regular non-development of the axes on one side, while those on the other side are as regularly produced. This will be readily explained by a reference to the diagram (*fig.* 441). Here *a* represents the flower which terminates the primary axis; at the base of this flower are two bracts, only one of which develops a secondary axis *b*, which is in like manner terminated by a flower, at the base of which are also two bracts, only one of which, (i.e. that on the same side with the first) produces a tertiary axis c, also terminated by a flower with two bracts at its base, one of which gives origin to another

FIG. 438.

FIG. 439.

Fig. 438. Panicled cyme of the Privet (*Ligustrum vulgare*). a'. Primary axis. a'', a''. Secondary axes. a''', a'''. Tertiary axes. c, c. The central flowers of the respective clusters, which are seen to be in a more expanded state than those surrounding or below them. ——*Fig.* 439. Helicoid cyme of the Forget-me-not (*Myosotis palustris*).

FIG. 440.

Fig. 440. Helicoid cyme of Comfrey (*Symphytum officinale*).

axis, *d*, placed in a similar manner, and so on. The place of the axis which is undeveloped at each ramification is indicated by a dotted line. In consequence of this one-sided (or as it is called *secund*) manner in which the successive axes are produced, the direction of the inflorescence is constantly drawn to one side at the formation of each axis, and that in proportion to the size of the angle formed by it with the axis from which it springs, and thus when the angle is large, and many flowers are produced in succession, the upper extremity becomes completely coiled up in a circinate manner (*fig.* 441). In plants with alternate bracts, the helicoid cyme arises from the primary axis (*fig.* 442, 1) being terminated by a flower, and giving off below it from the uppermost bract a secondary axis 2, which

Fig. 441.

Fig. 442.

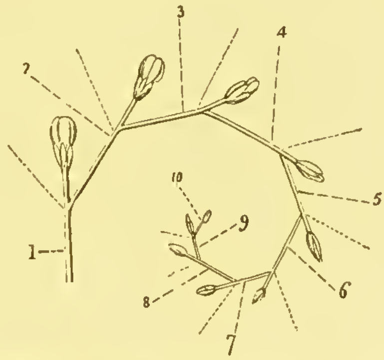


Fig. 441. Diagram to illustrate the formation of a helicoid or scorpioid cyme in a plant with opposite bracts. *a*. Flower terminating the primary axis. *b*. Secondary axis. *c*. Tertiary axis. *d*. Quaternary axis. Each axis is terminated by a flower. The dotted lines represent the position of the undeveloped axes.——*Fig.* 442. Diagram to illustrate the formation of a helicoid or scorpioid cyme in a plant with alternate bracts. The figures represent the respective axes, and the dotted lines below the flowers the position of the bracts.

also terminates in a flower, and gives off below it in like manner from the same side as the former a third axis 3, which likewise terminates in a flower, and so on as seen by the figures. The place of the bracts is indicated by the dotted lines below the flowers.

The terms *helicoid* and *scorpioid* are thus used by us indifferently to indicate the same form of *unilateral*, *monochasial*, or *uniparous cyme*. This is the sense in which we have employed them in previous editions of this Manual, and in which we follow De Candolle, Le Maout, Decaisne, Hooker, and many other botanists. We are still induced to do so, because their nature is at present by no means well defined, and from the synonymy being best understood and practically exemplified in Descriptive Botany, at least in this country. But many Continental botanists distinguish two kinds of uniparous cymes, under the respective names of *helicoid cyme* or *bostryx*, and *scorpioid cyme* or *cicinnus*. Thus in what is termed the *helicoid cyme*, the successive lateral branches always arise from the same side,—that is, either right or left of the main axis (see page 110, and *fig.* 216, A), as in *Hemerocallis*; while in the *scorpioid cyme* the successive lateral axes are developed alternately right and left of the main axis (see page 110, and *fig.* 216, B), as in the Rock Rose (*Helianthemum*), and Sundew (*Drosera*).

Both helicoid and scorpioid cymes have been commonly regarded as sympodial inflorescences; and to consist of a series of single-flowered axes, all of which are developed on one side as in the former, or alternately on opposite sides as in the latter. The investigations, however, in recent years of Kraus, George Henslow, Goebel, and other botanists, seem to prove that the scorpioid cyme is not a sympodial development, but a monopodial or indefinite kind of inflorescence, or, in other words, a unilateral raceme.

Practically, the helicoid or scorpioid cyme, in the sense as defined by us above, may be distinguished from the ordinary raceme, at least when the bracts are developed, as follows:—thus, in the raceme, the flowers always arise from the axil of the bracts, while in the cyme they are placed opposite to the bracts (*fig.* 442), or, at all events, more or less extra-axillary. But in those cases where the bracts are abortive, as in most plants of the Boraginaceæ, its discrimination from the raceme is often difficult, or even impossible, and its nature can only be ascertained by comparison with allied plants.

Other views of the nature of these cymes have been also entertained by botanists; thus, Kaufmann and Warming believe that bracteate scorpioid cymes arise from repeated dichotomy of the apex of an axillary bud. The further discussion of this subject, however, would be out of place in an elementary manual, and therefore for more detailed particulars we must refer our readers to Sachs's 'Text-Book of Botany,' and to an article in 'Trimen's Journal of Botany,' for January 1881, on 'The History of the Scorpioid Cyme,' by Sydney H. Vines.

c. *The Fascicle or Contracted Cyme.*—This name is applied to a cyme which is rather crowded with flowers placed on short pedicels of nearly equal length, and arising from about the same point, so that the whole forms a flattened top, as in the Sweet William and some other plants of the Pink order to which it belongs.

a definate capitulum

d. *The Glomerule.*—This is a cyme which consists of a few sessile flowers, or of those where the pedicels are very short, collected into a rounded head or short spike. Examples may be seen in many Labiate plants, in species of Nettle, and in the Box (*fig.* 443).

e. *The Verticillaster.*—This kind of cyme is seen in the

an axillary cyme.

White Dead-nettle (*fig.* 393), and commonly in other plants of the Labiate order to which it belongs. In it the flowers appear at first sight to be arranged in whorls around the axis, but upon examination it will be seen that in each apparent whorl there are two clusters or glomerules axillary to two leafy bracts, the central flowers of which open first, and hence the mode of expansion is centrifugal. To these false whorls, thus formed of two axillary glomerules, the term *verticillaster* is frequently applied ; but this variety of inflorescence is sometimes regarded as a contracted form of the dichasium.

We have now finished our description of the different kinds of regular inflorescence, and from what we have already stated,

FIG. 443.

FIG. 444.

Fig. 443. Inflorescence of the Box (*Buxus sempervirens*).——*Fig.* 444. Mixed inflorescence of a species of *Senecio*.

it may be readily understood that they may be situated either at the apex of the stem, or at the extremities of branches, or in the axil of bracts. But besides the above regular kinds of inflorescence, all of which are comprehended under the two divisions of indefinite and definite as now described, there is a third division, which consists in a combination of these two forms, to which the term *mixed inflorescence* has been accordingly given.

3. MIXED INFLORESCENCE.—This kind of inflorescence is by no means uncommon. It is usually formed by the general inflorescence developing in one way, and the partial or individual inflorescences in another. Thus in plants of the natural order Compositæ (*fig.* 444), the terminal capitulum is the first to expand, and the capitula, as a whole, are therefore developed in

a centrifugal manner; while the individual capitula open, as we have seen (page 208), their florets from the circumference to the centre, or centripetally; hence, here the general inflorescence is *definite*, and each partial inflorescence *indefinite*. In Labiatæ plants we have a directly reverse arrangement, for here the individual verticillasters open their flowers centrifugally (*fig.* 393), but the general inflorescence is centripetal; hence the general inflorescence is here *indefinite*, while each partial inflorescence is *definite*.

Section 2. Of the Parts of the Flower; and their Arrangement in the Flower-bud.

In common language, the idea of a flower is restricted to that portion in which its bright colours reside; but botanically, we understand by the flower, the union of all the organs which contribute to the formation of the seed. We have already stated that the parts of the flower are only leaves in a modified condition, or rather, the *analogues* of those organs, or more properly *homologous* formations adapted for special purposes; and that hence a flower-bud is to be considered as the analogue of a leaf-bud, and the flower itself of a branch the internodes of which are but slightly developed, so that all its parts are placed in nearly the same plane. The detailed examination of this theoretical notion of a flower will be reserved till we have finished the description of its different parts or organs, when we shall be better able to understand it, as well as other matters connected with its symmetry, and the various modifications to which it is liable. (*See* General Morphology.)

1. Parts of the Flower.

The parts of a flower have been already treated of in a general manner. (See page 17.) But before describing them in detail we must treat of their arrangement in the flower-bud—that is, of *æstivation*.

2. Æstivation or Præfloration.

As the general arrangement of the rudimentary leaves of the leaf-bud is called *vernation* (the spring state), or *præfoliation*, so the mode in which the different parts of the flower are disposed in the flower-bud is termed their *æstivation* (the summer state), or *præfloration*. The various modifications of æstivation are generally the same as those of vernation, and the terms employed in describing them are therefore similar; but the former present some peculiarities, which renders it necessary for us briefly to refer to their different arrangements. The terms used in æstivation especially refer to the relative positions of the component parts of the calyx and corolla, because the stamens and carpels, from their peculiar forms, can give us no such arrangements of their parts as are exhibited by the more or less flattened floral envelopes.

In describing the modifications of æstivation, we have, as in the case of vernation, to include: 1st, the disposition of each of the component parts of the floral envelopes, considered independently of the others; and 2nd, the relation of the several members of either of the floral envelopes taken as a whole in respect to one another. With regard to the disposition of each of the component parts of the floral envelopes considered independently of the others, the same terms are used as in similar modifications of vernation (page 156), with the addition of the *crumpled* or *corrugated* form, which is not found in the parts of the leaf-bud. This latter variety may be seen in the petals of the Poppy (*Papaver*), and Rock Rose (*Helianthemum*); and it derives its name from the parts being irregularly contracted into wrinkled folds.

With respect to the relation of the several members of either of the floral envelopes taken as a whole to one another, various

FIG. 445. FIG. 446. FIG. 447. FIG. 448.

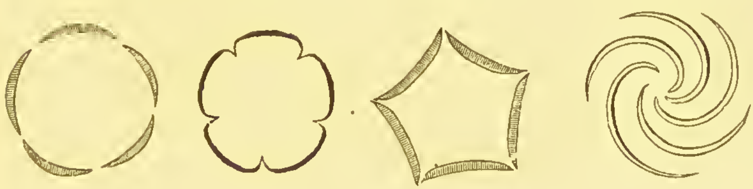


Fig. 445. Diagram to illustrate valvate æstivation.——*Fig.* 446. Diagram to illustrate induplicate æstivation.——*Fig.* 447. Diagram to illustrate reduplicate æstivation.——*Fig.* 448. Diagram to illustrate contorted or twisted æstivation.

modifications occur, all of which may be arranged in two divisions: namely, the *Circular*, and the *Imbricated* or *Spiral Æstivation*. The former includes all those varieties in which the component parts of the whorl are placed in a circle, and in nearly the same plane: and the latter those where they are placed at slightly different levels in a more or less spiral manner, and overlap one another.

1. *Varieties of Circular Æstivation.*—We distinguish three well-marked varieties of circular æstivation, i.e. the *valvate*, *induplicate*, and *reduplicate*. The *valvate* (*fig.* 445) may be seen in the calyx of the Lime, and in that of *Guazuma ulmifolia*; in this variety the component parts are flat or nearly so, and in contact by their margins throughout their whole length without any overlapping. This variety of æstivation may be generally distinguished, even when the flowers are expanded, by the margins

of its component parts being slightly thickened, or at all events not thinner than the rest of the organ: whereas in all varieties of imbricated or spiral æstivation, the overlapping margins are usually thinner, as may be well seen in the sepals of the species of Geranium. When the component sepals, or petals, instead of being flattened, are folded inwards at the points where they come in contact (*fig.* 446), the æstivation is *induplicate*, as in the petals of *Guazuma ulmifolia*, and in the sepals of some species of *Clematis*. When the margins are turned outwards under the same circumstances (*fig.* 447), the æstivation is *reduplicate*, as in the sepals of the Hollyhock (*Althæa rosea*), and some other Malvaceous plants; and in the petals of the Potato.

When the parts of a whorl are placed at the same height, or apparently so, as in the ordinary forms of circular æstivation, and one margin of each part is directed obliquely inwards, and is overlapped by the part adjacent on that side, while the other margin covers the corresponding margin of the adjoining part on the other side, so that the whole presents a more or less twisted appearance (*fig.* 448), the æstivation is *contorted* or *twisted*. It occurs very frequently in the corolla, but is very rare in the calyx. Examples may be seen in the corolla of the Hollyhock and other Malvaceous plants; in that of the common Flax (*Linum usitatissimum*), and generally in the order Linaceæ; in the St. John's Wort (*Hypericum*); in the Periwinkle (*Vinca*), and in many other plants of the order Apocynaceæ, to which this plant belongs. Twisted æstivation may be regarded as intermediate between the circular and imbricated forms. When in this variety of æstivation the component organs become united, they may be variously *plaited* or *plicate*, as in the corolla of the common Bindweed and of other Convolvulaceæ, in which case the æstivation is usually termed *plicate* or *plaited*.

2. *Varieties of Imbricated or Spiral Æstivation.*—We distinguish five varieties of this kind of æstivation, i.e., the *imbricate*, *convolute* or *enveloping*, *quincuncial*, *cochlear*, and *vexillary*. The true *imbricate* æstivation, as seen for instance in the calyx of *Camellia japonica* (*fig.* 449), is formed by the component parts being placed at different levels, and overlapping each other more or less by their margins like the tiles on the roof of a house, the whole forming a spiral arrangement; this is a very common variety. When the parts, instead of merely overlapping, completely envelope each other, as in those of the calyx of *Magnolia grandiflora*, and in those of the corolla of *Camellia japonica*, the æstivation is termed *convolute* by some botanists; but this term is now more frequently applied to the contorted variety of æstivation, when the parts overlap to a considerable degree, as in the Wallflower. When the parts of a floral whorl are five in number, and these arranged in such a manner that there are two parts placed on the outside, two inside, and the fifth over-

lapping one of the internal by one margin, while it is itself overlapped on its other margin by one of the external parts, the æstivation is said to be *quincuncial* (*fig.* 450). Familiar examples of this form are afforded by the corolla of the Rose, and the calyx of the Bindweed (*Calystegia sepium*). In this kind of æstivation the spiral arrangement of the parts is well seen, and is indicated in the diagram (*fig.* 450) by a dotted line. The spiral cycle thus formed, which is the normal one in *pentamerous* or *quinary* flowers (those with the parts in fives), and which occurs in the majority of Dicotyledons, corresponds to the $\frac{2}{5}$, *pentastichous*, or *five-ranked* arrangement of leaves. When in a quincuncial arrangement the second part of the cycle becomes wholly internal instead of being external, the regularity of the quincunx is interrupted, and a variety of æstivation occurs to which the name *cochlear* has been given

Fig. 449.

Fig. 450.

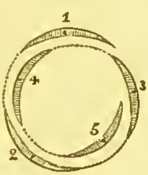


Fig. 451.

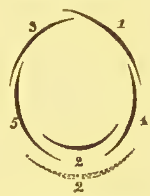


Fig. 452.

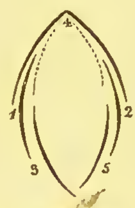


Fig. 449. Diagram to illustrate imbricate æstivation. The figures 1, 2, 3, 4, 5, show that the successive parts are arranged in a spiral manner.——*Fig.* 450. Diagram to illustrate quincuncial æstivation. 1 and 2 are external, 4 and 5 internal, and 3 is partly external and partly internal.——*Fig.* 451. Diagram to illustrate cochlear æstivation. The part marked 2 in the preceding diagram is here wholly internal instead of external as in the quincuncial arrangement. The dotted line marked 2 indicates its normal position in the true quincuncial variety of æstivation.——*Fig.* 452. Diagram to illustrate vexillary æstivation. 1 and 2 form the alæ or wings, 3 and 5 the carina or keel, 4 the vexillum. (See *Papilionaceous Corolla.*)

(*fig.* 451). Familiar examples of this are afforded by the Snapdragon (*Antirrhinum majus*), and other allied plants. Another marked modification of imbricated æstivation occurs in the corolla of the Pea and other allied plants, where the superior petal 4, which is generally the largest, and called the *vexillum*, is folded over the others which are arranged face to face (*fig.* 452). This kind of æstivation is commonly termed *vexillary*.

It frequently happens that the calyx and corolla exhibit different kinds of æstivation. Thus, in *Guazuma ulmifolia* the calyx is *valvate* ; and the corolla *induplicate*. In Malvaceous plants the calyx is *valvate* or some form of circular æstivation ; and the corolla *twisted*. In these two examples the different varieties of æstivation, as exhibited by the two floral envelopes, may be considered to belong to the same class of æstivation, i.e. the *circular*. But instances also frequently occur where the calyx and corolla present different modifications, and which belong to both classes ; thus, in the Corn Cockle (*Githago segetum*), the species of St. John's Wort (*Hypericum*), the Geranium, and in many other plants, the calyx is *quincuncial* or *imbricate* ; and the corolla *twisted.*

The kinds of æstivation above described are always constant in the same individual, and frequently throughout entire genera, and even natural orders ; hence they are of great importance in Systematic Botany. For a similar reason they are also of much value in Structural Botany, by the assistance they commonly afford in enabling us to ascertain the relative succession and position of the parts of the flower on the axis.

The term *anthesis* is sometimes used to indicate the period at which the flower-bud opens.

Besides the definite and constant relations which the parts of the floral envelopes have to one another in the flower-bud, they have also a definite and constant relation in the same plant to the axis upon which they are placed. In describing these positions we use the terms *anterior* or *inferior*, *superior* or *posterior*, and *lateral.* Thus, we call that organ *posterior* or *superior*, which is turned towards the axis ; and that next the bract from the axil of which it arises, *inferior* or *anterior.* When there are four organs in a whorl, one will be *superior*, one *inferior*, and two *lateral*, as in the petals of the Wallflower (*fig.* 25, *p*, *p*). If there are five we have two arrangements. Thus, in the calyx of the order *Leguminosæ*, two sepals are *superior*, two *lateral*, and one *inferior* ; while in the corolla one petal is *superior*, two *inferior*, and two *lateral* (*figs.* 452 and 477). But in plants of the order *Rosaceæ* we have a precisely reverse position exhibited by the parts of the two floral envelopes ; thus, here we have two sepals *inferior*, two *lateral*, and one *superior* ; while in the corolla there are two petals *superior*, two *lateral*, and one *inferior* (*fig.* 476).

The same definite relation with respect to the axis also holds good in many cases in the staminal and carpellary whorls, by which important distinctive characters are frequently obtained, as will be seen afterwards when treating of Systematic Botany.

Section 3. The Floral Envelopes.

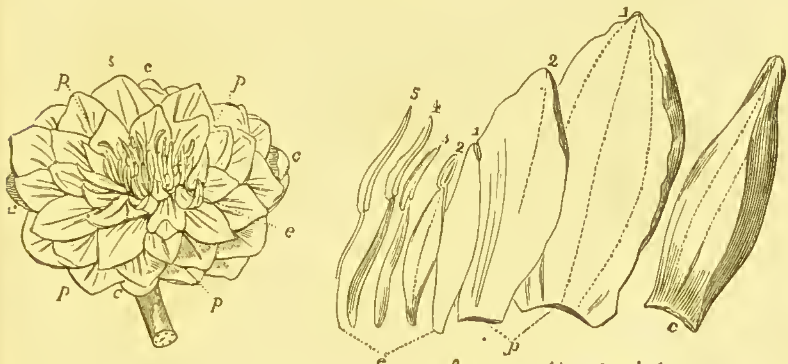
1. THE CALYX.

We have already stated that the calyx is the outermost envelope of the flower, and that it is composed of one or more leafy organs called *sepals.* These sepals are usually green like the foliage leaves, by which character, as well as by their position and more delicate texture, they may, in most cases, be distinguished from the petals. There are numerous instances, however, especially when the number of petals is much increased, in which there is a gradual transition from the sepals to the petals,

reverse

so that it is difficult or almost impossible to say, in many cases, where the calyx ends and the corolla begins. The White Water-lily (*fig.* 453) affords a familiar and good illustration of this. In some plants, again, the green colour disappears, and the calyx becomes coloured with the same tints as the corolla, or with some other bright hues. In such cases it is said to be *petaloid*, and the chief distinctive character between it and the corolla is then afforded by its position on the outside of the latter organ. The Fuchsia, Indian Cress, Columbine, Larkspur, and Monkshood may be mentioned as affording familiar examples of a petaloid calyx amongst Dicotyledons. In Monocotyledons generally, as in the Lily, Iris, Tulip, Crocus, and Squill (*fig.* 28), as we have mentioned (page 17), the

FIG. 453.



Exogen Thallamiflora

Fig. 453. Flower of the White Water-lily (*Nymphæa alba*) reduced in size. After Jussieu. *c, c, c, c.* The four sepals. *p, p, p, p.* Petals. *e.* Stamens. The parts on the right show the gradual transition from the calyx, *c*, to the petals, *p*, and from these organs to the stamens, *e*. The stamens from 1 to 5 are gradually more distinctive.

two floral envelopes are usually coloured, although rarely green, and in other respects so closely resemble each other, that we then use the collective name of *perianth* to indicate the two whorls taken together. When there is but one whorl of floral envelopes, as in the Goosefoot (*fig.* 29), it is customary with some botanists to call this the calyx, whether it is coloured or green; it is so termed in this volume. Other botanists, however, under such circumstances, call the whorl that is present a *perianth*. Those, again, who use the term *perianth* in this sense also sometimes apply it, in all cases, to flowers whether of Monocotyledons or Dicotyledons, when the true floral envelopes are all coloured as in the Lily, or all green as in the Dock. The term is also sometimes employed in a *general sense* as synonymous with the *floral envelopes.*

In their structure, venation, and characters generally, the sepals resemble the foliage leaves, and are covered like them with

description should be reversed as the flower is an
mple of the stamens passing into petals +
als.

epidermis ; this is also frequently furnished on the lower or outer surface with stomata, and also occasionally with hairs, glands, or other appendages. From the duration of the sepals being usually more transitory than that of the foliage leaves, the veins which form their skeleton chiefly consist of spiral vessels, and are commonly arranged like those of the leaves in the two classes of plants respectively—that is, reticulated in Dicotyledons, and parallel in Monocotyledons.

The sepals also exhibit various characters as regards their figure, margins, apex, &c., although they are by no means so

FIG. 454.

FIG. 455.

FIG. 456.

FIG. 457.

Fig. 454. Vertical section of the flower of the Rose. *r*, *r*. Concave thalamus, upon which are placed several carpels, *o*, *o*, each of which is furnished with a style and stigma, *s*. *e*, *e*. Stamens. *ct*. Tube of the calyx. *cf*, *cf*. Free portions of the calyx divided at their margins. ——*Fig.* 455. Calyx of *Rumex uncatus*, after Jussieu. *ce*. Outer divisions of the calyx which are entire. *ci*. Inner divisions with hooked teeth at their margins. *g*. Swelling on one of the inner divisions.——*Fig.* 456. Flower of Strawberry (*Fragaria*) with a regular polysepalous calyx surrounded by a whorl of leafy organs, to which the name of epicalyx or involucre is applied.——*Fig.* 457. Flower of Monkshood (*Aconitum Napellus*), with an irregular polysepalous calyx. The upper sepal is petaloid, and hooded or helmet-shaped.

liable to the numerous variations in these particulars as the blades of foliage leaves exhibit. The terms used in defining these modifications are applied in the same sense as with the blades of leaves.

Sepals are almost without exception destitute of a stalk, or, in other words, they are sessile upon the thalamus. They are also generally entire at their margins, although exceptions to this latter character occasionally occur : thus, in the Pæony and Rose (*figs.* 454, *cf*, and 476, *cf*), the sepals are incised ; in many species of Dock they are toothed (*fig.* 455, *ci*) ; in *Chamælaucium* *plumosum* each sepal is divided into five deep lobes or partitions; and in *Passiflora fœtida* the sepals are first pinnatisected, and then each segment pinnatifid.

In their direction, the sepals are either *erect* or turned upwards; *connivent* or turned inwards; *divergent* or *patulous*, when spreading outwards; or *reflexed*, when their extremities are turned downwards.

The sepals may be either distinct from each other, as in the Poppy, Buttercup, Wallflower, and Strawberry (*fig.* 456); or more or less united into one body (*figs.* 458-60), as in the Pimpernel (*fig.* 458), Campion (*fig.* 459), and Henbane (*fig.* 461). In the former case, the calyx is usually termed *polysepalous*, *polyphyllous*, or *dialysepalous*; in the latter it is commonly called *monosepalous*. But this latter term is incorrect, as it indicates literally one sepal; and hence many botanists use instead the more correct term of *gamosepalous* calyx, which simply implies that the sepals are united. The terms polysepalous and monosepalous, however, from being in more general use, will be ordinarily employed in this volume.

1. Polysepalous, Polyphyllous, or Dialysepalous Calyx. A polysepalous calyx may consist of two or more parts, the number being indicated by the prefix of Greek numerals; as *disepalous* for a calyx composed of two distinct sepals, *trisepalous* for one with three, *tetrasepalous* if it have four, *pentasepalous* if five, *hexasepalous* if six, *heptasepalous* if seven, and so on.

A polysepalous calyx is called *regular* if it consist of sepals of equal size and like figure or form, and arranged in a symmetrical manner, as in the species of *Ranunculus* (*fig.* 432), and Strawberry (*fig.* 456); and it is said to be *irregular* when these conditions are not complied with, as in the Monkshood (*fig.* 457).

2. Monosepalous or Gamosepalous Calyx.—When the sepals are united so as to form a monosepalous calyx, various terms are used to indicate the different degrees of union. Thus, the union may only take place near the base, as in the Pimpernel (*fig.* 458), when the calyx is said to be *partite*; or it may take place to about the middle, as in the Centaury (*fig.* 459), when it is *cleft* or *fissured*; or the sepals may be united almost to the top, as in the Campion (*fig.* 460), when it is *toothed*; or if the union is quite complete, it is *entire*. The number of partitions, fissures, or teeth, is indicated by the same prefixes as those previously referred to as being used in describing analogous divisions in the lamina of a leaf; thus a monosepalous calyx where the divisions are five, would be described as *five-partite* or *quinquepartite*, *five-cleft* or *quinquefid*, *five-toothed* or *quinquedentate*, according to the depth of the divisions. In like manner the terms *tripartite*, *trifid*, or *tridentate* would indicate that such a calyx was *three-partite*, *three-cleft*, or *three-toothed*, and

so on. The number of divisions in the majority of cases corresponds to that of the component sepals of which the calyx is formed; although exceptions to this rule sometimes occur, as for instance in those cases where the divisions are themselves

FIG. 458.

FIG. 459.

FIG. 460.

Fig. 458. Partite inferior calyx of the Pimpernel (*Anagallis*).——*Fig.* 459. Cleft or fissured calyx of the Centaury (*Erythræa*).——*Fig.* 460. Dentate or toothed calyx of Campion (*Lychnis*).

divided into others. A little care in the examination will, however, generally enable the observer to recognise the primary from the secondary divisions. When a monosepalous calyx is entire, the number of sepals can then be ascertained by the

FIG. 461.

FIG. 463.

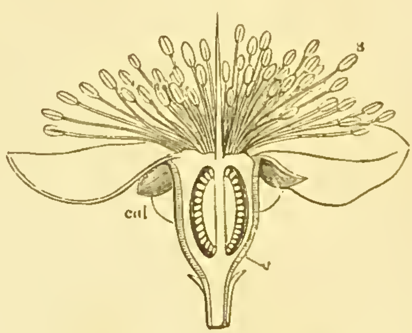


FIG. 462.

Fig. 461. Urceolate calyx of the Henbane (*Hyoscyamus*).——*Fig.* 462. Bilabiate calyx of the Dead-nettle (*Lamium*).——*Fig.* 463. Vertical section of the flower of the Myrtle (*Myrtus communis*). *cal.* Tube of the calyx adherent to the ovary, *o.* *s.* Stamens.

venation, as the principal veins from which the others diverge generally correspond to the midribs of the component sepals. In a monosepalous calyx in which the union exists in a marked degree, the part where the sepals are united is called the *tube*, the free portion the *limb*, and the orifice of the tube the *throat* or *faux* (*figs.* 460–462).

If the union between the sepals is unequal, or the parts are of different sizes, or of irregular figures or forms, the calyx is said to be *irregular* (*fig.* 462); if, on the contrary, the parts are alike in figure and form, of the same size, and united so as to form a symmetrical body, it is *regular* (*fig.* 461). Some varieties of the irregular and also of the regular calyx have received special names. Thus in the Dead-nettle (*fig.* 462), the irregular calyx is said to be *labiate*, *bilabiate*, or *lipped*, because the five sepals of which it is composed are united in such a manner as to form two lips. Of the regular forms of the monosepalous calyx a number are distinguished under the names of *tubular*, *bell-shaped* or *campanulate*, *urceolate* (*fig.* 461), *conical*, *globose*, &c. The application of these terms will be also shown when speaking of the corolla, in which similar forms occur, and in which they are usually more evident.

The tube of a monosepalous calyx, or of that of a perianth (the parts of which, like the sepals, are frequently united to a varying extent), sometimes adheres more or less to the ovary, as in the Iris, Gooseberry, Currant, Myrtle (*fig.* 463, *cal*), in all the plants of the order Compositæ, and in those allied to it (*figs.* 464-466), and in numerous other plants. When this takes place, the calyx is said to be *adherent*, or, because it appears to arise from the summit of the ovary, it is termed *superior*; the ovary in such a case is then described as *inferior*. When the calyx is free, or quite distinct from the walls of the ovary, as in the Pimpernel (*fig.* 458), Wallflower, Poppy, and Buttercup, it is said to be *free*, *non-adherent*, or *inferior*; and the ovary is then termed *superior*.

Fig. 464.

Fig. 465.

Fig. 466.

Fig. 464. Calyx of the Madder (*Rubia*), adherent to the ovary, with its limb reduced to a mere rim.——*Fig.* 465. One of the tubular florets of the Ox-eye (*Chrysanthemum*). The calyx is completely united to the ovary and presents no appearance of a limb.——*Fig.* 466. One of the tubular florets of the Sunflower (*Helianthus*). The limb of the adherent calyx is membranous.

When the calyx or perianth is thus adherent to the ovary, its limb presents various modifications: thus in the Iris, Crocus, and Orchids, it is *petaloid*; in the Quince, *foliaceous* (*fig.* 473); in the Sunflower (*fig.* 466), and Chamomile, it is *membranous*; in the Madder (*fig.* 464), it exists only in the form of a circular rim; while in the Ox-eye it is altogether absent (*fig.* 465). In the two latter cases the calyx is commonly described as *obsolete*. In many plants of the order Compositæ and the allied orders Dipsacaceæ and Valerianaceæ, the limb of the calyx is only developed in the form of a circle or tuft of bristles, hairs, or feathery processes, to which the name of *pappus* is given, and the calyx under such circumstances is said to be *pappose*. The pappus is further described as *feathery* or *plumose*, and *simple* or *pilose* ; thus it is *feathery*, as in the Valerian (*fig.* 467), when each of its divisions is covered on the sides by little hair-like projections arranged like the barbs of a feather ; and *pilose*, when the divisions have no marked projections from their sides, as in the Dandelion and Scabious (*fig.* 468). The pappus is also described as *sessile* when it arises immediately from the tube of the adherent calyx, and thus apparently from the top of the ovary or fruit, as in the Valerian (*fig.* 467) ; and *stalked* or *stipitate*, if it is raised above the ovary or fruit, on a stalk, as in the Dandelion and Scabious (*fig.* 468).

Fig. 467.

Fig. 468.

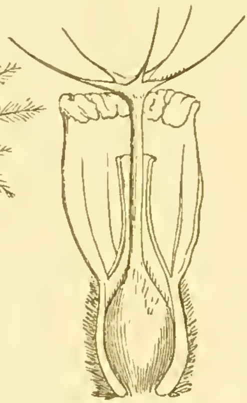


Fig. 467. Fruit of the Valerian surmounted by a feathery sessile pappus.——*Fig.* 468. Fruit of Scabious surmounted by a stalked pilose pappus.

Appendages of the Calyx.—The calyx, whether monosepalous or polysepalous, is subject to various other irregularities besides those already alluded to, which arise from the expansion or growing outwards of one or more of the sepals or the tube of a monosepalous calyx into appendages or processes of different kinds. Thus in the Monkshood (*fig.* 457),

Fig. 469.

Fig. 470.

Fig. 469. Flower of the Indian Cress (*Tropæolum*). *c.* Spurred calyx. ——*Fig.* 470. Calyx of *Hibiscus* surrounded by an epicalyx or involucre.

the superior sepal is prolonged upwards into a sort of hood or helmet-shaped process, in which case it is said to be *hooded*, *helmet-shaped*, or *galeate*. In the Wallflower (*fig.* 25, *c*), and other plants of the Cruciferæ, the two lateral sepals are expanded on one side at the base into little sacs, when they are termed *gibbous* or *saccate*. If the calyx has one or more tubular prolongations downwards, it is said to be *spurred*. Only one spur may be present, as in the Indian Cress (*fig.* 469, *c*), where the spur is formed by three sepals ; or in the Larkspur, where it is formed by one ; or each of the sepals may be spurred. In the Pelargonium, the spur instead of being free from the pedicel, as in the above instances, is united to it.

On the outside of the calyx of some flowers, as in those of many plants of the Mallow (*fig.* 470), Pink (*fig.* 474, *b*), and Rose orders (*fig.* 456), there is placed a whorl of leaf-like organs which is considered by some botanists as an outer calyx, and to which the name of *epicalyx* or *calyculus* has been accordingly given ; but this outer whorl is evidently of the same nature as the *involucre* already noticed (see page 193), and has been so described in this volume.

Duration of the Calyx.—The duration of the calyx varies in different flowers. Thus it is *caducous* or *fugacious*, when it

Fig. 471.

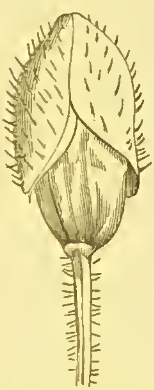


Fig. 472.

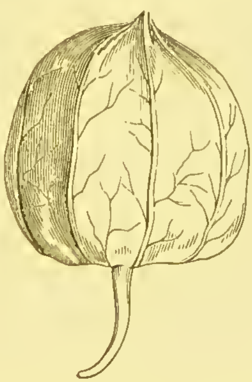


Fig. 473.

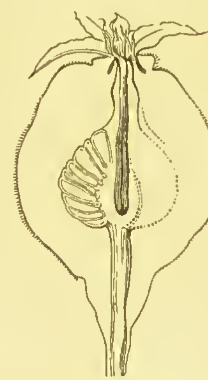


Fig. 471. Flower of the Poppy, showing a caducous calyx.——*Fig.* 472. Accrescent calyx of the Winter Cherry (*Physalis Alkekengi*).——*Fig.* 473. Vertical section of the fruit of the Quince (*Pyrus Cydonia*), showing the tube of the calyx adherent to the matured carpels, and forming a part of the pericarp ; the free portion or limb being foliaceous.

falls off as the flower expands, as in the Poppy (*fig.* 471). In the *Eschscholtzia* the calyx, which is caducous, separates from the hollow thalamus to which it is articulated, in the form of a funnel, or the extinguisher of a candle. A somewhat similar separation of the calyx occurs in the *Eucalyptus*, except that here the part which is left behind after the separation of the upper portion evidently belongs to the calyx, instead of to the thalamus, as in the former instance. In these two latter cases the calyx is said to be *calyptrate* or *operculate*. When the calyx falls off about the same time as the corolla, as in the Crowfoot or Buttercup, it is then called *deciduous*. In other cases the calyx remains after the flowering is over, as in the Henbane (*fig.* 461), and Mallow; when it is described as *persistent*. When the calyx is adherent or superior it is necessarily *persistent*, and forms a part of the fruit, as in the Quince (*fig.* 473), Apple, Pear, Gooseberry, Melon, and Cucumber. When it is persistent and assumes a shrivelled or withered appearance, as in the species of *Campanula*, it is *marcescent*; or, if it is persistent, and continues to grow after the flowering, so as to form a bladdery expansion round the fruit, as in the Winter Cherry, and other species of *Physalis* (*fig.* 472), it is termed *accrescent*.

2. THE COROLLA.

The corolla is the inner envelope of the flower. It consists of one or more whorls of leafy organs, called *petals*. In a complete flower (*fig.* 25, *p*), it is situated between the calyx and andrœcium, and is generally to be distinguished from the former, as we have already seen, by its coloured nature and more delicate structure. When there is but one whorl of floral envelopes, as we have also before noticed (page 17), this is to be considered as the calyx, and the flower is then termed *apetaloid* or *monochlamydeous*. The corolla is usually the most showy and conspicuous part of the flower, and what in common language is termed *the flower*. In some rare cases, however, it is green like the calyx, as in certain Cobæas and some Asclepiadaceous plants. The corolla is also, in the majority of flowers which possess odoriferous properties, the seat of those odours. Sometimes, as we have seen, there is a gradual transition from the sepals to the petals, as in the White Water-lily (*fig.* 453); and in the same plant there is also a similar transition from the petals to the stamens.

In structure the petals resemble the sepals and leaves, being composed of parenchyma, supported by veins which are chiefly formed of spiral vessels; the venation is usually reticulated. The whole petal is invested by epidermis, which is commonly destitute of stomata, but these organs may be sometimes found on the lower surface. The corolla is generally smooth, although hairs occasionally occur, as in the *Bombax*; when they exist they are usually coloured, as in the Buckbean, and on the inner whorl of the perianth of the Iris, which corresponds in position to the corolla. Petals are frequently narrowed below into a stalk-like portion, which is analogous to the petiole of a leaf, as in the

Wallflower and Pink (*fig.* 475); the narrow portion is then termed the *unguis* or *claw*, *o*, and the expanded portion the *limb*, *l*, and the petal is said to be *unguiculate* or *clawed*. In this particular, petals must be considered to resemble the leaves more than the sepals do, as the latter organs are almost without exception *sessile*, or destitute of claws.

The outline of the petals, like those of the sepals and leaves, is subject to great variation. Thus, they may be *linear*, *oblong*, *lanceolate*, *elliptic*, *ovate*, *cordate*, &c. The application of these terms having been already fully explained when speaking of leaves, need not be further alluded to. The condition of their margins also, the mode in which they are divided, and their

FIG. 474.

FIG. 475.

Fig. 474. The flower of a species of Pink (*Dianthus*). *b*. Bracts, forming an epicalyx or involucre. *c*. Calyx. *p*, *p*. Petals, the limbs of which are fringed at their margins. *e*. Stamens.——*Fig.* 475. One of the petals of the same flower. *o*. Claw or unguis. *l*. Limb, which is fringed at the margins.

terminations, are also indicated by the same terms as those previously described under similar heads in our chapter on Leaves. Thus the petals may be *dentate*, *serrate*; *cleft*, *partite*, *sected*; *acute*, *emarginate*, &c. The petals are not however liable to any further division than that of the primary one; thus, although sometimes *pinnatifid*, or *pinnatipartite*, &c., they are never *bipinnatifid*, or *bipinnatipartite*. One term is occasionally used in describing the condition of the margins which has not been alluded to when speaking of the leaves; thus the petals are said to be *fimbriated* or *fringed*, as in some species of *Dianthus* (*figs.* 474 and 475, *l*), when they present long thread-like processes at their margins.

Again, the petals may be either flat, as is usually the case, or *concave*, *tubular*, *boat-shaped*, &c. These terms sufficiently explain their meaning; but a few anomalous forms of petals will be described hereafter (page 237). In texture the petals are commonly soft and delicate, but they sometimes differ widely from this, and become thick and fleshy, as in the *Stapelias*; or dry and membranous, as in the Heaths; or stiff and hard, as in *Xylopia*.

In describing their direction, we use the terms *erect*, *connivent*, *divergent*, *patulous*, or *reflexed*, in the same sense as already described when speaking of similar conditions of the sepals (page 225).

The petals also, like the sepals, may be either distinct or more or less united into one body. In the former case, the corolla is said to be *polypetalous* or *dialypetalous* (*figs.* 474–477); in the latter *monopetalous* or *gamopetalous* (*figs.* 478–495). The same objection applies to the use of the term monopetalous as to that of monosepalous already mentioned (page 225), but we shall continue to employ it from its being the one more commonly in use.

1. Polypetalous or Dialypetalous Corolla.—The number of petals which enter into the composition of the corolla is indi-

Fig. 476.

Fig. 477.

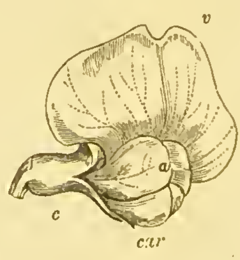


Fig. 476. Flower of the Rose. *b.* Bract. *ct.* Tube of the calyx. *cf, cf, cf, cf, cf.* Divisions of the calyx. *p, p, p, p, p.* Petals.——*Fig.* 477. The flower of the Sweet Pea (*Lathyrus odoratus*). *c.* Calyx. *v.* Vexillum. *a.* Alæ or wings. *car.* Carina or keel.

cated, as in the case of the polysepalous calyx, by the prefix of the Greek numerals. Thus a corolla of two petals is said to be *dipetalous*; of three, *tripetalous*; of four, *tetrapetalous*; of five, *pentapetalous*; of six, *hexapetalous*; of seven, *heptapetalous*; of eight, *octapetalous*; and so on.

When the petals are all of the same size, and of like figure or form, and arranged in a symmetrical manner, the corolla is termed *regular*, as in Rosaceous flowers (*figs.* 456 and 476); but when the petals vary in these particulars, as in the Pea and allied plants (*figs.* 452 and 477), it is said to be *irregular*. Some varieties of polypetalous corollas have received special names which we will now proeeed to describe under the two divisions of *regular* and *irregular*.

A. *Regular Polypetalous Corollas.*—Of these we may mention three forms, viz. the *cruciform* or *cruciate*; the *caryophyllaceous*; and the *rosaceous*.

1. *Cruciform or Cruciate.*—This eorolla gives the name to the natural order *Cruciferæ*; but it also occurs elsewhere. It eonsists of four petals, usually with claws, as in the Wallflower (*fig.* 25, *p*), and Stock; but sometimes without claws, as in the Celandine, and the whole arranged in the form of a eross.

2. *Caryophyllaceous.*—This consists of five petals, with long claws enclosed in the tube of the calyx, and with their limbs commonly placed at right angles to the claws, as in the Campion, Single Pink (*figs.* 474 and 475), and Carnation.

3. *Rosaceous.*—This is composed of five petals, without, or with very short claws, and spreading in a regular manner, as in the Strawberry (*fig.* 456), and Single Rose (*fig.* 476).

B. *Irregular Polypetalous Corollas.*—There are many anomalous forms of irregular polypetalous eorollas to which no particular names are applied. There is one form, however, whieh is of much importanee, namely, the *Papilionaceous*.

This derives its name from the fancied resemblanee which it bears to a butterfly. It is composed of five petals (*fig.* 452), one of which is superior or posterior, and eommonly larger than the others, and termed the *vexillum* or *standard* (*fig.* 477, *v*); two inferior or anterior, which are usually more or less united and form a somewhat boat-shaped eavity, *car*, called the *keel* or *carina*; and two lateral, *a*, called the *wings* or *alæ*.

2. Monopetalous or Gamopetalous Corolla.—When the petals unite so as to form a monopetalous corolla, various terms are used as in the case of the monosepalous calyx to indicate the degrees of adhesion; thus the corolla may be *partite*, *cleft*, *toothed*, or *entire*, the terms being employed in the same sense as with the ealyx (see page 225). The part also where union has taken plaee is in like manner called the *tube*, *t*, the free portion, the *limb*, *l*, and the orifiee of the tube, the *throat* or *faux* (*fig.* 478).

The monopetalous corolla, like the monosepalous calyx, is *regular* when its parts are of the same size, and of like figure or form, and united so as to form a symmetrical body (*figs.* 478–483); or if these eonditions are not complied with it is *irregular* (*figs.* 484–495). Some varieties of both regular and irregular monopetalous eorollas have reccived special names, as follows:—

A. *Regular Monopetalous Corollas.*—Of these we may deseribe the following:—

1. *Tubular*, where the form is nearly cylindrical throughout, the limb not spreading; as in *Spigelia* (*fig.* 478), and in the

central florets of many Compositæ, as the Ox-eye (*Chrysanthemum*), and Sunflower (*Helianthus*) (*fig.* 466).

2. *Campanulate* or *bell-shaped*, when the corolla is rounded at the base, and gradually enlarged upwards to the summit, so as to resemble a bell in form, as in the Harebell (*fig.* 479).

FIG. 478.

FIG. 479.

FIG. 480.

Fig. 478. Flower of *Spigelia marylandica* *c.* Calyx. *t.* Tubular corolla. *l.* Limb of the corolla. *s.* Summit of the style and stigmas.——*Fig.* 479. Flower of the Harebell (*Campanula rotundifolia*), showing a campanulate corolla.——*Fig.* 480. Flower of the Tobacco Plant (*Nicotiana Tabacum*), with infundibuliform corolla.

3. *Infundibuliform* or *funnel-shaped*, where the form of the corolla is that of an inverted cone, like a funnel, as in the Tobacco (*fig.* 480).

FIG. 481.

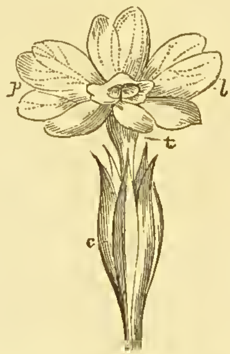


FIG. 482.

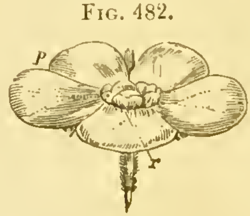


Fig. 481. Flower of a species of *Primula*. *c.* Calyx, within which is seen a hypocrateriform corolla, *p.* *t.* Tube of the corolla. *l.* Limb.——*Fig.* 482. Flower of the Forget-me-not (*Myosotis palustris*). *p.* Rotate corolla. *r.* Scales projecting from its throat.

4. *Hypocrateriform* or *salver-shaped* (*fig.* 481), when the tube is long and narrow, and the limb placed at right angles to it, as in the Primrose.

5. *Rotate* or *wheel-shaped*, when the tube is short, and the limb at right angles to it, as in the Forget-me-not (*fig.* 482) and Bittersweet (*Solanum Dulcamara*).

6. *Urceolate* or *urn-shaped*, when the corolla is swollen in the middle, and contracted at both the base and apex, as in the Purple Heath (*fig.* 483), and Bilberry (*Vaccinium Myrtillus*).

FIG. 483.

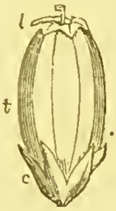


FIG. 484.

FIG. 485.

Fig. 483. Flower of a species of Heath (*Erica*). *c*. Calyx, within which is an urceolate corolla, *t*, *l*.——*Fig.* 484. Ringent or gaping corolla of the Dead-nettle (*Lamium album*), showing the entire upper lip.——*Fig.* 485. Back view of the flower of a species of *Teucrium*, showing the bifid upper lip of the corolla.

B. *Irregular Monopetalous Corollas.*—Of these we shall describe the following :—

1. *Labiate, bilabiate, or lipped.*—When the parts of a corolla are so united that the limb is divided into two portions which are placed superiorly and inferiorly, the upper portion overhang-

FIG. 486.

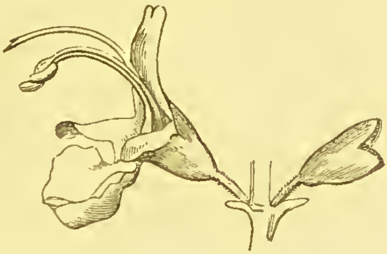


FIG. 487.

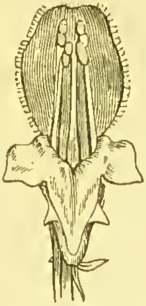


Fig. 486. Flower of the Rosemary (*Rosmarinus*) with upper lip divided.——*Fig.* 487. Front view of the labiate corolla of *Galeobdolon*, with trifid lower lip.

ing the lower, and each portion so arranged as not to close the orifice of the tube, thus resembling in some degree the lips and open mouth of an animal (*figs.* 484–487), the corolla is termed *labiate*, *bilabiate*, or *lipped*. The upper lip is composed of two petals, which are either completely united, as in the White Dead-nettle (*fig.* 484), or more or less divided, as in the

Rosemary (*fig.* 486) and Germander (*Teucrium*) (*fig.* 485); and the lower lip of three petals, which are also, either entire as in the Rosemary (*fig.* 486), or bifid as in some species of *Lamium*, or trifid as in *Galeobdolon* (*fig.* 487). When a labiate corolla has its upper lip much arched, as in the White Dead-nettle (*fig.* 484), it is frequently termed *ringent* or *gaping*. The labiate corolla gives the name to the natural order Labiatæ, in the plants belonging to which it is of almost universal occurrence. It is found also in certain plants belonging to some other orders.

2. *Personate or Masked.*—This form of corolla resembles the labiate in being divided into two lips, but it is distinguished by the lower lip being approximated to the upper, so as to close the orifice of the tube or throat. This closing of the throat is caused by a projection of the lower lip called the *palate* (*fig.* 488, *l*). Examples occur in the Snapdragon (*fig.* 488), and the Toadflax (*fig.* 489). In the species of *Calceolaria* the two lips become hollowed out in the form of a slipper, hence such a corolla, which is but a slight modification of the personate, is sometimes termed *calceolate*.

FIG. 488.

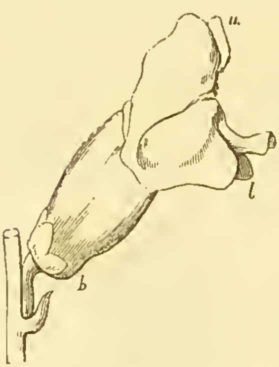


FIG. 489.

FIG. 490.

Fig. 488. Personate corolla of the Snapdragon (*Antirrhinum*). *l.* Lower lip. *u.* Upper lip. *b.* Gibbous base.——*Fig.* 489. Personate corolla of the Toadflax (*Linaria*), spurred at its base.——*Fig.* 490. Ligulate corolla of a Composite flower, with five teeth at its apex.

3. *Ligulate or Strap-shaped.*—If what would otherwise be a tubular corolla is partly split open on one side, so as to become flattened like a strap above (*figs.* 490 and 491), it is called *ligulate* or *strap-shaped*. This kind of corolla frequently occurs in the florets of the Compositæ, either in the whole of those constituting the capitulum, as in the Dandelion (*Leontodon*); or only in some of them, as in the outer florets of the Ox-eye (*fig.* 491). The apex of a ligulate corolla has frequently five teeth indicating the number of its component petals (*fig.* 490).

Besides the above described forms of regular and irregular monopetalous corollas, others also occur, some of which are but slight modifications of these, and arise from irregularities that are produced in certain parts in the progress of their development. Thus in the Foxglove (*fig.* 492), the general appearance of the corolla is somewhat bell-shaped, but it is longer than this form,

FIG. 491.

FIG. 492

FIG. 493.

Fig. 491. Ligulate corolla of the Ox-eye (*Chrysanthemum*).——*Fig.* 492. Digitaliform or glove-shaped corolla of the Foxglove (*Digitalis purpurea*).——*Fig.* 493. Irregular rotate corolla of Speedwell (*Veronica*).

and slightly irregular, and as it has been supposed to resemble the finger of a glove, it has received the name of *digitaliform* or *glove-shaped*. In the Speedwell (*fig.* 493), the corolla is nearly rotate, but the divisions are of unequal size and shape, hence it may be described as irregularly rotate; and in the Red Valerian the corolla is irregularly salver-shaped (*fig.* 495).

APPENDAGES OF THE COROLLA.—The corolla, like the calyx, whether polypetalous or monopetalous, is subject to various irregularities, arising from the expansion or growing outwards of one or more of the petals, or the tube of a monopetalous corolla, into processes or appendages of different kinds. Thus in the Snapdragon (*fig.* 488, *b*) and Valerian (*fig.* 494), the lower part of the tube of the corolla becomes dilated on one side, so as to form a little bag or sac; it is then termed *saccate* or *gibbous*, this term being used in the same sense as previously described (see page 229) when speaking of the calyx. At other times, one or more of the petals, or the tube of a monopetalous corolla, becomes prolonged downwards and forms a *spur*, in which case the petal or corolla is described as *spurred* or *calcarate*. Examples of spurred petals or corollas may be seen in the Heartsease, Columbine (*fig.* 497), Toadflax (*fig.* 489), and Red Valerian (*fig.* 495). Only one spur may be present, as in the Heartsease, or each of the petals may be spurred, as in the Columbine (*fig.* 497). The Yellow Toadflax, which usually only produces one

Fig. 494.

Fig. 495.

Fig. 494. Flower of a species of Valerian (*Valeriana*). c. Calyx, adherent to the ovary. l. Limb of the calyx rolled inwards. The corolla has a projection towards its base, and is hence said to be gibbous.——*Fig.* 495. Flower of the Red Valerian (*Centranthus*). The corolla is irregularly salver-shaped and spurred at its base.

spur, in rare instances is found with five. Such a variety was termed by Linnæus Peloria, a name which is now frequently applied by botanists to all flowers which thus pass from irregularity to regularity. In the Monkshood (*fig.* 496), the two

Fig. 496.

Fig. 497.

Fig. 496. A portion of the flower of the Monkshood (*Aconitum*), with numerous stamens below, and two stalked somewhat horn-shaped petals above.——*Fig.* 497. Flower of the Columbine (*Aquilegia vulgaris*) with each of its petals spurred.

petals which are situated under the helmet-formed sepals already noticed (*fig.* 457) are each shaped somewhat like an irregularly curved horn placed on a long channelled stalk.

The corolla is usually composed of but one whorl of petals, and it is then termed *simple* ; but in some flowers there are two or more whorls, as in the White Water-lily (*fig.* 453, *p*), in which case it is called *multiple*. When the corolla is composed of but

FIG. 498.

FIG. 499.

FIG. 500.

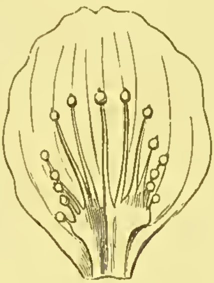


Fig. 498. Petal of a Crowfoot with a nectariferous scale at its base.——*Fig.* 499. One of the petals of Mignonette (*Reseda*).——*Fig.* 500. A petal of the Grass of Parnassus (*Parnassia palustris*) bearing a fringed scale at its base.

one whorl, its parts in a regular arrangement alternate with the sepals, although cases sometimes occur in which they are opposite to them. The cause of these different arrangements will be explained hereafter, under the head of the Symmetry of the Flower.

FIG. 501.

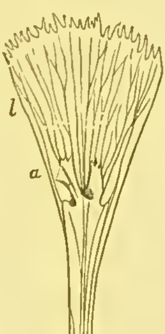


FIG. 502.

Fig. 501. A petal of a species of *Lychnis*. *o*. Claw. *l*. Limb. *a*. Scaly appendages.——*Fig.* 502. Flower of the Daffodil (*Narcissus Pseudo-narcissus*). The cup or bell-shaped process towards the centre is termed a corona.

On the inner surface of the petals of many flowers we may frequently observe appendages of different kinds in the form of scales or hair-like processes of various natures. These are commonly situated at the junction of the claw and limb (*fig.* 501, *a*); or at the base of the petals (*figs.* 498 and 500). Such appendages may be well seen in the Mignonette (*fig.* 499), Crowfoot (*fig.* 498), Lychnis (*fig.* 501, *a*), and Grass of Parnassus (*fig.* 500). Similar scales may be also frequently noticed in monopetalous corollas near the throat, as in many Boraginaceous plants, for instance, the Comfrey, Borage, Forget-me-not (*fig.* 482, *r*); and also in the Dodder, and many other plants. Sometimes these scales become more or less united and form a cup-shaped process, as in the perianth of the Daffodil (*fig.* 502) and other species of *Narcissus*; to this the term *corona* is commonly applied, and the corolla is then said to be crowned. By many botanists, however, this latter term is applied whenever the scales or appendages are arranged in the form of a ring on the inside of the corolla, whether united or distinct. The beautiful fringes on the corolla of the Passion-flower are of a similar nature.

The origin of these scales is by no means clearly ascertained; by some botanists they are supposed to be derived from the petals, by others to be abortive stamens; but they are now more commonly regarded as ligules (see page 182) developed on the petals. Formerly many of these appendages were described under the name of *nectaries*, although but few of them possess the power of secreting the honey-like matter or nectar from which they derived their names; they were therefore improperly so termed. The nature of the so-called *nectaries* has been already described under the head of Glands (see page 71).

Duration of the Corolla.—The duration of the corolla varies like that of the calyx, but it is almost always more fugitive than it. It is *caducous* if it falls as the flower opens, as in the Grape-vine; commonly it is *deciduous*, or falls off soon after the opening of the flower. In rare instances it is *persistent*, in which case it usually becomes dry and shrivelled, as in Heaths and the species of *Campanula* (*fig.* 437), when it is said to be *marcescent*.

Section 4. The Essential Organs of Reproduction.

The essential organs of reproduction are the andrœcium and gynœcium, and these together form the two inner whorls of the flower. They are called the essential organs because the action of both is necessary for the production of perfect seed.

Flowers which possess both these organs are called *hermaphrodite* or *bisexual* (*fig.* 518); when only one is present, they are *unisexual* or *diclinous*, as in the species of *Carex* (*fig.* 503), and *Salix* (*figs.* 415 and 416). The flower is also then further described as staminate or staminiferous (*figs.* 415 and 503) when it contains only a stamen or stamens; and carpellary, pistillate, or pistilliferous, when it has only a carpel or carpels (*fig.* 416). When a flower possesses neither andrœcium nor gynœcium, as is sometimes the case with the outer florets of the capitula of the Compositæ, it is said to be *neuter*. When the flowers are unisexual both staminate and pistillate flowers may be borne upon the same plant, as in the Hazel, Oak, Cuckoo-pint (*fig.* 403), and the species of *Carex*, in which case the plant is stated to be *monœcious*; or upon different plants of the same species, as in the Willows (*figs.* 415 and 416), when the plant is said to be *diœcious*. In some cases, as in many Palms and in the Pellitory (*Parietaria*), staminate, pistillate, and hermaphrodite flowers are situated upon the same individual, and then the plant is called *polygamous*.

Fig. 503.

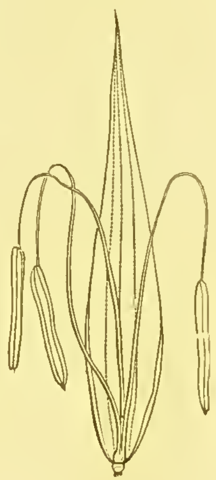


Fig. 503. Unisexual staminate flowers of a species of *Carex*. The filaments are long and capillary, and the anthers pendulous and innate.

Like the sepals and petals, the stamens and carpels are considered as homologous with leaves, but they generally present much less resemblance to these organs than the component parts of the floral envelopes. Their true nature is shown, however, by their occasional conversion into leaves, and by other circumstances, which will be described hereafter when treating of the General Morphology of the Flower.

1. THE ANDRŒCIUM.

The andrœcium, or male system of Flowering Plants, is the whorl or whorls of organs which, in a *complete flower*, is situated between the corolla (*fig.* 522) or perianth (*fig.* 28) on the outside, and the gynœcium on the inside; or it is placed between the calyx and gynœcium when the corolla is absent (*fig.* 29), as in monochlamydeous flowers; or in achlamydeous flowers, it is either outside the gynœcium (*fig.* 30) when those flowers are bisexual, or it stands alone (*fig.* 34) when the flowers are unisexual and staminate. It is composed of one or more parts termed *Stamens*. Each stamen consists generally of a thread-like portion or stalk, called the *filament* (*fig.* 27, *f*), which is analogous to the petiole of the leaf; and of a little bag or case, *a*, which is the representative of the blade, called the *anther*, and which contains a powdery, or more rarely waxy, matter, termed the pollen, *p*. The only essential part of the stamen, however, is the anther with its contained pollen; but in rare cases the pollen is absent, and as the stamen cannot then perform its special functions, it is said to be *abortive* or *sterile* (*fig.* 517, *ls*); in other cases it is termed *fertile*. It not unfrequently happens that flowers contain sterile filaments, that is, filaments without anthers, in which case these structures are termed *staminodes*. These commonly preserve a flattened appearance, as in the flowers of the species of *Canna*. When, as is rarely the case, the filament is absent, as in the Cuckoo-pint (*fig.* 504), the anther is described as *sessile*.

1. The Filament.—In its structure the filament consists, 1st, of a central usually unbranched bundle of spiral vessels; and 2nd, of parenchymatous tissue which surrounds the bundle of spiral vessels, and which is itself covered by thin epidermal tissue. The epidermis occasionally presents stomata and hairs; and these hairs are sometimes coloured, as in the Spiderwort and Dark Mullein. The structure of the filament is thus seen to be strictly analogous to that of the petiole of a leaf, which presents a similar disposition of its component parts.

Fig. 504.

Fig. 504. Stamen of the Cuckoo-pint (*Arum maculatum*), consisting simply of an anther which is sessile upon the thalamus.

The filament varies in form, length, colour, and other particulars; a few of the more important modifications of which will be now alluded to.

Form.—As its name implies, the filament is usually found in the form of a little thread-like or cylindrical prolongation which generally tapers in an almost imperceptible manner from the base to the apex, when it is described as *filiform*, as in the Rose; or if it is very slender, as in most Sedges and Grasses, it is *capillary* (*figs.* 503 and 505). In the latter case the filament, instead of supporting the anther in the erect position as it usually does, becomes bent, and the anther is then pendulous (*figs.* 503 and 505). At other times the filament becomes enlarged, or it is flattened in various ways. Thus in some cases, it is dilated gradually from below upwards like a club, when it is *clavate* or *club-shaped*, as in *Thalictrum*; or it is slightly enlarged at the base, and tapers upwards to a point like an awl, as in the Flowering Rush (*Butomus umbellatus*); in other cases it is flattened at the base, the rest of the filament assuming its ordinary rounded form, as in *Tamarix gallica* (*fig.* 506), and species of *Campanula* (*fig.* 507); or the whole of the filament is flattened, and then it frequently assumes the appearance of a petal, when it is described as *petaloid*, as in the Water-lily (*figs.* 453, *c*, and 522), and in *Canna* and allied plants.

Sometimes, again, the filament is *toothed* as in *Allium* (*fig.* 508), or *forked* as in *Crambe* (*fig.* 509); or furnished with various appendages as in the Borage (*fig.* 510, *a*), in which case it is said to be *appendiculate*. e.g. Violet & Pansy.

Length, Colour, and Direction.—The length of the filament varies much. Thus, in the Borage (*fig.* 510, *f*), and plants generally of the order Boraginaceæ (*fig.* 511), the filaments are very short; in the Primrose (*fig.* 543), and commonly in the Primulaceæ, a similar condition also occurs. In the Fuchsia, Lily, Grasses (*fig.* 505), and Sedges (*fig.* 503), the filaments are usually very long.

In *colour* the filaments are generally white, but at other times they assume vivid tints like the corolla or perianth; thus in the Spiderwort they are blue, in various species of *Ranunculus* and of *Œnothera* yellow, in some Poppies black, in Fuchsia red, &c.

In *direction* the filaments, and consequently the stamens, are either *erect*, *incurved*, *recurved*, *pendulous*, &c.; these terms being used in their ordinary acceptation. When the filaments are all turned towards one side of the flower, as in the Horsechest-

FIG. 505.

FIG. 506.

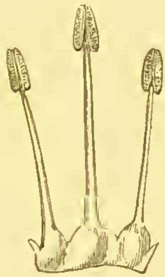


FIG. 507.

FIG. 508.

Fig. 505. A locusta of Wheat (*Triticum sativum*), consisting of several flowers, the stamens of which have very long capillary filaments, and versatile pendulous anthers. The anthers are notched or forked at each extremity, and thus resemble somewhat the letter *x* in form.——*Fig.* 506. Three of the stamens of *Tamarix gallica*, with their filaments flattened at the base and united with each other.——*Fig.* 507. Pistil of a species of *Campanula*, with a solitary stamen arising from the summit of the ovary. The filament is flattened.——*Fig.* 508. Dilated toothed filament of a species of *Allium*.

nut and Amaryllis, they are said to be *declinate*. Generally speaking, their direction is nearly the same from one end of the filament to the other, but in some cases the original direction is departed from in a remarkable manner, and the upper part of the filament forms an angle more or less obtuse with the lower, in which case it is termed *geniculate*, as in *Mahernia*. This appearance sometimes arises from the presence of an articulation at the point where the angle is produced, as in *Euphorbia* (*fig.* 512, *a*). In such a case, or whenever an articulation exists on the apparent filament, this is not to be considered as a true filament, but to consist in reality of a flower-stalk supporting a single stamen. The flower here, therefore, is reduced to a single stamen, all the parts except it being abortive. This is proved by the occasional production in some allied plants of one or more whorls of the floral envelopes at the point where the joint is situated. In the Pellitory (*Parietaria*), the filament assumes a spiral direction.

Duration.—The filament usually falls off from the thalamus after the influence of the pollen has been communicated to the

Fig. 509.

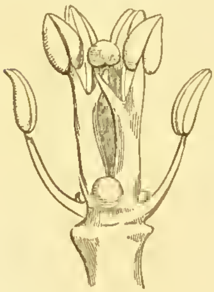


Fig. 510.

Fig. 511.

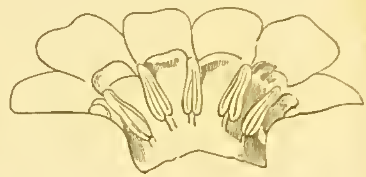


Fig. 512.

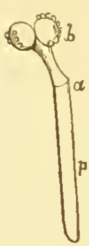


Fig. 513.

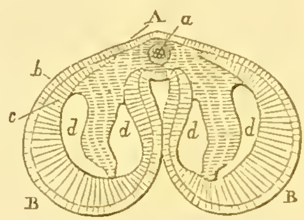


Fig. 509. Gynœcium and andrœcium of *Crambe*. The longer filaments are forked.——*Fig.* 510. A stamen of the Borage (*Borago officinalis*). *f*. Filament. *a*. Curved appendage to the filament. *l*. Anther.——*Fig.* 511. Corolla of *Myosotis* or Forget-me-not, laid open. There are five stamens with very short filaments attached to the corolla and included within its tube.——*Fig.* 512. Male flower of *Euphorbia*, consisting of a solitary stamen, *b*, without any floral envelopes surrounding it, hence it is said to be naked or achlamydeous. The anther is two-lobed, and the connective very small. *a*. Articulation, indicating the point of union of the true filament and peduncle, *p*.——*Fig.* 513. Transverse section of a young anther of *Neottia picta*. From Schleiden. A. Back of the anther to which the connective is attached. B. B. The two lobes of the anther. *a*. Vascular bundle of the connective. *b*. Epidermal layer or exothecium. *c*. Layer of fibrous cells which is commonly termed the endothecium, and which is the mesothecium of the anther in an earlier stage of development. *d*, *d*, *d*, *d*. The four loculi or cells of the anther. Each lobe is seen to be divided into two loculi by a septum or partition.

carpel, or is *deciduous*; but in rare cases, as in the species of *Campanula*, the filament is persistent, and remains attached to the ovary in a withered condition.

2. The Anther.—*Its Parts.*—The different parts of which the anther is composed may be best seen by making a transverse section as shown in *fig.* 513. Thus here we observe two parallel *lobes*, B, B, separated by a portion, A, *a*, called the *connective*, to which the filament is attached. Each lobe is divided

into two cavities, *d*, *d*, *d*, *d*, by a septum which passes from the connective to the walls of the anther. The cavities thus formed in the lobes of the anther are called *cells* or *loculi*. All anthers in an early stage of development possess *four loculi*, and this

FIG. 514.

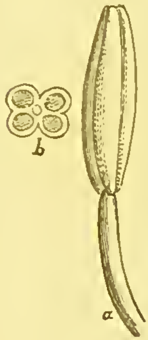
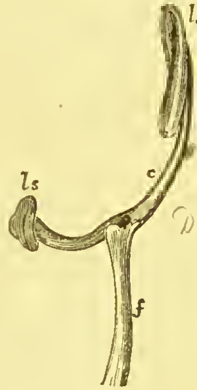


FIG. 515.

FIG. 516.

FIG. 517.



Sage.

FIG. 518.

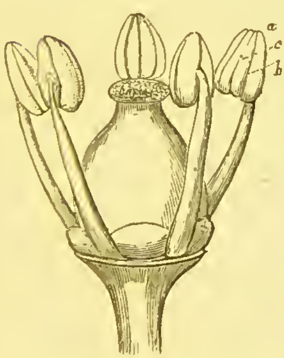


FIG. 519.

Fig. 514. Four-celled anther of the Flowering Rush (*Butomus umbellatus*). *a*. Filament bearing an entire anther. *b*. Section of the anther with its four cells.——*Fig.* 515. Andrœcium of Milkwort (*Polygala*), with eight one-celled anthers dehiscing at their apex.——*Fig.* 516. One of the stamens of the Lady's Mantle (*Alchemilla*). The anther is one-celled, and dehisces transversely.——*Fig.* 517. Stamen of the Sage (*Salvia*). *f*. Filament. *c*. Connective bearing at one end a cell, *lf*, containing pollen, when it is said to be fertile; and at the other end a cell, *ls*, without pollen, in which case it is sterile.——*Fig.* 518. The Essential Organs of Reproduction of the Vine (*Vitis vinifera*). *a*. Anther. *c*. Furrow in its face which is turned towards the pistil or gynœcium. *b*. Suture or line of dehiscence. The anther is introrse.——*Fig.* 519. The perianth cut open, showing the stamens, of the Meadow Saffron (*Colchicum autumnale*), with the faces of their anthers turned towards the floral envelopes, and hence termed extrorse.

is considered the normal state. When a fully-developed anther exhibits a similar structure, as in the Flowering Rush, it is *four-celled* or *quadrilocular* (*figs*. 514, *b*, and 537, *l*); or when, as is far more commonly the case, the partitions separating the two loculi of each anther-lobe become absorbed, it is *two-celled* or *bilocular* (*fig.* 536). In rare cases, the anther is *unilocular* or *one-celled*, as in the Mallow (*fig.* 535), Milkwort (*fig.* 515), and Lady's Mantle (*fig.* 516): this arises either from the abortion of one lobe of the anther, and the absorption of the septum between the two cells of the lobe that is left; or by the destruction of the partition wall of the two lobes as well as of the septa between the cells of each lobe. In some plants, again, as in many species of *Salvia*, the connective becomes elongated into a kind of stalk, each end of which bears an anther lobe (*fig.* 517), in which case there appear to be two *unilocular* or *one-celled* anthers. When this occurs one lobe only, *lf*, contains pollen; the other, *ls*, is sterile.

That surface of the anther to which the connective is attached is called the *back* (*fig.* 513, A), and the opposite surface, B, B, is the *face*. The latter always presents a more or less grooved appearance (*figs.* 513 and 518, *e*), indicating the point of junction of the two lobes. Each lobe also commonly presents a more or less evident furrow (*fig.* 518, *b*), indicating the point at which the mature anther will open to discharge the pollen; this furrow is termed the *suture*. By these furrows the face of the anther may be generally distinguished from the back, which is commonly smooth (*fig.* 513, A), and has moreover the filament attached to it. The face is generally turned towards the gynœcium or centre of the flower, as in the Water-lily (*fig.* 522), Vine (*fig.* 518), and Tulip (*fig.* 523), in which case the anther is called *introrse*; but in some instances, as in the Iris, and Meadow Saffron (*fig.* 519), the face is directed towards the petals or circumference of the flower, when the anther is said to be *extrorse*.

Its Development and Structure.—When first formed the anther consists of parenchymatous cells of about the same size and form; but ultimately each lobe presents two central masses of cells which are termed parent or mother-cells, from being devoted to the formation of the pollen (*fig.* 520, *cm*), and over which we have three distinct layers of cells. The inner one, *cl*,—that is the layer immediately enclosing each central mass, is called the *endothecium* or *tapetum*; it is formed of but a single row of delicate cells, which appear to contain nitrogenous matter, and supposed to be concerned in the nourishment of the pollen-cells in their early growth. This layer commonly disappears as the pollen becomes matured, but it is persistent in those anthers which have porous dehiscence. The layer, *ci*, immediately outside the endothecium, is termed the *mesothecium*. It is a permanent layer, and consists of one or more rows of cells, some of which, except in the case of anthers opening by pores, contain spiral, reticulated, or annularly arranged fibres. The third or external layer, *ce*, is of an epidermal nature, with a well-marked cuticle, and is called the *exothecium*, and upon which stomata are frequently found.

The anther in its mature form presents therefore, in nearly all cases, but two coats, as shown in *figs.* 513 and 521, that is, an *exothecium* (*fig.* 521, *ce*), or outer coat; and an *endothecium*, *cf*, or inner coat, which corresponds in structure to the mesothecium of the immature anther. The connective, as a general rule, has a similar structure to the filament. Each lobe of the anther, as already noticed, is divided at an early age into two cavities, by the septum (*fig.* 513), which extends from the connective to the suture. This septum, which forms the *placentoid* of Chatin, is usually more or less destroyed when the pollen is matured, but generally traces of it may be seen in the form of cellular projections from the connective, by which each cell of the anther is

FIG. 520.

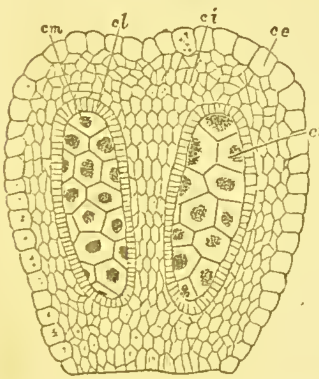


FIG. 521.

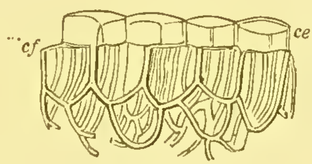


Fig. 520. Vertical section of a loculus or cell of a young anther of the Melon. *ce.* Epidermal layer constituting the exothecium or outer covering of the anther. *ci.* The parenchymatous cells forming the *mesothecium*. *cm*, *cm*. The two central masses of cells which are placed in each half or lobe of the anther, in which the pollen is formed, and hence they are termed parent or mother cells. These cells are surrounded by a special layer of cells, *cl*, forming the endothecium or tapetum. From Le Maout. *Fig.* 521. Horizontal section of a portion of the wall of a mature anther of *Cobæa scandens* at the time of dehiscence. It is composed of an external epidermal layer, *ce*, forming the exothecium, and an internal layer of fibrous cells, *cf*, which is commonly termed the endothecium, and which is the mesothecium of the immature anther.

partly subdivided. To these processes the name of placentoids was given by M. Chatin, under the impression that they assisted in the nourishment of the pollen.

We have already shown that the floral envelopes are homologous with leaves, representing them as they do in all their essential characters (pages 224 and 230). We have now to examine the stamen with the view of ascertaining whether its parts have in like manner any resemblance to those of the leaf. We have no difficulty in recognising the filament as the homologue of the petiole, as in its form, position, and structure it is essentially the same (page 242). The connective of the anther, again, is clearly analogous to the midrib of the blade, and hence we readily see that the two lobes of the anther correspond to the two halves of the lamina folded upon themselves; in fact, if we take the blade of a leaf and fold it in the above manner, and then make a transverse section, it will present a great resemblance to the section of the anther already described (*fig.* 513). We may therefore conclude: that the anther corresponds generally to the lamina of the leaf, the connective to the midrib, the outer surface to the epidermis of its lower side, and the septa to the epidermis of the two halves of the upper surface of the lamina united and considerably thickened. The pollen corresponds to the parenchyma situated between the epidermis of the upper and lower surfaces of the lamina of the leaf.

FIG. 522.

FIG. 523.

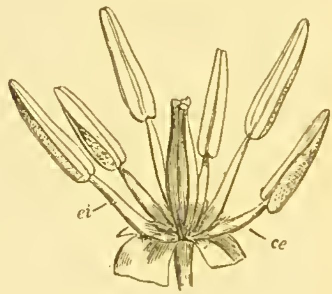


Fig. 522. A portion of the flower of the White Water-lily (*Nymphæa alba*), consisting of a gynœcium invested by a large fleshy disk which is prolonged from the thalamus. The pistil is surrounded by some stamens which have petaloid filaments and adnate introrse anthers; and by two petals. ——*Fig.* 523. Gynœcium and andrœcium of the Tulip. The stamens *ei* and *ce* have introrse anthers, which dehisce longitudinally.

Attachment of the Filament to the Anther.—The mode in which the anther is attached to the filament varies in different plants, but it is always constant in the same individual, and frequently throughout entire natural orders, and hence the characters afforded by such differences are important in practical botany. There are three modes of attachment which are distinguished by special names. Thus: 1st, the anther is said to be *adnate* or *dorsifixed* when its back is attached throughout its whole length to the filament, or to its continuation called the connective, as in the Magnolia (*fig.* 526), and Water-lily (*fig.* 522); 2nd, it is *innate* or *basifixed* when the filament is only attached to its base, and firmly adherent, as in the species of *Carex* (*fig.* 503); and 3rd, it is *versatile*, when the filament is only attached by a point to about the middle of the back of the connective, so that the anther swings upon it, as in Grasses generally (*fig.* 505), and in the Lily, Evening Primrose, and Meadow Saffron.

Connective.—The relations of the anther to the filament, as well as its lobes to each other, are much influenced by the appearance and size of the connective. Thus in all adnate anthers the connective is large, and the lobes generally more or less parallel to each other throughout their whole length (*fig.* 526). In other cases the connective is very small, or altogether wanting, as in species of *Euphorbia* (*fig.* 524), so that the lobes of the anther are then immediately in contact at their base. In the Lime the connective completely separates the two lobes of the anther (*fig.* 525). In the Sage (*fig.* 517) and other species of *Salvia*, the connective forms a long stalk-like body placed horizontally on the top of the filament, one end of which bears

FIG. 524. FIG. 525. FIG. 526. FIG. 527. FIG. 528.

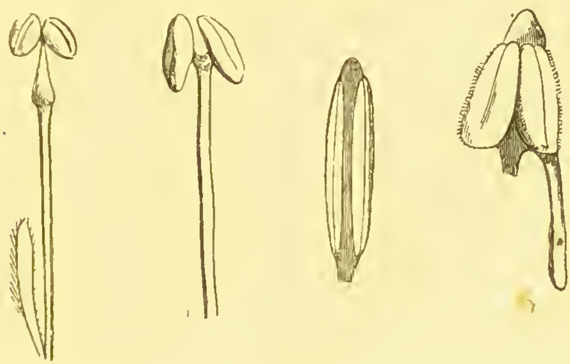


Fig. 524. A male naked flower of a species of *Euphorbia*, showing the two lobes of the anther, and the almost total absence of the connective.——*Fig.* 525. A stamen of the Lime (*Tilia*), showing the large connective separating the lobes of the anther.——*Fig.* 526. An inside view of a stamen of *Magnolia glauca*, showing the adnate anther and prolonged connective.——*Fig.* 527. Two stamens of the Heartsease (*Viola tricolor*). The connective of one of them is prolonged downwards in the form of a spur.——*Fig.* 528. Sagittate anther lobes of the Oleander (*Nerium Oleander*), and the prolonged feathery connective.

an anther lobe, *l f*, containing pollen, the other merely a petaloid plate or abortive anther lobe, *l s*; it is then said to be *distractile*. Sometimes the connective is prolonged beyond the lobes of the anther; either as a little rounded or tapering expansion, as in the Magnolia (*fig.* 526), or as a long feathery process, as in the Oleander (*fig.* 528), or in various other ways. At other times, again, it is prolonged downwards and backwards as a kind of spur, as in the Heartsease (*fig.* 527). Anthers with such appendages are termed *appendiculate*.

Forms of the Anther Lobes and of the Anther.—The lobes of the anther assume a variety of forms. Thus in *Mercurialis annua* (*fig.* 530), they are somewhat *rounded*; very frequently they are more or less *oval*, as in the Almond and Lime (*fig.* 525); in the *Acalypha* they are *linear* (*fig.* 529); in the Gourd tribe (*fig.* 531) *linear* and *sinuous*; in the *Solanum* (*fig.* 539) four-sided; and at other times pointed, or prolonged in various ways. These and other forms which they assume, combined with those of the connective, determine that of the anther, which may be *oval*, *oblong*, &c. ; or *bifurcate* or *forked* as in *Vaccinium uliginosum*

Fig. 529.

Fig. 530.

Fig. 531.

Fig. 529. A stamen of a species of *Acalypha* in a young state. *f.* Filament. *l.* Linear anther lobes.——*Fig.* 530. A stamen of *Mercurialis annua.* *f.* Filament. *c.* Connective. *l, l.* Rounded anther lobes dehiscing longitudinally.——*Fig.* 531. The linear and sinuous anther lobes, *l*, attached to the filament, *f*, of the common Bryony (*Bryonia dioica*). The above figures are from Jussieu.

(*fig.* 533), or *quadrifurcate* (*fig.* 534) as in *Gualtheria procumbens*, or *sagittate* (*fig.* 528) as in the Oleander, or *cordate-sagittate* as in the common Wallflower (*figs.* 26 and 27). In the Grasses the

Fig. 532.

Fig. 533.

Fig. 534.

Fig. 532. Appendiculate anther attached to filament, *f*, of the Fine-leaved Heath (*Erica cinerea*). *a.* Appendage. *l.* Lobes. *r.* Lateral short slit where dehiscence takes place.——*Fig.* 533. Bifurcate anther of *Vaccinium uliginosum* attached to filament, *f.* *l.* Anther lobes. *a.* Appendages. *p.* Points of the anther lobes where dehiscence takes place.——*Fig.* 534. Quadrifurcate anther of *Gualtheria procumbens*, attached to filament, *f.* *l.* Anther lobes. The above figures are from Jussieu.

anthers are forked at each extremity (*fig.* 505), so as to resemble somewhat the letter *x* in form.

The lobes of the anther also, like the connective, frequently present appendages of various kinds. Thus in the *Erica cinerea* they have a flattened leafy body at their base (*fig.* 532, *a*); at other times the surface of the anther presents projections in the form of pointed bodies (*fig.* 533, *a*), as in *Vaccinium uliginosum*, or warts, &c. Such anthers, like those which present appendages from the connective, are termed *appendiculate.*

Colour of the Anther.—The anther when young is of a greenish hue, but when fully matured it is generally yellow. There are however many exceptions to this: thus it is dark purple or black in many Poppies, orange in *Eschscholtzia*, purple in the Tulip, red in the Peach, &c.

Dehiscence of the Anther.—When the anthers are perfectly ripe they open and discharge their contained pollen (*figs.* 27, *a*, and 535); this act is called the *dehiscence* of the anther. Dehiscence commonly takes place in the line of the sutures (*fig.* 518, *b*), and at the period when the flower is fully expanded, and the pistil consequently sufficiently developed to receive the influence of the pollen: at other times, however, the anthers burst before the flower opens and while the pistil is still in an imperfect state. All the anthers may open at the same period, or in succession; and in the latter case the dehiscence may either commence with the outer stamens, as is usually the case, or rarely with the inner.

Dehiscence is produced, partly by the development and growth of the pollen in the lobes of the anther pressing upon their coats and causing an absorption of their tissue; and partly by the special action of the fibrous cells which form the lining of the anther (*fig.* 521, *cf*); and it takes place commonly at the sutures, because at these parts the endothecium is altogether wanting, and the exothecium is also usually very thin, so that they are the weakest points of the anther-walls.

The dehiscence of the anther may take place in four different ways, which are respectively called: 1. *Longitudinal*; 2. *Transverse* (mallow); 3. *Porous* (Heath, Rhododendron); 4. *Valvular.* (Barbary)

1. *Longitudinal or Sutural.*—This, the usual mode of dehiscence, consists in the opening of each anther-lobe from the base to the apex in a longitudinal direction along the line of suture, as in the Vine (*fig.* 518, *b*), the Wallflower (*fig.* 27, *a*), and Tulip (*fig.* 523).

2. *Transverse.*—This kind of dehiscence mostly occurs in unilocular anthers, as in those of *Alchemilla* (*fig.* 516), *Lemna*, and *Lavandula.* It consists in the splitting open of the anther transversely or in a horizontal direction, that is, from the connective to the side. It sometimes happens that by the enlargement of the connective the loculus of a one-celled anther is placed horizontally instead of vertically, in which case the dehiscence when it takes place in the line of the suture would be apparently transverse, although really longitudinal. An example of this kind of dehiscence is afforded by the Mallow (*fig.* 535), and other plants belonging to the natural order Malvaceæ. In

practical botany such anthers, like the former, are said to dehisce transversely.

3. *Porous or Apical.*—This is a mere modification of longitudinal dehiscence. It is formed by the splitting down of the

FIG. 535.

FIG. 536.

FIG. 537.

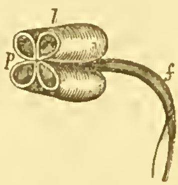


FIG. 538.

FIG. 539.

Fig. 535. Stamen of the Mallow (*Malva*), the anther of which has an apparently transverse dehiscence.——*Fig.* 536. Two-celled anther of the *Pyrola rotundifolia*, suspended from the filament, *f*. *l*. Loculi, each opening by a pore, *p*.——*Fig.* 537. Quadrilocular anther of *Poranthera*, attached to filament, *f*. *l*. Loculi, each opening by a pore, *p*.——*Fig.* 538. Anther of *Tetratheca juncea*, opening by a single pore at the apex. These figures are from Jussieu.——*Fig.* 539. Anther lobes of a species of *Solanum*, each opening by a pore at the apex.

anther lobes being arrested at an early period so as only to produce pores or short slits. In such anthers there is commonly no trace of the sutures to be seen externally. The pores or slits

FIG. 540.

FIG. 541.

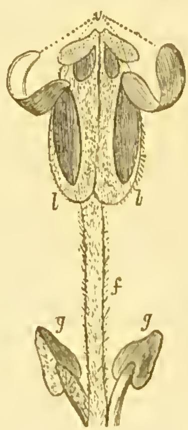


Fig. 540. Anther of Barberry (*Berberis vulgaris*), opening by two valves.——*Fig.* 541. Stamen of a species of *Laurus*. *f*. Filament, with two glands, *g*, *g*. at its base. *l*, *l*. Loculi, of which there are four. *v*. Valves.

may be either situated at the apex, as in the species of *Solanum* (*fig.* 539) and Milkwort (*fig.* 515); or laterally, as in the Heaths (*fig.* 532, *r*). There may be either two pores, as is usually the case (*fig.* 536, *p*), or four as in *Poranthera* (*fig.* 537, *p*), or many as in the Mistletoe, or only one as in *Tetratheca juncea* (*fig.* 538).

4. *Valvular or Opercular.*—This name is applied when the whole or portions of the face of the anther open like trap-doors, which are attached at the top and turn back as if on a hinge. In the Barberry (*fig.* 540) there are but two such valves or lids; while in plants belonging to the Laurel order there are two or four such lids (*fig.* 541, *v*), according as the anthers have two or four cells.

THE STAMENS GENERALLY, OR THE ANDRŒCIUM.—Before describing the pollen which is contained within the anther, it will be better to take a general view of the stamens as regards their relations to one another, and to the other whorls of the flower. We shall consider this part of our subject under four heads, namely:—1. Number; 2. Insertion or Position; 3. Union; 4. Relative Length.

1. *Number.*—The number of stamens is subject to great variation, and several terms are in common use to indicate such modifications. In the first place, certain names are applied to define the number of the stamens when compared in this respect with the component parts of the floral envelopes. Thus when the stamens are equal in number to the sepals and petals, the flower is said to be *isostemenous*, as in the Primrose; and if they are unequal, as in the Valerians (*figs.* 494 and 495), the flower is *anisostemenous*. Or, when greater accuracy is required, in the latter case, we say *diplostemenous*, if the stamens are double the number, as in the Stonecrop; *meiostemenous*, if fewer in number, as in the Lilac; and *polystemenous*, if more than double, as in the Rose.

Secondly, the flower receives different names according to the actual number of stamens it contains, without reference to the number of parts in the outer whorls. This number is indicated by the Greek numerals prefixed to the word *androus*, which means male, in reference to the function of the stamen. Thus, a flower having one stamen is *monandrous*, two *diandrous*, three *triandrous*, four *tetrandrous*, and so on. We shall have to refer to these terms again when treating of the Linnæan system of classification, as many of the classes in that system are determined by the number of stamens contained in the flower.

2. *Insertion or Position.*—When the stamens are free from the calyx and pistil, and arise from the thalamus below the latter organ, as in the Poppy (*fig.* 32) and Crowfoot (*fig.* 542), they are said to be *hypogynous*, which signifies under the female or pistil; this is the normal position of the stamens. When the stamens are attached to the corolla, as in the Primrose (*fig.* 543), they are *epipetalous*. When the stamens adhere to the calyx more or less, so that their position becomes somewhat

lateral to the pistil instead of below it, as in the Cherry (*fig.* 544), they, as well as the corolla, are said to be *perigynous*. When the calyx is adherent to the ovary so that it appears to

FIG. 542.

FIG. 543.

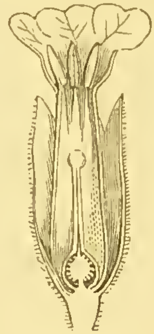


FIG. 544.

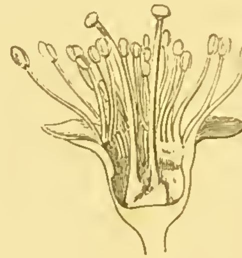


Fig. 542. Apocarpous pistil of the Crowfoot (*Ranunculus*), with two stamens arising from the thalamus below it, or hypogynous.——*Fig.* 543. Vertical section of a flower of the Primrose (*Primula*), showing epipetalous stamens. The pistil in the centre has an ovary with a free central placenta, one style, and a capitate stigma.——*Fig.* 544. Vertical section of the flower of the Cherry, showing the perigynous stamens surrounding the pistil.

rise from its apex, the intermediate stamens and petals or corolla are also necessarily placed on the summit, and are said to be *epigynous*, as in the species of *Campanula* (*fig.* 545), and Ivy.

FIG. 545.

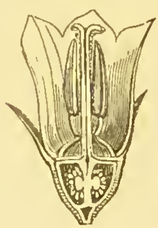


FIG. 546.

FIG. 547.

Fig. 545. Vertical section of the flower of a species of *Campanula*, with epigynous stamens.——*Fig.* 546. Flower of *Orchis mascula*. The column in the centre is formed by the union of the stamens and style.——*Fig.* 547. The pistil and stamens of Birthwort (*Aristolochia*). The ovary is seen below, and the stamens above united into a column with the style.

It sometimes happens that the stamens not only adhere to the ovary or lower part of the pistil, as in the epigynous form of insertion, but the upper part of the stamen or stamens and pistil become completely united also, and thus form a column in the centre of the flower, as in the Orchis (*fig.* 546), and Birthwort (*fig.* 547); this column is then termed the *gynostemium*, and the flowers are said to be *gynandrous*.

3. *Union or Cohesion.*—When the stamens are perfectly free and separate from each other, as in the Vine (*fig.* 518), they are said to be *free* or *distinct*; when united, as in the Mallow (*fig.* 549), they are *coherent* or *connate.*

When the stamens cohere, the union may take place either by their anthers, or by their filaments, or by both anthers and filaments. When the anthers unite, the stamens are termed *syngenesious* or *synantherous* (*fig.* 548). This union occurs in

FIG. 548.

FIG. 549.

FIG. 550.

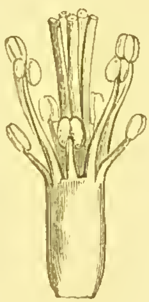


FIG. 551.

Fig. 548. Syngenesious anthers of a species of Thistle (*Carduus*).——*Fig.* 549. Monadelphous stamens of a species of Mallow (*Malva*).——*Fig.* 550. Monadelphous stamens of Wood Sorrel (*Oxalis*), forming a tube round the pistil. ——*Fig.* 551. Male flower of *Jatropha Curcas.* c. Calyx. p. Corolla. e. Stamens united by their filaments into a tube, *a*, which occupies the centre of the flower, as there is no pistil.

all the Compositæ, the Lobelia, and in some other plants. When the anthers thus unite the filaments are commonly, though not always, distinct. When union occurs between the stamens, however, it is more common to see the filaments united, and the anthers free. This union by the filaments may take place in one or more bundles, the number being indicated by a Greek numeral prefixed to the word *adelphous*, which signifies *brotherhood.* Thus, when all the filaments unite together and form one bundle, as in the Mallow (*fig.* 549), and Wood Sorrel (*fig.* 550), the stamens are said to be *monadelphous.* When such a union takes place in a complete flower, the coherent filaments necessarily form a tube or ring round the pistil placed in their centre, as in the Wood Sorrel (*fig.* 550); but when the pistil is absent, and the flower therefore incomplete, the united filaments form a more or less central column, as in *Jatropha Curcas* (*fig.* 551, *a*). When the filaments unite so as to form two bundles, the stamens are termed *diadelphous*, as in the Pea (*fig.* 552), Milkwort (*fig.* 515), and Fumitory ; in which case the number of filaments in each bundle may be equal as in the Milkwort (*fig.* 515) and Fumitory ; or unequal as in the Sweet Pea (*fig.* 552), where there are ten stamens, the filaments of nine of them being united to form one bundle, while the other filament remains free. When the stamens are united by their filaments into three bundles, they are *triadelphous*, as in most species of St. John's Wort (*fig.* 554) ; and when in more than three, *polyadelphous*, as in the Orange (*fig.* 553). The term polyadelphous is applied by many botanists, in all cases, where there are more than two bundles of stamens ; it was used in this latter sense by Linnæus.

The union of the filaments in the above cases may either take place more or less completely, and thus form a tube of varying heights, as in the Mallow (*fig.* 549) and Wood Sorrel

FIG. 552.

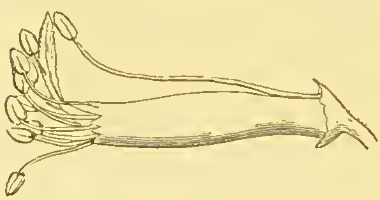


FIG. 553.

Fig. 552. Diadelphous stamens of the Sweet Pea (*Lathyrus odoratus*), surrounding the simple pistil. There are ten stamens, nine of which are united and one free.——*Fig.* 553. Flower of the Orange divested of its corolla, to show the polyadelphous stamens.

(*fig.* 550) ; or the union may only take place at the base, as in the *Tamarix gallica* (*fig.* 506). The bundle or bundles, again, may be either unbranched, as in the Mallow (*fig.* 549) ; or branched, as in the Milkwort (*fig.* 515) and Castor-oil Plant (*fig.* 555). When the union takes place so as to form a tube or column, the term *androphore* has been applied to such a column, as in the Mallow (*fig.* 549) and Wood Sorrel (*fig.* 550).

4. *Relative Length.*—There are two separate subjects to be treated of here, namely, 1st, the relative length of the stamens with respect to the corolla ; and 2nd, their length with respect to each other. In the first place, when the stamens are shorter than the tube of the corolla so as to be enclosed within it, as in the Forget-me-not (*fig.* 511), they are said to be *included* ; and when the stamens are longer than the tube of the corolla so as to extend beyond it, as in the Valerians (*figs.* 495 and 556), they are *exserted* or *protruding*.

Secondly, the relative length of the stamens with respect to each other presents several peculiarities, some of which are important in Descriptive Botany. Thus, sometimes all the stamens

Fig. 554.

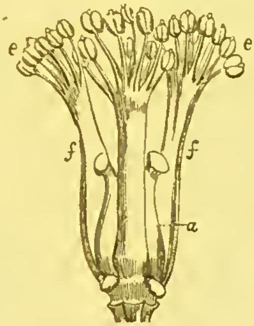


Fig. 555.

Fig. 556.

Fig. 554. The pistil, *a*, of *Hypericum ægyptiacum*, surrounded by the stamens, *e*, *e*, which are united by their filaments, *f*, *f*, into three bundles.——*Fig.* 555. One of the branched bundles of stamens of the Castor-oil Plant (*Ricinus communis*). *f.* United filaments.——*Fig.* 556. Flower of a species of Valerian (*Valeriana*), showing the stamens prolonged beyond the tube of the corolla, or exserted. The corolla is gibbous at the base.

of the flower are nearly of the same length; while at other times they are very unequal. This inequality may be altogether ir-

Fig. 557.

Fig. 558.

Fig. 559.

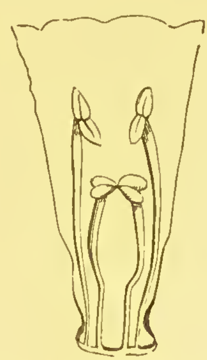


Fig. 557. One of the bundles of stamens of *Luhea paniculata*, the inner stamens on the right are longer than the others and are provided with anthers: the shorter stamens are generally sterile.——*Fig.* 558. Tetradynamous stamens of the Wallflower (*Cheiranthus Cheiri*).——*Fig.* 559. Didynamous stamens of the Foxglove (*Digitalis purpurea*).

regular again, following no definite rule, or take place in a definite and regular manner; thus, when the flowers are polystemenous, the stamens nearest the centre may be longer than those at the circumference, as in *Luhea paniculata* (*fig.* 557) ; or the reverse may be the case, as in many of the Rosaceæ. In the case of diplostemenous flowers, as with the Willow Herb (*Epilobium*), the stamens alternating with the petals are almost always longer than those opposite to them. When the stamens are of unequal length in the same flower, or in different flowers of the same species, as in the Primrose, they are said to be *dimorphic*, and will be afterwards alluded to in speaking of fertilisation.

When there is a definite relation existing between the long and short stamens with respect to number, certain names are applied to indicate such forms of regularity. Thus in the Wallflower (*figs.* 26 and 558), and Cruciferous plants generally, there are six stamens to the flower, of which four are long and arranged in pairs opposite to each other, and alternating with two solitary shorter ones ; to such an arrangement we apply the term *tetradynamous.* When there are but four stamens, of which two are long and two short, as in Labiate plants generally (*figs.* 485 and 487), and in the Foxglove (*fig.* 559), and most other Scrophulariaceous plants, they are said to be *didynamous.*

The Pollen.—The pollen consists of microscopic cells, which correspond to the *microspores* of the higher Cryptogams. It has also been stated, that the pollen was formed in certain cells developed originally in the centre of the parenchyma of the lobes of the young anther (*fig.* 520, *cm*) ; also that these cells were enclosed in a special covering of their own, *cl*, and that in the course of growth they pressed upon the coats of the anther, so as to cause their more or less complete absorption, and finally assisted in promoting the dehiscence of the anther (page 251). We have now more particularly to describe the mode of formation and the structure of the pollen.

Formation of the Pollen.—The formation of the pollen may be described as follows :—The large cells (*fig.* 520, *cm*), which are developed in the parenchyma of the young anther, and which are destined for its formation, are called *parent* or *mother* cells ; these are surrounded in the earlier stages of development by a single stratum of thin-walled cells forming an internal epithelial layer or *tapetum*, *cl*, which, however, becomes subsequently pressed upon and absorbed. Usually these parent cells remain connected to one another, but in some instances, and more especially in Monocotyledons, they become isolated and float free in a more or less viscid material occupying the cavity of the anther. As development proceeds the nucleus of each parent cell disappears, and in its place four new nuclei are ultimately formed (*fig.* 560, *a*). (See 'Karyokinesis' in Physiology.) Then follows an infolding of the protoplasm, or, according to Mohl, of the primordial utricle, *a*, *b*, *c*, by which the mother-cell is either divided at once into four parts ; or first into two, and subsequently, each of these again divided into two others. The four cells thus formed become each surrounded by a cellulose membrane which is in direct connexion with the cellulose coat of the mother-cell; and thus constitute what are known as the '*special mother-cells.*' Finally, each protoplasmic mass of the special mother-cells separates from the cell-wall and secretes around itself a membrane, so that ultimately we have four perfect cells, *d*, which constitute the true *pollen-cells,* formed in each parent cell.

As these pollen-cells progress in development, and increase in size, they distend the wall of the mother-cell, and ultimately cause its absorption; and subsequently, by their continued growth, the walls of the special mother-cells are generally absorbed also, by which the pollen-cells are set free in the cells of the anther. Sometimes the membrane of the special mother-

FIG. 560.

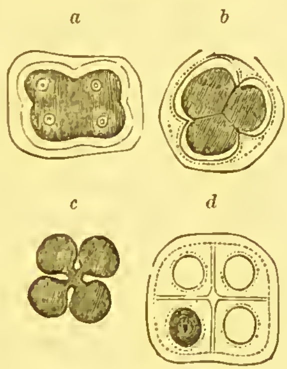


FIG. 561. FIG. 562.

FIG. 563.

Fig. 560. Formation of the pollen in the Hollyhock (*Althæa rosea*). After Mohl and Henfrey. *a* shows four nuclei in the parent cell, and four septa commencing to be formed. The primordial utricle and cell-contents are contracted by the action of alcohol. *b*. The development of the septa more advanced. *c*. The primordial utricle removed from the parent or mother cell, but not yet completely divided into four parts. *d*. The division of the parent or mother cell into four parts completed, and each part containing one pollen-cell.——*Fig.* 561. Pollen of *Inga anomala.*——*Fig.* 562. Pollen of *Periploca græca*. After Jussieu.——*Fig.* 563. Mass of spherical pollen-cells from a species of *Acacia*.

cells is not completely absorbed, in which case the pollen-cells of the mother-cell are more or less connected, and form a compound body consisting of four pollen-cells, as in *Periploca græca* (*fig.* 562); or if the membranes of two or more united mother-cells are also incompletely absorbed, we may have a mass consisting of eight pollen-cells, as in *Inga anomala* (*fig.* 561); or of some multiple of four, as in many species of *Acacia* (*fig.* 563). In the Onagraceæ, the pollen-cells are loosely connected by long viscid filaments or threads, which seem in this case to be wholly derived from a secretion left by the imperfect solution of the mother-cells; while in the Orchidaceæ the pollen-cells cohere in a remarkable degree and form pollen-masses which are commonly of a waxy nature, to which the name of *pollinia* has been given (*fig.* 564, *p*). In the Asclepiadaceæ somewhat similar masses occur (*fig.* 565, *p*, and *b*); but in the latter, the whole surface of each pollen-mass is invested by a special cellular covering. By a careful examination of these pollinia we find that they are formed of compound masses agglutinated together, and when separated, each of these masses is found to consist of four pollen-cells. In the pollinia of the Orchidaceæ we also find other peculiarities; thus each is prolonged downwards in the form of a stalk called the *caudicle* (*fig.* 564, *c*), which adheres commonly at the period of dehiscence to one or two little glandular masses called *retinacula* (*figs.* 566, *a*, and 564, *r*, *r*),

Fig. 564. Fig. 565. Fig. 566.

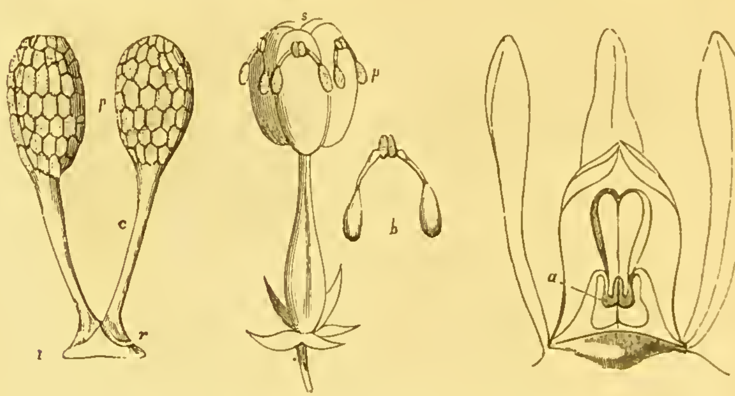


Fig. 564. Pollinia, *p*, of a species of Orchis with their caudicles, *c*, adhering to the retinacula, *r*, *r*.——*Fig.* 565. Pistil of a species of *Asclepias*, with the pollinia, *p*, adhering to the stigma, *s*. *b*. Pollen-masses separated. ——*Fig.* 566. Upper part of the flower of an Orchis, showing the pollinia adhering to the stigma by the retinacula, *a*.

which are placed on the upper surface of a little projection of the stigma or style, called the *rostellum*, which is situated at the base of the anther.

Structure of the Pollen.—We must now more particularly describe the structure of the pollen-cell, or pollen-grain as it is more frequently called. We shall treat of it under three heads, viz.:—1. Its Wall or Coats; 2. Its Contents; and 3. Its Form and Size.

1. *Wall or Coats of the Pollen-Cell.*—When mature the wall of the pollen-cell generally consists of two membranes: an internal or *intine*, and an external or *extine*. In rare cases the outer coat appears to consist of two, or even three layers; while in *Zostera*, *Zannichellia*, and some other submersed aquatic plants, there is but one membrane, which is of a similar nature to the intine.

The *intine* is the first formed layer, and appears to be of the same nature and appearance in all pollen-cells. It is usually smooth, very delicate, and transparent, and is composed of pure cellulose. It is generally applied so as to form a complete lining to the extine, except perhaps in those cases where the latter presents various processes, as in *Œnothera*, when Henfrey believes that the intine does not extend into them in the mature pollen.

The *extine* is a hard thick resisting layer, forming a kind of cuticle over the intine or proper cell-coat. While the intine usually presents a similar appearance in the pollen of different plants, the extine is liable to great variation; thus it is sometimes smooth, at others marked with little granular processes (*fig.* 73), or spiny protuberances (*fig.* 567), or reticulations (*fig.* 571). The nature of these markings is always the same for the pollen of any particular species or variety of plant, but varies much in that of different plants. The extine is generally

FIG. 567.

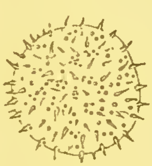


FIG. 568.

FIG. 569.

FIG. 570.

Fig. 567. Pollen of Hollyhock (*Althæa rosea*).——*Fig.* 568. Elliptical pollen of Milkwort (*Polygala*). *e.* Extine. *f.* Slits.——*Fig.* 569. The same pollen viewed from above.——*Fig.* 570. Pollen-cell of *Dactylis glomerata*. After Jussieu.

covered by a viscid or oily secretion, which is commonly supposed to be derived from matter remaining from the solution or absorption of the walls of the parent-cells. The colour of pollen-cells also resides in the extine. In by far the majority of cases the pollen-cells are yellow, but various other colours are also occasionally found; thus they are red in species of *Verbascum*, blue in some species of *Epilobium*, black in the Tulip, rarely green, and occasionally of a whitish tint.

Besides the various markings just described as existing on the extine, we find also either *pores* (*fig.* 570), or *slits* (*figs.* 568, *f*, and 569, *f*), or both pores and slits, and which vary in number and arrangement in different plants. At the spots where these slits or pores are found, it is generally considered that the extine is absent; but some botanists believe that the outer membrane always exists, but that it is much thinner at these points than elsewhere. In the greater number of Monocotyledons there is but one slit; while three is a common number in Dicotyledons. Sometimes there are six, rarely four, still more rarely two, and in some cases we find twelve or more slits. These slits are generally straight (*fig.* 568, *f*), but in *Mimulus moschatus* they are curved ; and other still more complex arrangements occasionally occur.

The pores, like the slits, also vary as to their number. Thus we commonly find one in Monocotyledons, as in the Grasses ;

FIG. 571. FIG. 572.

FIG. 573.

Fig. 571. Pollen of the Passion-flower (*Passiflora*), before bursting. *o, o, o.* Lid-like processes.——*Fig.* 572. Pollen of the Gourd, at the period of bursting. *o, o*, Lid-like processes of the extine protruded by the projections, *t, t*, of the intine. From Jussieu.——*Fig.* 573. Trigonal pollen of the Evening Primrose (*Œnothera biennis*).

and three in Dicotyledons. Sometimes again the pores are very numerous, in which case they are either irregularly distributed, or arranged in a more or less regular manner. The pores, also, may be either simple, or provided with little lid-like processes, as in the Passion-flower (*fig.* 571, *o, o, o*), and Gourd (*fig.* 572). These processes (*fig.* 572, *o, o*) are pushed off by corresponding projections of the intine, *t, t*, when the pollen bursts, or when it falls upon the stigma for the purpose of fertilising the ovules ; hence such pollen-cells have been termed *operculate*.

FIG. 574.

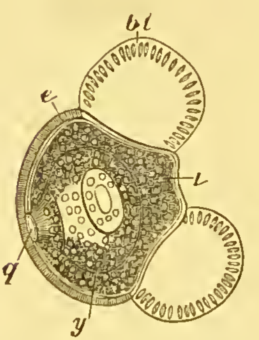


Fig. 574. Pollen of Spruce Fir (*Pinus excelsa*), consisting of a central cell and two lateral cells, *bl*, which are simply vesicular protrusions of the extine, *e*. *i*. Intine. *y*. The apical cell which forms the pollen-tube. *q*. Lowermost cell (or fissure, according to Strasburger), of the male prothallium in contact with the intine. After Schacht.

The pollen of all Angiosperms is usually regarded as a simple cell as above described, but in Gymnosperms the pollen is not a simple cell, but it contains other small cells, which adhere to the inside of its internal membrane close to the point where the external membrane presents a slit. These minute cells are termed daughter-cells. The recent investigations of Elfving have also shown that in some cases, at least, the pollen-cell of Angiosperms is not unicellular as generally regarded, but that before it escapes from the anther there is formed in it a mass of very small cells, which appear to be functionless, while the large cell produces the pollen-tube. (*See* 'Reproduction of Gymnospermia,' in Physiological Botany.)

2. *Contents of the Pollen-cells.*—The matter contained within the coat or coats of the pollen-cell is called the *fovilla*. This consists of a dense, coarsely-granular protoplasm, in which are suspended very small starch granules, and what appear to be oil globules. As the pollen-cell approaches to maturity, the fovilla becomes more concentrated, and contains less fluid matter, and more granules. Some of these granules are not more than about $\frac{1}{30000}$ of an inch in diameter, while the largest are about $\frac{1}{4000}$ or $\frac{1}{5000}$ of an inch. They vary also in form, some being spherical, others oblong, and others more or less cylindrical with somewhat tapering extremities. When water is applied to the granular contents they become opaque. When viewed under a high magnifying power, the starch granules at certain periods (especially at the period of the dehiscence of the pollen), exhibit a very active tremulous motion, moving to and fro in various directions and appearing as if repelled by each other. This is simply molecular motion, analogous to that of all other very minute particles when suspended in a liquid. The fovilla is without doubt the essential part of the pollen-cell, but the office it performs will be explained hereafter.

3. *Forms and Sizes of Pollen-cells.*—Pollen-cells are found of various forms. The most common forms appear to be the spherical (*figs.* 73 and 567), and oval (*fig.* 568); in other cases they are polyhedral, as in Chicory (*Cichorium Intybus*) and *Sonchus palustris*, or triangular with the angles rounded and enlarged (trigonal), as in the Evening Primrose (*Œnothera biennis*) and plants commonly of the order Onagraceæ (*fig.* 573), or cubical as in *Basella alba*, or cylindrical as in *Tradescantia virginica*, while in *Zostera* they are threadlike or of the form of a lengthened tube or cylinder, and other forms also occur. It should also be noticed that the form of the pollen is materially influenced according as it is dry or moist. Thus the pollen-cells of the Purple Loosestrife (*Lythrum Salicaria*) and some species of Passion-flower are oval when dry, but when placed in water they swell and become nearly globular: this arises from osmotic action taking place between the thickened fovilla and the water, by which some of the latter is absorbed, and the pollen-cells consequently distended. Again, when spherical pollen-cells are exposed to the air for some time they frequently assume a more or less oval form. In size, pollen-cells vary from about $\frac{1}{200}$ to $\frac{1}{1000}$ of an inch in diameter; their size, however, like their form, is liable to vary according as they are examined in a dry state or in water.

We have already stated that when the pollen-cells are placed in water they become distended in consequence of osmotic action taking place between their thickened contents and the surrounding fluid. If this action be continued by allowing the pollen-cells to remain in the liquid, they must necessarily burst at some point or other, and allow their contents to escape. Under these circumstances, as the intine is very extensible, while the extine is firm and resisting, it will be found that the former will form little projections through the pores or slits of the latter, so as to produce little blister-like swellings on its surface (*fig.* 575). Ultimately, however, as absorption of fluid by endosmose still goes on, the intine will itself burst and discharge the contents of the pollen-cell in the form of a jet (*fig.* 575). These changes will take place more rapidly if a little sulphuric or nitric acid be first added to the water.

When the pollen is thrown upon the stigma in the process of pollination (*fig.* 577, *stig*), the above described action becomes materially modified. In this case the pollen-cell does not

Fig. 575.

Fig. 576.

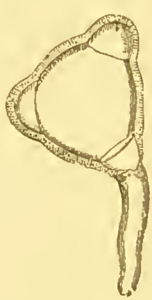


Fig. 577.

Fig. 575. Pollen of the Cherry discharging its fovilla through an opening in the intine.——*Fig.* 576. Trigonal pollen of *Œnothera* with a pollen-tube.——*Fig.* 577. Vertical section of the stigma and part of the style of *Antirrhinum majus.* *stig.* Stigma, on which two pollen-cells have fallen, each of which is provided with a pollen-tube, *tp*, which is passing through the tissue of the style, *styl.*

burst, but its intine protrudes through one or more of the pores or slits of the extine in the form of a delicate tube (*figs.* 576 and 577, *tp*), which is filled with the fovilla, and called the *pollen-tube* ; this penetrates, as will be afterwards described, through the tissue of the stigma (and style (*fig.* 577, *styl*) also, when this is present), to the placenta and ovules. This tube is frequently some inches in length, and its formation is a true growth, caused by the nourishment it derives from the stigma and conducting tissue of the style in its passage downwards to the interior of the ovary. (See page 271.)

Professor Duncan has proved that the pollen-tube is not, (in all cases at least,) as formerly supposed, a continuous tube, that is, having but one cavity ; but that in *Tigridia conchiflora* and other Monocotyledons with long styles which he examined, 'transverse inflexions of the tubular cell-wall of the pollen-tube exist every now and then;' so that then 'the pollen-tube is really a tube formed by elongated cells'; and hence having as many cavities as cells. In Dicotyledons, however, the pollen-tube appears to be in all cases unicellular, and, therefore, to have one continuous cavity.

2. THE DISK.

The term disk is variously understood by botanists: thus, by some it is used as synonymous with *thalamus*, *receptacle*, or *torus* (see page 292); by others, it is understood to include all abnormal or irregular bodies of whatever form or character which are situated on the thalamus between the andrœcium and gynœcium; by others, again, it is defined as that part of the thalamus which is situated between the calyx and the gynœcium, and which forms a support to the corolla and andrœcium; while others, again, define the disk as the portion of the thalamus situated between the calyx and gynœcium, when that part assumes an enlarged or irregular appearance; and lastly, the term disk is understood to include all bodies of whatever form which are situated on the thalamus between the calyx and gynœcium, or upon or in connexion with either of these organs, but which cannot be properly referred to them. It is applied in the latter sense in this volume.

Although the disk is not an essential organ of the flower, it is best treated of in this place, as it is most commonly placed between the andrœcium and gynœcium, and therefore comes next in order as we proceed with our examination of the parts of the flower. The disk seems, in many cases at least, to be merely a modification of the andrœcium; this appears to be proved not only from its parts occasionally alternating with the stamens, as in *Gesnera*, but also from the circumstance of portions of it when highly developed becoming occasionally changed into them. It is frequently of a nectariferous nature, and hence was treated of by Linnæus and many succeeding botanists under the head of Nectaries. We have already referred to nectaries under Glands (page 71) and Corolla (page 240).

The disk is developed in a variety of forms; thus, in the Orange and Rue (*fig.* 579), it forms a fleshy ring surrounding the base of the pistil; in the Tree Pæony (*fig.* 580), it occurs as a dark red cup-shaped expansion covering nearly the whole of the pistil except the stigmas; in the Rose and Cherry (*fig.* 544), it forms a sort of waxy lining to the tube of the calyx; and in Umbelliferous plants the disk constitutes a swelling on the top of the ovaries adhering to the styles (*fig.* 578, *d*); this latter form of disk has been termed the *stylopodium*. In other cases the disk is reduced to little separate glandular bodies, as in Cruciferous plants (*fig.* 26, *gl*); or to scales, as in the Stonecrop (*fig.* 581), and Vinc (*fig.* 518); or to various petaloid expansions, as in the Columbine.

When the disk is situated under the ovary, as in the Orange

Fig. 578.

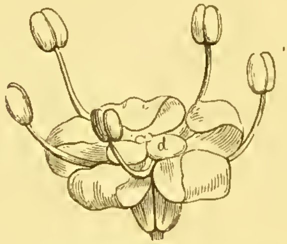


Fig. 579.

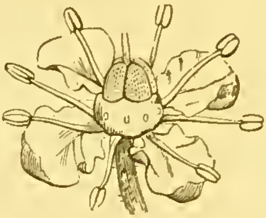


Fig. 578. Flower of the Fennel (*Fœniculum capillaceum*). The ovary is surmounted by a disk, *d*.——*Fig.* 579. Flower of the Rue (*Ruta graveolens*). The pistil is surrounded by a disk in the form of a fleshy hypogynous ring, on the outside of which the stamens are inserted.

and Rue (*fig.* 579), it is termed *hypogynous*; when it is attached to the calyx, as in the Rose and Cherry (*fig.* 544), it is *perigynous*; or when on the summit of the ovary, as in Umbelliferous plants

Fig. 580.

Fig. 581.

Fig. 580. Pistil of the Tree Pæony (*Pæonia Moutan* or *Moutan officinalis*) invested by a large cup-shaped expansion or disk.——*Fig.* 581. Pistil of Stonecrop (*Sedum*), consisting of five distinct carpels, on the outside of each of which at the base a small scaly body may be noticed. The pistil is compound and apocarpous.

(*fig.* 578, *d*), *epigynous*; these terms being used in the sense already described when treating of the insertion of the stamens under the head of the Andrœcium.

3. THE GYNŒCIUM OR PISTIL.

We now arrive at the consideration of the last organ of the flower, namely, the gynœcium or female system. The gynœcium, or pistil as it is frequently called, occupies the centre of the flower, the andrœcium and floral envelopes being arranged around it when they are present (*fig.* 26); the floral envelopes alone in the ordinary pistillate flower; or it stands alone when the flower is pistillate and naked (*fig.* 35). The gynœcium consists of one or more modified leaves called *carpels* which are either distinct from each other, as in the Stonecrop (*fig.* 581); or combined into one body, as in the Primrose (*fig.* 582) and Tobacco (*fig.* 584). When there is but one carpel as in the Pea (*fig.* 603), Broom (*fig.* 583), and Leguminous plants generally, the pistil is said to be *simple*; when there is more than one, whether distinct from each other, as in the Stonecrop (*fig.* 581), or combined into one body, as in the Tobacco (*fig.* 584), and Primrose (*fig.* 582), it is described as *compound*. Before proceeding to examine the gynœcium or pistil generally, it is necessary to describe the parts, nature, and structure of the carpel, of one or more of which organs it is composed.

Fig. 582.

Fig. 584.

Fig. 583.

Fig. 582. Pistil of Primrose (*Primula vulgaris*), composed of several united carpels, and hence termed compound and syncarpous. There is but one style, which is surmounted by a capitate stigma.—*Fig.* 583. Simple pistil of Broom. *o.* Ovary. *s.* Style. *t.* Stigma.—*Fig.* 584. Compound syncarpous pistil of Tobacco (*Nicotiana Tabacum*). *t.* Thalamus. *o.* Ovary. *s.* Style. *g.* Capitate stigma.

The Carpel.—This name is derived from a Greek word signifying the fruit, because the pistil forms, as will be afterwards explained, the essential part of that organ. Each carpel, as we have already noticed (page 19), consists, 1st, of a hollow inferior part arising from the thalamus, called the *ovary* (*fig.* 585, *o*), containing in its interior one or more little somewhat roundish or oval bodies called ovules, *ov*, and which are attached to a projection on the walls termed the *placenta*, *p*. 2nd, of a *stigma* or space of variable size, composed of loose parenchymatous tissue without epidermis; this stigma is either placed directly on the ovary, in which case it is said to be *sessile*, as in the Barberry (*fig.* 585, *st*); or it is elevated on a stalk prolonged from the ovary, called the *style*, as in the Broom (*fig.* 583, *s*). The only essential parts of the carpel, therefore, are the ovary and stigma, the style being no more necessary to it than the filament is to the stamen. The terms ovary, style, and stigma are applied in precisely the same sense when speaking of a compound pistil in which the parts are completely united (*figs.* 32, 582, and 584), as with the simple carpel. The simple ovary (page 279) has two sutures, one of which corresponds to the union of the margins of the lamina of the carpellary leaf out of which it is formed, and which is turned towards the axis of the plant; and another, which corresponds to the midrib of the lamina, is directed towards the floral envelopes or to the circumference of the flower; the former is called the *ventral suture* (*fig.* 586, *vs*), the latter the *dorsal*, *ds*. (See also page 300).

FIG. 585.

FIG. 586.

Fig. 585. Vertical section of the ovary of the Barberry (*Berberis vulgaris*), on the outside of which are seen a stamen dehiscing by two valves and a petal. *o.* Ovary. *ov.* Ovules attached to a projection called the placenta, *p.* *st.* Sessile stigma.——*Fig.* 586. Vertical section of the flower of the Pæony (*Pæonia*). *ds.* Dorsal suture of the ovary. *vs.* Ventral suture.

Nature of the Carpel.—That the carpel is analogous to the leaf is proved in various ways, some of which will be more particularly mentioned hereafter, when treating of the General Morphology of the Flower; we shall here only allude to the proofs of its nature which are afforded by the appearance it sometimes presents in double or cultivated flowers; and by tracing its development. Thus, in a double flower of the Cherry the carpels do not present a distinct ovary, style, and stigma, as is the normal condition of the solitary carpel in the single flower (*fig.* 590); but they either become flattened into green expansions, each of which resembles the blade of a leaf (*fig.* 587), or into organs intermediate in their nature between carpels and leaves as represented by the figures 588 and 589. Here the lower portion (*fig.* 589, *l*), representing the blade of the leaf, is clearly analogous to the ovary of a complete carpel, and the prolonged portion, *s*, to the style and stigma. The carpel of the single-flowering Cherry being thus convertible into a leaf, affords at once conclusive evidence of its being an analogous structure.

A *second proof* of the nature of the carpels is afforded by tracing their development. Thus when first examined they appear on the thalamus as little slightly concave bodies of a green colour like young leaves (*fig.* 591, *car*), in a short time they become more and more concave (*fig.* 592), and ultimately the two margins of the concavity in each unite (*fig.* 593), and thus form a hollow portion or ovary, in which the ovules soon make their appearance. This gradual transition of little leafy organs into carpels may be well seen in the Flowering Rush.

FIG. 587.

FIG. 588.

FIG. 589.

FIG. 590.

Figs. 587–589. Carpellary leaves from the double flowers of the Cherry-tree in different stages of development. *l.* Lamina. *p.* Midrib. *s.* Prolonged portion corresponding to the style and stigma of a perfectly formed carpel.——*Fig.* 590. Carpel from the single flower of the Cherry. *o.* Ovary. *t.* Style. *s.* Stigma.

We have thus in the first place shown that carpels become sometimes transformed into leaves, or into organs intermediate in their characters between carpels and leaves, in the flowers of cultivated plants; and secondly, that they make their first

FIG. 591.

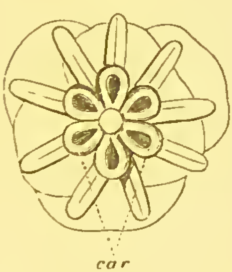


FIG. 592.

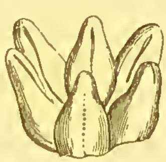


FIG. 593.

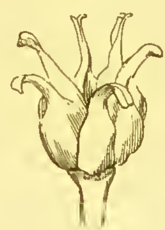


Fig. 591. Young flower-bud of the Flowering Rush (*Butomus umbellatus*). The carpels, *car*, are still concave on the inside, and resemble small leaves. ——*Fig.* 592. The carpels in a more advanced state, but the folded margins still separated by a slit.——*Fig.* 593. The same carpels in a perfect condition.

appearance in the form of little organs resembling leaves; and in both ways, therefore, we have proofs afforded us of their leaf-like nature.

Structure of the Carpel.—The ovary being the homologue of the blade of the leaf, it presents, as might have been expected, an analogous structure. Thus it consists of parenchyma, which is often much developed, and through which the vascular bundles composed of spiral and other vessels ramify, and either converge towards the base of the style, or terminate at the upper part of the ovary when the style is absent. The whole is covered externally by a layer of epidermis (*fig.* 594, *ep*). The parenchyma is usually of a more lax nature as we proceed towards the inside of the ovary, where it forms a very delicate lining, *end*, which is called by Schleiden *epithelium* ; it corresponds to the epidermis of the upper surface of the blade of the leaf. The epidermis on the outside of the ovary corresponds to that of the lower surface of the blade, and like it is frequently clothed with stomata, and sometimes with hairs. The parenchyma, *me*, between the inner lining of the ovary and epidermis, corresponds to the general parenchyma of the lamina, which is similarly placed. Where the margins of the blade of the carpellary leaf meet and unite at the ventral suture (*fig.* 586, *vs*), a layer of parenchymatous tissue is developed, which forms a more or less projecting line in the cavity of the ovary, called the *placenta* (*fig.* 585, *p*), to which the ovule or ovules are attached (*fig.* 628, *pl*). This placenta is essentially double, the two halves being developed from the two contiguous margins of the blade of the carpellary leaf.

FIG. 594.

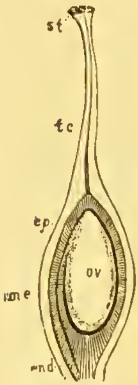


Fig. 594. Vertical section of the carpel of the Apricot. *ov.* Ovule, which is enclosed in an ovary. *ep.* Epidermis, forming the external coat of the ovary. *me.* Middle layer. *end.* Inner coat *tc.* Style with a canal in its centre. *st.* Stigma.

The *style* has been considered by some botanists as a prolongation of the midrib of the blade (*fig.* 589, *p*, *s*), but from the arrangement of its tissue it is to be regarded rather as a prolongation of its apex, the margins of which have been rolled inwards and united. It consists of a cylindrical process of parenchyma, traversed by vascular tissue, which is so arranged as to form a sort of sheath at its circumference (*fig.* 596, *v*, *v*, *v*), and is a continuation of that of the ovary ; it proceeds upwards without branching towards the apex of the style, but always terminates below that point. The style is invested by epidermis continuous with that of the ovary, and furnished occasionally, like it, with stomata and hairs.

Upon making a transverse (*fig.* 596), or vertical section (*fig.* 594), of the style, we find it is not a solid body as we might have supposed, but that it is rarely traversed by a very narrow canal (*figs.* 594 *tc*, and 596, *p*), which communicates below with the cavity of the ovary, and above with the stigma. This canal is either always entirely open, or more or less obstructed, as in Orchids (*fig.* 595, *can*), or far more commonly filled up by a number of variously formed very loosely aggregated cells (*fig.* 596, *p*). The walls of the canal also, in all cases, are formed of a loose papillose parenchyma. This canal may be considered as a prolongation of the cavity of the ovary, in an upward direction, consequently the loose tissue by which it is surrounded is to be regarded as corresponding to the epidermis of the upper surface of the lamina of the leaf, merely modified to adapt itself to the peculiar conditions under which it is placed. At the period of fertilisation, these cells, as well as those of the stigma, and canal of the style generally, secrete a peculiar viscid saccharine fluid, which is sometimes called the *stigmatic fluid* (see Nectariferous Glands, page 71). Hence at this period the centre of the style is filled with very loose humid tissue, to which the

FIG. 595.

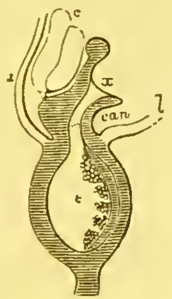


FIG. 596.

Fig. 595. Vertical section of the flower of *Epipactis latifolia*. *a.* One of the divisions of the perianth. *c.* Stamen. *e.* Ovules. *x.* Stigma. *can.* Canal leading from the stigma to the interior of the ovary. From Schleiden.—— *Fig.* 596. Transverse section of the style of the Crown Imperial (*Fritillaria imperialis*). *p.* Canal in its centre lined by projecting papillæ. *v, v, v.* Vascular bundles corresponding to the three styles of which this compound style is composed. From Jussieu.

name of *conducting tissue* has been given, because from its loose nature and nourishing properties it serves to conduct (as it were) the pollen-tubes (page 264) down the style (*fig.* 577, *tp*) to the placenta and ovules, as will be explained hereafter in Physiological Botany.

The Stigma.—The tissue of the stigma is analogous to that found in the interior of the style, and just described under the name of conducting tissue; in fact, it seems to be nothing more than an expansion of this tissue externally. It may be either on one side of the style (*figs.* 600 and 602), or at its apex (*fig.* 597, *s*), or on both sides (*fig.* 598, *s s*), the position depending upon the point or points where the conducting tissue or canal terminates. Its tissue is usually elongated into papillæ (*fig.* 597, *s*), hair-like (*fig.* 599, *s*), or feathery processes (*fig.* 601). It is never covered by epidermis. By means of the corresponding conducting tissue of the style it is in direct continuity with the placenta. At the period of fertilisation, as just noticed, it becomes moistened by a viscid fluid which renders the surface more or less sticky, and thus admirably adapted to retain the pollen, which is thrown upon it in various ways in the process of pollination (page 20).

Fig. 597. Fig. 598. Fig. 599. Fig. 600. Fig. 601.

Fig. 597. A portion of the pistil of *Daphne Laureola*. *o.* Summit of the ovary. *t.* Style terminated by a stigma, *s.*——*Fig.* 598. A portion of the pistil of *Plantago saxatilis*. *o.* Summit of the ovary. *t.* Style. *s, s.* Bilateral stigma. The above figures are from Jussieu.——*Fig.* 599. Pistil of the Periwinkle (*Vinca*). *o.* Ovary. *t.* Style. *s.* Hairy stigma. *d.* Disk. *Fig.* 600. Ventral view of the pistil of *Isopyrum biternatum*, showing the double stigma.——*Fig.* 601. Pistil of Wheat (*Triticum sativum*) surrounded by three stamens, and two squamulæ, *sp.* Two feathery styles or stigmas arise from the top of the ovary.

The Gynœcium or Pistil.—Having now described the parts, nature, and structure of the carpel, we are in a position to examine in a comprehensive manner the gynœcium or pistil generally, which is made up of one or more of such carpels.

When the gynœcium is formed of but one carpel, as in the Broom (*fig.* 583) and Pea (*fig.* 603), it is, as we have already seen, called *simple* (page 267), and the terms gynœcium or pistil and carpel are then synonymous ; when there is more than one carpel, the pistil or gynœcium is termed *compound* (*figs.* 581 and 582). In a compound pistil, again, the carpels may be either separate from each other, as in the Stonecrop (*fig.* 581), and Pheasant's-eye (*fig.* 607) ; or united into one body, as in the Primrose (*fig.* 582), Carnation (*fig.* 602), and Tobacco (*fig.* 584): in the former case the pistil is said to be *apocarpous*, in the latter *syncarpous*.

When the pistil is apocarpous, the number of carpels of which it is composed is indicated by a Greek numeral prefixed to the termination *gynia*, which means woman or female, in reference to the function it performs in the process of fertilisation ; and the flower receives corresponding names accordingly. In a syncarpous pistil, the number of the styles, or of the stigmas if the styles are absent, is also defined in a similar way. Thus, a flower with one carpel, style, or stigma, is *monogynous*, with two *digynous*, with three *trigynous*, and so on. These terms will be more particularly referred to when we treat of the Linnæan System of Classification, as most of the Orders of that arrangement are determined by the number of carpels, styles, or stigmas, in the flower.

FIG. 602.

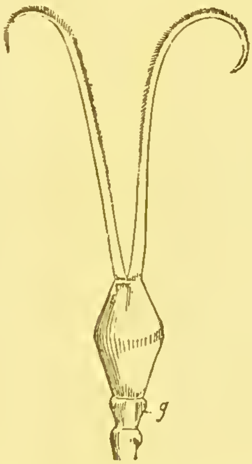


FIG. 603.

Fig. 602. Pistil of *Dianthus Caryophyllus* on a stalk, *g*, called the gynophore, below which is the peduncle. On the top of the ovary are two styles, the face of each of which is traversed by a continuous stigmatic surface.——*Fig.* 603. Pistil of *Lathyrus odoratus*. *o*. Ovary. *c*. Persistent calyx. On the top of the ovary is the style and stigma, *stig*.

1. *Apocarpous Pistil.*—An apocarpous pistil may consist of two or more carpels, and they are variously arranged accordingly. Thus, when there are but two, they are always placed opposite to each other ; when there are more than two, and the number coincides with the sepals or petals, they are opposite or alternate with them ; it is rare, however, to find the carpels corresponding in number to the sepals or petals, they are generally fewer, or more numerous. The carpels may be either arranged in one whorl, as in the Stonecrop (*fig.* 581) ; or in several whorls alternating with each other, and then either at about the same level, or, as is more generally the case, at different heights upon the thalamus so as to form a more or less spiral arrangement. When an apocarpous pistil is thus found with several rows of carpels, the thalamus, instead of being a nearly flattened top, as is usually the case when the number of carpels is small, frequently assumes other forms ; thus, in the *Magnolia* and Tulip-tree, it becomes cylindrical (*fig.* 604) ; in the Raspberry (*fig.* 606, *l*), and *Ranunculus* (*fig.* 542), conical ; in the Strawberry (*fig.* 605), hemispherical ; while in the Rose (*fig.* 454, *r*, *r*), it becomes hollowed out like a cup, or urn, and has the carpels

arranged upon its inner surface. These modifications of the thalamus, together with some others, will be more particularly

FIG. 604.

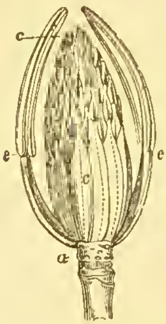


FIG. 605.

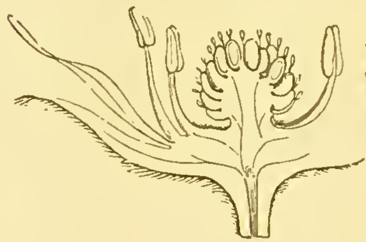


FIG. 606.

Fig. 604. Central part of the flower of the Tulip-tree (*Liriodendron tulipifera*). The thalamus, *a*, is more or less cylindrical. *c, c.* Carpels. *e, e.* Stamens. *Fig.* 605. Section of the flower of the Strawberry. The thalamus is nearly hemispherical, and bears a number of separate carpels on its upper portion.——*Fig.* 606. Section of the ripe pistil of the Raspberry, showing the conical thalamus, *l*.

referred to hereafter under the head of Thalamus (page 292). These varying conditions of the thalamus necessarily lead to corresponding alterations in the mutual relation of the different whorls of carpels which compose an apocarpous pistil, and modify very materially the appearance of different flowers.

FIG. 607.

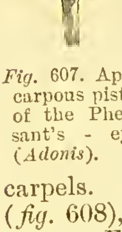


Fig. 607. Apocarpous pistil of the Pheasant's - eye (*Adonis*).

2. *Syncarpous Pistil.*—We have already seen, in speaking of the floral envelopes and andrœcium, that the different parts of which these whorls are respectively composed may be distinct from each other, or more or less united. From the position of the carpels with respect to one another, and from their nature, they are more frequently united than any other parts of the flower. This union may take place either partially, or entirely, and it may commence at the summit, or at the base of the carpels. Thus in the former case, as in *Xanthoxylon fraxineum* (*fig.* 608), the carpels are united by their stigmas only; in *Dictamnus Fraxinella* (*fig.* 624) the upper parts of their styles are united; while in the Labiatæ (*fig.* 609, *s*), and most Boraginaceæ (*fig.* 610, *d*), the whole of the styles are united. In all the above cases the ovaries are distinct; and in many Boraginaceæ, the stigmas also; but in all Labiatæ the stigmas are distinct. These examples aro to be considered, therefore, as transitional states between apocarpous and syncarpous pistils.

It is far more common to find the carpels united by their lower portions or ovaries, and this union may also take place to various extents. Thus, in the Rue (*fig.* 611, *ov*), the union only takes place at the base of the ovaries, the upper parts remaining distinct, in which case the ovary is commonly described as lobed. In *Dianthus* (*fig.* 602) the ovaries are completely united, the styles being distinct; while in the Primrose (*fig.* 582), the ovaries, styles, and stigmas are all united. When two or more ovaries are thus completely united so as to form one body, the organ resulting from their union is called a *compound ovary*.

FIG. 608.

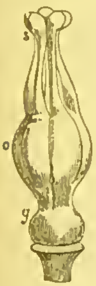


FIG. 609.

FIG. 610.

FIG. 611.

Fig. 608. Pistil of *Xanthoxylon fraxineum* supported on a gynophore, *g*. The ovaries, *o*, and styles are distinct, but the stigmas, *s*, are united.——*Fig.* 609. Pistil of Horehound (*Marrubium vulgare*), a Labiate plant. Its ovaries, *ov*, are distinct, the styles, *s*, being united, and the stigmas distinct.——*Fig.* 610. Pistil of *Myosotis*, a Boraginaceous Plant. *ov.* Distinct ovaries. *d.* Styles united.——*Fig.* 611. Flower of the Rue (*Ruta graveolens*), showing the ovaries, *ov*, united at their bases.

Compound Ovary.—The compound ovary formed as just stated may either have as many cavities separated by partitions as there are component ovaries; or it may only have one cavity. These differences have an important influence upon the attachment of the ovules, as will be afterwards seen when speaking of placentation. It is necessary for us, therefore, to explain at once the causes which lead to these differences. Thus if we have three carpels placed side by side (*fig.* 612, *a*), each of these possesses a single cavity corresponding to its ovary, so that if we make a transverse section of the whole, *b*, we necessarily have three cavities, each of which is separated from those adjoining by two walls, one being formed by the side of its own ovary, and the other by that of the one next to it. But if these three carpels, instead of being distinct, are united by their ovaries (*fig.* 613, *a*), so as to form a compound ovary, the latter must necessarily also have as many cavities as there are component carpels, *b*, and each cavity must be separated from those adjoining by a wall which is called a *dissepiment* or *partition*. Each dissepiment must be also composed of the united sides of the two adjoining ovaries, and is consequently double, one half being formed by one of the sides of its own ovary, the other by that of the adjoining ovary.

In the normal arrangement of the parts of the ovary, it must necessarily happen that the styles, (when they are distinct), must alternate with the dissepiments, for as the former are prolongations of the apices of the blades of the carpellary leaves, while the latter are formed by the union of their margins, the dissepiments must have the same relation to the styles as the sides of the blade of a leaf have to its apex ; that is, they must be placed right and left of them, or alternate.

Fig. 612. Fig. 613.

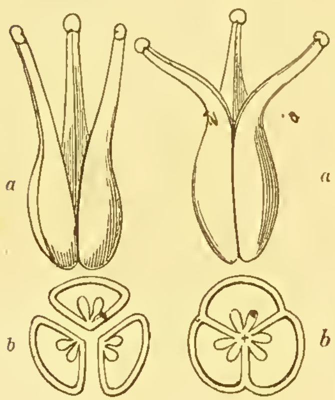


Fig. 612. *a.* Diagram of three carpels placed side by side, but not united. *b.* A transverse section of the ovaries of the same.——*Fig.* 613. *a.* Diagram of three carpels united by their ovaries, the styles and stigmas being free. *b.* A transverse section of the ovaries of the same.

The cavities of the compound ovary are called cells or loculi, and such an ovary as that just described would be therefore termed *three-celled* or *trilocular*, as it is formed of three united ovaries ; or if formed of the united ovaries of two, four, five, or many carpels, it would be described respectively as *two-celled* or *bilocular*, *four-celled* or *quadrilocular*, *five-celled* or *quinquelocular*, and *many-celled* or *multilocular*. As all dissepiments are spurious or false which are not formed by the united walls of adjoining ovaries, it must necessarily follow that a simple carpel can have no true dissepiment, and is hence, under ordinary and normal circumstances, *unilocular* or *one-celled*.

From the preceding observations it must also follow that when ovaries which are placed side by side cohere, and form a compound ovary, the dissepiments must be vertical, and equal in number to the ovaries out of which that compound ovary is formed. When a compound ovary is composed, however, of several whorls of ovaries placed in succession one over the other, as in the Pomegranate, horizontal true dissepiments may be formed by the ovaries of one whorl uniting by their base to the apices of those placed below them (*fig.* 723).

We have just observed that all dissepiments are said to be spurious except those which are formed by the union of the walls of contiguous ovaries, and it occasionally happens that such spurious dissepiments are formed in the course of growth, by which the ovary acquires an irregular character. These false dissepiments commonly arise from projections of the placentas inwards ; or by corresponding growths from some other parts of the walls of the ovaries. Some of these are horizontal, and are called *phragmata*, as in the *Cassia Fistula* (*fig*. 614), where the ovary, after fertilisation, is divided by a number of transverse dissepiments, which are projections from its walls. Others are vertical, as in Cruciferous plants, where the dissepiment, called a *replum* (*fig*. 615, *cl*), is formed from the placentas. Also, in *Datura Stramonium*, where the ovary is formed of two carpels, and is hence normally two-celled ; but instead of thus being bilocular, it is four-celled below (*fig*. 616) from the formation of a spurious vertical dissepiment, but towards the apex it is two-celled (*fig*. 617), the

FIG. 614.

FIG 615.

FIG. 616.

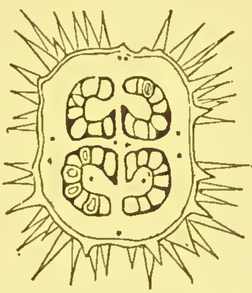


FIG. 617.

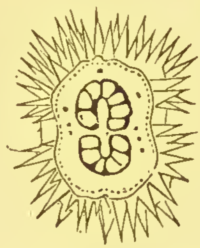


Fig. 614. Vertical section of a portion of the mature ovary of *Cassia Fistula*, showing a number of transverse spurious dissepiments (*phragmata*).——*Fig*. 615. Vertical section of the ovary of the Wallflower. *ov*. Ovules, each attached by a stalk to the placenta, *cn*. *cl*. Vertical spurious dissepiment called the replum.——*Fig*. 616. Transverse section of the lower part of the ovary of the Thorn-apple (*Datura Stramonium*), showing that the ovary is here four-celled. ——*Fig*. 617. Transverse section of the same ovary at its upper part, showing that it is here two-celled.

dissepiment not being complete throughout, and thus the true nature of the ovary is there indicated. In the Gourd tribe (*fig*. 721), also, spurious dissepiments appear to be formed in the ovary in a vertical direction by projections from the placentas. In the Flax, again (*fig*. 618, *b*), spurious incomplete vertical dissepiments are formed in the ovary by projections from the dorsal sutures. In the ovary of the *Astragalus* (*fig*. 619), a spurious dissepiment is also formed by a folding inwards of the dorsal suture ; while in *Oxytropis* and *Phaca* (*fig*. 620), a spurious incomplete dissepiment is produced in the ovary of each by a folding inwards of the ventral suture. Various other examples of the formation of spurious dissepiments might be quoted, but the above will be sufficient for our purpose. It should be noticed that in our description of spurious dissepiments, we have not confined our attention to those of compound ovaries alone, but have also referred to those of simple ovaries, in which they may equally arise. Thus the spurious dissepiments of *Cassia Fistula*, *Astragalus*, *Phaca*, and *Oxytropis* are all examples of such formations in simple ovaries.

FIG. 618.

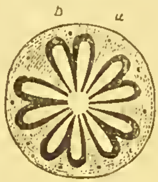


FIG. 619.

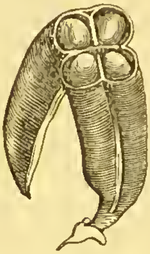


FIG. 620.

Fig. 618. Transverse section of the ovary of the Flax (*Linum usitatissimum*), showing five complete and true dissepiments, *a*, and five incomplete spurious dissepiments, *b*.——*Fig.* 619. Transverse section of the mature ovary of *Astragalus*, showing spurious dissepiment proceeding from the dorsal suture.——*Fig.* 620. Transverse section of the mature ovary of *Phaca*.

We have now to consider the *formation of the compound ovary which presents but one cavity, instead of two or more, as in that just alluded to.* Such an ovary is formed either by the union of the contiguous margins of the flattened open ovaries

FIG. 621.

FIG. 622.

FIG. 623.

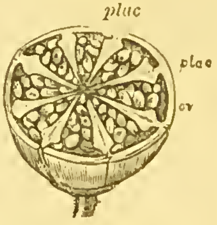


Fig. 621. Transverse section of the one-celled ovary of Mignonette (*Reseda*). *c*. The lower flattened portion or ovary of one of the three carpels of which it is formed. *pl*. One of the three parietal placentas.——*Fig.* 622. Transverse section of the one-celled ovary of an Orchis. *c*. The lower portion or ovary of one of the three carpels of which it is formed, slightly infolded. *pl*. One of the three parietal placentas.——*Fig.* 623. Transverse section of the ovary of a species of Poppy. *ov*. Ovules. *plac*, *plac*. Placentas, which in the young ovary nearly meet in the centre, and thus the ovary becomes almost many-celled, but as the ovary progresses in development it is only one-celled.

of the carpels of which it is composed, as in the Mignonette (*fig.* 621) and Cactus (*fig.* 631); or by the union of carpels the ovaries of which are only partially folded inwards, so that all their cavities communicate in the centre, and hence such a compound ovary is really unilocular, as in the Orchis (*fig.* 622), and Poppy (*fig.* 623).

Having now described the parts, nature, and structure of the carpel, and of the gynœcium or pistil generally, we proceed in the next place to allude separately to the constituent parts of the carpel, both in a free and combined state, namely, the ovary, style, and stigma.

1. The Ovary.—The ovary, as already mentioned (page 275) is called *compound* when it is composed of two or more ovaries combined together; or, on the contrary, it is *simple* when it constitutes the lower part of a simple pistil (*fig.* 583, *o*), or of one of the carpels of an apocarpous pistil (*fig.* 581). It should be noticed, therefore, that the terms simple pistil and simple ovary are not in all cases synonymous terms; thus, a pistil is only said to be simple (*figs.* 583 and 603), when it is

Fig. 624.

Fig. 625.

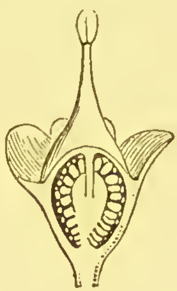


Fig. 626.

Fig. 624. Pistil of *Dictamnus Fraxinella.* The ovary is supported on a gynophore, *g*, and is superior.——*Fig.* 625. Vertical section of the flower of a Saxifrage, showing the ovary partially adherent to the calyx.——*Fig.* 626. Compound irregular mature ovary of *Antirrhinum.*

formed of but one carpel, the terms pistil and carpel being then mutually convertible; but an ovary is simple, as just noticed, whether it forms part of a simple pistil, as in Leguminous plants generally (*fig.* 603), or of one of the carpels of an apocarpous pistil, as in the Stonecrop (*fig.* 581). An ovary is also said to be *monomerous* when it is formed of only one carpel; or *dimerous*, *trimerous*, *tetramerous* or *polymerous* when it is formed by the coherence of two, three, four, or many carpels.

Generally speaking, the ovary is *sessile* upon the thalamus, the carpellary leaves out of which it is formed having no stalks. In rare cases, however, the ovary is more or less elevated above the outer whorls, when it is said to be *stalked* or *stipitate*, as in the *Dictamnus* (*fig.* 624, *g*), and *Dianthus* (*fig.* 602, *g*); this stalk has received the name of *gynophore*. We shall refer to the gynophore again under the head of Thalamus (page 292).

e.g. Poppy
Euphorbia
+ Pink

The ovary, whether simple or compound, may be either adherent to the calyx or free from it (see page 227). In the former case, as in the Myrtle (*fig.* 463), it is *inferior* or *adherent*, and the calyx is *superior*; in the latter, as in *Dictamnus* (*fig.* 624), it is *superior* or *free*, and the calyx is *inferior*. In some flowers the ovary is but partially adherent to the calyx, as in the species of Saxifrage (*fig.* 625), in which case it is sometimes termed *half-adherent* or *half-inferior*; and the calyx is then said to be *half-superior*; the latter terms are, however, but rarely used, the ovary being commonly described as inferior, whether its adhesion to the calyx be complete, or only partially so, and *vice versâ*.

The student must be careful not to confound the inferior ovary, as now described, with the apparently inferior ovaries of such flowers as the Rose (*fig.* 454), where the thalamus, *r*, *r*, is concave and attached to the tube of the calyx, *ct*, and bears a number of carpels, *o*, *o*, on its inner walls. A transverse section will at once show the difference; thus, in the Rose, we should then find a single cavity open at its summit, and its walls covered with distinct carpels; whereas, on the contrary, a true adherent ovary would show, under the same condition, one or more cells containing ovules. The ovaries of the Rose are therefore superior or free.

Schleiden contends that the ovary is not always formed of carpels, but sometimes also of the stem, and at other times of the two combined. His views are not however generally received by botanists, and we need not therefore further allude to them. It is probable, however, that the thalamus by becoming hollowed out may, in some cases, form part of the ovary, in the same manner as it occasionally, under similar circumstances, forms a part of the calyx, as already noticed in *Eschscholtzia*. (See page 229.)

The ovary varies much in form and in the character of its surface: when *simple* it is generally more or less irregular in form; but when *compound*, it is commonly regular. Exceptions to the regularity of compound ovaries may be seen in the *Antirrhinum* (*fig.* 626), and in other instances. In form, the compound ovary is generally more or less spheroidal, or ovate. The outer surface may be either perfectly even or uniform, thus showing no trace of its internal divisions; or it may be marked by furrows extending from its base to the origin of the style and corresponding to the points of union of its constituent ovaries. When these furrows are deep, the ovary assumes a lobed appearance, and is described as *one*, *two*, *three*, *four*, *five*, or *many-lobed*, according to the number of its lobes. Sometimes we find, in addition to the furrows which correspond to the points of union of the ovaries, others of a more superficial character which correspond to the dorsal sutures. At the latter points, however, it is more common to find slight projections, which then give a somewhat angular appearance to the ovary.

The epidermis covering the surface of the ovary may be either perfectly smooth, or furnished in various ways with different kinds of hairs; or it may assume a glandular appearance. In these cases the same terms are used as in describing similar conditions of the surface of the leaves, or of the other organs of the plant.

When the ovary is compound, the number of carpels of which it is composed may be ascertained in one or more of the following ways. Thus, when the styles (*fig.* 464), or stigmas (*fig.* 32), remain distinct, the number of these generally corresponds to the number of carpels. It does, however, occasionally happen, as in *Euphorbia* (*fig.* 627), that the styles are themselves divided, in which case they would of course indicate a greater number of carpels than are actually present; we must then resort to other modes of ascertaining this point, such, for instance, as the fur-

FIG. 627.

FIG. 628.

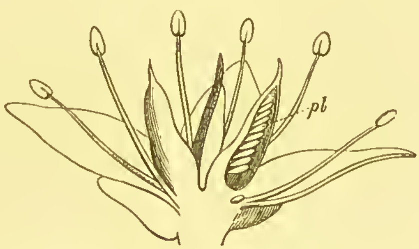


Fig. 627. Pistillate flower of a species of *Euphorbia*, with three forked styles. ——*Fig.* 628. Vertical section of the flower of the Stonecrop. *pl.* Placenta of one of the ovaries arising from the ventral suture.

rows or lobes on the external surface of the ovary; or the number of partitions or loculi which it contains, as these commonly correspond in number to the carpels of which that ovary is composed. The mode of venation may in some cases also form a guide in the determination; while in others the manner in which the ovules are attached must be taken into consideration. We now pass to the examination of the latter point.

Placentation.—The term *placenta* is commonly applied to the more or less marked projection occurring in the cavity of the ovary (*figs.* 585, *p*, and 628, *pl*), to which the ovule or ovules are attached. The placentas are variously distributed in the ovaries of different plants, but their arrangement is always the same for that of any particular species, and frequently throughout entire genera, or even natural orders; hence their accurate discrimination is of great practical importance (see page 286). The term *placentation* is used to indicate the manner in which the placentas are distributed. The placenta is called by Schleiden the *spermophore*.

1. *Kinds of Placentation.*—In the simple ovary the placenta is always situated at the ventral suture or that point which corresponds to the union of the two margins of the blade of the carpellary leaf (*figs.* 585, 586, and 628), out of which it is formed ; such a placenta is therefore usually termed *marginal*, or sometimes *axile* from its being turned towards the axis of the plant. The latter term is better reserved for the placentation of certain compound ovaries, as described below.

In compound ovaries we have three kinds of placentation ; namely, *axile* or *central*, *parietal*, and *free central*. The *axile* or *central* occurs in all compound many-celled ovaries, because in these each of the ovaries of the component carpels is placed in a similar position to that of the simple ovary (*figs.* 612 and 613), and hence the placentas situated at their ventral sutures will be arranged in the centre or axis, as in the Lily (*fig.* 629), and *Campanula* (*fig.* 630). By many botanists this mode of placen-

Fig. 629.

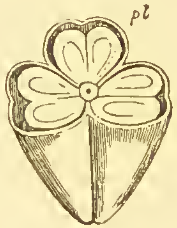


Fig. 630.

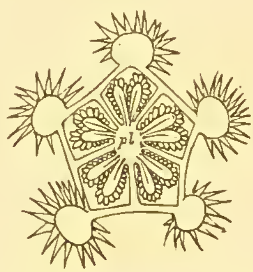


Fig. 631.

Fig. 629. Transverse section of the compound ovary of the Lily. The ovary is three-celled (trilocular). The placentas, *pl*, are axile or central.——*Fig.* 630. Transverse section of the ovary of a species of *Campanula*. The ovary is five-celled or quinquelocular, and the placentation, *pl*, axile or central.——*Fig.* 631. Transverse section of the ovary of a species of *Cactus*. The ovary is one-celled and the placentation parietal.

tation is called *central*, and the term *axile* is restricted to the form of placentation where the placenta is supposed to be a prolongation of the axis. This will be afterwards alluded to (page 285).

In a compound one-celled ovary there are two forms of placentation, namely, the *parietal*, and the *free-central*. The placentation is termed *parietal*, when the ovules are attached to placentas either placed directly on the inner wall of the ovary, as in the Mignonette (*fig.* 621, *pl*), and Cactus (*fig.* 631) ; or upon incomplete dissepiments formed, as already noticed, by the partially infolded ovaries, as in the species of *Orchis* (*fig.* 622, *pl*) and Poppy (*fig.* 623, *plac*). In parietal placentation, the number of placentas corresponds to the number of carpels of which the ovary is formed. When the placentas are not attached to the inner wall of the ovary, but are situated in the centre of the cavity and perfectly unconnected with the wall, they form what is called a *free central placenta*, as in the Caryophyllaceæ (*figs.* 633, *pl*, and 634, *p*), and the Primulaceæ (*fig.* 635, *pl*).

Besides the regular kinds of placentation just described, it sometimes happens that the ovules are placed more or less

FIG. 632.

FIG. 633.

FIG. 634.

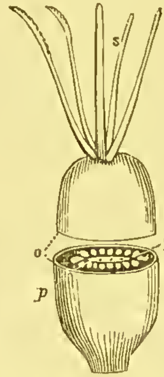


Fig. 632. Transverse section of the young ovary of Campion (*Lychnis*), showing five partitions proceeding from the walls of the ovary to the placentas in the centre; these partitions are destroyed by the growth of the ovary, so that the placentation is ultimately free.——*Fig.* 633. Vertical section of *Cerastium hirsutum* (*Caryophyllaceæ*). *o.* Ovary. *p.* Free central placenta. *g.* Ovules. *s.* Styles and stigmas.——*Fig.* 634. Transverse section of the same with the two portions or sections separated. *o.* Ovary. *p.* Placenta. *g.* Ovules. *s.* Styles and stigmas. From Jussieu.

irregularly in the cavity of the ovary. Thus, in the Flowering Rush (*fig.* 636), they cover the whole inner surface of the ovary

FIG. 635.

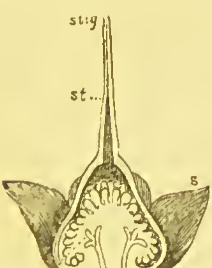


FIG 636.

Fig. 635. Vertical section of the pistil of Cyclamen (*Primulaceæ*). *s.* Sepals. *pl.* Free central placenta. *st.* Style. *stig.* Stigma.——*Fig.* 636. Vertical section of the flower of the Flowering Rush (*Butomus umbellatus*), showing the inner surface of the ovaries covered all over with ovules.

except the midrib; in which case the placentation is sometimes described as *superficial*.* Other irregularities also occur: thus, in * fi, 6 the *Nymphæa*, they are attached all over the dissepiments; in

Cabomba, they arise from the dorsal suture; and in the Broom-rapes (*Orobanche*), from placentas placed within the margins of the ventral suture.

2. *Origin of the Placenta.*—It is generally believed that the placenta is, in most cases at least, a cellular growth developed from the confluent margins of the carpels, or, more strictly speaking, from the confluent margins of the blades of the carpellary leaves. In some cases the placenta extends along the whole line of union of the carpel (*fig.* 628, *pl*), or it may be confined to its base or apex. Each placenta is therefore to be considered as composed of two halves, one half being formed by each margin of the carpel. Thus in simple ovaries the placenta is developed by a single carpel; in compound many-celled ovaries the placentas are in like manner formed from the contiguous margins of each individual carpel of which it is composed; while in compound one-celled ovaries presenting parietal placentation, each placenta is formed from the contiguous margins of two carpels, and is hence produced by two adjoining carpels.

That the placentas are really developed in the above forms of placentation from the margins of the carpels seems to be proved in various ways. Thus, in the first place, the placentas always correspond in regular kinds of placentation to the points of union of the margins of the carpel or carpels, and hence would naturally be considered as formed from them; and secondly, we frequently find, that in monstrosities or abnormal growths where the carpel is developed in a more or less flattened condition, a placenta bearing ovules is formed upon each of its margins. The productions of the ovules in these cases may be considered as analogous to the formation of buds on the margins of leaves, as in *Bryophyllum calycinum* (*fig.* 217), and *Malaxis paludosa* (*fig.* 218), already referred to. The formation of the placentas from the margins of the carpels in axile and parietal placentation may be considered, therefore, as capable of being proved by direct observation, and from analogy to what occurs in certain ordinary leaves.

But in reference to the origin of the free central placenta two different views are entertained. Thus it was formerly supposed that this also was a development from the margins of the carpels. It was thought that the carpels of which the compound ovary was formed originally met in the centre and developed placentas from their margins in the same manner as in ordinary axile placentation, but that subsequently the walls of the ovary grew more rapidly than the dissepiments, so that the connexion between them was soon destroyed; and that from this cause, and also from the great subsequent development of the placenta, the septa ultimately became almost or quite broken up, so that the placenta was left free in the cavity of the ovary. This theory is strengthened by the fact, that in several of the Caryophyllaceæ we often find dissepiments in the young ovary (*fig.* 632); and even traces of these at the lower part of the mature ovary; hence it may be concluded that these are the remains of dissepiments which have become ruptured on account of the unequal development of the parts of the ovary. In the Primrose, however, and many other plants, which have a free central placenta, no traces of dissepiments can be found at any period of the growth of the ovary. Duchartre, and others also, who have traced the development of the ovary in the Primulaceæ, state that the placenta is free in the centre from its earliest appearance; that it is originally a little papilla on the apex of the thalamus, and that the walls of the future ovary grow up perfectly free, and ultimately enclose it. The formation of such a free central placenta cannot therefore be well explained upon the marginal theory, as the carpels have never had any connexion with it except at their bases. Hence this kind of placentation has been supposed by many botanists not to be formed from the carpels at all, but to be a prolongation of the axis, which bears ovules, instead of buds as is the case with branches. This theory explains very readily the formation of the free central placenta of *Primula*, and hence such a placenta has been denominated *axile* by some botanists; but this name, as already noticed (page 282), having been already applied to another kind of placentation, the adoption of such a term cannot but lead to much confusion. The free central placenta of *Primula* can only be explained on the marginal or carpellary theory of the formation of placentas, by supposing, either that the placentas are only produced at the base of the carpels, and subsequently elongate and enlarge; or that they are formed by a whorl of placentas developed separately from the carpels by a process of chorisis (see *Chorisis*), and that these afterwards become united in the centre of the ovary.

Schleiden, indeed, and some other botanists regard the placenta in all cases as a development from the axis of the plant. The axile and free central placentation are readily to be explained by it, but the formation of the parietal placenta is by no means so clear. It is supposed in the latter case that the axis ramifies in the cavity of the ovary, and that the branches curve directly from their origin towards the side, and become blended with the margins of the two adjoining carpels on their inner side, and form parietal placentas bearing ovules as lateral buds. Schleiden thinks that the formation of the ovule in the Yew, where it terminates a branch, and is naked, is incompatible with the marginal theory. He also believes that the formation of the ovules generally in the Coniferæ supports his views of placentation. He regards the ovules in these plants as being given off from the axis of the cone, which he calls a placenta, and the scales, or bracts, which are situated between them, he maintains are open carpellary leaves. Schleiden also states, that no satisfactory explanation can be given by the advocates of the marginal theory of placentation of the formation of the ovule and placenta in *Armeria*, in which the ovary composed of five carpels surrounds a single ovule, which rises from the bottom of the axis, supported on a stalk which curves downwards at its apex, and thus suspends the ovule free in the centre of the cavity (*fig.* 637). He accordingly concludes, that the ovule and placenta are developments of the axis. Many other arguments in favour of the universal applicability of the axial theory in the formation of the placenta have been brought forward by Schleiden and other botanists, but their further discussion would be out of place here.

Fig. 637.

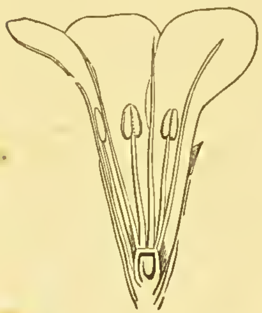


Fig. 637. Vertical section of the flower of *Armeria*. The ovary is seen to contain only a single ovule suspended from a funiculus or stalk. The ovule is here said to be reclinate.

From all that has now been stated, we may draw the following conclusions, namely :—that no one theory sufficiently accounts for the production of the placenta in all cases ; but that the axile and some forms of the free central placentation may be explained on both hypotheses ; that the parietal placentation is best explained upon the marginal theory ; and that the formation of the free central placenta of the Primulaceæ, Santalaceæ, and some other plants, can only be satisfactorily explained by considering the placenta as a production of the axis.

In a practical point of view, the mode of production of the placenta is of little importance. The accurate discrimination of the different kinds is, however, of much value in Descriptive Botany, by affording us constant, and hence important characters for distinguishing plants. Some natural orders exhibit more than one variety of placentation, and cannot be therefore distinguished by any particular kind ; hence, in such orders, the placentation can only be applied in obtaining good characteristics of the genera. In the majority of instances, however, we find one kind of placentation occurring throughout all the plants of a particular natural order. Thus, the Scrophulariaceæ, Ericaceæ, and Campanulaceæ present us with axile placentation ; the Papaveraceæ, Violaceæ, and Cruciferæ with parietal ; and the Caryophyllaceæ, Santalaceæ, and Primulaceæ, with free central placentation.

2. The Style.—We have already described (page 270) the general nature and structure of the style in speaking of the carpel. There are, however, certain other matters connected with it still to be alluded to.

The style usually arises from the geometrical summit of the ovary, of which it is a continuation in an upward direction, as in the Primrose (*fig.* 582): it is then termed *apicilar* or *apical*. In other cases, the apex of the ovary becomes inflected towards the side or base, from the carpel or carpels of which it is formed, being folded like ordinary leaves in reclinate vernation, the style then becomes *lateral* as in the Strawberry (*fig.* 638), or *basilar* as in *Alchemilla* (*fig.* 639). In the two latter cases, therefore, the geometrical and organic apices of the ovary do not correspond, as the point of origin of the style always determines the latter.

The style is generally directly continuous with the ovary, which gradually tapers upwards to it, as in *Digitalis*, in which case it is more or less *persistent*, and then it forms a more or less evident part of the fruit; at other times, however, there is a kind of contraction or species of articulation at the point where the style springs from the ovary, as in *Scirpus*, and then

Fig. 638.

Fig. 639.

Fig. 640.

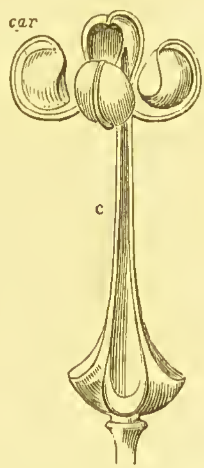


Fig. 638. One of the carpels of the Strawberry with a lateral style.——*Fig.* 639. Carpel of *Alchemilla* with a basilar style. The stigma is capitate.——*Fig.* 640. The carpophore, *c*, of a species of *Geranium*, with the rolled-back carpels, *car*.

the style always falls off after the process of fertilisation is completed, in which case it is said to be *deciduous*, and has no connexion with the fruit.

When the style is basilar or lateral, and the ovary to which it is attached more or less imbedded in the thalamus, it frequently appears to spring from the latter part; such an arrangement is called a *gynobase*, and the ovary is said to be *gynobasic*. Thus in the Labiatæ (*fig.* 609), and Boraginaceæ (*fig.* 610), the ovaries are free, but the styles become connected and form a central column, which appears therefore to be a prolongation of the thalamus.

Such an arrangement must not be confounded with that of

the ovaries and styles of the species of *Geranium* (*fig.* 640), and some other plants, where the axis is prolonged in the form of a beak-like process, to which the ovaries and styles become united, and from which they separate when the fruit is ripe. This prolongation of the thalamus is termed a carpophore. (See Thalamus, page 294.)
umbelliferae

We have already stated (page 281), that when the styles of a syncarpous pistil are distinct, they usually correspond to the number of carpels of which that pistil is composed. It sometimes happens, however, that the style of each carpel bifurcates or becomes forked, as in some Euphorbiaceæ, either once (*figs.* 627 and 642), or twice (*fig.* 641); in which case the apparent number of the styles above is then double or quadruple that of the carpels.

FIG. 641.

FIG. 642.

Fig. 641. Female flower of one of the *Euphorbiaceæ*. c. Calyx. *p, p.* Petals. *t.* Membranous expansion round the ovary. *o.* Ovary with three styles, *s*, each of which is twice forked.——*Fig.* 642. Ovary of the Castor-oil Plant (*Ricinus communis*), belonging to the Euphorbiaceæ. The styles in this case are once-forked.

When two or more styles are united into one body, this is termed a *compound style*. This adhesion may take place either entirely as in the Primrose (*fig.* 582), when the style is improperly termed *simple* (undivided or entire would be a better term); or the union is more or less incomplete as we proceed towards its apex, and corresponding terms are used accordingly. These terms are similar to those previously mentioned in describing the degrees of division of the other parts of the plant: thus the style is said to be cleft, when the union between the component styles extends to at least midway between their base and apex; and the style is said to be *bifid*, *trifid*, *quadrifid*, *quinquefid*, or *multifid*, according as it is *two*, *three*, *four*, *five* or *many-cleft*. If the union between the component styles does not extend to midway between their base and apex, the style is *partite*, and is described as *bipartite*, *tripartite*, *quadripartite*, &c., according to the number of partitions.

Form and Surface of the Style.—In form the style is generally more or less cylindrical; and either tapering from the base to the apex, as is more frequently the case, or becoming enlarged as it proceeds upwards. At other times the style is filiform, or more or less thickened, or angular; and rarely thin, coloured, and flattened like a petal, as in the species of *Canna* and *Iris* (*fig.* 643), when it is said to be *petaloid*.

The surface of the style may be either smooth, or covered in various ways with glands or hairs. These hairs when situated on the style frequently serve the purpose of collecting the pollen

FIG. 643.

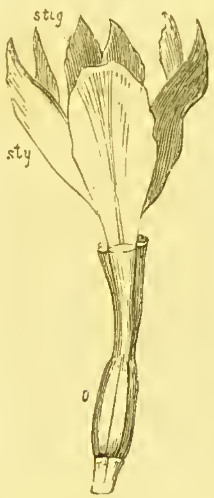


FIG. 644.

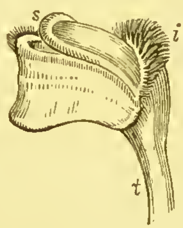


FIG. 645.

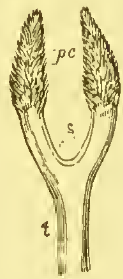


Fig. 643. Pistil of a species of *Iris*. *o*. Ovary. *sty*. Petaloid styles. *stig*. Stigmas.——*Fig.* 644. Upper part of the style and stigma of *Leschenaultia formosa*. *t*. Style. *s*. Stigma. *i*. Indusium.——*Fig.* 645. Upper part of the style, *t*, of a Composite plant, dividing into two branches, which are covered above by collecting hairs, *pc*. *s*. True stigma.

as it is discharged from the anther, and are hence termed *collecting hairs*. The collecting hairs on the style of the species of *Campanula* (*figs.* 158 and 159) are retractile; they have been already described under the head of Hairs (page 68). In the Compositæ the surface of the style is also more or less covered with stiff collecting hairs (*fig.* 645, *pc*), and as the style is developed later than the stamens, it is at first shorter than these organs; but as growth proceeds, it breaks through the adhering anthers, and thus the hairs on its surface come in contact with the pollen and become covered with it. In some of the allied orders to the Compositæ, the hairs form a little ring below the stigma (*fig.* 644, *i*), to which the term of *indusium* has been given

3. The Stigma.—The stigma has been already described (page 271), as being connected with the placenta by means of the conducting tissue of the style; hence it may be considered as a portion of the placenta prolonged upwards, but differing from it in not bearing ovules. If this be the proper view of the structure of the stigma, it must be regarded, like the placenta, as double, one half being formed by each margin of the carpellary leaf, and hence each simple pistil or carpel has necessarily two stigmas, the normal positions of which are lateral. In many Rosaceæ, as in the Rose, the stigma is notched on the side corresponding to that from which the placenta arises, which is another proof of its double nature.

The stigmas of a syncarpous pistil are generally opposite to the cells, and alternate with the dissepiments, but it sometimes happens, as in the Poppy (*fig.* 32, *sti*), that half the stigma of one carpel unites with a similar half of that of the adjoining carpel, and thus it becomes alternate with the cells, and opposite to the dissepiments, which are here, however, imperfect (*fig.* 623).

The term stigma is only properly applied to that portion of the style which is destitute of epidermis, and which secretes the stigmatic fluid (page 271); but it is often improperly given to mere divisions of the style. Thus in the species of *Iris* (*fig.* 643), the three petaloid portions of the style, *sty*, are by some botanists termed petaloid stigmas; whereas the stigma, *stig*, is properly confined to a little transverse space near the apex of each division. In many plants of the natural order Leguminosæ, such as *Lathyrus* (*fig.* 603, *stig*), the hairy part towards the summit of the style has been termed a stigma, but the latter is confined to the apex of that organ. In Labiate plants, also, the style divides above into two branches (*fig.* 609), and these have been called stigmas; but the latter, as in the instances just alluded to, are confined to the apices of the divided portions of the style.

We have already seen that the stigma may be separated from the ovary by the style (*figs.* 582 to 584); or the latter organ may be absent, in which case the stigma is said to be *sessile*, as in the Barberry (*fig.* 585, *st*) and Poppy (*fig.* 32, *sti*). In Orchids the stigma is sessile on the gynostemium (*fig.* 595, *x*), and appears as a little cup-shaped viscid space just below the attachment of the pollen-masses.

In a syncarpous pistil the stigmas may be either united together as in the Primrose (*fig.* 582), or distinct as in the *Campanula* (*fig.* 507); in the latter case, instead of looking upon these separate parts as so many distinct stigmas, it is usual to describe them as if they were portions of but one; thus we speak of the stigma as *bifid*, *trifid*, &c., or as *bilobate*, *trilobate*, &c., according to the number and character of its divisions. Thus the term *lobe* is usually applied when the divisions are thick, as in the Lily (*fig.* 646) and Melon (*fig.* 647); or when these are flattened and somewhat strap-shaped, as in the Compositæ (*fig.* 648), the stigma is *fissured* or *cleft*; or when flattened into

FIG. 646.

FIG. 647.

FIG. 648.

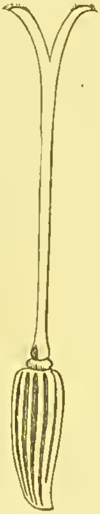


Fig. 646. Pistil of a Lily, with one style and a trilobate stigma.——*Fig.* 647. Lobed stigma of the Melon.——*Fig.* 648. Pistil of a species of *Chrysanthemum*, with one style and a bifid stigma, the divisions with hairs at their extremities.

plates or bands they are termed *lamellæ*, as in the *Bignonia* (*fig.* 649) and *Mimulus*. The number of these divisions in the majority of instances corresponds to the number of carpels of

FIG. 649.

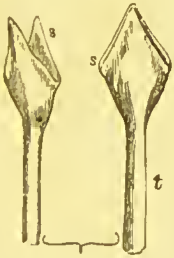


FIG. 650.

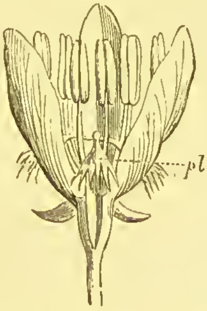


Fig. 649. Stigma, *s*, attached to style, *t*, of *Bignonia arborea*. In the left-hand figure the *lamellæ* are separate, in the other applied closely to each other.——*Fig.* 650. Flower of a species of *Rumex*, showing fringed stigmas, *pl*.

which the pistil is composed; and if the latter organ is many-celled, the number of cells will generally correspond also to the divisions of the stigma. Thus the five-cleft stigma of some Campanulas indicates that there are five cells to the ovary, and that the pistil is formed of five carpels. In the Gramineæ (*fig.* 601) and Compositæ (*figs.* 645 and 648), however, we have a bifid stigma, and but one cell in the ovary; but this arises from the non-development in the ovary of one of the two carpels of which the pistil in the plants of these orders is formed.

The lobes assume different appearances: thus, they may be smooth, or thick and fleshy as in the Melon (*fig.* 647), or feathery as in many Grasses (*fig.* 601), or fringed or laciniate as in the *Rumex* (*fig.* 650, *pl*).

FIG. 651.

FIG. 652.

FIG. 653.

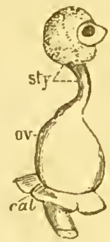


Fig. 651. *s.* Peltate or shield-shaped stigma surmounting the style, *t*, of a species of *Arbutus*.——*Fig.* 652. Pistil of *Daphne*. *o.* Ovary. *st.* Style. *stig.* Stigma.——*Fig.* 653. Pistil of Pansy (*Viola tricolor*). *cal.* Remains of calyx. *ov.* Ovary. *sty.* Style, surmounted by an irregular hooded stigma.

When the stigmas are united, the number of parts in the compound stigma is usually indicated by radiating furrows, or grooves. When the stigmas unite and form a compound body upon the top of the style, which is larger than it, this compound stigma or head is said to be *capitate*; and this head may be either globular as in *Daphne* (*fig.* 652, *stig*), or hemispherical as in the Primrose (*fig.* 582), or polyhedral, or club-shaped, or peltate or shield-shaped as in the *Arbutus* (*fig.* 651, *s*), and Poppy (*fig.* 32, *sti*). In the Violet (*fig.* 653), the stigma presents an irregular hooded appearance.

4. THE THALAMUS.

The extremity of the peduncle or pedicel, or any part of the axis upon which the parts of a solitary flower are arranged, has been variously distinguished by botanists as the *thalamus*, *receptacle*, and *torus*. The use of these names indifferently has often led to much confusion; and the uncertainty is still further increased in consequence of the terms receptacle and torus being also sometimes applied in a different sense. Thus, that of receptacle is employed in a special manner, as already mentioned (page 198), to indicate a more or less enlarged peduncle bearing usually a number of flowers; while the term torus is used by some botanists as synonymous with disk (page

265). To prevent confusion, therefore, it would be far better to limit the terms receptacle and torus to their special applications; and to employ the term thalamus only as defined above, and as it is used in this work.

In the majority of plants the thalamus is a little flattened surface or point, and accordingly presents nothing remarkable;

FIG. 654.

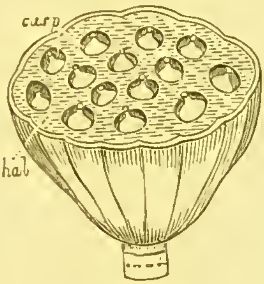


FIG. 655.

FIG. 656.

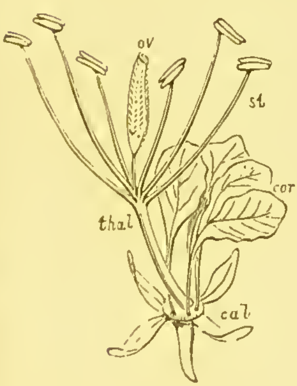


Fig. 654. *thal.* Thalamus of *Nelumbium.* *carp.* Carpels.——*Fig.* 655. Monstrous development of the flower of the Rose, showing the axis prolonged beyond the flower and bearing foliage leaves.——*Fig.* 656. Flower of a species of *Gynandropsis*, belonging to the Capparidaceæ. *cal.* Calyx. *cor.* Corolla. *thal.* Prolonged thalamus or gynophore, supporting the stamens, *st*, and ovary, *ov.*

but in other plants it becomes much enlarged, and then assumes a variety of appearances, and thus modifies to a considerable extent the form of the flower. Most of these forms of the thalamus have been already referred to (page 273), when describing the apocarpous pistil, but it will be more convenient for reference, &c., if we now speak again of these and all other essential modifications. In the species of *Magnolia*, *Liriodendron*, and plants of the order Magnoliaceæ generally, the thalamus is cylindrical (*fig.* 604, *a*); in plants also of the order Anonaceæ, it usually acquires a somewhat similar form; in the Raspberry (*fig.* 606, *l*), and species of *Ranunculus* (*fig.* 542) it is conical; in the Strawberry (*fig.* 605) hemispherical; in *Nelumbium* (*fig.* 654, *thal*) it is a large tabular expansion, in which there are a number of cavities containing the separate carpels. In the Rose it forms a concavity upon which the carpels are placed (*fig.* 454, *r*, *r*).

In the Primulaceæ, Santalaceæ, and in all cases where the placenta is free from the wall of the ovary from its earliest appearance, the thalamus becomes prolonged into the cavity of the ovary and forms the placenta (*fig.* 635). At other times the thalamus becomes prolonged beyond the ovary, as in the Geraniaceæ and Umbelliferæ; this prolongation is termed a *carpophore*. In the species of *Geranium* (*fig.* 640, *c*), this carpophore forms a long beak-like process to which the carpels, *car*, are attached, and from which they separate when the fruit is ripe. In many cultivated flowers, as in the Rose, the thalamus will frequently acquire a monstrous development, and become extended beyond the flower into a branch bearing foliage leaves (*fig.* 655). To this prolongation of the axis beyond the flower the term *median prolification* is usually applied.

In some plants the thalamus becomes prolonged beyond the calyx, and forms a stalk to the ovary, to which the term *gynophore* has been applied; and upon this stalk the stamens are also commonly placed, and in some cases the petals as well. Examples of this may be seen in some of the Capparidaceæ (*fig.* 656, *thal*); in the Pink (*fig.* 602, *g*), *Dictamnus* (*fig.* 624, *g*), and *Xanthoxylon* (*fig.* 608, *g*). This prolongation or stalk of the ovary is by some considered to be formed by the union of the petioles of the carpellary leaves of which that ovary is composed.

Section 5. The Fruit.

We have already seen that the ovary has in its interior one or more little oval or roundish bodies called ovules, which ultimately by fertilisation from the pollen become the seeds (page 19); their description, therefore, in a regular arrangement, should follow that of the ovary. It is, however, far more convenient to examine, in the first place, the nature and general characters of the fruit, as this is composed essentially of the mature ovary or ovaries, and its description comes therefore naturally at the present time, when the details connected with the ovary are fresh in our memories. Such an arrangement has, also, the further advantage of enabling us to describe the seed immediately after the ovule, as these two organs are, in like manner, only different conditions of one body.

Nature of the Fruit.—After the process of fertilisation has been effected, important changes take place in the pistil and surrounding organs of the flower, the result of which is the formation of the fruit. The fruit consists essentially of the mature ovary or ovaries, containing the fertilised ovule or ovules, which are then termed seeds. The styles and stigmas mostly disappear, but the remains of the style frequently exist in the form of a little point on the fruit, which is then commonly described as *apicilar*. Some traces indeed of the style may be usually observed, by which we are enabled to distinguish small fruits from seeds ; thus the fruits of the species of *Ranunculus*, those of Labiate plants, the Boraginaceæ, Umbelliferæ, and others, may be in this way commonly known from seeds. Generally speaking, however, the style forms but a very small portion of the fruit, the greater part of it, together with the stigma, dying away soon after the process of fertilisation has been effected ; but in some cases the style is not only persistent but continues to grow, and it then forms a lengthened appendage to the fruit, as in the Traveller's-joy (*fig.* 657), and in the Pasque-flower (*fig.* 700). The style in these two cases is also hairy, and hence the fruit is called *caudate* or *tailed*.

Fig. 657.

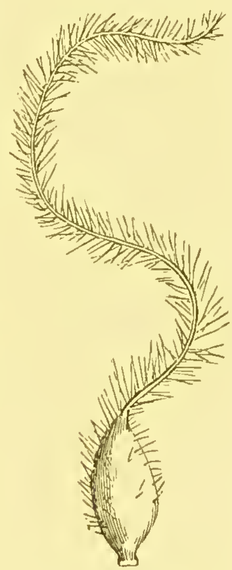


Fig. 657. Fruit of the Traveller's-joy (*Clematis Vitalba*). This fruit is called an Achænium ; it is caudate or tailed.

Although the fruit may thus be described as consisting essentially of the mature ovary or ovaries, other parts of the flower are also frequently present, and enter into its composition. Thus, in those cases where the calyx is adherent to the ovary, as in the Apple, Quince (*fig.* 473), Pear, Melon, and Gooseberry, it necessarily forms a part of the fruit ; in the Rose the concave thalamus (*fig.* 454, *r*, *r*), which bears the carpels on its inner surface, and the adherent calyx-tube, *ct*, become a portion of the fruit ; in the Strawberry (*fig.* 661), the fruit consists of the succulent hemispherical thalamus, bearing the carpels on its convex surface ; in the Acorn (*fig.* 400), Hazel-nut (*fig.* 401), and Filbert, it consists of pistil, calyx, and bracts, combined together ; while in the Pineapple (*fig.* 292), it is formed of the ovaries, floral envelopes, and bracts of several flowers ; in the Fig also (*fig.* 406) we have a fruit produced by a number of separate flowers enclosed in a hollow fleshy receptacle. These examples, and a number of others might be alluded to, will show, that although the fruit consists essentially of the mature ovary or ovaries, enclosing the fertilised ovules or seeds, yet the term is also applied to whatever is combined with the ovary, so as to form a covering to the seed or seeds. All fruits which are not formed entirely out of the fertilised pistil, but which consist in part of other portions of the flower, peduncle, or other parts, are now commonly termed *spurious fruits* or *pseudocarps*. as Rose Strawberry or Apple

Changes produced in the Ovary in the course of its Development.—The fruit being essentially the ovary in a mature state, it should correspond with it in structure. This is the case generally, and we find the fruit therefore consisting of the same parts as the ovary, only in a modified condition ; thus, the walls of the ovary commonly alter in texture, and either become dry, membranous, coriaceous, woody, &c. ; or, on the contrary, more or less pulpy, fleshy, &c.

At other times more important changes take place during the ripening of the ovary, which disguise the real structure of the fruit. These changes either arise from the addition, abortion, or alteration of parts. Thus, 1st. The addition of parts is commonly produced by the formation of the spurious dissepiments already alluded to. In *Datura Stramonium*, for instance, we have a two-celled ovary converted into an imperfectly four-celled fruit by the formation of a spurious vertical dissepiment (*figs.* 616 and 617) ; this dissepiment appears to be formed by the projection of the placentas on the two sides which meet and become united to corresponding projections from the dorsal sutures. In *Cassia Fistula*, again (*fig.* 614), and some other fruits of a similar nature, we have a one-celled ovary converted into a many-celled fruit by the formation of a number of transverse dissepiments. In *Pretrea zanguebarica*, a one-celled ovary is converted into a six-celled fruit (*fig.* 658), by an extension and doubling inwards of the placenta. In *Tribulus terrestris* the ovary is five-celled ; but as it approaches to maturity, each cell (*figs.* 659 and 660) becomes divided into as many divisions as there are seeds contained within it, in consequence of a corresponding number of projections from its walls. Other examples of the formation of spurious dissepiments producing changes in the ovary have been already mentioned when speaking of these processes (see pages 277 and 278).

2nd. Other alterations are produced by the abortion or obliteration of parts, as the ovary ripens. Thus the ovary of the Oak and Hazel consists of three cells, each of which contains two ovules, but the fruit has only one cell and one seed, so that in the course of development five ovules and one cell have become obliterated. In the Birch we have an ovary with two cells, containing one ovule in each, but the fruit is one-celled and one-seeded, so that here one cell and one ovule have become obliterated. In the Ash, Horsechestnut, Elm, and many other plants, similar changes are produced in the matured ovary by the abortion or obliteration of certain parts.

3rd. Other changes are caused in the ovary as it proceeds to maturity, in consequence of the alteration of parts, as, for instance, from a great development of succulent parenchyma. Thus, as already noticed, the thalamus of the Strawberry (*fig.* 605) becomes enlarged and succulent, and forms what is commonly termed the fruit, but the real fruit consists of the small dry carpels which are scattered over its surface (*fig.* 661). The pulp of the Guava, Gooseberry, Tomato, and some other fruits, in which the seeds are imbedded, appears to be produced from the placentas ; and that of the Orange is of a similar nature.

Fig. 658.

Fig. 659.

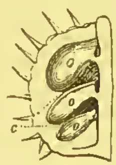


Fig. 660.

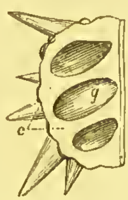


Fig. 661.

Fig. 658. Transverse section of the fruit of the *Pretrea zanguebarica*. From Lindley.——*Fig.* 659. A vertical section of a cell of the ovary of *Tribulus terrestris*. *o, o, o.* Ovules. *c.* Projections from the wall which are commencing to separate the ovules.——*Fig.* 660. A vertical section of a cell of the mature ovary or fruit of the same, in which the partitions, *c*, completely separate the seeds, *g*.——*Fig.* 661. Fruit of the Strawberry.

From the above examples it will be evident that, although the fruit consists essentially of the mature ovary or ovaries, yet that in the progress of the latter towards maturity it becomes frequently much altered from its original structure, so that in order to have a clear idea of the nature of the fruit, it is important to examine that of the ovary, and trace its development up to the fruit.

General Characters of the Fruit.—The structure of the fruit resembling in all important particulars that of the ovary, the modifications which it presents, as to composition, position, &c., are described by similar terms. Thus we may have *simple* and *compound* fruits, as also *apocarpous* and *syncarpous* ones. Simple fruits, like simple ovaries, are normally *one-celled* or *unilocular* ; while a compound fruit may have one or more cells, according as the dissepiments are absent or present, and the number of cells is indicated by similar terms to those used when speaking of the compound ovary (page 276).

The fruit, like the ovary, necessarily possesses a placenta, to which the seeds are attached ; and the same terms are used in describing the different kinds of placentation, as with those of the ovary ; these kinds are usually more evident in the fruit.

The fruit, again, is described as *superior* or *inferior*, in the same sense as these terms are used in speaking of the ovary. Thus a fruit is inferior, when it is formed from an inferior ovary, in which case the calyx necessarily enters into its composition, as in the Melon, Apple, Pear, and Quince (*fig.* 473); or it is superior, as in the Poppy (*fig.* 32) and Pea (*fig.* 668), when the ovary is superior, and the calyx non-adherent.

The *base* of the fruit is that point by which it is united to the thalamus ; the *apex* is indicated by the attachment of the style, hence in those ovaries where the style is lateral or basilar, as in many Rosaceæ (*figs.* 638 and 639), Labiatæ (*fig.* 609), and Boraginaceæ (*fig.* 610), the organic apex of the fruit will be also thus situated, so that the geometrical and organic apices will then be very different.

Composition of the Fruit.—The fruit when perfectly formed consists of two parts ; namely, the *pericarp*, and the *seed* or *seeds* contained within it. In the majority of cases the pericarp withers, and the fruit does not ripen, when the seeds are abortive. But there are many exceptions to this ; thus, many Oranges and Grapes produce no seeds, but the pericarp is nevertheless fully developed ; and in the Bananas, Plantains, and Bread-fruit, the pericarps develop most extensively, and become best adapted for food, when the seeds are chiefly or entirely abortive. Generally speaking, however, the development of the seeds and pericarp proceeds together after the process of fertilisation has been effected, and then only *perfect fruit* can be formed ; for although in common language we apply the term fruit in those instances where no seeds are produced, yet strictly speaking such are not fully formed fruits, but only enlarged and swollen pericarps.

Having now alluded to the seeds as a component part of the perfect fruit, we must leave their particular examination till we have become acquainted with the structure of the ovules, and now proceed, therefore, to the description of the pericarp.

Pericarp.—In the majority of fruits the pericarp consists simply of the walls of the ovary in a modified state ; but, when the calyx is adherent, it necessarily presents a more complicated structure. The pericarp exhibits three layers or regions (*fig.* 695), an external, called the *epicarp* or *exocarp*, *ep* ; a middle, the *mesocarp*, *mt* ; and an inner, the *endocarp*, *en*. The middle layer, being frequently of a fleshy or succulent nature, is also then termed the *sarcocarp* ; while the inner layer, from its hardness in some fruits, is likewise called the *stone*, *putamen*, or *pyrene*. When the pericarp consists simply of the matured walls of the ovary, its three parts correspond to the three parenchymatous layers of the lamina of the carpellary leaf : thus, the epicarp represents the epidermis of the under surface, or that on the outer surface of the ovary ; the mesocarp corresponds to the general parenchyma of the lamina, or of that of the ovary ; and the endocarp to the epidermis of the upper surface, or to the inner lining of the ovary. When the calyx is completely united to the ovary, the relation of parts must necessarily differ, and probably somewhat vary according to circumstances. Thus, in the Apple, which we may take as an illustration of an inferior fruit, the epicarp corresponds to the epidermis of the under surface of the calyx ; the mesocarp to the rest of the calyx, and the whole of the ovary except the inner lining, which corresponds to the endocarp. The parenchyma of the fruit, like that of the ovary and the blade of a leaf, is traversed by fibro-vascular tissue.

Fig. 662.

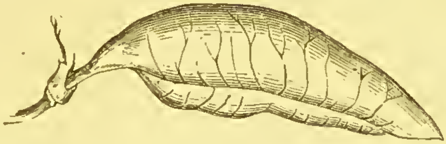


Fig. 662. Foliaceous bladdery legume of the Bladder Senna (*Colutea arborescens*).

In some cases the pericarp clearly indicates its analogy to the blade by remaining in a condition not very dissimilar to that part of a leaf folded inwards and united by its margins, as in the Bladder Senna (*fig.* 662) ; such a fruit is described as *foliaceous* or *leafy*. Generally speaking, however, one or more of the layers of the pericarp become more developed, by which its resemblance to the lamina of a leaf is rendered much less evident. The epicarp usually retains an epidermal appearance, suffering but little change, except in becoming slightly thickened. The endocarp is more liable to alteration, and frequently differs much in appearance from the corresponding part of the blade of a leaf or ovary ; thus, its cells sometimes become hardened by thickening layers in its interior and form a stony shell surrounding the seed, which is commonly called the *putamen*. The mesocarp is however the layer which commonly presents the greatest development, and differs most in appearance and texture from the general parenchyma of the lamina of a leaf.

The above remarks will be rendered more intelligible by being illustrated by a few examples taken from well-known fruits. Thus in the Peach, Apricot, Cherry, Plum, and most other drupaceous fruits (page 311), the separable skin is the epicarp ; the pulpy part, which is eaten, the mesocarp or sarcocarp ; and the stone enclosing the seed, the endocarp or putamen. In the Almond, the seed is enveloped by a thin woody shell, constituting the endocarp, which is itself surrounded by a thin green layer, formed of the combined mesocarp and epicarp. In the Apple and Pear, the skin is the epicarp ; the fleshy part, which is eaten, the mesocarp or sarcocarp ; and the core containing the seeds, the endocarp. A similar disposition of parts occurs in the Medlar, except that here the core becomes of a stony nature. In the Date the outer brownish skin is the epicarp ; the thin paper-like layer enclosing the seed is the endocarp ; and the intermediate pulpy part is the mesocarp or sarcocarp. In the Walnut, the woody shell enveloping the seed, which is commonly termed the nut, is the endocarp ; and the green covering of this, called the husk, consists of the mesocarp and epicarp combined. In the Orange, the outer separable rind is composed of the mesocarp and epicarp ; and the thin membranous partitions which divide the pulp into separate portions form the endocarp ; the edible pulp itself is a development of succulent parenchyma from the inner lining of the ovary, or probably from the placentas only. In the above fruits, and numerous others might be quoted, the different layers of the pericarp are more or less evident ; but in some fruits, as in the Nut, these layers become so blended, that it is difficult, if not impossible, to distinguish them. The examples of fruits now mentioned, together with those previously alluded to, will show in a striking manner the very varying nature and origin of the parts which are commonly eaten.

Sutures.—In describing the structure of the carpel, we found that the ovary presented two sutures (page 267) ; one of which (*fig.* 586, *vs*), called the ventral suture, corresponded to the union of the margins of the lamina of the carpellary leaf, and was consequently turned towards the axis or centre of the flower ; and the other, *ds*, termed the dorsal suture, corresponding to the midrib of the lamina, which was directed towards its circumference. The simple fruit being formed, in most cases, essentially of the mature ovary, also presents two sutures, which are distinguished by similar names. These, like those of the ovary, may be frequently distinguished externally, either by a more or less projecting line, or by a slight furrow ; thus in the Peach (*fig.* 693), Cherry, Plum, and Apricot, the ventral suture is very evident, although the dorsal suture has become nearly effaced ; while in the Bladder Senna (*fig.* 662), Pea, and other fruits of the Leguminosæ, both dorsal and ventral sutures are clearly visible externally.

In a compound ovary with two or more cells, in which the placentation is axile, it must be evident, of course, that the dorsal sutures can alone be observed externally, as the ventral sutures of the component ovaries are turned towards, and meet in the axis of the flower, and are hence removed from view ; it follows also that the number of dorsal sutures will necessarily correspond to the number of component ovaries of which such an ovary is formed. In a fruit presenting similar characters, we find of course a similar disposition of the sutures. When an ovary, on the contrary, is formed of the blades of two or more carpellary leaves, the margins of which are not inflected, or only partially so, and therefore one-celled, and the placentation parietal or free central, both ventral and dorsal sutures may be observed externally alternating with each other. The fruit, which is formed in a similar manner, necessarily presents a similar alternation of the sutures on its external surface.

Dehiscence.—The pericarp at varying periods, but commonly when the fruit is ripe, either opens, so as to allow the seed or seeds to escape ; or it remains closed, and the seeds can then only become free by its rupture or decay. In the former case the fruit is said to be *dehiscent* ; in the latter, *indehiscent.* Those fruits, such as the Nut, Cherry, Apricot, Plum, and Date, which have very hard or fleshy pericarps, are usually indehiscent.

Dehiscent fruits open in various ways :—1st. By splitting longitudinally in the line of one or both of the sutures ; or at the junction of the component carpels only ; or at these points as well as at the dorsal sutures. In all the above cases the pieces into which the fruit separates are called *valves*, and these valves, when the fruit is normal in its structure, are either equal in number to the cells, or component carpels, or they are twice as numerous. Thus in fruits formed of a single carpel, which only open by the ventral or dorsal suture, there will be only one valve (*figs.* 666 and 667), corresponding to the one carpel ; but if the carpels open by both sutures (*fig.* 668), there will be two valves. In fruits formed of compound ovaries composed of several cells, the valves will be equal in number to the component carpels, if the dehiscence only takes place by the dorsal suture (*figs.* 672–674), or in the line of union of the component ovaries (*figs.* 669–671) ; or they will be double the number, if the dehiscence takes place by both these parts. In compound one-celled fruits, the valves will be equal in number to the component carpels, if the dehiscence occurs only by the ventral (*fig.* 680) or dorsal sutures 681) ; or double the number, if by both sutures. When there is a distinct axis left after the separation of the valves, this is called the *columella* (*fig.* 675, *a*). According to the number of valves, the fruit is described as *one-valved*, *two-valved*, *three-valved*, or *many-valved.*

2nd. Dehiscence, instead of taking place longitudinally, or in a valvular manner, sometimes occurs in a transverse direction, by which the upper part of the fruit separates from the lower like the lid from a jar or box. And 3rd. It may take place in an irregular manner by little pores. We have thus three kinds or classes of dehiscence, which are called respectively :—1. *Valvular* ; 2. *Transverse* or *Circumscissile* ; and 3. *Porous*.

1. Valvular Dehiscence.—This may be either partial or complete ; thus, in *Dianthus* (*fig.* 664), *Lychnis* (*fig.* 663), and many other Caryophyllaceous plants, the dehiscence only

Fig. 663.

Fig. 664.

Fig. 665.

Fig. 668.

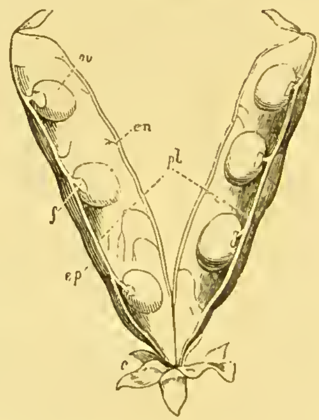


Fig. 666.

Fig. 667.

Fig. 663. Fruit of *Lychnis*.——*Fig.* 664. Fruit of *Dianthus*.——*Fig.* 665. Fruit of Mignonette (*Reseda*).——*Fig.* 666. Follicle of Columbine (*Aquilegia*), dehiscing by ventral suture.——*Fig.* 667. Follicles of *Magnolia glauca*, each dehiscing by its dorsal suture. The seeds are suspended from the fruits by long stalks or funiculi.——*Fig.* 668. Legume of the Pea which has opened by both dorsal and ventral sutures ; hence it is two-valved. *c.* Calyx. *ep.* Epicarp. *pl.* Placenta. *ov.* Seeds attached to the placenta by a funiculus or stalk, *f.* *en.* Endocarp.

takes place at the upper part of the fruit, which then appears toothed, the number of teeth corresponding to that of the valves in complete dehiscence. A somewhat similar mode of partial dehiscence occurs in certain Saxifrages, and in the Mignonette (*fig.* 665); in the latter plant one large orifice may be observed at the summit of the fruit at an early stage of its growth, and long before the seeds are ripe. At other times the separation of the fruit into valves is more or less complete, so that the nature of the dehiscence is at once evident. There are various modifications of these complete forms of valvular dehiscence. Thus, in fruits which are formed of but one carpel, the dehiscence may take place by the ventral suture only, as in the Columbine (*fig.* 666), and Aconite (*fig.* 698); or by the dorsal suture only, as in some Magnolias (*fig.* 667); or by both dorsal and ventral sutures, as in the Pea (*fig.* 668), Bean, and many other Leguminous plants. This form of dehiscence is commonly known as *sutural*.

In compound fruits having two or more cells, and therefore with axile or central placentation, there are three principal kinds of dehiscence, which are called respectively, *septicidal*, *loculicidal*, and *septifragal*.

A. *Septicidal Dehiscence.*—In this the fruit is separated into its component ovaries or carpels, by a division taking place

FIG. 669.

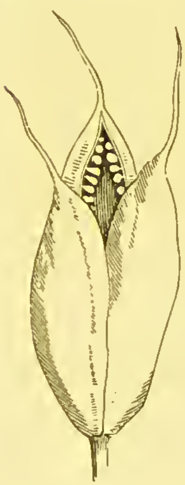


FIG. 670.

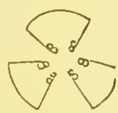


FIG. 671.

Fig. 669. Capsule of the Meadow Saffron (*Colchicum autumnale*), showing septicidal dehiscence.——*Fig.* 670. Diagram of septicidal dehiscence showing the placentas and seeds carried away with the valves.——*Fig.* 671. Diagram of septicidal dehiscence, showing the valves breaking away from a central column formed by the union of the placentas.

between the two halves of each dissepiment (*figs.* 669-671). Examples may be seen in *Colchicum* and *Rhododendron*. Here each valve corresponds to a carpel, and the valves are said to have their margins turned inwards. In this dehiscence the placentas with the seeds attached are either carried away with the valves (*fig.* 670), as in *Colchicum*; or the valves break away from the placentas, which remain united and form a central column (*fig.* 671).

B. *Loculicidal Dehiscence.*—This is said to occur when each carpel opens by its dorsal suture, or through the back of the cells, the dissepiments remaining undivided (*figs.* 672-674). Here each valve is composed of the united halves of two adjoining carpels, and the valves are said to bear the dissepiments in the middle. Examples may be seen in the Iris (*fig.* 712) and *Hibiscus* (*fig.* 672). As in septicidal dehiscence, the valves may either carry the placentas and seeds with them (*fig.* 673), as in the *Hibiscus* and *Iris*; or they may break away from the placentas, and leave them united in the form of a central column (*fig.* 674); or each carpel may simply open at its dorsal suture, and the valves bearing the dissepiments may remain attached to the placentas.

In some forms of septicidal dehiscence the carpels separate without opening, as in *Scrophularia*, in which case they may

FIG. 672.

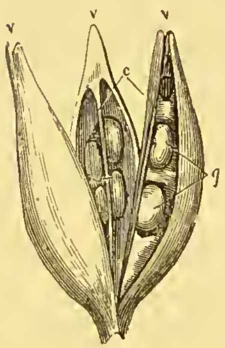


FIG. 673.

FIG. 674.

FIG. 675.

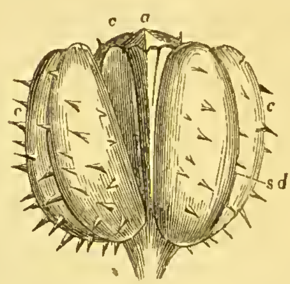


FIG. 676.

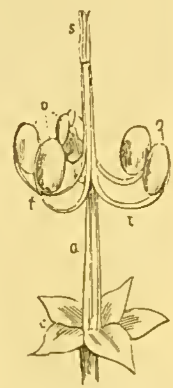


Fig. 672. Capsule of a species of *Hibiscus*, dehiscing loculicidally. *v, v, v.* Valves. *c.* Dissepiments. *g.* Seeds.——*Fig.* 673. Diagram of loculicidal dehiscence, in which the valves carry the placentas with them.——*Fig.* 674. Diagram of loculicidal dehiscence, in which the valves have separated from the placentas which remain as a central column with the seeds attached.——*Fig.* 675. Fruit of the Castor-oil Plant (*Ricinus communis*), dehiscing in a septicidal manner. *c, c, c.* Carpels. *a.* Columella. *sd.* Dorsal suture where each carpel ultimately opens.——*Fig.* 676. Fruit of a species of *Geranium*. *c.* Persistent calyx. *a.* Axis or carpophore from which the ovaries, *o, o,* with their styles, *t, t,* are separating. *s.* Stigmas.

afterwards open by their dorsal sutures, that is, in a loculicidal manner. In other cases, the axis is prolonged in the form of a columella or carpophore, as in the Mallow and Castor-oil Plant (*fig.* 675, *a*), and in the Geraniaceæ (*fig.* 676, *a*), and Umbelliferæ (*fig.* 717), and the carpels which are united to it also separate without their ovaries opening. The ovaries of such carpels frequently open afterwards by their dorsal sutures (*fig.* 675, *sd*). When such carpels separate with a certain amount of elasticity from the axis to which they are attached, as in some Euphorbiaceæ, they have been called *cocci* (*fig.* 675, *c, c, c*). By some botanists, all carpels which thus separate from the axis in a septicidal manner are termed *cocci*, and the fruit is described as *dicoccous*, *tricoccous*, &c., according to their number. In certain fruits, such as those of the *Linum catharticum*, the ovaries open first by their dorsal suture, and then separate from each other in a septicidal manner.

Some botanists call all fruits, the carpels of which separate from each other without opening—*schizocarps*; and term their component carpels *cocci* if there are more than two, or if only two in number, as in the Umbelliferæ,—*mericarps*.

C. *Septifragal Dehiscence.*—In this form of dehiscence the carpels open by their dorsal sutures, as in loculicidal dehiscence, and at the same time the dissepiments separate from the walls

FIG. 677.

FIG. 678.

FIG. 679.

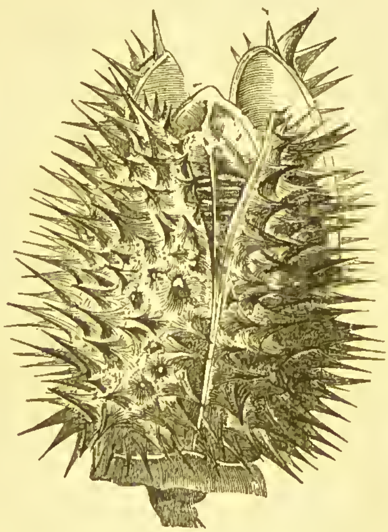


Fig. 677. Capsule of *Cedrela angustifolia*, showing septifragal dehiscence. *v*, *v*, *v*. Valves. *a*. Axis bearing the dissepiments, *c*, *c*, and seeds, *g*.——*Fig.* 678. Diagram illustrating septifragal dehiscence.——*Fig.* 679. Capsule of *Datura Stramonium*, showing septifragal dehiscence.

and remain united to each other and to the axis (*figs.* 677 and 678), which in this case is generally more or less prolonged. Here each valve is composed of the two halves of adjoining ovaries. This form of dehiscence may be seen in *Datura Stramonium* (*fig.* 679), and *Cedrela* (*fig.* 677). The placentas bearing the seeds are here attached to the axis, *a*, between the dissepiments, *c*, *c*.

In compound fruits with one cell having parietal or free central placentation, we have two forms of dehiscence; these are analogous to the ordinary septicidal and loculicidal kinds just described. Thus, in compound fruits with parietal placentation, the dehiscence may take place either through the confluent margins or sutures of the adjoining carpels, so that each placenta is divided into its two lamellæ, as in the species of Gentian (*fig.* 680), in which case the dehiscence is analogous to the septicidal form, and each valve, therefore, represents one of the component carpels of the fruit ; or the dehiscence may take place through the dorsal sutures, as in the Heartsease (*fig.* 681), in which case it is analogous to the loculicidal form of dehiscence, and each valve is composed of the adjoining halves of two carpels. These forms may be readily distinguished by the varying attachment of the placentas and seeds in the two cases ; thus, in the former instance, each valve will bear the placentas and seeds on its two margins (*fig.* 680), and the valves are said

FIG. 680.

FIG. 681.

FIG. 682.

Septifragal

FIG. 683.

Fig. 680. One-celled fruit of a species of Gentian dehiscing in a septicidal manner.——*Fig.* 681. One-celled fruit of Heartsease (*Viola tricolor*), dehiscing in a loculicidal manner.——*Fig.* 682. Fruit or siliqua of the Wallflower, showing the separation of two valves from the replum.——*Fig.* 683. Fruit (*ceratium*) of Celandine (*Chelidonium majus*), with the valves separating from the placentas.

to be *placentiferous at their borders* ; in the latter, the placenta and seeds will be attached to the centre of each valve (*fig.* 681), and the valves are then said to be *placentiferous in their middle.* It sometimes happens, as in the fruit of the *Chelidonium* (*fig.* 683), and Wallflower (*fig.* 682), that the placentas bearing the seeds remain undivided, and the valves break away from them, so that they are left attached to a frame or *replum* (page 277).

In compound fruits with a free central placentation, the same forms of dehiscence occur as in those with parietal placentation, but here it is difficult in many cases to speak positively as to the nature of the dehiscence from the absence of seeds or dissepiments upon the valves. The means usually adopted in such cases is to count the number of the valves and compare their position with the sepals or divisions of the calyx. Thus, as the different whorls of the flower in a regular arrangement alternate with one another, the component carpels of the fruit should alternate with the divisions or sepals of the calyx. If the fruit therefore separates into as many portions as there are parts or sepals to the calyx, and if these valves are then placed alternate to them, they represent the component carpels, and the dehiscence is consequently analogous to the septicidal form ; if, on the contrary, the valves are equal and opposite to the sepals or divisions of the calyx, each valve is composed of the adjoining halves of two carpels, and the dehiscence is analogous to the loculicidal form. Sometimes the number of valves is double that of the calycine segments or sepals, in which case each valve is formed of half a carpel, the dehiscence of the fruit having taken place both by its dorsal and ventral sutures.

In all the above varieties of valvular dehiscence, the separation may either take place from above downwards, which is by far the more usual form (*figs.* 669, 672, 677, and 679) ; or occasionally from below upwards, as in the Celandine (*fig.* 683), and universally in Cruciferous plants (*fig.* 682).

2. Transverse or Circumscissile Dehiscence.—In this kind of dehiscence the opening takes place by a transverse fissure through the pericarp across the sutures, so that the upper part is separated from the lower like the lid of a jar or box, as in *Hyoscyamus* (*fig.* 684) and *Anagallis* (*fig.* 709). Sometimes the dehiscence only takes place half round the fruit, as in *Jeffersonia*, in which case the lid remains attached to the pericarp on one side, as by a hinge. The fruits which present transverse dehiscence may be supposed to be formed either of carpellary leaves in which the laminæ are articulated to the petioles, as in the Orange (*fig.* 320), and which become separated at the points of articulation, so that the united petioles form the lower part of the fruit, and the united laminæ the upper ; or they may result from the prolongation and hollowing out of the thalamus, and the articulation of the carpellary leaves to its circumference, so that in the dehiscence the lower part of the fruit is formed by the concave thalamus, and the upper part by the carpellary leaves ; thus resembling the separation of the calyx in *Eschscholtzia* (page 229) from the thalamus.

Fig. 684.

Fig. 684. Fruit of Henbane (*Hyoscyamus*) with transverse dehiscence. This fruit is termed a pyxis (page 316).

In the Monkey-pot (*fig.* 685), the lower part of the ovary is adherent to the tube of the calyx, and the upper portion is free ; and when dehiscence takes place, it does so in a transverse manner and at the part where the upper free portion joins the lower adherent one, so that it would appear as if the adherence of the calyx had some effect in this case in producing the transverse dehiscence. Such fruits are sometimes called *operculate*, a term which is also applied by other botanists to all forms of transverse dehiscence in which the upper portion of the pericarp separates from the lower in the form of a *lid* or *operculum*.

Fig. 685.

BRAZIL NUT.

Fig. 686.

Fig. 685. Pyxis of the Monkey-pot (*Lecythis ollaria*).——*Fig.* 686. Lomentum of a species of *Hedysarum* separating transversely into one-seeded portions.

Transverse dehiscence may also occur in fruits which are formed by a single ovary or carpel, as well as in the compound ones mentioned above. Thus, the legumes of *Coronilla*, *Hedysarum* (*fig.* 686), *Ornithopus*, &c., separate when ripe into as many portions as there are seeds. The separation taking place in these cases has been supposed to be effected by a process called *solubility*. Some botanists regard such legumes as formed of folded pinnate carpellary leaves analogous to the ordinary pinnate leaves of the same plants, the divisions taking place at the points of union of the different pairs of pinnæ.

3. Porous Dehiscence.—This is an irregular kind of dehiscence, in which the fruits open by little pores or slits formed in

Fig. 687.

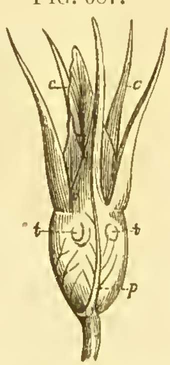


Fig. 688.

Fig. 687. Immature fruit of a species of *Campanula*. *p*. Pericarp. *t*, *t*. Pores at the sides. *c*, *c*. Persistent calyx united below to the wall of the fruit so as to form a part of the pericarp.——*Fig.* 688. Fruit of a species of *Campanula* dehiscing by pores at its base.

their pericarps by a process called *rupturing*. These openings may be either situated at the apex, side, or base of the fruit, hence they are described accordingly, as *apicular*, *lateral*, or *basilar*. Examples of this kind of dehiscence occur in the

Poppy, in which a number of pores are placed beneath the peltate disc to which the stigmas are attached ; in the *Antirrhinum* (*fig.* 626), where there are two or three orifices, one of which is situated near the summit of the upper cell or ovary, and the other (one or two) in the lower ; and in various species of *Campanula* (*figs.* 687, *t*, *t*, and 688). In the latter the calyx is adherent to the ovary, and the pores, which have a very irregular appearance at their margins, penetrate through the walls of the pericarp formed by the adherent calyx and ovary ; these pores correspond to the number of cells in the ovary, and are either situated at the sides (*fig.* 687, *t*, *t*), or towards the base (*fig.* 688).

Kinds of Fruit.—A number of different kinds of fruit have been distinguished and named, and several classifications of the same have been proposed at various times, but at present there is little accordance amongst botanists upon this subject. This is much to be regretted, as there can be no doubt that a strictly definite phraseology of fruits, founded essentially upon the structure and position of the ovary, would be of great value in Descriptive Botany. The difficulties attending this subject have been also much increased by the same names having been given by authors to totally distinct kinds of fruits, and even to different classes of fruits. In a work like the present it would be impossible to describe all the kinds of fruits which have received names. At the same time, the subject is of too much importance to be hastily disposed of, and as much space as possible will be therefore devoted to its consideration. The classification here adopted is founded upon that given many years since in Lindley's *Introduction to Botany*, from which, however, it differs in some important particulars. We have taken the gynœcium as our guide, and have accordingly used the terms when applied to fruits in precisely the same sense as previously defined in its description.

The leading divisions of the classification here adopted are as follow :—

1. Fruits formed by a Single Flower.
    - *a.* Simple Fruits.
    - *b.* Apocarpous Fruits.
    - *c.* Syncarpous Fruits.
2. Fruits formed by the combination of Several Flowers.

1. Fruits formed by a Single Flower.

a. Simple Fruits.—*By a simple fruit, we mean one which is formed of a single mature carpel or ovary, and only one produced by a single flower.* By some botanists this term is used to signify all fruits, of whatever nature, which are the produce of a single flower ; thus including the *simple*, *apocarpous*, and *syncarpous* fruits of our classification. We describe four kinds of simple fruits :—namely, the Legume, the Lomentum, the Drupe, and the Utriele.

1. *Legume or Pod.*—This is a superior, one-eelled, one or many-seeded fruit, dehiseing by both ventral and dorsal sutures, so as to form two valves, and bearing its seed or seeds on the ventral suture. Examples oeeur in the Pea (*fig.* 668), Bean, Clover, and most plants of the order Leguminosæ, whieh has derived its name from this eireumstanee. The legume assumes a variety of forms, but it is generally more or less convex on its two surfaees and nearly straight ; at other times, however, it beeomes spirally eontorted so as to resemble a serew (*fig.* 691), or a snail twisted, as in some speeies of *Medicago* (*fig.* 690) ; or it is eoiled up like a eaterpillar, as in *Scorpiurus sulcata* (*fig.* 689) ;

FIG. 689.

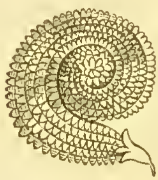


FIG. 690.

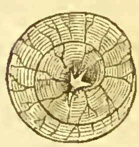


FIG. 691.

FIG. 692.

Fig. 689. Coiled-up legume of *Scorpiurus sulcata.*——*Fig.* 690. Snail-like legume of *Medicago orbiculata.*——*Fig.* 691. Spiral or screw-like legume of Lucerne (*Medicago*).——*Fig.* 692. Lomentum of a species of *Acacia.*

or eurved like a worm, as in *Cæsalpinia coriaria* ; or it assumes a number of other irregular forms. Certain deviations from the ordinary strueture of a legume are met with in some plants ; thus, in *Astragalus* (*fig.* 619), and *Phaca* (*fig.* 620), it is two-eelled, in eonsequenee of the formation of a spurious dissepiment, whieh in the first plant proeeeds from the dorsal suture, and in the latter from the ventral. (See page 277.) At other times a number of spurious horizontal dissepiments are formed, by whieh the legume beeomes divided into as many eells as there are seeds, as in Cassia Fistula (*fig.* 614). Another irregularity also oeeurs in the latter plant, the legume being here indehiseent, but the two sutures are elearly marked externally. Other indehiseent legumes are also met with, as in *Arachis* and *Pterocarpus*, in whieh there is sometimes no evident mark of the sutures externally ; sueh legumes will, however, frequently split into two valves like those of a pea,

rachis Hypogaea
Leguminosae
MONKEY
NUTS
Ol Nucis is
obtained
from these

if a little pressure be applied as in the ordinary process of shelling peas.

2. *The Lomentum.*—This is a kind of legume which is contracted in a moniliform manner between each seed, as in *Hedysarum* (*fig.* 686), *Ornithopus*, and *Acacia Sophora* (*fig.* 692). It is sometimes called a *lomentaceous legume.* This fruit, together with the legume, characterise the plants of the Leguminosæ. When the lomentum is ripe, it commonly separates into as many pieces as there are contractions on its surface (*fig.* 686), or it remains entire (*fig.* 692); in the latter case the seeds are separately enclosed in cavities which are formed by the production of as many internal spurious dissepiments as there are external contractions.

3. *The Drupe.*—This is a superior, one-celled, one- or two-seeded, indehiscent fruit, having a fleshy or pulpy sarcocarp, a hard or bony endocarp or pyrene, and the pericarp altogether separable into its component parts, namely, of epicarp, sarco-

Fig. 693.

Fig. 694.

Fig. 693. Drupe of the Peach.——*Fig.* 694. The same cut vertically.

carp, and endocarp. The Drupe is sometimes called a *stone-fruit.* Examples occur in the Peach (*figs.* 693 and 694), Apricot, Plum, Cherry (*fig.* 695), and Olive. In the Almond, the fruit presents all the characters of the drupe, except that here the sarcocarp is of a toughish texture, instead of being succulent. Many fruits, such as the Walnut and Cocoa-nut, are sometimes termed drupes, but improperly so, as they are in reality compound, or formed originally from two or more carpels or ovaries, besides presenting other characters differing from simple fruits. (See Tryma, page 318, and Glans, page 319.) A number of drupes aggregated together on a common thalamus form collectively a kind of Etærio (*see* Etærio). Any fruit which resembles the drupe in its general characters is frequently termed *drupaceous* or *drupe-like.*

4. *The Utricle* is a superior, one-celled, one or few-seeded fruit, with a thin, membranous, loose pericarp, not adhering to

the seed ; generally indehiscent, but rarely opening in a transverse manner. Examples of this kind of fruit may be seen in *Amaranthus* and *Chenopodium* (*fig.* 696).

FIG. 695

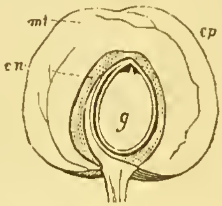


FIG. 696.

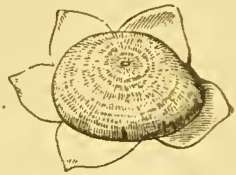


Fig. 695. Vertical section of the drupe of the Cherry. *ep.* Epicarp. *en.* Endocarp. *mt.* Mesocarp. *g.* Seed with embryo.——*Fig.* 696. Utricular fruit of *Chenopodium*, surrounded by the persistent calyx.

b. APOCARPOUS FRUITS.—*Under this name we include those fruits which are formed of a single mature carpel or ovary, but of which two or more are produced by a single flower.* The simple fruits just described are frequently placed by botanists under this head, together with those to which we are now about to allude. Apocarpous fruits are also sometimes called *multiple*, and this latter term is again applied by others to those fruits which are the produce of several flowers. We distinguish three kinds of Apocarpous fruits :—The Follicle, the Achænium, and the Etærio.

1. *The Follicle.*—This is a superior, one-celled, one- or many-seeded fruit, dehiscing by one suture only, which is commonly

es: ample
Strophanthus
Savadilla

FIG. 697.

FIG. 698.

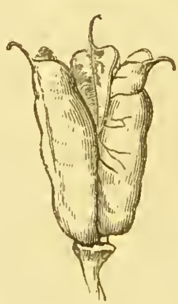


FIG. 699.

Fig. 697. Follicles of the Columbine (*Aquilegia*).——*Fig.* 698. Follicles of the Aconite (*Aconitum*).——*Fig.* 699. Follicles of the Pæony (*Pæonia*).

the ventral, and is consequently one-valved (*fig.* 666). By the latter character it is known at once from the legume, which opens, as we have seen, by two sutures, and is two-valved ; in other respects the two fruits are alike. In *Magnolia glauca* (*fig.* 667), and some other species of *Magnolia*, the follicle opens by the dorsal suture instead of the ventral. Examples of the follicle occur in the Columbine (*fig.* 697), Hellebore, Larkspur, and Aconite (*fig.* 698), in all of which plants the fruit is composed of three or more follicles placed in a whorled manner on the thalamus; in the *Asclepias*, Periwinkle, and Pæony (*fig.* 699), where each flower generally forms two follicles; and in the *Liriodendron* and *Magnolia* (*fig.* 667), where the follicles are numerous, and arranged in a spiral manner on a more or less elongated thalamus. It rarely happens that a flower produces but a single follicle; this, however, sometimes occurs in the Pæony and in other plants. The two follicles of *Asclepias* are more or less united at their bases, and the seeds, instead of remaining attached to the ventral suture, as is the case in the true follicle, lie loose in the cavity of the fruit. This double fruit has therefore by some botanists received the distinctive name of *Conceptaculum*.

2. *The Achænium* or *Achene* is a superior, one-celled, one-seeded fruit, with a dry indehiscent pericarp, which is separable from the seed, although closely applied to it. Linnæus mistook some of these achænia for seeds, and called the plants producing them *gymnospermous* (naked-seeded). Such fruits may be, however, generally distinguished from seeds by presenting on some point of their surface the remains of the style. This style is in some cases very evident, as in the Clematis (*fig.* 657), and Anemone (*fig.* 700). Examples may be seen in the Clematis and Anemone, as just noticed, and in the plants of the orders Labiatæ and Boraginaceæ (*fig.* 701). In rare cases we find a flower producing but a single achænium.

Fig. 700.

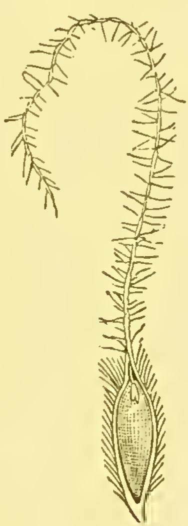


Fig. 701.

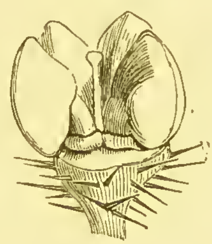


Fig. 700. Vertical section of an achænium of the Pasque-flower (*Anemone Pulsatilla*). The fruit is said to be tailed in this instance in consequence of being surmounted by a feathery style. —— *Fig.* 701. Achænia of Bugloss (*Lycopsis*).

3. *The Etærio.*—When the achænia borne by a single flower are so numerous that they form more than a single whorl or series, they constitute collectively an *etærio*. Examples may be seen in the species of *Ranunculus* and *Adonis* where the achænia are placed upon a convex thalamus of a dry nature; and in the Strawberry (*fig.* 702), where they are situated upon a fleshy

thalamus. Hence, in the Strawberry, the so-called seeds are in reality so many separate achænia, while the part to which the Strawberry owes its value as a fruit is the succulent thalamus.

In the fruit of the Rose the achænia, instead of being placed upon an elevated thalamus, as in the ordinary etærio, are situated upon a concave thalamus, to which the calyx is attached (*fig.* 454, *r*, *r*). This modification of the ordinary etærio has been made a separate fruit by some botanists, to which the name of *Cynarrhodum* has been given. A similar kind of fruit also occurs in *Calycanthus*.

Fig. 702.

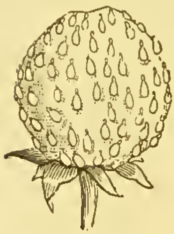


Fig. 703.

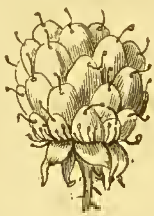


Fig. 702. Fruit of the Strawberry.——*Fig.* 703. Fruit (*etærio*) of the Raspberry (*Rubus Idæus*).

In the Raspberry (*fig.* 703) and Bramble, we have a kind of etærio formed of a number of little drupes, or drupels as these small drupes are sometimes termed, crowded together upon a dry thalamus. The etærio and its modifications are placed by Lindley under a class of fruits called by him *aggregate fruits*, the characters of which are 'Ovaria strictly simple; more than a single series produced by each flower.' The term aggregate is also by some botanists applied to fruits which are the produce of several flowers.

c. Syncarpous Fruits.—*Under this head we include all fruits which are formed by the more or less complete combination of two or more mature carpels or ovaries, and where only one fruit is produced by a single flower.* In the two former classes the fruits are formed of simple ovaries; in this class from ovaries of a more or less compound nature. In describing these fruits we shall follow generally the classification of Lindley. Thus, in the first place, we arrange them, from their superior or inferior character, in two divisions; and each of these divisions is again separated into others, derived from the dry or fleshy nature of the pericarp, and its dehiscent or indehiscent character.

Division 1. *Superior Syncarpous Fruits.*

a. WITH A DRY INDEHISCENT PERICARP.

1. *The Caryopsis* is a superior, one-celled, one-seeded, indehiscent fruit, with a thin dry membranous pericarp, completely and inseparably united with the seed (*figs.* 704 and 705). This fruit resembles the achænium, but it is distinguished by the complete union which exists between the pericarp and the seed.

It is, moreover, generally considered as being of a compound nature, from the presence of two or more styles and stigmas on the ovary (*fig.* 601). It is found in the Oat, Maize, Rye, Wheat, Barley, and generally in the Grass order. These fruits, like the achænia, are commonly called seeds, but their true nature is at once evident when they are examined in their early state.

2. *The Samara* is a superior, two- or more celled fruit, each cell being dry, indehiscent, one- or few-seeded, and having its pericarp extended into a winged expansion. Examples may be found in the Maple (*fig.* 706), Ash, and Elm. By some botanists each winged portion of such a fruit is called a samara, and thus such fruits as the Maple are considered to be formed of two united samaræ.

FIG. 704.

FIG. 705.

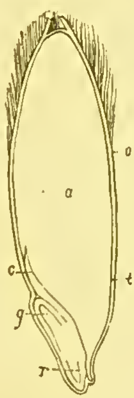


FIG. 706.

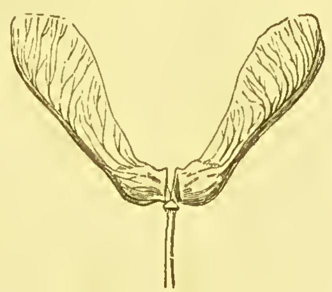


FIG. 707.

Fig. 704. Caryopsis or fruit of the Oat.——*Fig.* 705. The same cut vertically. *o.* Pericarp. *t.* Integuments of the seed. *a.* Albumen or endosperm. *c.* Cotyledon. *g.* Gemmule or plumule. *r.* Radicle.——*Fig.* 706. Samara or fruit of the Maple.——*Fig.* 707. Carcerule or fruit of the Mallow (*Malva*).

3. *The Carcerule* is a superior, many-celled fruit, each cell being dry, indehiscent, and one- or few-seeded, and all the cells more or less cohering by their united styles to a central axis. The common Mallow (*fig.* 707) is a good example of this fruit.

4. *The Amphisarca* is a 'superior, many-celled, indehiscent, many-seeded fruit, indurated or woody externally, pulpy internally.' Examples, *Omphalocarpus*, *Adansonia*, *Crescentia*.

b. WITH A DRY DEHISCENT PERICARP.

1. *The Capsule* is a superior, one or more celled, many-seeded, dry, dehiscent fruit. The dehiscence may either take place by valves, as in *Colchicum* (*fig.* 669) and *Datura* (*fig.* 679); or by pores, as in the Poppy and *Antirrhinum* (*fig.* 626); or *transversely*, as in the Pimpernel (*fig.* 709) and Henbane (*fig.* 684); or only *partially*, as in Mignonette (*fig.* 665), *Dianthus* (*fig.* 664), and *Lychnis* (*fig.* 663). When the capsule dehisces transversely the fruit has received the distinctive name of *Pyxis*.

FIG. 708.

FIG. 709.

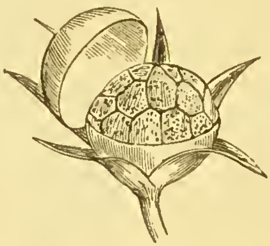


FIG. 710.

Fig. 708. Spiral capsule of a species of *Helicteres*.——*Fig.* 709. Pyxis of Pimpernel (*Anagallis*).——*Fig.* 710. Capsule of a species of *Scrophularia*, dehiscing in a septicidal manner.

FIG. 711.

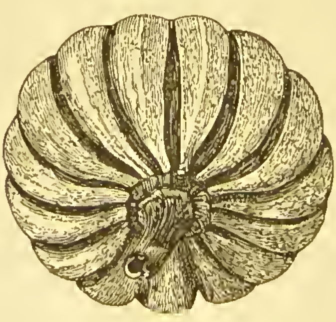


FIG. 712.

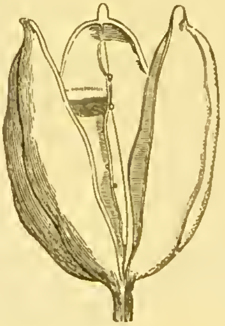


Fig. 711. Fruit of Sandbox-tree (*Hura crepitans*). It is composed of fifteen carpels which separate from the axis when ripe, and burst with great force.——*Fig.* 712. Inferior capsular fruit (*diplotegia*) of the Iris, opening in a loculicidal manner.

The capsule is either one-celled as in the Mignonette (*fig.* 665), Heartsease (*fig.* 681), and Gentian (*fig.* 680); or two-celled as in the *Scrophularia* (*fig.* 710); or three- or more celled, as in *Colchicum* (*fig.* 669), and *Datura* (*fig.* 679). It assumes various forms, some of which are remarkable, as in *Helicteres* (*fig.* 708), where it is composed of five carpels twisted spirally together, and *Illicium anisatum*, where the carpels are arranged in a stellate manner. The capsule is a very common fruit, and is found almost universally in many natural orders, as Papaveraceæ, Caryophyllaceæ, Primulaceæ, Scrophulariaceæ, Liliaceæ, Gentianaceæ, &c., &c.

When a capsule consists of three or more carpels, which separate from the axis, and burst with elasticity (*cocci*) (page 304), as in *Ricinus* (*fig.* 675) and *Hura crepitans* (*fig.* 711), it has been termed a *Regma.*

When a fruit resembles the ordinary capsule in every respect, except that it is inferior, as in the species of *Iris* (*fig.* 712) and *Campanula* (*figs.* 687 and 688), it has received the name of *Diplotegia.* (See Diplotegia, page 319.) In the natural orders we shall describe such a fruit as *capsular.*

Fig. 713. Fig. 714.

Fig. 713. Fruit or siliqua of the Wallflower showing the separation of the two valves from the replum.—*Fig.* 714. Silicula of Shepherd's Purse (*Thlaspi*).

2. *The Siliqua* is a superior, one- or two-celled, many-seeded, long, narrow fruit, dehiscing by two valves separating from below upwards, and leaving the seeds attached to two parietal placentas, which are commonly connected together by a spurious vertical dissepiment, called a *replum* (*fig.* 713). The placentas are here opposite to the lobes of the stigma, instead of alternate, as is the case in all fruits which are regular in structure. When the replum extends entirely across the cavity, the fruit is two-celled ; if only partially, it is one-celled. Examples of this fruit occur in the Wallflower (*fig.* 713), Stock, Cabbage, and a large number of other Cruciferæ. When a fruit possesses the general characters of the siliqua, but with the lobes of the stigma alternate to instead of opposite the placentas, as in *Chelidonium* (*fig.* 683), it has been named a *Ceratium* or a *siliquæform capsule.*

The siliqua is sometimes contracted in the spaces between each seed, like the lomentum (page 311), in which case it is indehiscent, as in *Raphanus sativus*, and is then called a *lomentaceous siliqua.*

3. *The Silicula.*—This fruit resembles the siliqua in every respect except as to its length ; and in usually containing fewer seeds. Thus the *siliqua* may be described as long and narrow, the *silicula* as broad and short. Examples occur in the Shepherd's Purse (*fig.* 714) and Scurvy-grass.

The siliqua and silicula are only found in plants of the order Cruciferæ. Both fruits are occasionally one-seeded, and indehiscent.

c. WITH A FLESHY INDEHISCENT PERICARP.

1. *The Hesperidium* is a superior, many-celled, few-seeded, indehiscent fruit, consisting of a separable pericarp, formed of the epicarp and mesocarp combined together (*fig.* 715, *p*, *e*), and having an endocarp, *d*, projecting internally in the form of membranous partitions, which divide the pulp into a number of portions or cells, which are easily separated from each other. This pulp, as already noticed (page 300), is either a development of succulent parenchyma from the inner lining of the ovary generally, or from the placentas only. The seeds, *s*, *s*, are imbedded

FIG. 715.

FIG. 716.

Fig. 715. Transverse section of the fruit of the Orange (*Citrus Aurantium*). *p*. Epicarp. *e*. Mesocarp. *d*. Endocarp. *s*, *s*. Seeds.——*Fig.* 716. Abnormal development of the fruit of the Orange, in which the carpels, *ce*, and *ci*, are more or less distinct instead of being united.

in the pulp, and attached to the inner angle of each of the portions into which the fruit is divided. The fruits of the Orange, Lemon, Lime, and Shaddock are examples of the hesperidium. It is by no means uncommon to find the carpels of this fruit in a more or less separated state (*fig.* 716), and we have then produced what are called 'horned oranges,' 'fingered citrons,' &c., and the fruit becomes somewhat apocarpous instead of entirely syncarpous.

2. *The Tryma* is a superior, one-celled, one-seeded, indehiscent fruit, having a separable fleshy or leathery rind, consisting of epicarp and mesocarp, and a hard two-valved endocarp, from the inner lining of which spurious dissepiments extend so as to divide the seed into deep lobes. It differs but little from the ordinary drupe, except in being formed from an originally compound ovary. Example, the Walnut. +Cocoanut.

3. *The Nuculanium.*—This fruit, of which the Grape (*fig.* 720) may be taken as an example, does not differ in any important characters from the berry, except in being superior. (*See* BERRY.)

also called

Division 2. Inferior Syncarpous Fruits.

a. WITH A DRY INDEHISCENT PERICARP.

1. *The Cremocarp* is an inferior, dry, indehiscent, two-celled, two-seeded fruit. The two cells or halves of which this fruit is composed are joined face to face to a common axis or *carpophore*, from which they separate when ripe, but to which they always remain attached by a slender cord which suspends them (*fig.* 717). Each half-fruit is termed a *hemicarp* or *mericarp*, and the inner face the *commissure*. Each portion of the fruit resembles an achænium, except in being inferior; hence the name *diachænium* has been given to this fruit. Examples of the cremocarp as above defined are found universally in the plants of the order Umbelliferæ, but in no other order. By Lindley, the definition of cremocarp is extended so as to include fruits of a similar nature, but which contain more than two cells, as, for instance, those of *Aralia*.

Fig. 717.

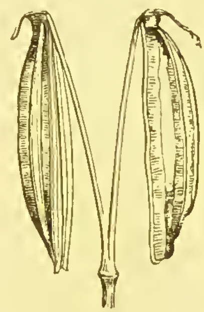


Fig. 717. Cremocarp or fruit of *Angelica*.

2. *The Cypsela.*—This differs in nothing essential from the achænium, except in being inferior and of a compound nature (see page 292). It occurs in all plants of the order Compositæ. When the calyx is pappose it remains attached to the fruit, as in Salsafy and Dandelion.

3. *The Glans* or *Nut* is an inferior, dry, hard, indehiscent, one-celled, one or two-seeded fruit, produced from an ovary of two or more cells, with one or more ovules in each cell, all of which become abortive in the progress of growth except one or two (page 296). The three layers constituting the pericarp of the nut are firmly coherent and undistinguishable, and the whole is more or less enclosed by a *cupule*. The Acorn (*fig.* 400), and the Hazel-nut (*fig.* 401), may be taken as examples. SWEET CHEST-NUT BEECHNUT By some botanists the fruit of the Cocoa-nut Palm is called a nut, but this differs in being superior, and in its pericarp presenting a distinction into epicarp, mesocarp, and endocarp. (See Drupe, page 311.) Such a fruit is better described as *nut-like*.

b. WITH A DRY DEHISCENT PERICARP.

1. *Diplotegia.*—This is the only kind of inferior fruit which presents a dry dehiscent pericarp. It has already been stated under the head of Capsule (page 317), that the diplotegia differs in nothing from it, except in being inferior. The species of *Iris* (*fig.* 712) and *Campanula* (*figs.* 687 and 688) are examples of this fruit. The diplotegia may open either by pores (*fig.* 688),

Vanilla is a diplotegia having 3 parietal placentas valves (*fig.* 712), or transversely (*fig.* 685) like the ordinary capsule. In the latter case, as with the true capsule with transverse dehiscence, the fruit is called a *Pyxis.*

c. WITH A FLESHY INDEHISCENT PERICARP.

1. *The Bacca* or *Berry* is an inferior, indehiscent, one- or more celled, many-seeded, pulpy fruit (*figs.* 718 and 719). The pulp is produced from the placentas, which are parietal (*fig.* 718, *pl*), and have the seeds, *s*, *s*, at first attached to them; but these become ultimately separated and lie loose in the pulp, *p*. Examples may be found in the Gooseberry and Currant. We have already stated (page 318), that the fruit of the Grape is called a Nuculanium (*fig.* 720), and that it differs in nothing essential from the berry, except in being superior. The name *baccate* or *berried* is applied by many botanists to any fruit of a pulpy nature, and will sometimes be used in this sense in our description of the natural orders.

FIG. 718.

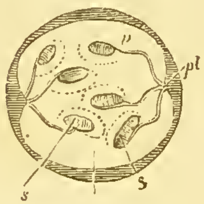


FIG. 720.

FIG. 719.

FIG. 721.

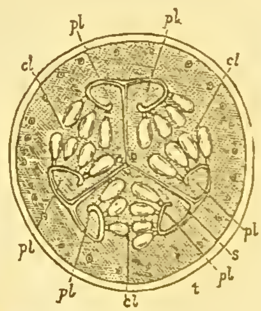


Fig. 718. Transverse section of a berry of the Gooseberry (*Ribes Grossularia*). *pl.* Placentas. *s, s,* Seeds imbedded in pulp, *p.*——*Fig.* 719. Raceme of berries of the Red Currant (*Ribes rubrum*).——*Fig.* 720. Nuculanium or fruit of the Vine (*Vitis vinifera*).——*Fig.* 721. Transverse section of the pepo of the Melon. *cl, cl, cl.* Carpels. *pl, pl, pl, pl, pl, pl.* Curved placentas, sending processes, *s*, from the circumference, *t*, to the centre, and thus causing the fruit to be spuriously three-celled.

2. *The Pepo* is an inferior, one-celled or spuriously three-celled (*fig.* 721), many-seeded, fleshy or pulpy fruit. The seeds are attached to parietal placentas, and are imbedded in pulp, but they never become loose as is the case in the berry; and hence this fruit is readily distinguished from it.

There has been much discussion with regard to the nature of the pepo. By some botanists the placentas are considered as axile, and the fruit normally three-celled, as it is formed of three

Cucurbitaceae
Cucumber
Veg. Marrow
Colocynth
Ecballium
Loofah
Mallow

ovaries or carpels ; while by others the placentas are regarded as parietal, and the fruit normally one-celled, as defined above. Those who adopt the first view believe that each placenta sends outwards a process towards the walls of the fruit, and that these processes ultimately reach the walls and then become bent inwards and bear the seeds on the curved portions. If these processes remain, the fruit is three-celled ; if, on the contrary, they become absorbed, it is only one-celled, and the placentas are spuriously parietal. According to the view here adopted, the placentas are parietal and send processes inwards which meet in the centre, and thus render the fruit spuriously three-celled ; or, if these are afterwards obliterated, or imperfectly formed, the fruit is one-celled. This fruit is illustrated by the Melon, Gourd, Cucumber, Elaterium, and other Cucurbitaceæ. The fruit of the Papaw-tree resembles a pepo generally, except in being superior.

3. *The Pome* is an inferior, indehiscent, two or more celled, few seeded, fleshy fruit ; the endocarp of which is papery, cartilaginous, or bony, and surrounded by a fleshy mass consisting of mesocarp and epicarp, which is generally considered to be formed by the cohesion of the general parenchyma of the ovary with the tube of the calyx. Some botanists, however, regard the fleshy portion as consisting of the enlarged end of the flower-stalk, in which the true carpels are imbedded. Examples may be seen in the Apple (*fig.* 722), Pear, Quince (*fig.* 473), Medlar, and Hawthorn.

FIG. 722.

FIG. 723.

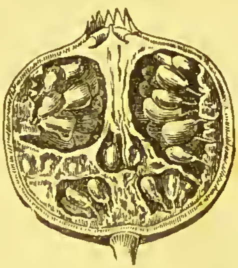


Fig. 722. Vertical section of the pome or fruit of the Apple (*Pyrus Malus*).——*Fig.* 723. Vertical section of the balausta or fruit of the Pomegranate.

4. *The Balausta* is an inferior, many-celled, many-seeded, indehiscent fruit, with a tough pericarp. It is formed of two rows of carpels, one row being placed above the other, and surrounded by the calyx ; the seeds being attached irregularly to the walls or centre. The Pomegranate fruit (*fig.* 723), is the only example.

2. Fruits formed by the Combination of Several Flowers.

These fruits have been termed *Anthocarpous*, as they consist not only of the mature carpels of several flowers united, but also usually of the bracts and floral envelopes in combination with them, that is to say, the whole inflorescence is blended to form the fruit. They have been also called

Multiple, *Aggregate*, and *Collective fruits*, and the two former terms have also been applied in a different sense, as mentioned under the head of *Apocarpous fruits* (pages 312 and 314). Some botanists also term them *Infrutescences* or *Confluent fruits.* Such fruits have been likewise termed *polythalamic*, to distinguish them from fruits formed by single flowers, which are called *monothalamic*. The following have received distinctive names:—

1. *The Cone* is a more or less elongated fruit, composed of a number of indurated scales, each of which bears one or more naked seeds (*fig.* 730) on its inner surface. This fruit is seen in the Scotch Fir (*fig.* 724), Larch, Hemlock Spruce (*fig.* 420), and a great many other plants of the order Coniferæ; which derives its name from this circumstance. All plants also of the Cycas family which possess fruit have one of a similar structure, but here the seeds are more numerous and placed on the borders of the scales. There are two views as to the nature of the indurated scales: thus, by some botanists they are regarded as carpels spread open, each representing a female flower; by

FIG. 724.

FIG. 725.

FIG. 726.

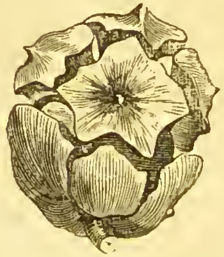


FIG. 727.

Fig. 724. Cone or fruit of the Scotch Fir.——*Fig.* 725. Galbulus or fruit of the Juniper (*Juniperus communis*).——*Fig.* 726. Galbulus or fruit of the Cypress (*Cupressus sempervirens*).——*Fig.* 727. Sphalerocarpium or fruit of the Yew (*Taxus baccata*), surrounded by bracts at the base.

others, as bracts. They certainly more resemble the latter organs in appearance, as they never present any trace of style or stigma on their surface. Other botanists (see page 204) regard the cone as the *spurious fruit* or *pseudocarp* of a single flower, and not as a collection of fruits, as here described. Some again make no distinction between a cone and a Strobilus (*see* Strobilus).

2. *The Galbulus.*—This fruit is but a modification of the Cone; differing only in being more or less rounded in form instead of somewhat conical, and in having the heads of the scales much enlarged. It is seen in the Cypress (*fig.* 726), and in the Juniper (*fig.* 725). In the latter the scales become fleshy, and are united together into one mass, so that it somewhat resembles at first sight a berry, but its nature is at once seen by examining the apex, when three radiating lines will be observed corresponding

to the three fleshy scales of which the fruit is formed, and which are here but imperfectly united.

No other kind of fruits except the Cone and Galbulus are found in the natural orders Coniferæ and Cycadaceæ.

In the Yew (*Taxus baccata*) (*fig.* 727) and other plants belonging to the Taxaceæ, an order closely allied to the Coniferæ and Cycadaceæ, the so-called fruit is in reality not a fruit at all, as it consists simply, as demonstrated by Sir Joseph Hooker, of a naked seed, surrounded, except at the apex, by a fleshy cup or aril. This so-called fruit has been termed a *Sphalerocarpium.* Properly speaking, even if regarded as a fruit, it does not belong to the class of Collective fruits at all; as it is formed of but a single flower. We have placed it here, following Lindley's arrangement, and because, like the two preceding fruits, its essential character consists in its naked seed. Some other fruits are, however, included by Lindley and others with this under the name of Sphalerocarpium.

The Cone must be carefully distinguished from Cone-like fruits, such as those of the *Magnolia* (*fig.* 667) and *Liriodendron.* The latter are not collective fruits at all, but they consist of the mature carpels or follicles of a single flower, placed upon an elongated thalamus.

3. *The Strobilus or Strobile.*—The fruit of the Hop (*Humulus Lupulus*) (*fig.* 421) is by some botanists considered as a kind of Cone with membranous scales, to which the name of *Strobilus* or *Strobile* has been given ; but the strobile differs essentially from the cone, in having its seed distinctly enclosed in a carpel placed at the base of each scale. We distinguish this fruit, therefore, as a distinct kind, under the above name. It should also be noticed that the term Strobilus is frequently employed as synonymous with Cone.

Fig. 728.

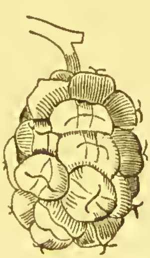


Fig. 729.

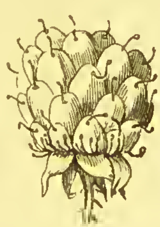


Fig. 728. Sorosis or fruit of the Mulberry (*Morus nigra*). —— *Fig.* 729. Fruit (*etærio*) of the Raspberry (*Rubus Idæus*).

4. *The Sorosis* is a collective fruit, formed of a number of separate flowers firmly coherent into a fleshy or pulpy mass with the floral axis upon which they are situated. Examples of this may be seen in the Pineapple (*fig.* 292), where each square portion represents a flower ; and the whole is surmounted by a crown of empty bracts. The Bread-fruit and Jack-fruit are other examples of the sorosis. The Mulberry (*fig.* 728) may be also cited as another well-known fruit, which presents an example of the sorosis. At first sight, the Mulberry appears to resemble the Raspberry (*fig.* 729), Blackberry, and other

fruits of the genus *Rubus*, but in origin and structure the latter are totally different. Thus, as already noticed in speaking of the Etærio (page 314), the Raspberry, and other fruits of the genus *Rubus*, consist of a number of drupes or fleshy achænia crowded together upon a dry thalamus, and are all the produce of a single flower. But in the Mulberry, on the contrary, each rounded portion of which the fruit is made up is derived from a flower, the calyx of which has become succulent and united to the ovary; the combination of a number of flowers in this case therefore forms the fruit, while in the Raspberry the fruit is produced by one flower only.

4. *The Syconus* is a collective fruit, formed of an enlarged and more or less succulent receptacle, which bears a number of separate flowers. The Fig (*fig.* 406) is an example of a syconus. In this, the flowers are almost entirely enclosed by the enlarged hollow, pear-shaped receptacle, and what are commonly called seeds are in reality one-seeded fruits resembling achænia. The *Dorstenia* (*fig.* 407) is another example of the syconus, although it differs a good deal from that of the Fig in its general appearance; thus the receptacle is less succulent, and only slightly concave except at its margins, so that the separate fruits are here readily observed.

All the more important fruits which have been named and described by botanists have now been alluded to, but in practice only a few are in common use—such as the Legume, Drupe, Achene, Follicle, Caryopsis, Siliqua, Silicula, Capsule, Nut, Pome, Berry, and Cone. This has arisen, partly from the same names having been given by different botanists to totally distinct kinds of fruits; and partly from botanists in many cases preferring to describe a particular fruit according to the special characters it presents. It is, however, much to be regretted that a comprehensive arrangement of accurately-named and well-defined fruits should not be generally adopted, as it cannot be doubted that, if such were the case, it would be attended with much advantage, and save a good deal of unnecessary description and repetition.

Section 6. The Ovule and Seed.

Having now described the nature, structure, and general characters of the gynœcium or unimpregnated pistil, and the fruit or mature pistil, we pass to the description of the bodies contained respectively within them, namely, the Ovule or infertilised body, and the Seed or fertilised Ovule.

1. THE OVULE.

The ovule is a small, somewhat rounded or oval, pulpy body, borne by the placenta, and which when fertilised becomes the seed. It is either attached directly to the placenta, when it is said to be *sessile* (*figs.* 33, *o*, *o*, and 633, *g*) ; or indirectly by a stalk called the *funiculus* or *funicle* (*figs.* 615, *ov*, and 637), when it is described as stalked. The point of attachment of the ovule to the placenta if sessile, or to the funiculus when stalked, is termed the *hilum*. These terms are applied to the seed in the same sense as to the ovule. The ovule has been compared to a bud, and has been called the *seed-bud* by Schleiden and others.

The ovules are commonly enclosed in an ovary (*fig.* 33, *o*, *o*), but all plants of the Coniferæ, Cycadaceæ, and allied orders are exceptions to this ; thus in the Cycadaceæ they are situated on the margins of leaves in a peculiarly metamorphosed condition, and in the Coniferæ at the base of indurated bracts or open carpellary leaves (*fig.* 730, *ov*). Such ovules are therefore termed *naked*, and as the seeds of these plants are also naked, such plants are called *Gymnospermous* ; while those plants in which the ovules are distinctly enclosed in an ovary, are said to be *Angiospermous*. It should be noticed, however, that there are some plants in which the seeds become partially naked in the course of the development of the ovary into the fruit, as in the Mignonette (*fig.* 665), *Leontice*, and *Cuphea*, in which cases they are sometimes termed *seminude*. True Gymnospermous plants, or those in which the ovules are naked from their earliest formation, should be carefully distinguished from those with seminude ovules, as the former character is always associated with important structural peculiarities in the plants themselves, as we have already noticed in treating of the stem and other organs. Other important differences will also be described hereafter, and more especially in the Physiological part of this volume, under the head of Reproduction of Gymnospermia.

FIG. 730.

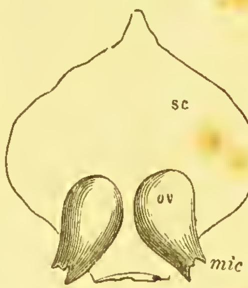


Fig. 730. Bract or carpellary leaf, *sc*, of a species of *Pinus*, bearing two naked ovules, *ov*, at its base. *mic*. Micropyle or foramen.

NUMBER AND POSITION OF THE OVULES.—*a. Number.*—The number of ovules in the ovary, or in each of its cells, varies in different plants. Thus in the Polygonaceæ, Compositæ, Thymelaceæ, and Dipsacaceæ, the ovary contains but a solitary ovule ; in the Umbelliferæ and Araliaceæ, there is but one ovule in each cell. When there is more than one ovule in the ovary, or in each of its cells, the number may be either few and easily counted, when the ovules are said to be *definite*, as in *Æsculus* (*fig.* 735),—and the ovary or cell is then described as *biovulate*, *triovulate*, *quadriovulate*, *quinqueovulate*, &c. ; or, the ovules may be very numerous, when they are said to be *multiovulate* or *indefinite*, as in the Pansy (*fig.* 33, *ov*).

b. Position.—The position of the ovules with regard to the cavity or cell in which they are placed is also liable to vary. Thus when there is but one ovule, this may arise at the bottom of the ovary or cell and be directed towards the summit, as in Compositæ and Polygonaceæ (*fig.* 731), when it is said to be *erect*; or it may be inserted at the summit of the ovary and be turned downwards, as in *Hippuris* (*fig.* 732), in which case it is *inverse* or *pendulous*; or if it is attached a little above the base, and directed obliquely upwards, as in *Parietaria* (*fig.* 733), it is *ascending*; or if, on the contrary, it arises a little below the summit, and is directed obliquely downwards, as in the Mezereon (*fig.* 734) and Apricot, it is *suspended*; or if from the side of the ovary, without turning upwards or downwards, as in *Crassula*, it is *horizontal* or *peltate*. In some plants, as in *Armeria* (*fig.* 637), the ovule is suspended from the end of a long funiculus arising

FIG. 731.

Fig. 731. Vertical section of the fruit of a species of *Rumex* (*Polygonaceæ*). *p*. Enlarged calyx surrounding the fruit. The fruit contains a single erect orthotropous seed. The position of the ovule in the ovary is also described as erect and orthotropous. The embryo is inverted or antitropous.

FIG. 732. FIG. 733. FIG. 734. FIG. 735.

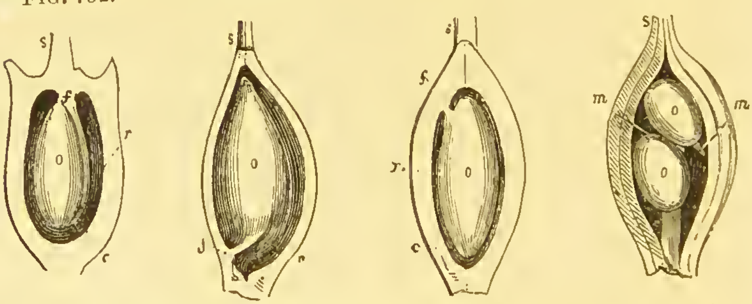


Fig. 732. Vertical section of the ovary of the Mare's Tail (*Hippuris vulgaris*). *o*. Ovule, which is inverse or pendulous, and anatropous. *s*. Base of the style. *f*. Funiculus. *r*. Raphe. *c*. Chalaza.——*Fig.* 733. Vertical section of the ovary of the Pellitory (*Parietaria officinalis*), with a single ascending ovule. The letters have the same references as in the last figure.——*Fig.* 734. Vertical section of the ovary of the Mezereon (*Daphne Mezereum*), containing a solitary suspended ovule. The letters refer as before. From Jussieu.——*Fig.* 735. Vertical section of a cell of the ovary of a species of *Æsculus* containing two ovules, *o*, *o*, one of which is ascending and the other suspended. *m*, *m*. The micropyle or foramen in the two ovules. *s*. Base of the style. From Jussieu.

from the base of the ovary; such an ovule is frequently termed *reclinate*.

In the above cases the position of the ovule is in general constant, and hence this character is frequently of much importance in distinguishing genera, and even natural orders. Thus, in the Compositæ the solitary ovule is always erect; while in the allied orders, the Valerianaceæ and Dipsacaceæ, it is suspended or pendulous;—the two latter terms are frequently used indifferently by botanists. In the Polygonaceæ (*fig.* 731), the ovule is also always solitary and erect; and in the Thymelaceæ (*fig.* 734), it is suspended. In other natural orders we find the position varying in different genera, although generally constant in the same; thus, in the Rosaceæ, the genera *Geum*, *Alchemilla*, and others, have an ascending ovule, while those of *Poterium*, *Sanguisorba*, &c., have it suspended, and in *Potentilla* both ascending and suspended ovules are found. In the Ranunculaceæ also we find the ovule varying in like manner as regards its position.

We will now consider the position of the ovules when their number is more than one. Thus when the ovary or cell has two ovules, these may be either placed side by side at the same level and have the same direction, as in *Nuttallia*, when they are said to be *collateral*; or they may be placed at different heights, and then they may either follow the same direction, when they are *superposed*, or one ovule may be ascending and the other suspended, as in *Æsculus* (*fig.* 735). The position of the ovules in those cases where they are in definite numbers, is also usually constant and regular, and similar terms are employed; but when the number of ovules in the ovary or cell is indefinite, the relations are less constant, and depend in a great measure upon the shape of the cell and the size of the placentas. Thus in the long ovaries of many of the Leguminosæ and Cruciferæ (*fig.* 615), the ovules are superposed, and by not crowding each other they will all be turned in the same direction; while, on the contrary, if the ovules are numerous, and developed in a small space, they will necessarily press against each other, and acquire irregular forms and varying positions, according to the direction of the pressure. In describing these varying positions the same terms are used as those referred to when speaking of the relations of the solitary ovule. These terms are also applied in the same sense to the relations of the seed in the pericarp.

Development and Structure of the Ovule.—The ovule first appears on the placenta as a little conical cellular projection, which gradually enlarges and ultimately acquires a more or less rounded or oval form, which is sessile or stalked, and is termed the *nucellus* or *nucleus* (*fig.* 738), and which may be regarded as corresponding to the *megasporangium* of some of the vascular Cryptogams (page 369). This *nucellus* is at first perfectly uniform in texture and appearance, presenting no cavities except those of the ordinary parenchymatous cells of which it is composed, and having no integuments or coats; but as development proceeds a special cavity is formed at or near its apex (*fig.* 739, *c*), in which the embryo or rudimentary future plant is developed after fertilisation; hence this cavity is called the *embryo-sac.* It is analogous to the *megaspore* (page 370) of cryptogamous plants. In rare cases, as in the Mistletoe, two or three embryo-sacs are formed. This sac is produced by the special development of one of the cells lying near the centre of the nucellus, which as it continues to increase in size presses upon the surrounding parenchymatous cells, and thus occasions their more or less complete absorption. This sac sometimes causes the almost entire absorption of the nucellus, and even projects beyond it, either through the opening in its coats afterwards to be described, called the *micropyle* (*figs.* 742, *e*, and 743, *m*), or through its sides in various directions, by which one or more saccate processes are formed. More usually, however, the tissue of the nucellus is not entirely absorbed, but a variable proportion is left surrounding the embryo-sac. The sac contains at first an abundance of watery cell-sap and protoplasm, in which, before fertilisation takes place, there are usually three rounded or oval large nucleated cells formed at its apex, which have been termed the *germinal* or *embryonic vesicles* (*fig.* 737, *b*). Different views have been entertained of the structure of these germinal vesicles. But they are now universally regarded as simply nucleated masses of protoplasm, or, in other words, *primordial cells*, as will be afterwards fully explained when treating of the Reproduction of the Angiospermia. Less frequently one, three, or more of these cells make their appearance. Sometimes the germinal vesicles are considerably elongated, being attached to the wall of the embryo-sac by the narrower end, and projecting by their free rounded extremity into the cavity of the sac. The two upper of these germinal vesicles (*fig.* 736) have been termed the *synergidæ*, *s*, *s*; and the third, which is placed somewhat laterally lower down, is the *oosphere* or *ovum-cell*, *e*, which ultimately becomes the embryo, as will be explained hereafter (see Reproduction of the Phanerogamia). Besides these germinal vesicles, the embryo-sac usually contains, before fertilisation has been accomplished, two or more small nucleated cells which have been called *antipodal cells* (*fig.* 737, *c*), from

FIG. 736.

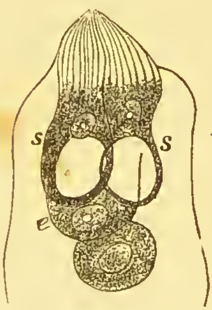


FIG. 737.

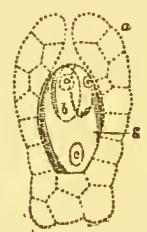


Fig. 736. Apex of the embryo-sac in the ovule of *Polygonum divaricatum*. *s*, *s*. Synergidæ. *e*. Oosphere.——*Fig.* 737. The internal parts of the ovule a short time before fertilisation. *a*. Inner coat of the ovule. *s*. Embryo-sac. *b*. Germinal vesicles. *c*. One of the antipodal cells. (After Hofmeister.)

being commonly situated at the opposite end of the sac to the germinal vesicles, that is, at its base. These cells have a cell-wall formed of cellulose; but their purport is unknown, and their existence is temporary, as they disappear after fertilisation.

Some ovules, as those of the Mistletoe (*fig.* 739), consist simply of the nucellus, *n*, and embryo-sac, *c*, as above described, in which case the nucellus is termed *naked* (*fig.* 738); but in almost all plants it becomes enclosed in one or two coats. Thus, in the Walnut there is but one coat, which appears at first as a little circular process around its base; this gradually increases in size, and by growing upwards ultimately forms a sheath or cellular coat to the nucellus, which it entirely closes except at the apex, where a small opening may be always observed (*fig.* 740, *end*). The coat thus formed, where there is but one, is called the *integumentum simplex*, *s*; and the orifice, *end*, at the apex of the nucellus, *n*, is termed the *micropyle* or *foramen*. Besides the

FIG. 738.

FIG. 739.

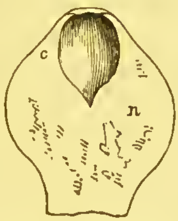


FIG. 740.

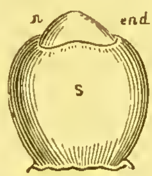


FIG. 741.

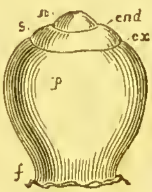


Fig. 738. Ovule of the Mistletoe (*Viscum album*), consisting of a naked nucellus.——*Fig.* 739. The same ovule cut vertically to show the embryo-sac, *c*, in the nucellus, *n*.——*Fig.* 740. Ovule of the Walnut (*Juglans regia*). *n*. Projecting end of the nucellus. *s*. Coat covering the nucellus except at the foramen, *end*.——*Fig.* 741. Ovule of a species of *Polygonum*. *f*. End of ovule where it is attached to the placenta. *p*. Primine. *s*. Secundine. *ex*. Exostome. *end*. Endostome. *n*. Projecting end of the nucellus.

Walnut, there is only one coat formed in the Compositæ, Campanulaceæ, Lobeliaceæ, and some other orders.

In most plants, however, the ovule has two coats, in which case we observe two circular or annular processes around the base of the nucellus, the inner one being first developed; these processes continue to grow upwards as before described, until they also ultimately form two sheaths or coats, which entirely enclose the nucellus except at its apex (*fig.* 741). The inner coat is at first seen to project beyond the outer, but the latter ultimately reaches and encloses it. The inner coat is usually termed the *secundine* (*figs.* 741, *s*, and 742, *c*), and the outer the *primine*; but some botanists, following the order of development of the coats, term the inner coat the *primine*, and the outer the *secundine*, thus reversing the order of names as above mentioned. Others, to prevent confusion, more properly term the inner coat or secundine, the *integumentum internum*; and the outer coat, or primine, the *integumentum externum*. The orifice left at the apex of the nucellus, as in the former instance where only one coat is present, is called the *foramen* or *micropyle.* The openings in the two coats commonly correspond to each other, but it is sometimes found convenient to distinguish them by distinct names; thus, that of the outer is called the *exostome* (*fig.* 741, *ex*); that of the inner, *endostome*, *end.* In some plants, as in *Welwitschia*, the primine appears as a prolonged tubular body beyond the apex of the ovule, in which case it closely resembles a style.

FIG. 742.

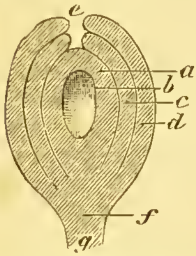


Fig. 742. Section of an ovule (diagrammatic). *a.* Nucellus. *b.* Embryo-sac. *c.* Inner coat. *d.* Outer coat. *e.* Micropyle. *f.* Chalaza. *g.* Funiculus or funicle.

The nucellus and its coat or coats are intimately connected at one point by a cellulo-vascular cord or layer, called the *chalaza* (*figs.* 743, *ch*, and 744, *ch*); but at the other parts of the ovule they are more or less distinct. This chalaza is the point where the vessels pass from the placenta, or when the ovule is stalked from the funiculus, into the ovule, for the purpose of affording nourishment to it; it is generally indicated by being coloured, and of a denser texture than the tissue by which it is surrounded. The chalaza is by some considered as the organic base of the ovule, and the micropyle as the organic apex; but it is better to speak of the hilum as the organic base of the ovule, and the chalaza as the base of the nucellus. Through the micropyle the influence of the pollen is conveyed to the embryo-sac, as will be hereafter fully described.

The development and structure of the ovules as described above refer only to those of the Angiospermia; those of the Gymnospermia present some very striking differences, which will be described hereafter, when speaking of their reproduction.

RELATION OF THE HILUM, CHALAZA, AND MICROPYLE TO ONE ANOTHER.—When an ovule is first developed, the point of union of its coats and nucellus, called the chalaza, is at the base or hilum, close to the placenta or funiculus; in which case a straight line would pass from the micropyle through the axis of the nucellus and its coats to the hilum. In rare instances this relation of parts is preserved throughout its development, as in the Polygonaceæ (*fig.* 743); when the ovule is termed *orthotropous*, *atropous*, or *straight.* In such an ovule, therefore, the micropyle, *m*, would be situated at its geometrical apex, or at the end farthest removed from the hilum, in which case the organic apex would correspond to the geometrical apex; while the chalaza, *ch*, would be placed at the base of the ovule or hilum.

It generally happens, however, that the ovule, instead of being straight as in the above instance, becomes more or less curved, or even altogether inverted. Thus in the Wallflower (*fig.* 744), and other plants of the order to which it belongs, as well as in the Caryophyllaceæ and many other plants, the apex of the ovule becomes gradually turned downwards towards its base, and is ultimately placed close to it, so that the whole

FIG. 743.

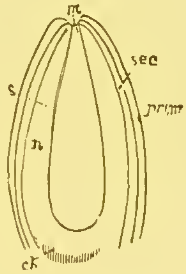


FIG. 744.

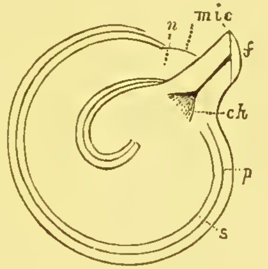


Fig. 743. Vertical section of the orthotropous ovule of *Polygonum*. *ch.* Chalaza. *prim.* Primine. *sec.* Secundine. *n.* Nucellus. *s.* Embryo-sac. *m.* Micropyle.——*Fig.* 744. Vertical section of a campylotropous ovule of Wallflower (*Cheiranthus*). *f.* Funiculus. *ch.* Chalaza. *d.* Primine. *s.* Secundine. *n.* Nucellus. *mic.* Micropyle.

ovule is bent upon itself, and a line drawn from the micropyle, *mic*, through the axis of the nucellus, *n*, and its coats, would describe a curve ; hence such ovules are called *campylotropous* or *curved*. In these ovules, the chalaza, *ch*, and hilum correspond as in orthotropous ones, but the micropyle, *mic*, instead of being at the geometrical apex of the ovule, is brought down close to

FIG. 745.

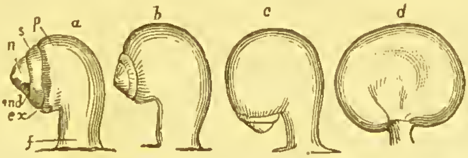


Fig. 745. The campylotropous ovule of the Mallow in its different stages of development. From Le Maout. In *a* the curvature is commencing, in *b* it is more evident, in *c* still more marked, and in *d* it is completed. *f.* Funiculus. *p.* Primine. *s.* Secundine. *n.* End of nucellus. *ex.* Exostome. *end.* Endostome.

the hilum or base. The progressive development of the *campylotropous* ovule is well seen in the Mallow, as represented in *figure* 745, *a*, *b*, *c*, *d*. This kind of ovule appears to be formed by one side developing more extensively than the other, by which the micropyle is pushed round to the base.

In a third class of ovules the relative positions of parts is exactly the reverse of that of orthotropous ones—hence such are called *anatropous* or *inverted* ovules. This arises from the adherence of the funiculus to the outer coat of the ovule, so that during its development the base of the nucellus is pushed up and completely inverted, so that the chalaza (*fig.* 746, *ch*) is removed from the hilum, *h*, to the geometrical apex of the ovule ; the micropyle, *f*, being at the same time turned towards the hilum, *h*. In anatropous ovules a connexion is always maintained between the chalaza and the hilum by means of a vascular cord or ridge called the *raphe* (*fig.* 746, *r*), which is the elongated funiculus adherent to the ovule. This raphe or cord of nutritive vessels passing from the placenta or funiculus, and which by its expansion forms the chalaza, is generally situated in anatropous ovules on the side which is turned towards the

Fig. 746.

Fig. 747.

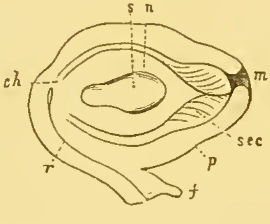


Fig. 746. Vertical section of the anatropous ovule of the Dandelion. *h.* Hilum. *f.* Micropyle or foramen. *n.* Nucellus. *s.* Base of the nucellus. *ch.* Chalaza. *r.* Raphe.——*Fig.* 747. Longitudinal section of the amphitropous or transverse ovule of *Lemna trisulca*. *f.* Funiculus. *n.* Nucellus. *p.* Primine. *sec.* Secundine. *s.* Embryo-sac. *ch.* Chalaza. *r.* Raphe. *m.* Micropyle. From Schleiden.

placenta or funiculus. Anatropous ovules are very common ; examples may be found in the Dandelion (*fig.* 746), Apple, and Cucumber.

Besides the three kinds of ovules mentioned above there is another kind more rarely met with which is intermediate between orthotropous and anatropous, to which the name of *amphitropous* has been given. In this ovule, which is also called *heterotropous* or *transverse*, the hilum, *f*, is on one side, and the micropyle, *m*, and chalaza, *ch*, are placed transversely to it (*fig.* 747), and therefore parallel to the placenta. In this case the hilum is connected to the chalaza by a short raphe, *r*.

The further development of the ovule will be described hereafter under the head of Reproduction of the Phanerogamia.

2. THE SEED.

Nature and General Characters of the Seed as compared with the Ovule.—The seed is the fertilised ovule. Like the ovule, it is either attached directly to the placenta, in which case it is described as *sessile*; or by means of a stalk, called the *funiculus* or *funicle* (*figs*. 668, *f*, and 748, *f*), when it is said to be *stalked*; its point of attachment is also termed the *hilum*. The position of this hilum may be commonly seen on seeds which have separated from the funiculus or placenta, by the presence of a scar, or in a difference of colour to the surrounding integument. The hilum varies much in size, being sometimes very minute, while in other cases it extends for some distance over the surface of the outer coat of the seed, as in the Horsechestnut and Calabar Bean. The centre of the hilum, through which the nourishing vessels pass, has been called the *omphalodium*. The hilum, as in the ovule, indicates the base of the seed, while the apex is represented by the chalaza. This chalaza (*fig*. 748, *ch*) is generally more evident in the seed than in the ovule, and is frequently of a different colour to the other parts. It is well seen in the Orange, and commonly in all anatropous seeds, in which case also the raphe may be generally noticed forming a projection on the face of the seed.

Fig. 748.

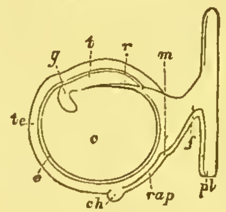


Fig. 748. The seed of a Pea, with its integuments removed on one side. *pl*. Placenta. *f*. Funiculus. *rap*. Raphe. *ch*. Chalaza. *m*. Micropyle. *te*. Testa or episperm. *e*. Endopleura or tegmen. The part within the endopleura is commonly called the nucleus of the seed, and is formed of cotyledons, *c*, gemmule or plumule, *g*, radicle, *r*, and *t* stalk or tigellum between the plumule and radicle.

The micropyle also, although smaller and less distinct than in the ovule, owing to a contraction of the surrounding parts, may be frequently observed on the seed (*fig*. 748, *m*); its detection is of some practical importance, as the radicle, *r*, of the embryo, with a few exceptions, is directed towards it. It should be noticed that while the micropyle constitutes the organic apex of the ovule, the chalaza indicates that of the seed.

The terms *orthotropous*, *campylotropous*, *anatropous*, &c., are applied to seeds in the same sense as to ovules; consequently the hilum, chalaza, and micropyle have the same relations to one another in the seed as in the ovule. Thus the hilum and chalaza are contiguous to each other in an orthotropous seed, and the micropyle is removed to the opposite end; in a campylotropous seed the hilum and chalaza are also near to each other, and the micropyle is brought round so as to approach the hilum; in an anatropous seed the chalaza is removed from the hilum and placed at the opposite end, while the micropyle and hilum correspond to each other ; while in amphitropous seeds, the chalaza and micropyle are both removed from the hilum, and placed transversely to it.

Almost all seeds, like ovules, are more or less enclosed in a pericarp, the only real exceptions to this law being in Gymnospermous plants, as already referred to (page 325) under the head of the OVULE ; and hence the division of Phanerogamous plants, as already noticed, into the Gymnospermia and the Angiospermia. The means of distinguishing small fruits from seeds have been also already described. (See pages 295 and 313.)

In describing the position of the seed in the fruit, the same terms are used as already mentioned (page 326) under the head of the OVULE. Thus a seed may be *erect*, *inverse*, *pendulous*, *suspended*, *ascending*, &c. The number of seeds contained in the fruit or pericarp is also subject to variation, and corresponding terms are employed accordingly ; thus we say the fruit or pericarp is *monospermous*, *bispermous*, *trispermous*, *quadrispermous*, *quinquespermous*, *multispermous*, &c. ; or *one-seeded*, *two-seeded*, *three-seeded*, *four-seeded*, *five-seeded*, *many-seeded*, &c.

Having now alluded to those characters, &c., which the seed possesses in common with the ovule, we pass to the consideration of its special characteristics.

FORMS OF SEEDS.—Seeds vary much in form, and, in describing these variations, similar terms are employed to those used in like modifications of the other organs of the plant.

FIG. 749.

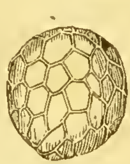


FIG. 750.

FIG. 751.

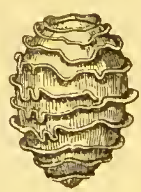


FIG. 752.

Fig. 749. Rounded seed of the Watercress (*Nasturtium officinale*). The testa is reticulated or netted.——*Fig.* 750. Reniform seed of the Poppy (*Papaver*), with an alveolate or pitted testa.——*Fig.* 751. Obovoid seed of the Larkspur (*Delphinium*), the testa of which is marked with ridges and furrows.——*Fig.* 752. Seed of Chickweed (*Stellaria*), the testa of which is tuberculated.

Thus, a seed may be rounded, as in the *Nasturtium* (*fig.* 749) ; ovoid, as in *Polygala* (*fig.* 759) ; oval, as in *Asclepias* (*fig.* 755) ; obovoid, as in *Delphinium* (*fig.* 751) ; reniform, as in *Papaver* (*fig.* 750), &c. &c.

STRUCTURE OF THE SEED.—The seed consists essentially of two parts ; namely, of the inner substance or body of the seed, which is commonly termed the *Nucleus* or *Kernel* (*figs.* 36, *emb*, *alb*, and 757, N), and *Integuments* or *Coats* (*figs.* 36, *int*, and 757, T).

1. The Integuments or Coats.—There are two seed-coats or integuments. These have been variously named by botanists; the terms employed in this volume, and those most frequently used, are *testa* or *episperm* for the outer coat; and *tegmen* or *endopleura* for the inner.

a. *Testa, Episperm, or Outer Coat* (*fig.* 748, *te*).—This integument may be either formed of the primine of the ovule only, or, as is more frequently the case, by the combined primine and secundine. The testa is generally composed of ordinary parenchymatous cells; but in some seeds, as in those of *Acanthodium*, we have in addition a coating of hair-like cells containing spiral fibres (see page 65). These cells are pressed closely to the surface of the seed by a layer of mucilage; hence if such seeds be moistened with water, the mucilage which confines them becomes dissolved, by which they are set free, and then branch out in every direction. It frequently happens, also, that the membrane of the cells is ruptured, and the elastic fibres which they contain then becoming uncoiled, extend to a considerable distance from the testa. The seeds of *Collomia* (see page 45) and many other Polemoniaceous plants, &c., exhibit this curious structure, and form beautiful microscopic objects.

Colour, Texture, and Surface of the Testa.—In colour, the testa is more generally of a brown or somewhat similar hue, as in the Almond, but it frequently assumes other colours; thus, in some Poppies it is whitish or yellowish, in others black, in Indian Shot (*Canna*) and Pæony also somewhat black, in the Arnatto and Barricarri (*Adenanthera*) red, in French Beans and the seeds of the Castor-oil plant beautifully mottled, and various other tints may be observed in the seeds of different plants.

The testa also varies in texture, being either of a soft nature, or fleshy and succulent, or more or less spongy, or membranous, or coriaceous, or when the interior of its cell-walls is much thickened, it assumes various degrees of hardness, and may become woody, crustaceous, &c.

The surface of the testa also presents various appearances, and is often furnished with different appendages. Thus it may be smooth, as in *Adenanthera*; or wrinkled, as in *Nigella*; striated, as in Tobacco; marked with ridges and furrows, as in *Delphinium* (*fig.* 751); netted, as in *Nasturtium* (*fig.* 749); alveolate or pitted, as in the Poppy (*fig.* 750); tuberculated, as in Chickweed (*fig.* 752); spiny, as in the Mulberry, &c. The testa of some seeds is also furnished with hairs, which may either cover the entire surface, as in the various species of *Gossypium* where they constitute the material of so much value called Cotton (see page 67), and in the Silk-cotton tree (*Bombax*); or they may be confined to certain points of the surface, as in the Willow (*fig.* 756), *Asclepias* (*fig.* 755), and *Epilobium* (*fig.* 761). In the latter cases the tufts of hairs, thus confined to certain points of the testa, constitute what is called a *coma*, and the seed is said to be *comose*.

Other seeds, again, have winged appendages of various kinds; thus, in the Sandwort (*fig.* 754), the testa is prolonged, so as to form a flattened margin to the seed, which is then de-

FIG. 753.

FIG. 754.

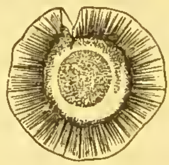


FIG. 755.

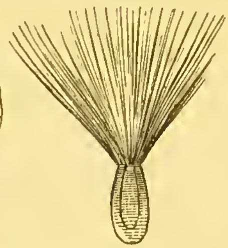


FIG. 756.

Fig. 753. Seed of a species of *Pinus*, with a winged appendage, *w*.——*Fig.* 754. Marginate or bordered seed of Sandwort (*Arenaria*).——*Fig.* 755. Comose oval seed of *Asclepias*. ——*Fig.* 756. Comose seed of a species of Willow (*Salix*).

scribed as *marginate* or *bordered*; while in the seeds of the *Pinus* (*fig.* 753, *w*), *Catalpa*, *Bignonia*, *Swietenia*, *Moringa*, &c., the testa forms wings, and the seed is said to be *winged*. These winged seeds must be carefully distinguished from samaroid fruits, such as the Ash, Elm, and Maple (*fig.* 706), where the wing is an expansion of the pericarp instead of the testa. In like manner, hairy seeds should not be confounded with pappose fruits, such as those of the Compositæ, Dipsacaceæ (*fig.* 468), and Valerianaceæ (*fig.* 467), where the hairy processes belong to the calyx.

FIG. 757.

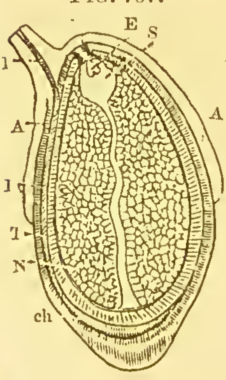


Fig. 757. Young anatropous seed of the White Water-Lily (*Nymphæa alba*) cut vertically. F. Funiculus. A, A. Gelatinous aril. T. Integuments of the seed. N. Nucleus. R. Raphe. *ch.* Chalaza. M. Micropyle. S. Embryo-sac. E. Rudimentary embryo.

Beneath the testa, in anatropous seeds (*figs.* 757, R, and 748, *rap*), and the modification of these termed *amphitropous*, the raphe or vascular cord connecting the hilum with the chalaza is found. Its situation is frequently indicated by a projecting ridge on the surface of the seed, as in the Orange, while at other times it lies in a furrow formed in the substance of the testa, so that the surface of the seed is smooth, and no evidence is afforded externally of its position.

The testa is also usually marked externally by a scar indicating the hilum or point by which it is attached to the funiculus or placenta. The micropyle, as already noticed (page 333), may be also sometimes seen on the surface of the testa, as in the Pea (*fig.* 748, *m*); but in those cases where no micropyle can be detected externally, its position can only be ascertained by dissection, when it will be indicated by the termination of the radicle; this being directed, as already alluded to (page 333), towards the micropyle. In some seeds, as in the Asparagus, the situation of the micropyle is marked by a small hardened point, which separates like a little lid at the period of germination: this has been termed the *embryotegia*.

On removing the testa, we observe the raphe, which frequently ramifies over the inner coat, and where it terminates it constitutes the *chalaza* (*fig.* 757, *ch*, and 774, *ch*). The structure and general appearances of these different parts have been already described. (See page 333.)

b. *Tegmen, Endopleura, or Internal Coat* (*fig.* 748, *e*).—The inner membrane or coat of the seed is essentially parenchymatous like the outer. This integument usually appears to originate either from the substance of the nucellus or from the secundine of the ovule; but sometimes in other ways. In many cases, however, it seems to be altogether wanting, which probably arises from its complete incorporation or adherence to the testa. Sometimes the embryo-sac in the ripe seed remains distinct from the albumen of the nucleus (*fig.* 762), and remains in the form of a bag or sac which envelopes the embryo, as in the Nymphæaceæ, Piperaceæ, and Zingiberaceæ. To this distinct membrane the name of *vitellus* has been given.

When clearly distinguishable the tegmen is generally of a soft and delicate nature, although sometimes it is of a fleshy character either entirely or in part. It is usually of a whitish colour, and more or less transparent. This layer is closely applied to the nucleus of the seed, which it accompanies in all its foldings and windings; and in some cases even dips down into the albumen of the nucleus, and thus divides it more or less completely into a number of parts, as in the Nutmeg and Betelnut (*fig.* 763, *p*). (See ALBUMEN, page 341.) The testa may either accompany the tegmen in its windings; or, as more frequently happens, especially when the nucleus is curved, the tegmen alone follows the windings of the nucleus, the testa remaining in an almost even condition.

Arillus.—Besides the two integuments described above as those that are usually found in all seeds, we occasionally find on the surface of some seeds an additional integument, which is generally of a partial nature (*fig.* 757, A, A), and to which the name of *arillus* or *aril* has been given. No trace of this structure is present in the ovule till after the process of fertilisation has taken place. Two kinds of aril have been described, which have been respectively called the *true arillus*, and the *false arillus* or *arillode.* These have an entirely different origin; thus, the *true arillus* arises in a somewhat similar manner to the coats of the ovule already described (page 329), that is to say, it makes its first appearance around the hilum in the form of an annular process derived from the placenta or funiculus, and gradually proceeds upwards, so as to produce a more or less complete additional covering to the seed, on the outside of the testa. This arillus is well seen in the *Nymphæa* (*fig.* 757, A, A). But the *false arillus* or *arillode* arises from the micropyle, and seems to be a development or expansion of the exostome, which gradually extends itself more or less over the testa to which it forms a covering, and after thus coating the seed, it

Fig. 758.

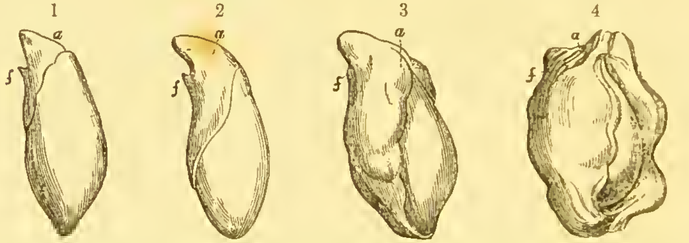


Fig. 758. Progressive development of the arillode in the seed of the Spindle-tree (*Euonymus*). *a.* Arillode. *f.* Funiculus. 1, represents the youngest seed; 2 and 3, the progressive development of the arillode; 4, the oldest and fully developed seed.

may be even bent back again so as to enclose the micropyle. The gradual development of the arillode in the seed of the Spindle-tree is well shown in *fig.* 758. In the Nutmeg, the arillus originates from both the hilum and the micropyle; it forms a scarlet covering to the testa, and is commonly known in commerce when dried and preserved, under the name of *mace.* According to Miers, the arillode in the Spindle-tree is produced from the funiculus and not from the exostome, in which case it would necessarily be an arillus, and not an arillode as commonly described. In practical Botany both the true arillus and arillode are commonly designated under the general term of aril.

Caruncules or Strophioles.—These are small irregular protuberances which are found on various parts of the testa. They are always developed, like the arillus and arillode, subsequent to fertilisation, and are accordingly not found in the ovule. In the Milkwort (*fig.* 759) they are situated at the base or hilum of the seed; in the Asarabacca (*fig.* 760) and Violet on the side, in a line with the raphe ; while in the Spurge they are placed at the micropyle. Some writers consider these caruncules as forms of the aril, of which they then distinguish four varieties, namely :—1. The *true arillus*, as in *Nymphæa* (*fig.* 757, A, A) ; 2. The *arillode* or *micropylar arillus*, as in *Euonymus* (*fig.* 758); 3. The *raphian arillus*, as in *Asarum* (*fig.* 760) ; and 4. The *chalazal arillus*, as in *Epilobium* (*fig.* 761), where the tuft of hairs at one end of the seed is regarded as an aril. Other writers again partially adopt these views, and define the caruncules as little protuberances growing from the raphe, and therefore originating independently of the funiculus or micropyle ; hence the caruncules of Milkwort and Spurge would be regarded as true or false arils according to their respective origins, and the appendages of Asarabacca and Violet would be true caruncules. Other botanists again, instead of using the two terms strophioles and caruncules as synonymous with each other, apply

FIG. 759.

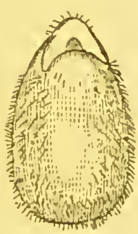


FIG. 760.

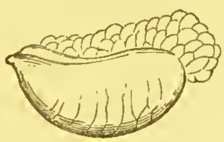


FIG. 761.

Fig. 759. Ovoid seed of Milkwort (*Polygala*), with a caruncule at its base or hilum.——*Fig.* 760. Seed of Asarabacca (*Asarum*), with a caruncule on the side, which is called by some a raphian arillus.——*Fig.* 761. Section of the comose seed of *Epilobium*. The tuft of hairy processes is sometimes called a chalazal arillus.

the former term only when the processes proceed from the hilum, and the latter to those coming from the micropyle. Altogether, there is a great difference of opinion among botanists, as to the application of the terms caruncules and strophioles ; but in this country they are more commonly understood in the sense in which we have first defined them.

2. THE NUCLEUS OR KERNEL (*figs.* 36, *emb*, *alb*, and 757, N). In order to understand the structure of the body of the seed, or, as it is commonly termed, the nucleus, we must briefly narrate the changes which the nucellus of the ovule undergoes after the process of fertilisation has been effected. We have already stated, that at an early period before impregnation has taken place, a quantity of protoplasmic matter of a semi-fluid nature is present in the embryo-sac. Very soon after fertilisation has been accomplished in the Angiospermia, frequently even before

any change is apparent in the oosphere, a number of cells are produced by free cell-formation (see Cell-development) in the protoplasm of the embryo-sac around the embryo. These cells, which contain nutritive matters of various kinds, especially designed for the nourishment of the embryo developed in the sac, form what is usually termed *endosperm*. In the Gymnospermia the endosperm is formed *before fertilisation*. The cells existing outside the embryo-sac, or those of the nucellus generally, also become filled with starch and other nutritive material in rudimentary seeds, and form what has been called the *perisperm*.

The embryo, by absorbing the nourishment by which it is surrounded, begins to enlarge, and in so doing presses upon the parenchymatous cells by which it is enclosed, and thus causes their absorption to a greater or less extent, according to the size to which it ultimately attains. In some cases, the embryo continues to develop until it produces the destruction, not only of the parenchymatous tissue within the embryo-sac, as well as the sac itself, but also of that of the nucleus, and it then fills the whole interior of the seed, and is coated directly by the integuments. But at other times the embryo does not develop to any such degree ; in which case it is separated from the integuments by a mass of parenchymatous tissue of varying thickness which may be derived from that of the nucleus itself, or from both that of the nucleus and embryo-sac according to the extent to which the embryo has developed. To the tissue which thus remains and forms a solid mass round the embryo, the name of *albumen* has been commonly applied ; but as the nature of this substance is different from that called by chemists vegetable albumen, it is now often designated as the *perisperm* or *endosperm* according to its origin as described above. Both *endosperm* and *perisperm* may be seen in the *Nymphæa* (*figs.* 757 and 762). The general name of *albumen* will be alone generally employed in future in this volume, as it is the one best understood, and so long as we recollect its origin and nature, the adoption of such a name can lead to no confusion.

Fig. 762.

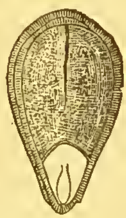


Fig. 762. Vertical section of the seed of the White Water-lily, showing the embryo enclosed in the remains of the embryo-sac or vitellus, and on the outside of this the albumen surrounded by the integuments.

From the above considerations it will be evident that the nucleus of the seed may either consist of the embryo alone, as in the Bean and Pea (*fig.* 748) ; or of the embryo enclosed in *albumen*, as in the Poppy (*fig.* 775), Pansy (*fig.* 774, *al*), Oat (*fig.* 705, *a*), and *Nymphæa* (*fig.* 762). We have two parts, therefore, to describe as constituents of the nucleus, namely, the albumen and the embryo.

a. *Albumen, Endosperm, Perisperm.*—Those seeds which have the embryo surrounded by albumen, that is, by either endosperm or perisperm, or both, are said to be *albuminous*; while those in which it is absent are *exalbuminous.* The amount of albumen will in all cases, as described above, be necessarily in inverse proportion to the size of the embryo.

The cells of the albumen contain various substances, such as starch, albuminoids, oily matters, &c., and thus act as reservoirs of nutriment for the use of the embryo during the process of germination. The varying contents of the cells, together with certain differences in the consistence of their walls, cause the albumen to assume different appearances in ripe seeds, and thus frequently to afford good characteristic marks of different seeds. Thus, the albumen is described as *mealy*, *starchy*, or *farinaceous*, when its cells are filled with starch-granules, as in the Oat and other Cereal grains; it is said to be *fleshy*, as in the Barberry and Heartsease, when its walls are soft and thick; or when its cells contain oil-globules, as in the Poppy and Cocoa-nut, it is *oily*; or when the cells are soft, and chiefly formed of mucilage, as in the Mallow, it is *mucilaginous*; and when the cells are thickened by layers of a hardened nature, so that they become of a horny consistence, as in the seeds of the Vegetable Ivory Palm and Coffee plant, the albumen is described as *horny.* These different kinds of albumen are frequently more or less modified in different seeds by the admixture of one with the other.

Generally speaking, the albumen also presents a uniform appearance throughout, as in the seeds of the Vegetable Ivory Palm; but at other times it is more or less separated into dis-

FIG. 763.

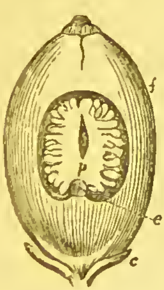


FIG. 764.

Fig. 763. Vertical section of the fruit of the Betel-nut Palm (*Areca Catechu*). *c.* Remains of perianth. *f.* Pericarp. *p.* Ruminated albumen of the seed. *e.* Embryo.——*Fig.* 764. Embryo of the Lime-tree (*Tilia europæa*). *c, c.* Cotyledons, each with five lobes arranged in a palmate manner. *r.* Radicle.

tinct compartments by the folding inwards of the tegmen as already described (see page 337). In the latter case the albumen is said to be ruminated, as in the Nutmeg and Betel-nut or Areca (*fig.* 763, *p*).

b. *The Embryo* is the rudimentary plant, and is therefore necessarily present in all true seeds; it is the *fertilised oosphere* of the embryo-sac. The embryo being the rudimentary plant, it is necessarily the most important part of the seed, and it contains within itself, in an undeveloped state, all the essential parts of which a plant is ultimately composed. Thus we distinguish, as already noticed in the first chapter, three parts in the embryo ; namely, a *radicle*, *plumule* or *gemmule*, and one or more *cotyledons*. These parts may be readily recognised in many seeds ; thus in the embryo of the Lime (*fig.* 764), the lower portion, *r*, is the radicle or portion from which the root is developed ; the two expanded lobed bodies above, *c*, *c*, are the cotyledons ; and between these the plumule or gemmule is placed. In the Pea, again (*fig.* 16), the two fleshy lobes, *c*, *c*, are the cotyledons, between which there is situated a little axis, *t* (*tigellum*), the upper part or bud-like portion of which is the plumule, *n*, and the lower part, *r*, the radicle. These parts are still better observed when the embryo has begun to develop in the process of germination ; thus in *fig.* 18, which represents the French Bean in that condition, *r* is the radicle from which the roots are being given off below, the cotyledons are marked *c*, *c*, and the plumule is seen coming off from between the cotyledons, and forming a direct continuation of the axis from which the root is developed below. The *tigellum* or *hypocotyledonary axis* is generally a mere point, but at other times it forms a short stalk (*figs.* 16, and 748, *t*). Plants which thus possess two cotyledons in their embryo are called *Dicotyledonous*. But there are plants in which, as already noticed, there is commonly but one cotyledon present (*figs.* 705, *c*, and 765, *c*), and which are, accordingly, termed *Monocotyledonous*. In rare instances, however, a monocotyledonous embryo has more than one cotyledon, and then the second cotyledon alternates with the first, instead of being opposite to it, as is invariably the case with the two cotyledons of Dicotyledonous plants. By the difference thus presented in the embryos of Flowering Plants, as already described in the first chapter, these plants are divided into two great classes, called respectively *Dicotyledones* and *Monocotyledones*.

Fig. 765.

Fig. 765. Germinating embryo of the Oat. *r*. Rootlets coming through sheaths, *co*. *c*. Cotyledon. *g*. Young stem.

(a) *The Monocotyledonous Embryo.*—The parts of the monocotyledonous embryo are in general by no means so apparent as those of the dicotyledonous. Thus the embryo at first sight, externally, usually appears to be a solid undivided body of a cylindrical or somewhat club-shaped form, as in *Triglochin* (*fig.* 767) ; but if this be more carefully examined, a little slit, *f*, or chink, will be observed on one side near the base ; and if a vertical section be made parallel to this slit, a small conical projection will be noticed, which corresponds to the plumule : and now, by making a horizontal section, the cotyledon will be noticed to be folded round the plumule, which it had thus almost entirely removed from view, only leaving a little slit corresponding to the union of the margins of the cotyledon ; and which slit thus became an external indication of the presence of the plumule. In fact, the position of the cotyledon thus rolled round the plumule is analogous to the sheaths of the leaves in most Monocotyledonous plants, which thus, in a similar manner, enclose the young growing parts of the stem.

Fig. 766. Fig. 767.

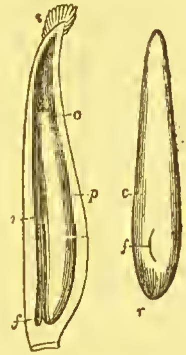


Fig. 766. Vertical section of a mature carpel of a species of *Triglochin*. *p.* Pericarp. *s.* Stigma. *g.* Seed. *r.* Raphe. *f.* Funiculus. *c.* Chalaza.—*Fig.* 767. Embryo of *Triglochin*. *r.* Radicle. *f.* Slit corresponding to the plumule. *c.* Cotyledon. From Jussieu.

In other monocotyledonous embryos the different parts are more manifest ; thus, in many Grasses, as, for instance, the Oat (*fig.* 705), the cotyledon, *c*, only partially encloses the plumule, *g*, and radicle, *r* ; and thus these parts may be readily observed in a hollow space on its surface (*fig.* 704).

We have already stated (page 342) that a monocotyledonous embryo has occasionally more than one cotyledon, in which case the cotyledons are always alternate, and hence such embryos are readily distinguished from those of Dicotyledonous plants, where the cotyledons are always opposite to each other if there are but two (*fig.* 773), or whorled (*fig.* 772, *c*) when they are more numerous (page 344).

The inferior extremity of the radicle is usually rounded (*fig.* 767, *r*), and it is through this point that the rootlets, *r*, burst in germination (*fig.* 765). The radicle is usually much shorter than the cotyledon, and generally thicker and denser in its nature ; but in some embryos it is as long, or even longer, in which case the embryo is called *macropodous*.

(b) *The Dicotyledonous Embryo.*—These embryos vary very much in form : most frequently they are more or less oval, as in the Bean and Almond (*fig.* 768), where the embryo consists of two nearly equal cotyledons, *c*, between which is enclosed a small axis or *tigellum*, *t*, the upper part of which, *g*, is the *plumule*, and the lower, *r*, the *radicle*. The tigellum upon germination appears as a little stalk (*fig.* 18, *t*), supporting the cotyledons, and hence it is also termed the *hypocotyledonary axis* (see page 342).

In by far the majority of cases the two cotyledons are nearly of equal size, as in the Pea (*fig.* 16, *c*, *c*) ; but in some embryos, as in *Trapa*, some *Hiræas*, &c. (*fig.* 769, *c′*, *c*), they are very unequal. Again, while the cotyledons usually form the greater part of the embryo (*fig.* 16, *c*, *c*); in other instances, as in *Pekea butyrosa* (*fig.* 771, *c*), they form but a small portion. In *Carapa* (*fig.* 770), again, the two cotyledons become united more or less

Fig. 768.

Fig. 769.

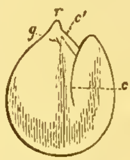


Fig. 770.

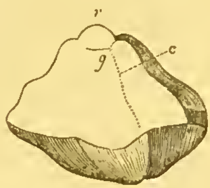


Fig. 771.

Fig. 768. The embryo of the Almond (*Prunus Amygdalus*), from which one of the cotyledons has been removed. *c*. The cotyledon which has been left. *r*. Radicle. *g*. Plumule. *t*. Tigellum. *c'*. Scar left by the removal of the other cotyledon.——*Fig.* 769. Vertical section of the embryo of a species of *Hiræa*. *c'*. Large cotyledon. *c*. Small cotyledon. *g*. Plumule. *r*. Radicle.——*Fig.* 770. Vertical section of the embryo of *Carapa guianensis*, showing the almost complete union of the cotyledons, the line, *c*, only dividing them. *r*. Radicle. *g*. Plumule.——*Fig.* 771. The embryo of *Pekea butyrosa*. *t*. Large tigellum. *c*. Rudimentary cotyledons.

completely into one body, so that the embryo appears to be monocotyledonous; but its nature is readily ascertained by the different position of the plumule in the two cases; thus, in the monocotyledonous embryo the plumule is situated just below the surface (*fig.* 705, *g*); but here (*fig.* 770), the plumule, *g*, is in the axis of the cotyledons.

Fig. 772.

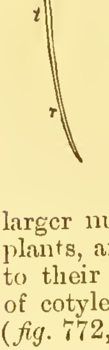


Fig. 773.

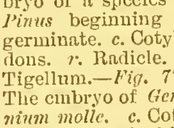


Fig. 772. The so-called polycotyledonous embryo of a species of *Pinus* beginning to germinate. *c*. Cotyledons. *r*. Radicle. *t*. Tigellum.—*Fig.* 773. The embryo of *Geranium molle*. *c*. Cotyledons, each of which is somewhat lobed, and furnished with a petiole, *p*. *r*. Radicle.

The cotyledons are sometimes altogether absent, as in *Cuscuta*. At other times their number is increased, and this may either occur as an irregular character, or as a regular condition, as in many Coniferæ (*fig.* 772, *c*), where we frequently find six, nine, or even fifteen cotyledons; hence such embryos have been termed *polycotyledonous*. It seems, however, that this appearance of a larger number of cotyledons than is usual in Dicotyledonous plants, arises from the normal number becoming divided down to their base into segments. In all cases where the number of cotyledons is thus increased, they are arranged in a whorl (*fig.* 772, *c*).

The cotyledons are usually thick and fleshy, as those of the Bean and Almond (*fig.* 768), in which case they are termed *fleshy*; at other times they are thin and leaf-like, as in the Lime (*fig.* 764, *c*, *c*), when they are said to be *foliaceous*. The foliaceous cotyledons are frequently provided with veins, and stomata may be also sometimes observed on their epidermis; but these structures are rarely to be found in fleshy cotyledons. Fleshy cotyledons serve a similar purpose to the albumen, by acting as reservoirs of nutritious matters for the use of the young plant during germination; hence, when the albumen is absent, the cotyledons are generally proportionately increased in size.

The cotyledons are commonly sessile, and their margins are usually entire, but exceptions occur to both these characters; thus, in *Geranium molle* (*fig.* 773, *p*), they are petiolate; while in the Lime (*fig.* 774, *c*, *c*) they are distinctly lobed; and in the Geranium (*fig.* 773, *c*), they are also somewhat divided or lobed at their ends.

The cotyledons also vary in their relative positions to each other. Generally they are placed parallel, or face to face, as in the Almond (*fig.* 768), Pea (*fig.* 16), and Bean; but they frequently depart widely from such a relation, and assume others analogous to those already described in speaking of the vernation of leaves and the æstivation of the floral envelopes. Thus each of the cotyledons may be either *reclinate*, *conduplicate*, *convolute*, or *circinate*. These are the commoner conditions, and in such instances both cotyledons are either folded or rolled in the same direction, so that they appear to form but one body; or in rare cases they are folded in opposite directions, and become *equitant* or *obvolute*; or other still more complicated arrangements may occur.

Fig. 774.

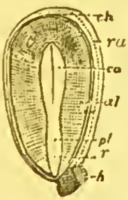


Fig. 775.

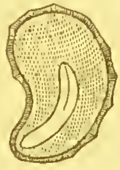


Fig. 776.

Fig. 774. Vertical section of the seed of the Pansy or Heartsease. *h.* Hilum. *pl.* Embryo with its radicle, *r*, and cotyledons, *co.* *ch.* Chalaza. *al.* Albumen. *ra.* Raphe. The embryo is erect or homotropous.——*Fig.* 775. Vertical section of the seed of the Poppy, with the embryo slightly curved in the axis of albumen.——*Fig.* 776. Vertical section of the seed of *Bunias*, showing its spiral embryo.

The position of the radicle in relation to the cotyledons is also liable to much variation. Thus the radicle may follow the same direction as the cotyledons, or a different one. In the former case, if the embryo be straight, the radicle will be more or less continuous in a straight line with the cotyledons, as in the Pansy (*fig.* 774, *r*); if, on the contrary, the embryo is curved, the radicle will be curved also (*fig.* 775), and sometimes the curvature is so great that a spiral is formed, as in *Bunias* (*fig.* 776). In the latter case, where the direction of the cotyledons and radicle is different, the latter may form an acute, obtuse, or right angle to them; or be folded back to such an extent as to lie parallel to the cotyledons, in which case the radicle may be either applied to their margins, as in the Wallflower (*fig.* 778, *r*), when the cotyledons are said to be *accumbent*; or against the back of one of them, as in *Isatis* (*fig.* 777, *r*), when they are termed *incumbent*.

FIG. 777.

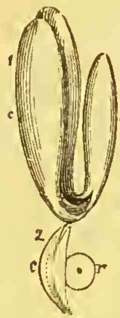


FIG. 778.

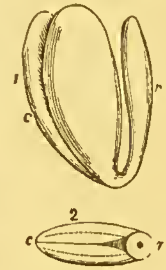


Fig. 777. Embryo of the Woad (*Isatis tinctoria*). 1. Undivided. 2. Horizontal section. *c.* Cotyledons. *r.* Radicle.——*Fig.* 778. Embryo of the Wallflower (*Cheiranthus Cheiri*). 1. Undivided. 2. Horizontal section. *r.* Radicle. *c.* Cotyledons.

Having now described the general characters of the monocotyledonous and dicotyledonous embryo, we have, in the last place, to allude briefly to the relation which the embryo itself bears to the other parts of the seed, and to the pericarp or cell in which it is placed.

Relation of the Embryo to the other Parts of the Seed, and to the Fruit.—In the first place with regard to the albumen. It must necessarily happen that when the albumen is present, the size of the embryo will be in the inverse proportion to it; thus in Grasses (*fig.* 705, *a*) we have a large deposit of albumen and but a small embryo, while in the Nettle (*fig.* 779) the embryo is large and the albumen very small. The embryo may be either external to the albumen (*figs.* 705 and 782), and thus in contact with the integuments, as in Grasses, in which case it is described as *external*; or it may be surrounded by the albumen on all sides, except on its radicular extremity, as in the Pansy or Heartsease (*fig.* 774), when it is *internal*. Sometimes the end of the radicle, as in the Coniferæ, becomes united to the albumen, and can no longer be distinguished.

The embryo is said to be *axile* or *axial* when it has the same direction as the axis of the seed, as in Heartsease (*fig.* 774, *pl*); or when this condition is not complied with, it is *abaxile* or *eccentric*, as in *Rumex* (*fig.* 780, *pl*). In the latter case, the embryo is frequently altogether on the outside of the albumen, and directly below the integuments, as in *Mirabilis Jalapa* (*fig.* 781, *e*) and *Lychnis* (*fig.* 782, *emb*), when it is described as *peripherical*.

We have already observed, that the radicle as a general character is turned towards the micropyle (*fig.* 780, *r*), in which case it is said to be *homoblastic* ; and the cotyledonary extremity is then directed to the chalaza, *ch.* Some apparent exceptions to these relative positions occur in the Euphorbiaceæ, and a few other plants, when the radicle is described as *enantioblastic* ; but such are merely accidental deviations arising from certain trifling irregularities in the course of the development of the parts of the seed.

FIG. 779.

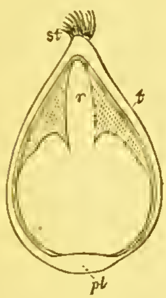


FIG. 780.

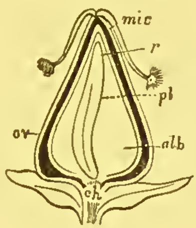


FIG. 781.

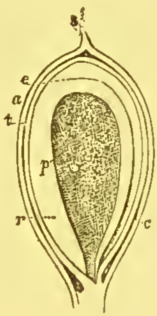


FIG. 782.

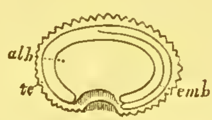


Fig. 779. Vertical section of the fruit of the Nettle, containing a single seed. *t.* Integuments of the seed. *pl.* Placenta. *r.* Radicle. *st.* Stigma. ——*Fig.* 780. Vertical section of the fruit and solitary erect orthotropous seed of the Dock (*Rumex*). *ov.* Pericarp. *mic.* Micropyle. *pl.* Embryo which is inverted or antitropous, and turned towards one side of the albumen, *alb.* *ch.* Chalaza. *r.* Radicle.——*Fig.* 781. Vertical section of the carpel of *Mirabilis Jalapa*, containing one seed. *a.* Pericarp. *s.* Style. *e.* Peripherical embryo with its radicle, *r*, and cotyledons, *c.* *p.* Albumen. *t.* Integuments of the seed.——*Fig.* 782. Vertical section of the seed of *Lychnis dioica.* *te.* Integuments. *emb.* Embryo on the outside of the albumen, *alb.* The embryo is amphitropous.

While the relation of the radicle and cotyledonary portion is thus seen to be generally constant, it must necessarily happen from the varying relation which the hilum bears to the micropyle and chalaza, that its relation to the radicle and cotyledonary portion of the embryo must also vary in like manner. Thus in an orthotropous seed, as *Rumex* (*fig.* 780), the chalaza and hilum coincide with each other, and the radicle is then turned towards the apex of the seed, and the cotyledonary portion to the chalaza and hilum ; in this case the embryo is said to be *antitropous* or *inverted* (*figs.* 731 and 780). In an anatropous seed, as Heartsease (*fig.* 774), where the micropyle is contiguous to the hilum, *h*, and the chalaza, *ch*, at the opposite extremity, the radicle, *r*, will point towards the hilum or base of the seed, and then the embryo is said to be *erect* or *homotropous.* In a campylotropous seed, where the chalaza and micropyle are both near to the hilum, as in *Lychnis* (*fig.* 782), the two extremities of the embryo, which in such cases is generally peripherical, become also approximated, and it is said to be *amphitropous*. Thus, when we wish to know the direction of the embryo, by ascertaining the position of the hilum, chalaza, and micropyle, it is at once evident.

We have now lastly to explain the different terms which are in use to express the relations which the embryo bears to the cavity or cell in which it is placed. We have already described the terms used in defining the position of the seed to the same cavity (see page 334), which we found might be either erect, inverse, suspended, pendulous, ascending, or horizontal, in the same sense as previously mentioned when speaking of the ovule (page 326). But as regards the radicle this is said to be *superior* or *ascending*, as in the Nettle (*fig.* 779, *r*) and *Rumex* (*fig.* 780, *r*), when it is directed towards the apex of the cell or pericarp; *inferior* or *descending* when it points to the base; *centripetal* if turned inwards towards the axis or centre; and *centrifugal* when it is turned towards the sides. The above relations of the embryo to the other parts of the seed and to the cavity or cell in which it is placed, are sometimes of much practical importance.

to here

(Germination see p. 852)

Section 7. Theoretical Structure or General Morphology of the Flower.

Having now taken a comprehensive view of the different organs of the flower, we are in a position to examine in detail the theory which has been kept constantly in view in their description, namely, that they are all modifications of one common type,—*the leaf*. The germ of this theory originated with Linnæus, but the merit of having first brought it forward in a complete form is due to the poet Goethe, who, as far back as 1790, published a treatise 'On the Metamorphoses of Plants.' The appearance of Goethe's treatise at once drew the attention of botanists to this subject, and it is now universally admitted that all the organs of the flower are formed upon the same plan as the leaf, or, in other words, that they are homologous parts, and that they owe their differences to special causes connected with the functions which they have severally to perform. Thus the leaf, being designed to elaborate nutriment for the support of the plant, has a form, structure, and colour which are adapted for that purpose; while the parts of the flower, being designed for the purpose of reproduction, have a structure and appearance which enable them to perform their several functions.

It was formerly said that the parts of the flower were metamorphosed leaves, but this is stating the question too broadly, because they have never been leaves; they are to be considered only as *homologous* parts to leaves, or parts of the same fundamental nature, that is, as well stated by Lindley, 'constructed of the same elements arranged upon a common plan, and varying in their manner of development, not on account of any original difference in structure, but on account of special, local, and predisposing causes : of this plan the leaf is taken as the type, because it is the organ which is most usually the result of the development of those elements,—is that to which the other organs generally revert, when from any accidental disturbing cause they do not sustain the appearance to which they were originally predisposed,—and, moreover, is that in which we have the most complete type of organisation,' and, we may add, is that which can always be distinctly traced by insensible gradations of structure into all the other parts.

Having first defined the general nature of the doctrine of Morphology, or that doctrine which investigates the various alterations of form, and other characters, which the different parts of plants undergo in order to adapt them to the several purposes for which they were designed, we shall then proceed to prove that all the parts of a flower are homologous with leaves. In doing so, we shall examine the several organs of reproduction, both as they exist in a natural condition, and in an abnormal state, commencing with the bract, and then proceeding in a regular manner with the different whorls of the flower, according to their arrangement from without inwards.

In the *first place*, it is evident that the *bract* is closely allied to the leaf, from its structure, form, colour, and from the ordinary development of one or more buds in its axil. But in order to be perfectly convinced of this analogy, let anyone examine the Foxglove, the Lilac, or the Pæony, and then it will be seen that all stages of transition occur between leaves and bracts, so that it will be impossible to doubt their being homologous parts.

That the *sepals* are homologous with leaves is proved, not only by their colour and other characters, but also by the fact, that many flowers exhibit in a natural condition a gradual transition between sepals and bracts, and the latter, as already noticed, are readily referable to the leaf as the type. Thus, in the Camellia the transition between the sepals and bracts is so marked, that it is almost impossible to say where the latter end and the former begin. In the Marsh Mallow (*fig.* 395) and Strawberry (*fig.* 396), again, the five sepals in the flowers of the two plants respectively alternate with five bracts ; and the difficulty of distinguishing them is so great, that some botanists call both sets of organs by the name of sepals. In many flowers in a natural condition, therefore, there is a striking resemblance between sepals and leaves ; and this analogy is at once proved to demonstration by the fact, that in monstrous flowers of the Rose, Clover, Primrose (*fig.* 783), and other plants, the sepals are frequently converted into true leaves.

FIG. 783.

Fig. 783. Monstrous Primrose with the sepals converted into true leaves. From Lindley.

We now pass to the *petals*, and although these in the majority of flowers are of a different colour to leaves and sepals, yet in their flattened character and general structure they are essentially the same; and their analogy to leaves is also proved in many natural flowers by the gradual transitions exhibited between them and the sepals. This is remarkably the case in the White Water-lily (*fig.* 453); also in the *Magnolia* and *Calycanthus*, where the flowers present several whorls of floral envelopes, which so resemble one another in their general appearance and colour, that it is next to impossible to say where the sepals end and the petals begin. In many other instances, also, there is no other way of distinguishing between the parts of the calyx and those of the corolla than by their different positions,—the calyx being the outer series, the corolla the inner. The analogy between petals and leaves is still further shown by the fact, that the former are occasionally green, as in certain species of *Cobæa*, in a variety of *Ranunculus*, and in one of *Campanula rapunculoides*; and also from their being occasionally converted, either entirely or partially, into leaves. We therefore conclude that petals like sepals and bracts are homologous with leaves.

The *stamen* is, of all organs, the one which has the least resemblance to the leaf. In describing the structure of the stamen we have shown (page 247), however, that the different parts of the leaf may be clearly recognised in those of the stamen. We find, moreover, that in many plants the petals become gradually transformed into stamens. This is remarkably the case in the White Water-lily (*fig.* 453); thus in the flowers of this plant the inner series of petals gradually become narrower, and the upper extremity of each petal exhibits at first two little swellings, which, in those placed still more internally, become true anthers containing pollen. From the fact that the stamens can thus be shown to be merely modified petals, while the latter have been already proved to be modified leaves, it must necessarily follow that the stamens are so also. If we now refer to what takes place in many cultivated flowers, we have conclusive evidence at once afforded to us of the leaf-like nature of stamens. Thus, in what are called double flowers, the number of petals is principally increased by the conversion of stamens into petals; hence the number of the latter increases as the former decreases.

Thus, if a double Rose be examined, all sorts of transitions may be observed between true petals and stamens. In other cases, the stamens have been actually transformed into true leaves. As far as the stamens, therefore, we have no difficulty in tracing, both in the normal and abnormal conditions of the parts of the flower, a regular and gradual transition from the ordinary leaves, thus forming conclusive evidence of their being developed upon a common type with them.

If we now pass to the *carpel*, we find that transitional states between the stamen and carpel are unknown in the normal condition of flowers, the difference in the functions performed by them respectively being so opposite, that it necessarily leads to corresponding differences in structure. We must, therefore, look to *monstrosities*, or deviations from ordinary structure, for examples of such conditions. Even these are by no means common. Such may, however, be occasionally found in the House-leek, some Poppies, and in other plants. In a paper, published by the author in the *Pharmaceutical Journal* for March, 1856, a very remarkable instance of this transition from stamens to carpels was described ; it occurred in *Papaver bracteatum*. In this case, several whorls of bodies, intermediate in their nature between stamens and carpels, were found between the true andrœcium and gynœcium. The outer whorls of the intermediate bodies differed from the ordinary stamens, in their colour, in being of a more fleshy nature, and in being enlarged at their upper extremity and inner surface into rudimentary stigmas ; in other respects they resembled the stamens, and possessed well-marked anthers containing pollen. The whorls next in succession gradually lost their anthers, became more fleshy, bore evident stigmas, and on their inner surfaces, which were slightly concave, they had rudimentary ovules. Still more internally, the intermediate bodies, whilst resembling those just described in their general appearance, became more concave on their inner surface, and bore numerous perfect ovules : and within these, the intermediate bodies had their two margins folded completely inwards and united, and thus formed perfect carpels. Such an example as this shows in a striking manner that the stamens and carpels are formed upon a common type, and hence, that the latter are, like the former, homologous organs with leaves. The analogy of the carpel to the leaf is, however, constantly shown in cultivated flowers, even in a more striking manner than the stamen is thus proved to be a modified condition of that organ. Thus in many double flowers, as Buttercups and Roses, the carpels, as well as the stamens, become transformed into petals. It is by no means rare, again, to find the carpels transformed into true leaves in cultivated Roses, &c. A similar condition also occurs in the Double Cherry (*figs.* 587–589), and has been already fully described when speaking of the carpel ; in which place we have also shown the analogy of the carpel with the leaf, by tracing its development from a little concave body but slightly differing in appearance from a leaf, up to its mature condition as a closed cavity, containing one or more ovules (see page 268). We have, therefore, as regards the carpel, the most conclusive evidence of its being formed upon a common type with the leaf, and that it is consequently homologous with it.

The carpel being thus shown to be homologous with the leaf, it must necessarily follow that the *fruit* is likewise a modified condition of the leaf, since it is formed of one or more carpels in a matured state.

Fig. 784.

Fig. 784. A monstrous or abnormally developed Pear, showing the axis prolonged beyond the fruit, and bearing true or foliage leaves.

Further proof of the homologous nature of the parts of the flower to the leaf is afforded by the fact that the floral axis, instead of producing flowers, will sometimes bear whorls of true leaves. In other cases the axis becomes prolonged beyond the flower, as in certain species of *Epacris*, and frequently in cultivated Roses (*fig.* 655), or beyond the fruit (*fig.* 784), and becomes a true branch bearing leaves. To this elongation of the axis the term *median prolification* is usually applied.

Various other examples might be adduced of the transformation of the floral organs into more or less perfect leaves. Thus, in the common White Clover, the parts of the flower are not unfrequently found in a leaf-like state. A similar condition has also been observed in monstrous Strawberry flowers. In fact, no one can walk into a garden, and examine cultivated flowers, without finding numerous instances of transitional states occurring between the different organs of the flower, all of which necessarily go to prove their common origin.

When a sepal becomes a petal, or a petal a stamen, or a stamen a carpel, the changes which take place are said to be owing to *ascending* or *direct metamorphosis*. But when a carpel becomes a stamen, or a stamen a petal, or a petal a sepal, or if any of these organs become transformed into a leaf, this is called *retrograde* or *descending metamorphosis*.

We have thus proved by the most conclusive facts, that all the organs of the flower are formed upon a common type with the leaf, and differ only in their special development, or, in other words, that they are homologous parts. Hence a flower-bud is analogous to a leaf-bud, as we have already stated (page

218), and the flower itself to a branch the internodes of which are but slightly developed, so that all its parts are situated in nearly the same plane ; and, as flower-buds are thus analogous to leaf-buds, their parts are also necessarily subject to similar laws of development and arrangement, and hence a knowledge of the latter gives the clue to that of the former.

The symmetrical arrangement of the parts of the flower arising from their being homologous parts with the leaves, will now be described, together with the various causes which interfere to prevent or disguise it.

Section 8. Symmetry of the Flower.

The term symmetry has been variously understood by different botanists. As properly applied, a symmetrical flower is one in which each whorl of organs has an equal number of parts ; or where the parts of one whorl are multiples of those of another. Thus, in some species of *Crassula* (*fig.* 785), we have a symmetrical flower composed of five sepals, five petals, five stamens, and five carpels ; in *Sedum* (*fig.* 786) we have five sepals, five petals, ten stamens in two rows, and five carpels ; in the Flax we have five sepals, five petals, five stamens, and five carpels, each of which is partially divided into two by a spurious dissepiment (*fig.* 618) ; in the *Circæa* (*fig.* 787) we have two organs in each whorl ; in the Rue (*figs.* 611 and 579) we have four or five sepals, four or five petals, eight or ten stamens, and a four- or five-lobed pistil ; and in the Iris there are three organs in each whorl. All the above are therefore *symmetrical* flowers. When the number of parts in each whorl does not correspond, or when the parts of a whorl are not multiples of one another, the flower is *unsymmetrical*, as in *Verbena*, where the calyx and corolla have five parts in each whorl, and the andrœcium and gynœcium only four.

Fig. 785.

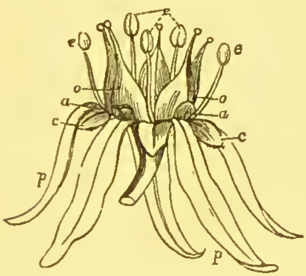


Fig. 786.

Fig. 785. Flower of *Crassula rubens.* *c, c.* Sepals. *p, p.* Petals. *e, e, e.* Stamens. *o, o.* Carpels, at the base of each of which is seen a scale, *a, a.* ——*Fig.* 786. Flower of a *Sedum.*

A symmetrical flower in which the number of parts in each whorl is the same, as in *Crassula* (*fig.* 785), is said to be *isomerous*, or when the number is unequal, as in the Rue (*figs.* 579 and 611) and *Sedum* (*fig.* 786), the flower is *anisomerous*. The number of parts is indicated by a Greek numeral prefixed to the word *meros*, signifying a part. Thus, when there are two parts in the whorls, as in *Circæa* (*fig.* 787), the flower is *dimerous*, and the symmetry is said to be *binary* or *two-membered*. This may be considered either as answering to the *distichous* or *two-ranked* arrangement of leaves (see page 151); each whorl forming a cycle composed of two organs, the internodes between them not being developed; or to successive pairs of opposite leaves decussating with each other. This arrangement is thus marked, $\sqrt[2]{}$. When there are three parts in a whorl, as in the Squill (*fig.* 28), Iris, and Lily, the flower is *trimerous*, and the symmetry is *ternary*, *trigonal*, or *triangular*; it is indicated thus, $\sqrt[3]{}$. This may be regarded, either as answering to the tristichous arrangement of leaves (page 152), each whorl forming a cycle of three organs, the internodes between them not

Fig. 787.

Fig. 788.

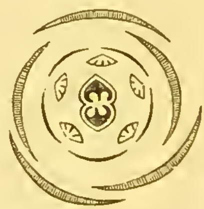


Fig. 787. Diagram of the flower of *Circæa* ——*Fig.* 788. Diagram of the flower of *Staphylea pinnata*.

being developed; or to successive whorls of three organs in each. When there are four parts in a whorl, as frequently in the Rue (*fig.* 579), the flower is *tetramerous*, and the symmetry, which is marked $\sqrt[4]{}$, is *quaternary* or *tetragonal*; the successive whorls in such a flower may be compared directly with whorls of leaves each consisting of four organs; or indirectly with opposite decussating leaves combined in pairs, the internodes not being developed. When there are five parts in a whorl, as in *Crassula rubens* (*fig.* 785), the flower is said to be *pentamerous*, and the symmetry, which is marked thus, $\sqrt[5]{}$, *quinary* or *pentagonal*. Such a flower may be considered as answering to the pentastichous arrangement of leaves (page 150) with the internodes undeveloped; or to be composed of successive whorls of five leaves, the internodes between each whorl being almost undeveloped, or very short.

Of the above arrangements, the pentamerous is most common among Dicotyledons, although the tetramerous is also by no means rare ; while the trimerous is generally found in Monocotyledons.

Although a symmetrical flower, as above described, necessarily infers that the parts in each whorl are equal to, or some multiple of one another, still it is very common for botanists to call a flower symmetrical when the three outer whorls correspond in such particulars, while the parts of the gynœcium are unequal to them ; as in *Staphylea pinnata* (*fig.* 788), where the three outer whorls are pentamerous, while the pistil is dimerous. The gynœcium of all the organs of the flower is that which less frequently corresponds in the number of its parts to the other whorls.

By some writers, again, a flower is said to be symmetrical, when it can be divided into two similar halves, as in Cruciferæ, where there are four sepals, four petals, six stamens, and two carpels (*figs.* 25 and 26), and the whole so arranged that the flower may be separated into two equal parts.

Various other terms are used in describing flowers, which will be best alluded to here, although some have been previously noticed. Thus a flower is said to be *complete*, when the four whorls—calyx, corolla, andrœcium and gynœcium—are present, as in the Rue (*fig.* 611) ; where one or more of the whorls is absent, the flower is *incomplete* (*figs.* 29 and 30). When the parts of each whorl are uniform in size and shape, as in the Rue (*figs.* 579 and 611), the flower is *regular* ; under other circumstances it is *irregular*, as in the Pea (*figs.* 452 and 477). In a normal arrangement of the parts of the flower, the successive whorls alternate with each other, as shown in *figs.* 785 and 787 ; thus here, the sepals alternate with the petals, the petals with the stamens, and the stamens with the carpels.

A perfectly normal and typical flower should possess a calyx, corolla, andrœcium, and gynœcium, each of which should be so arranged that its parts form but a single whorl ; the different whorls should consist of an equal number of members ; the parts of successive whorls should alternate with one another ; and the organs of each should be uniform in size and shape, and distinct from each other and from the surrounding whorls. This normal and typical flower is, however, liable to various alterations, arising from several disturbing causes, which modify and disguise one or more of their typical characters. Some of these causes have been already alluded to in the description of the different organs of the flower, but it will be necessary for us to investigate them more fully here, and classify for systematic study. All the more important deviations of the flower from its normal character may be arranged under the following heads :—

1st. The adhesion or union of the parts of the same whorl ; or those of different whorls.

2nd. The addition of one or more entire whorls in one or more of the floral circles ; or increase in the number of parts of a whorl.

3rd. The suppression or abortion of one or more whorls ; or of one or more parts of a whorl.

4th. Irregularity produced by unequal growth, or unequal degree of union of the members of the same whorl ; or by abnormal development of the thalamus or axis of the flower.

That part of Botany which has for its object the investigation of the various deviations from normal structure, both in the flower and other parts of the plant, is called *Teratology*.

1. THE CHANGES DUE TO UNION OR ADHESION OF PARTS.—We arrange these in two divisions : one of which is characterised by the more or less complete union of the members of the same whorl ; and the other by the adhesion of the different whorls. The first is frequently termed *coalescence*, *cohesion*, or *concrescence* ; and the latter *adnation* or *adhesion*.

a. *Coalescence, Cohesion, or Concrescence.*—This is of very common occurrence in the members of the different whorls of the flower. Thus it occurs in the calyx, when it becomes *monosepalous* or *gamosepalous* ; in the corolla, when it is *monopetalous* or *gamopetalous* ; in the filaments, when it gives rise to *monadelphous*, *diadelphous*, and *polyadelphous* stamens ; in the anthers, when they are *syngenesious* or *synantherous* ; and in the pistil, when the carpels are *syncarpous*.

b. *Adnation* or *Adhesion* of the different whorls is also by no means uncommon. Thus the calyx may be united to the corolla, or to the andrœcium, or to both ; or all these whorls may be united with the ovary. These different adhesions have been already explained, under the terms *perigynous*, *epigynous* (page 254), as regards the stamens ; and *superior* (page 227) as applied to the calyx. Again, the stamens may be united to the corolla, when they are said to be *epipetalous* (page 253) ; or to the pistil, when the term *gynandrous* is used (page 255). All the changes due to union or adhesion of parts have been fully described in treating of the different whorls of the flower.

2. ADDITION OR MULTIPLICATION OF PARTS.—This may be also considered under two heads :—1st. The addition of one or more entire whorls in one or more of the floral circles ; and 2ndly, the increase in the number of the parts of the whorl, which is usually said to be due to the multiplication by division of any or all of the organs of a whorl. The former is commonly termed *augmentation* ; the latter *chorisis*, *deduplication*, or *unlining*.

a. *Augmentation.*—The increase in the number of whorls may occur in one or more of the floral circles. Thus the Barberry (*fig.* 789) has two whorls of sepals, two of petals, and two of stamens ; in this flower, therefore, we have an addition of one whorl of organs to each of the three external floral circles. In the Poppy, we have a number of additional whorls of stamens (*fig.* 791). In the Magnolia order generally, the increase is chiefly remarkable in the carpels (*fig.* 604, *c*, *c*). In *Nymphæa* (*fig.* 790), the petals and stamens are greatly increased in number. In many of the Ranunculaceæ, as *Clematis* (*fig.* 792), the stamens and carpels are very numerous, owing to addition of whorls. As a rule, the increase in the number of whorls is most common among the stamens. When the increase is not excessive, the number of the organs so increased is a multiple of the normal

FIG. 789.

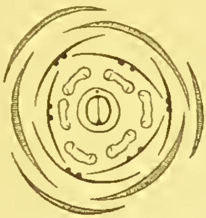


FIG. 790.

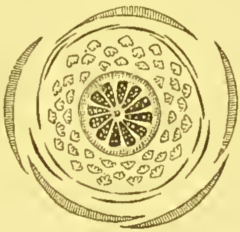


Fig. 789. Diagram of the flower of the Barberry (*Berberis*).——*Fig.* 790. Diagram of the flower of *Nymphæa*.

number of parts in each whorl; thus in the Barberry (*fig.* 789) the normal number is three, and that of the sepals, petals, and stamens, six, so that in each of these whorls we have double the normal number. When the addition of parts extends to beyond three or four whorls, this correspondence in number is liable to much variation; and when the addition is very great, as in the stamens of the species of *Clematis* (*fig.* 792), and the carpels of

FIG. 791.

FIG. 792.

Fig. 791. Diagram of the flower of the Poppy (*Papaver*).——*Fig.* 792. Diagram of the flower of Clematis (*Ranunculaceæ*).

Liriodendron (*fig.* 604, *c*, *c*), it cannot be well determined, and the symmetry is then disguised or destroyed; which is also the case if the whorls are crowded together.

b. *Chorisis or Deduplication.*—This is generally looked upon by botanists as another means of multiplication of the parts of a flower. It consists in the division or splitting of an organ in the course of its development, by which two or more organs are produced in the place of one. Chorisis differs from augmentation in the fact, that it not only increases the number of parts, but also interferes with their regular alternation; for augmentation does not necessarily interfere with alternation, it only obscures it when the number of additional parts is excessive, or when the whorls are crowded together.

Chorisis may take place in two ways, either transversely, when the increased parts are placed one before the other, which is called *vertical*, *parallel*, or *transverse chorisis*; or collaterally, when the increased parts stand side by side, which is termed *collateral chorisis*. *Transverse chorisis* is supposed to be of frequent occurrence; thus the petals of *Lychnis* (*fig.* 501, *a*) and many other Caryophyllaceous plants, exhibit a little scale on their inner surface at the point where the limb of the petal is united to the claw. A somewhat similar scale, although less developed, occurs at the base of the petals of some species of *Ranunculus* (*fig.* 498). The formation of these scales is supposed by many to be due to the chorisis or unlining of an inner portion of the petal from the outer. Other botanists consider these appendages as abortive stamens, or glands (see page 240). Each petal of *Parnassia* (*fig.* 500) has at its base a petal-like appendage divided into a number of parts, somewhat resembling sterile stamens; this is also stated to be produced by transverse chorisis.

In plants of the orders Rhamnaceæ (*fig.* 793), and others, the stamens are placed opposite to the petals, hence they are supposed by many botanists to be produced by chorisis from the corolla; but others explain this opposition of parts by supposing the suppression of an intermediate whorl (see page 360). Transverse chorisis is also frequently to be found in the andrœcium, but it is less frequent in the gynœcium. Examples of transverse chorisis in the gynœcium are furnished, however, by *Crassula* (*fig.* 785), where each carpel has at its base on the outside a little greenish scale, *a*, *a*, which is supposed by some to be due to it.

Fig. 793.

Fig. 793. Diagram of the flower of Buckthorn (*Rhamnus cath… articus*).

It will be observed, that in the above cases of transverse chorisis, the parts which are produced do not resemble those from which they arise, and this appears to be a universal law in this form of chorisis.

Collateral Chorisis.—We have a good example of this form in the Stock, Wallflower, and other plants of the order Cruciferæ. In these flowers, the two floral envelopes are each composed of four organs alternating with one another (*fig.* 794). Within these we find six stamens, instead of four, as should be the case in a symmetrical flower; of these two are placed opposite to the lateral sepals and alternate with the adjacent petals, while the other four are placed in pairs opposite the anterior and posterior sepals; we have here, therefore, four stamens instead of two, which results from the collateral chorisis of those two. In some Cruciferæ, as *Streptanthus* (*fig.* 795), we have a strong confirmation of this view presented to us in the fact that, in place of the two stamens, as commonly observed, we have a single filament forked at the top, and each division bearing an anther, which would seem to arise from the process of chorisis

FIG. 794.

FIG. 795.

FIG. 796.

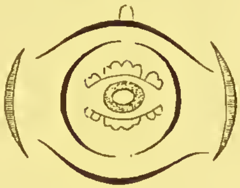


Fig. 794. Diagram of the flower of the common Wallflower.——*Fig.* 795. Flower of a species of *Streptanthus*, with the floral envelopes removed, showing a forked stamen in place of the two anterior stamens. From Gray.——*Fig.* 796. Diagram of the flower of the Fumitory.

being arrested in its progress. The flowers of the Fumitory are also generally considered to afford another example of collateral chorisis. In these we have two sepals (*fig.* 796), four petals in two rows, and six stamens, two of which are perfect, and four more or less imperfect; the latter are said to arise from collateral chorisis, one stamen here being divided into three parts. Other examples of this form are by some considered to be afforded by the flowers of many species of *Hypericum* (*fig.* 554, *f*, *f*); in which each bundle of stamens is supposed to arise from the repeated chorisis of a single stamen.

Collateral chorisis may be considered as analogous to a compound leaf which is composed of two or more distinct and similar parts. Transverse chorisis is supposed by Gray and some other botanists to have its analogue in the ligule of Grasses (*fig.* 374, *lig*), as that appendage occupies the same position as regards the leaf as the scales of *Lychnis* (*fig.* 501, *a*) and other plants do to the petals (see page 239).

Lindley held that the whole theory of chorisis 'is destitute of real foundation, for the following reasons:—

'1. There is no instance of unlining which may not be as well explained by the theory of alternation.

'2. It is highly improbable and inconsistent with the simplicity of vegetable structure, that in the same flower the multiplication of organs should arise from two wholly different causes; viz., alternation at one time, and unlining at another.

'3. As it is known that in some flowers, where the law of alternation usually obtains, the organs are occasionally placed opposite each other, it is necessary for the supporters of the unlining theory to assume that in such a flower a part of the organs must be alternate and a part unlined, or at one time be all alternate and at another time be all unlined, which is entirely opposed to probability and sound philosophy.

'4. The examination of the gradual development of flowers, the only irrefragable proof of the real nature of final structure, does not in any degree show that the supposed process of unlining has a real existence.'

According to Lindley's view, therefore, whenever the organs of adjacent whorls are opposite to each other instead of alternate, this is supposed to arise from the suppression of a whorl which should be normally situated between the two that are present.

3. SUPPRESSION OR ABORTION.—The suppression or abortion of parts may either refer to entire whorls; or to one or more parts of a whorl. We shall treat this subject briefly under these two heads.

a. *Suppression or Abortion of one or more Whorls.*—We have already stated that a complete flower is one which contains calyx, corolla, andrœcium, and gynœcium. When a whorl is suppressed, therefore, the flower necessarily becomes incomplete. This suppression may either take place in the *floral envelopes*; or in the *essential organs.*

Sometimes one whorl of the floral envelopes is suppressed, as in *Chenopodium* (*fig.* 29), in which case the flower is *apetalous* or *monochlamydeous*; sometimes both whorls are suppressed, as in the common Ash (*fig.* 30), when the flower is *naked* or *achlamydeous.*

When a whorl of the essential organs is suppressed, the flower is *imperfect*, as it then by itself cannot form seed. The andrœcium or gynœcium may be thus suppressed, in either of which cases the flower is *unisexual*; or both andrœcium and gynœcium may be suppressed, as in certain florets of some of the Compositæ, &c., when the flower is *neuter.* When the stamens are abortive, the flower is termed *pistillate* (*fig.* 35); or when the pistil is absent, *staminate* (*figs.* 34 and 503). The terms *monœcious*, *diœcious*, and *polygamous*, which have reference to this point, have been already sufficiently explained (see page 241).

Some botanists, as already noticed (page 358), consider that when the organs of adjacent whorls are opposite to each other instead of alternate, such an arrangement of parts arises from the suppression of an intermediate whorl; but this view is manifestly insufficient to account for such a circumstance in all cases. Thus in the Rhamnaceæ (*fig.* 793), the stamens are opposite to the petals, and frequently united to them at the base, and we cannot but regard them as produced by transverse chorisis from the petals. In some cases, therefore, we regard the opposition of the parts of contiguous whorls to be due to suppression, and in others to chorisis.

b. *Suppression of one or more Organs of a Whorl.*—This is a very common cause of deviation from normal structure ; we can here only bring forward a few examples.

This suppression of parts is most frequent in the gynœcium. Thus in the Cruciferæ (*fig.* 794), we have four sepals, four petals, six stamens, and two carpels ; here two carpels are suppressed. In the Heartsease (*fig.* 797), we have a pentamerous

FIG. 797.

FIG. 798.

FIG. 799.

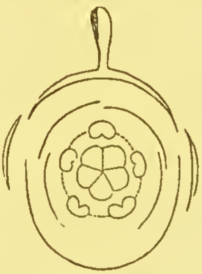


Fig. 797. Diagram of the flower of the Heartsease.——*Fig.* 798. Diagram of a Leguminous flower.——*Fig.* 799. Diagram of the flower of *Impatiens parviflora.*

flower, so far as the calyx, corolla, and andrœcium are concerned, but only three carpels, two carpels being here suppressed ; in Leguminous plants (*fig.* 798), we have five sepals, five petals, ten stamens, and only one carpel, four of the latter being here abortive ; in plants of the order Compositæ the calyx, corolla, and andrœcium have each commonly five organs, but only one, or, according to some botanists, two carpels.

In some species of *Impatiens* (*fig.* 799), we have five carpels, five stamens, and five petals, but only three sepals ; here two sepals are suppressed ; in *Tropæolum pentaphyllum* (*fig.* 800), there are five sepals, and but two petals, three of the latter organs being here abortive. In the Labiatæ and Scrophulariaceæ one of the stamens is commonly suppressed, and sometimes three ; thus in the *Lamium* we have five parts to the calyx and corolla, but only four stamens ; and in the *Salvia* we have also five parts to the calyx and corolla, but only two perfect stamens.

The abortion of whorls and parts of a whorl is well illustrated by plants of the Euphorbiaceæ, and the following diagram from Jussieu will show this fact in a remarkable manner (*fig.* 801). Thus, in No. 1 we have a flower consisting of but two whorls, the petals and carpels being suppressed; in No. 2, while the same whorls are present, one of the stamens is absent; in No. 3 two stamens are abortive; in No. 4 the calyx is suppressed, and one stamen, the place of the calyx being occupied by three bracts; while in No. 5 the place of the calyx is occupied by two bracts, and there is only one stamen present; this of itself constitutes the flower, which is thus reduced to its simplest condition.

FIG. 801.

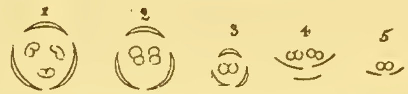


FIG. 800.

Fig. 800. Diagram of the flower of *Tropæolum pentaphyllum.*——*Fig.* 801. Diagram of flowers of Euphorbiaceous plants becoming more and more simple. After Jussieu.

1. Staminate flower of *Tragia cannabina.*
2. " " *Tragia volubilis.*
3. " " *Anthostema senegalense.*
4. " " *Adenopeltis colliguaya.*
5. " " *Euphorbia.*

Besides the above examples of the suppression of parts, there is another kind of suppression, to which the term abortion more properly applies. This consists in the *degeneration* or *transformation* of the parts of a flower. Thus in *Scrophularia* the fifth stamen is reduced to a scale; in the Umbelliferæ the limb of the calyx is commonly abortive, while in the Compositæ it is either abortive (*fig.* 465), membranous (*fig.* 466), or reduced to a pappose form. Many of the so-called nectaries of flowers are merely transformed stamens. In unisexual flowers such as *Tamus*, the stamens are frequently present as little scales. In cultivated *semi-double* flowers, such transformations are very common; thus we frequently find the stamens and carpels partially transformed into petals; or when the flowers are entirely double, all the parts of the andrœcium and gynœcium are thus converted into petals.

4. IRREGULARITY.—This may be produced by three different causes—namely, unequal growth of the members of a whorl; unequal degree of union; and abnormal development of the thalamus or axis of the flower. The first two causes cannot well be separated, and will be, therefore, treated of under one head.

a. *Unequal Growth and Unequal Degree of Union of the Members of a Whorl.*—From these causes such whorls become irregular, and we have produced what are called irregular flowers. These irregular forms have been already treated of in describing the different floral organs. All the examples of irregular forms of calyx and corolla, therefore, which have been alluded to under their respective heads, will afford good illustrations. The stamens of plants belonging to the sub-order Papilionaceæ of the Leguminosæ will afford numerous examples of unequal union in the staminal whorl ; and other illustrations will be found under the heads of the Andrœcium and Gynœcium.

b. *Abnormal Development of the Thalamus or Axis of the Flower.*—The irregular forms of flowers due to this cause have been also alluded to when describing the thalamus. Thus the flowers of the species of *Nelumbium* (*fig.* 654), *Liriodendron* (*fig.* 604), Strawberry (*fig.* 605), Raspberry (*fig.* 606), *Ranunculus* (*fig.* 542), *Rosa* (*fig.* 454), *Dianthus* (*fig.* 602), *Gynandropsis* (*fig.* 656), and *Geranium* (*fig.* 640), will furnish examples of this form of irregularity.*

CHAPTER 5.

REPRODUCTIVE ORGANS OF THE CRYPTOGAMIA OR FLOWERLESS PLANTS.

The nutritive organs of the Cryptogamia have been already briefly alluded to in the chapter on the General Morphology of the Plant, and in our descriptions of the stem, root, leaf, and other parts. But their reproductive organs have, at present, been only very generally referred to, hence we now proceed to describe them as fully as our space will allow.

The reproductive organs of the Cryptogamia differ widely from those of the Phanerogamia ; for, in the first place, they have no flowers properly so called—that is to say, they have no true andrœcium or gynœcium, the presence of which is essential to our notion of a flower ; and hence such plants are termed *Flowerless.* But although these plants have no flowers, and therefore no true stamens or carpels, they have organs which perform analogous purposes to them, and to which the names of Antheridia, Pistillidia, Archegonia, and many others, have been applied. As these organs are, however, more or less concealed or obscure, Flowerless plants have been also called *Cryptogamous*, which signifies, literally, concealed sexes. The term *asexual*, which was formerly applied, has now been proved to be generally incorrect.

Secondly, as Cryptogamous plants, or Cryptogams as they are commonly called, have no flowers, they do not produce true seeds or parts containing a rudimentary plant or embryo ;

* For full details relating to the General Morphology and Symmetry of the Flower, reference may be made to Masters's 'Vegetable Teratology,' and to Sachs's 'Text Book of Botany.'

but instead of seeds, they form reproductive bodies called *spores*, which in most cases consist of one cell, or rarely, two or more, with commonly one or two coats, and enclosing granular and other matters. The term spore is, however, used in a very varied sense, as our sketch of the Reproductive Organs of the Cryptogamia will show. As used above, it is intended to apply to *asexual reproductive cells.* A spore having no embryo can have no cotyledonary body, which is an essential part of the embryo, consequently flowerless plants have also been called *Acotyledonous.* In germination again, as the spores have no rudimentary stem or root, they have commonly no definite growth, but this takes place by an indifferent extension of one or both of their membranes. But some exceptions are afforded to this latter peculiarity by certain spores which have on their outer membrane certain spots or pores, through which, in germination, little threads are protruded from an extension of their inner membrane. This is exactly analogous to the production of the tubes from pollen-cells ; indeed, in their general structure, spores (especially those of the Fungi, which exhibit the above growth) have a striking similarity to pollen-cells. It should be noticed, however, that spores, although so similar in structure to pollen, perform essentially different functions. The threads which are thus produced by the germination of spores may either reproduce the plant directly, or give rise to an intermediate body of varying form, called the *prothallium* or *prothallus* (*figs.* 806 and 809), from which the fructiferous or fruit-bearing frond or stem ultimately springs.

Such are a few of the chief distinctive characters of the reproductive organs of Cryptogamous plants. The nature of these organs in the different orders of flowerless plants is, however, so remarkable, that, in order to become acquainted with them, it will be necessary for us to describe the peculiarities of each separately.

The Cryptogamia have been arranged, as already noticed (see page 11), in two great divisions, called Cormophytes and Thallophytes, under which heads we shall therefore give a sketch of the reproductive organs of the different natural orders or groups which are comprised respectively within them.

Section 1. Reproductive Organs of Cormophytes.

Cormophytes, or, as they have been also termed, Acrogens, have been divided into several sub-divisions, which are commonly called *Natural Orders* or *Orders* : these are the *Filices*, *Equisetaceæ*, *Lycopodiaceæ*, *Selaginellaceæ*, *Marsileaceæ*, *Musci*, and the *Hepaticaceæ*. These orders are differently arranged and defined by botanists ; but as our object is only to give a general sketch of their reproductive organs, we have adopted the above arrangement as perhaps, upon the whole, the simplest, and from its being the one most commonly in use, at least in practical Botany.

1 Filices or Ferns.—The fructification of these plants consists of little somewhat rounded cases, called *sporangia*, *capsules*, or *thecæ* (*fig.* 802, *sp*), containing spores in their interior, and springing commonly from the veins on the under surface or back of their leaves or fronds (*figs.* 802 and 803); or, in some few instances, as in *Acrostichum*, from their upper surface; and in others, as in *Hymenophyllum*, from the margins. The sporangia are arranged in little heaps called *sori*, which vary much in form (*figs.* 802, *sp*, and 803, *s*); these are either naked, as in *Polypodium* (*fig.* 802), or covered by a thin membranous layer continuous with the epidermis, which is called the *indusium*

Fig. 802.

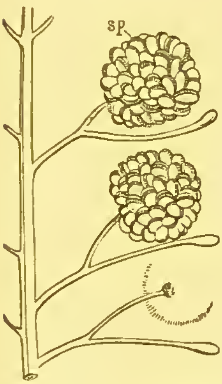


Fig. 803.

Fig. 804.

Fig. 802. A portion of a frond of the common Polypody (*Polypodium vulgare*), showing two sori springing from its veins. The sori are naked, and consist of a number of sporangia or capsules, *sp*, in which the spores are contained.——*Fig.* 803. Portion of a frond of the Male-fern (*Aspidium Filix-mas*), with two sori, *s*, *s*, covered by an indusium.——*Fig.* 804. Portion of a frond of the Royal or Flowering-fern (*Osmunda regalis*), with its sporangia or capsules arranged in a spiked manner on a branched rachis.

or *involucre*, as in *Aspidium Filix-mas* (*fig.* 803). Sometimes the sporangia are so densely compacted that no intervening parenchyma can be distinguished—the latter being destroyed by the excessive development of the former; in which case, instead of being collected in sori on the back of the fronds, they appear as little bodies arranged in a spiked manner on a simple or branched rachis, as in *Osmunda* (*fig.* 804).

The *sporangium* or *capsule* is a little cellular bag or case (*fig.* 805, *s*), usually stalked, *p*, and more or less completely surrounded by a ring or *annulus*; this ring is frequently elastic, and thus causes the bursting of the sporangium when ripe, and the escape of its contained spores. In some Ferns the ring is imperfect, and in others it is altogether wanting; hence Ferns provided with a ring are called *annulate*, while those in which it is absent are said to be *exannulate*.

The spores, *which are all of one kind* (*isosporous* or *homosporous*), are usually somewhat angular in form, and have two

Fig. 805.

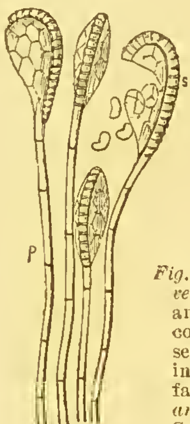


Fig. 806.

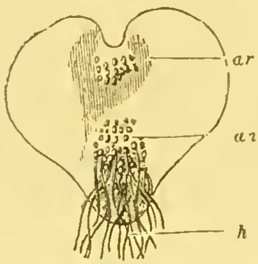


Fig. 805. Sporangia or capsules of a Fern (*Marginaria verrucosa*). *s.* Sporangium supported on a stalk, *p*, and surrounded by a ring or annulus, which is a continuation of the stalk. One sporangium is represented as burst on its side, and the contained spores in the act of being scattered.——*Fig.* 806. Under surface of the prothallium of a Fern, showing archegonia *ar*, antheridia *an*, and root hairs *h*. After Berg and Schmidt.

coats like pollen-cells; and like them, also, the outer coat, which has a yellowish or brownish colour, is either smooth or furnished with little points, streaks, ridges, or reticulations. In germination the inner coat is first protruded in the form of an elongated tube through an aperture in the outer coat, which ultimately bursts, and the tubular prolongation, by cell-division, forms a thin flat green parenchymatous expansion, called a *prothallium* (*fig.* 806), from which one or more root-hairs are commonly produced in its earliest stage (*fig.* 806, *h*). On the under surface of this body (*fig.* 806, *ar*, *an*) there are soon produced two different structures, called *antheridia* and *archegonia*, which represent respectively the andrœcium and gynœcium of flowering plants; hence the prothallia are monœcious. The *antheridia* are cellular bodies (*fig.* 807) containing other minute cells called *sperm-cells*, *se*, or *mother-cells*, in each of which is developed a little spiral ciliated filament, *sp*, termed

Fig. 807.

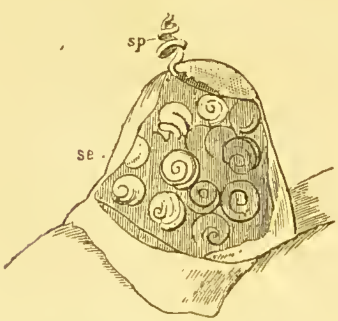


Fig. 807. Side view of an *antheridium* containing a number of *sperm-cells* or *mother-cells*, *se*. *sp*. Antherozoids escaping from the antheridium after having burst the sperm-cells.

the *antherozoid*, which performs the same function as the pollen of flowering plants. The *archegonia* (*fig.* 808) are little cellular papillæ of a somewhat oval form, with a canal in their centre leading to a cavity which has been called the *embryo-sac*, and in which, before impregnation, is a cell termed the *germ-cell* or

FIG. 808.

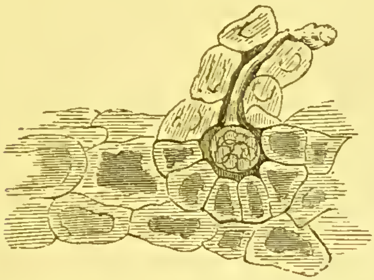


FIG. 809.

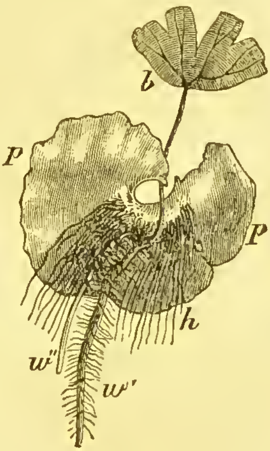


Fig. 808. Vertical section of an archegonium, passing through the canal and embryo-sac. After Henfrey.——*Fig.* 809. Prothallium, *p*, *p*, of *Adiantum Capillus-Veneris* seen from below, showing the Fern-plant developed from the fertilised germ-cell of the archegonium. *b*. First frond. *w*,' *w*.'' Roots. *h*. Root-hairs. After Sachs.

germ-corpuscle. Impregnation takes place by the contact of the antherozoids with the germ-corpuscle, and from the development of this, after fertilisation, ultimately the plant with fronds bearing sporangia is produced (*fig.* 809).

The Ferns are thus seen to exhibit in their growth two generations : in the first of which the spore produces a thalloid expansion, with antheridia and archegonia—the *prothallium* or *sexual generation* ; and in the second, a new plant resembling the one from which the spore was originally derived—the *asexual* or *non-sexual generation* (*sporoph~~ore~~*) or *Fern proper*. Thus, Ferns exhibit an instance of what has been called *alternation of generations*.

In some rare cases, as in *Pteris cretica*, no archegonia are produced, although the antheridia are fully developed. The Fern proper then arises from the prothallium in a simply vegetative manner ; this is known as *apogamy*.

2. EQUISETACEÆ OR HORSETAILS.—In these plants the fully developed fructification, found usually in the early spring, is borne in cone-like or club-shaped masses at the termination of the stem-like branches (*fig.* 13). Each mass is composed of a number of peltate stalked scales, on the under surface of which numerous spore-cases, called *sporangia*, or *capsules*, are arranged (*fig.* 810). These capsules, when ripe, open by a longitudinal fissure on their inner surface, and thus set free the contained spores.

The spores, *which are all of one kind*, present a very curious structure ; they are little rounded or somewhat oval bodies, with three coats, the outer of which ultimately splits up, so as to form four elastic filaments, whieh are attached at one end to the smooth inner coats of the spore, and terminated at the other by a club-shaped expansion (*figs.* 811 and 812). These

FIG. 810.

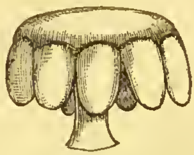


FIG. 811.

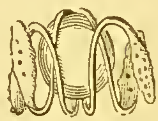


FIG. 812.

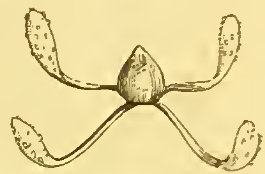


Fig. 810. Peltate stalked scale of a species of Horsetail (*Equisetum*), bearing on its lower surface a number of sporangia or capsules.——*Fig.* 811. Spore of a Horsetail furnished with four *elaters*, which are wound round it. The elaters are terminated by a club-shaped expansion.——*Fig.* 812. The same spore in a dry state, showing the elaters in an uncoiled condition.

spiral elastic filaments, whieh are called *elaters*, are at first wound round the spore (*fig.* 811), but they ultimately uncoil (*fig.* 812), and thus appear to assist in the dehiscence of the sporangium, and in the dispersion of the spore to which they are attached.

When these spores germinate, a little pouch-like proeess protrudes from their surface by an elongation of their membrane ; this ultimately forms a green lobed flattened expansion, the prothallium, which differs however from that of the Ferns in usually being furnished only with antheridia or archegonia—the prothallia therefore are said to be diœcious, instead of monœcious as ordinarily in Ferns.

The male and female prothallia moreover differ somewhat in size, the former being the smaller of the two. As in Ferns also, from the germ-cell of the archegonium after impregnation by the antherozoids, a new plant is ultimately produced resembling in every respect that of the parent plant from whieh the spores were derived. As is the case in Ferns, therefore, we have in the Equisetaeeæ also an instance of *alternation of generations*.

3. LYCOPODIACEÆ OR CLUB-MOSSES.—The sporangia or capsules in the plants of this order are placed, like those of the Selaginellaceæ, in the axils or at the base of the leaves or scales, on short stalks. The leaves (*fig.* 12) thus bearing the sporangia or fruetification are frequently eollected together into a kind of scale, cone, or spike, while at other times they are scattered along the stem. The spores, like those of the Filices and Equisetaceæ, *are of one kind only*, in which they differ from the Selaginellaceæ, to which in other respeets they are closely allied, the two orders until lately being plaeed together under the common name of Lyeopodiaceæ.

The sporangia are somewhat reniform, two-valved cases closely resembling the *antheridium* or *microsporangium* of the Selaginellaceæ, and containing a number of spores, the smaller of which ultimately contain antherozoids (see Selaginellaceæ). But little is known of the early development of the spores, but they ultimately produce large prothallia, with root-hairs like the Filices, and like them these prothallia are monœcious, bearing antheridia and archegonia on their upper surface, and from the sexual action of which new plants are formed. Hence the Lycopodiaceæ, like the Filices and Equisetaceæ, also exhibit an example of *alternation of generations.*

4. Selaginellaceæ or Selaginellas.—The sporangia or capsules in the plants of this order are situated in the axils or at

Fig 813.

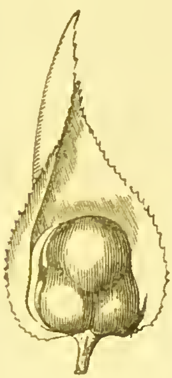


Fig. 814.

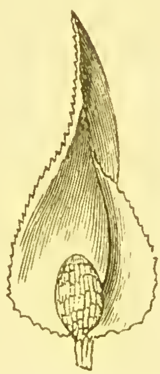
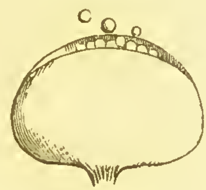


Fig. 815.



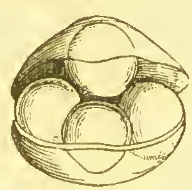


Fig. 816.

Fig. 813. Scale or leaf of *Selaginella apoda*, with macrosporangium in its axil.——*Fig.* 814. Antheridium or microsporangium of the above, placed in the axil of a leaf or scale. After Henfrey.——*Fig.* 815. Microsporangium of a species of *Selaginella.* It is two-valved, and contains a number of small spores or *microspores.*——*Fig.* 816. Macrosporangium or megasporangium of a species of *Selaginella.* This is a two-valved, four-lobed sac, and contains four large spores which are commonly called *macrospores.*

the base of the leaves (*figs.* 813 and 814). The leaves thus bearing the fructification are frequently collected together into a kind of cone or spike, while at other times they are scattered along the stem. The spores, like those of the Marsileaceæ, *are of two kinds* (*heterosporous*), and are enclosed in separate cases. These cases are variously named ; the names which would correspond to those commonly used in describing the Marsileaceæ would be *sporangia* and *antheridia* ; but the former are also more frequently called *megasporangia* or *macrosporangia* (*figs.* 813 and 816), and the latter *microsporangia* (*figs.* 814 and 815). The contents of the former are generally termed *large spores*, *megaspores*, or *macrospores* (*fig.* 816) ; and those of the latter *small spores* or *microspores* (*fig.* 815).

The *megasporangia* or *macrosporangia* are usually two-valved cases (*fig.* 816) with four lobes, each of which contains one large spore (*macrospore*); but in some cases they are 4-valved. The *macrospores* or *megaspores* are in number 2, 4, or 8.

The *antheridia* or *microsporangia* are somewhat reniform two-valved cases (*fig.* 815), containing a large number of small spores (*microspores*), in which antherozoids are ultimately produced.

The large spores are considered by Hofmeister and others as the analogues of the ovules. The antheridia or microsporangia are therefore to be considered as the male organs, and the macrosporangia as the female.

In germination, the large spore produces a prothallium in its interior, thus resembling the Marsileaceæ. In this archegonia are soon developed, and ultimately a new plant is produced by fertilisation taking place by means of the antherozoids.

An order called Isoëtaceæ, which includes the species of *Isoëtes*, is sometimes placed next to the Selaginellaceæ. It has essentially the same characters, except as regards its nutritive organs.

5. Marsileaceæ or Pepperworts.—In the plants of this order the fructification is placed at the base of the leaf-stalks. It consists usually of a two-valved stalked *sporocarp* (*fig.* 817, *s*), which is generally many-celled, or sometimes only one-celled. The contents of the sporocarps, and the mode in which they are arranged, vary, however, in the different genera of this order, and hence it will be necessary for us to allude to them separately.

Fig. 817.

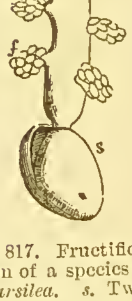


Fig. 817. Fructification of a species of *Marsilea*. *s*. Two-valved sporocarp. *p*. Peduncle. *f*. Fructification.

In *Marsilea*, the fructification consists of a stalked two-valved hardened sporocarp (*fig.* 817, *s*). The valves are held together by a gelatinous ring, which is at first connected with the stalk of the sporocarp, but when the latter organ bursts, the ring becomes detached from the stalk at one end, straightens, and appears as a long gelatinous cord protruding from the sporocarp (*fig.* 817, *p*), and bearing on its sides somewhat oblong spikes of fructification, *f*. These spikes are at first enveloped in a membrane, and are composed of two distinct organs, called *antheridia* or *microsporangia*; and *macrosporangia*, *megasporangia* or *sporangia*. These organs are attached to a sort of placenta, the antheridia being on one side, and the sporangia on the other.

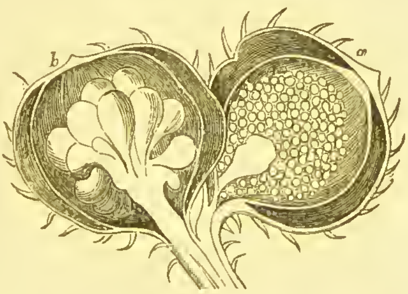
Each *sporangium* or female organ contains but one spore, called an *ovulary spore*, *macrospore*, or *megaspore*. It consists of a central nucleus, surrounded by a cellular coating except at its apex, where there is a little cavity. According to Hofmeister, 'this cavity is gradually filled up with cellular tissue, constituting a conical prothallium confluent with the nucleus. A single archegonium is formed in the centre, the orifice of which corresponds with the apex of the prothallium.' Fertilisation takes place by means of the antherozoids of the microspores.

The *antheridia* or male organs contain a number of small cells (*fig.* 818), which ultimately develop long spiral antherozoids. These small cells are called *pollen spores, small spores*, or *microspores*.

In *Pilularia* the fructification consists of stalked, pill-shaped, hairy sporocarps. The interior of each sporocarp is divided usually into four cells (*fig.* 819), and when ripe it opens by four valves. In the interior of each cell there is a mucilaginous process or placenta attached to the walls, upon which are placed numerous antheridia and sporangia, as in *Marsilea*. The structure of these antheridia and sporangia resembles in all essential

FIG. 818.

FIG. 820.



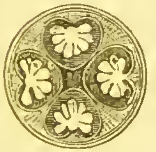


FIG. 819.

Fig. 818. Antheridium of a species of Marsilea containing microspores. After Le Maout. *Fig.* 819. Transverse section of the sporocarp or spore fruit of *Pilularia globulifera*. After Henfrey.——*Fig.* 820. Vertical section of the sporocarp of *Salvinia*, showing sporangia in one cavity, *b*, and antheridia in the other cavity, *a*.

particulars those of *Marsilea*. In fact, the only difference between the fructification of *Marsilea* and *Pilularia* is the more complicated nature of the sporocarps in *Marsilea*.

The fructification of *Salvinia* (*fig.* 820) appears to resemble that of *Marsilea* and *Pilularia*, except that the antheridia, *a*, and sporangia, *b*, are here contained in separate sacs, and are attached to a sort of central cellular placenta. In germination, also, the prothallium of *Salvinia* differs from that of *Marsilea* and of *Pilularia*, in producing several archegonia, instead of only one, as is the case with them. From these causes the Marsileaceæ are frequently divided into two orders, namely, Marsileaceæ and Salviniaceæ, the former including the genera *Pilularia* and *Marsilea*, and the latter those of *Salvinia* and *Azolla*. The common name of Rhizocarpeæ is also frequently applied to the two combined orders.

In reviewing the fructification of the Marsileaceæ, we find that it differs from the Filices, Equisetaceæ, and Lycopodiaceæ in producing *two distinct kinds of spores*, and in the prothallium not forming a distinct expansion on the outside of the spore, as is the case with them, but being confluent with the spore. These characters show that the Marsileaceæ are closely allied to the Selaginellaceæ.

6. Musci or Mosses.—The reproductive organs of this order are of two kinds, which are called *antheridia* (*fig.* 821), and *archegonia* or *pistillidia* (*fig.* 822). These are surrounded by leaves, called *perichætial* (*fig.* 824, *f*), which are usually of a different form and arrangement to those of the stem; and in some Mosses they have, in addition to the perichætial leaves, another covering formed of three or six small leaves, of a very different appearance to them, termed *perigonial*, and constituting collectively a *perigone*. The antheridia are regarded as the male organs, and the archegonia or pistillidia as the female.

Fig. 821.

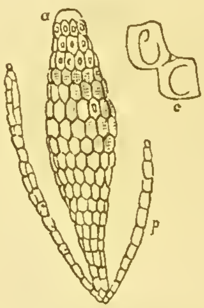


Fig. 822.

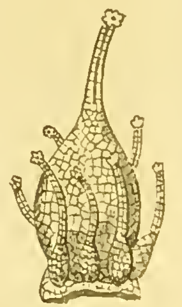


Fig. 821. Antheridium, *a*, of the Hair-moss (*Polytrichum*), containing a number of cells, *c*, in each of which there is a single *antherozoid*. *p*. *Paraphyses*, surrounding the antheridium.——*Fig.* 822. Archegonium or pistillidium of a Moss surrounded by *paraphyses*.

The antheridia and archegonia sometimes occur in the same perigone, in which case such Mosses have been termed *hermaphrodite*. More frequently, however, they are in different perigones, and then both kinds of reproductive organs may occur on the same plant, or on separate plants (*figs.* 9 and 10); in the former case we apply the term *monœcious*, in the latter *diœcious*.

The *antheridium* or male organ is a somewhat elliptical, more or less rounded or elongated cellular sac (*fig.* 821, *a*), which is filled at maturity with a number of minute cells, *c*, termed *sperm-cells* or *mother-cells*; in each of which there is a single spiral *antherozoid*. The antheridium opens by an irregular perforation at its apex, and thus discharges the sperm-cells with their antherozoids. Among the antheridia there are generally to be found slender cellular jointed threads (*fig.* 821, *p*), called *paraphyses*, which are probably nothing more than abortive antheridia, as they appear to perform no special function.

The *archegonia*, like the antheridia, are also usually surrounded by filamentous cellular bodies, called *paraphyses*, which appear to be in this case abortive archegonia (*fig.* 822). The *archegonium* or female organ is a flask-shaped cellular body with a long neck, the whole somewhat resembling an ovary with its style and stigma (*fig.* 822). The neck is perforated by a canal which leads into a cavity, at the bottom of which is a single cell, called the *germ* or *embryonal cell.* The case of the archegonium is called the *epigone.* This germ-cell appears to be fertilised, as in Ferns, by the antherozoids passing down the canal until they reach it. In the case of Mosses, however, the fertilised germ-cell does not directly develop a new plant like its parent, but after fertilisation has taken place, the germ-cell becomes gradually developed into a somewhat conical or more

FIG. 823.

FIG. 824.

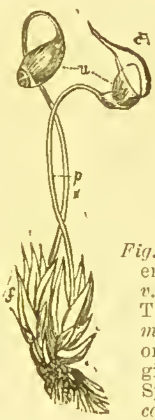


FIG. 825.

FIG. 826.

Fig. 823. *Coscinodon pulvinatus. sp.* Sporangium enclosed in the *calyptra. t. Seta* or stalk. *v.* Vaginule. From Henfrey.——*Fig.* 824. The Hygrometric Cord-moss (*Funaria hygrometrica*). *f.* Perichætial leaves. *p.* Stalks or *setæ*, each of which supports a sporangium, *u*, covered by a calyptra, *c.*——*Fig.* 825. Sporangium of the Extinguisher-moss (*Encalypta vulgaris*) before dehiscence. *u.* Sporangium covered by a transparent calyptra, *c*, and supported on a seta, *s.* Beneath the calyptra is seen the lid or operculum, *o.*——*Fig.* 826. The sporangium, *u*, of *fig.* 825 after dehiscence. The calyptra *c*, and operculum *o*, being removed, the *peristome*, *p*, may be seen.

or less oval body (*fig.* 823, *sp*) elevated on a stalk, *t*, and as it grows upwards it bursts the epigone, and carries one portion of it upwards as a kind of hood (*fig.* 824, *c*), while the other portion remains below as a sort of sheath (*fig.* 823, *v*), round the stalk. The central portion, formed by the development of the embryonal cell, is called the *sporangium* (*figs.* 824, *u*, and 825 *u*); the stalk the *seta* (*figs.* 824, *p*, and 825, *s*); the hood the *calyptra* (*figs.* 824, *c*, and 825, *c*); and the sheath at the base the *vaginule* (*fig.* 823, *v*).

The *sporangium*, or *capsule*, as it is also termed, when fully formed, is a hollow urn-like case (*figs.* 827 and 828, *u*), the centre of which is usually occupied by a cellular axis, called the *columella* (*fig.* 829), and the space between this axis and the walls of the sporangium is filled with free spores, which are small cells with two coats and markings resembling those of pollen-cells. The sporangium is either indehiscent; or it opens by four vertical slits so as to form four valves, as in the sub-order Andrææeæ; or more commonly by a transverse slit close to its apex, like fruits with circumscissile dehiscence, by which a kind of lid is produced, called the *operculum* (*figs.* 826, *o*, and 827); which is either persistent or deciduous. The sporangium is sometimes much dilated at the base, where it joins the seta; this swelling is called an *apophysis*, or, if it only occurs on one side, a *struma*.

The wall of the sporangium is commonly described as consisting of three cellular layers, the outer of which forms the *operculum*, just described, and the inner two layers the *peristome*.

FIG. 827.

FIG. 828.

FIG. 829

Fig. 827. *Pottia truncata*, showing the separation of the operculum from the sporangium. From Henfrey.——*Fig.* 828. Sporangium, *u*, of the Hair-moss, deprived of its calyptra and operculum. *p*. Peristome. *e*. Epiphragma or tympanum.——*Fig.* 829. Transverse section of a sporangium of the Hair-moss, showing the columella surrounded by free spores.

At the dehiscence of the sporangium the *stoma* or *mouth* is entire, smooth, or unfurnished with any processes (*fig.* 827); or it is surrounded by one or two fringes of teeth, called collectively the *peristome* (*fig.* 826, *p*), which, as just stated, are formed from the two inner layers of the wall of the sporangium. These teeth are always four or some multiple of that number. Sometimes a membrane from the inner wall is stretched across the mouth of the sporangium, and forms what has been called the *epiphragma* or *tympanum* (*fig.* 828, *e*). When the mouth is naked, the Mosses in which such a sporangium is found are called *gymnostomous* or *naked-mouthed*; when the mouth is surrounded by a single row of teeth, they are said to be *aploperistomous*; or, when with two rows, they are *diploperistomous*. The different appearances presented by the teeth, as well as their number and degree of cohesion, form important distinctive characters in the different genera of Mosses. The operculum, as already stated, is formed by a projection of the outer layer of the wall of the sporangium. At the point where the operculum separates an elastic ring or *annulus* is produced, which encircles the mouth of the sporangium.

In germination, the inner coat of the spore is protruded as a tubular process, which ultimately produces a kind of prothallium in the form of a green cellular branched mass, somewhat like a *Conferva*. This is called the *Protonema*, and upon its threads are subsequently developed leafy shoots, upon which archegonia and antheridia are afterwards developed. In Mosses, therefore, we have another instance of alternation of generations.

7. Hepaticaceæ or Liverworts.—The reproductive organs of Liverworts are of two kinds like those of Mosses, to which this order is closely allied; they are called *antheridia*, and

Fig. 830.

Fig. 831.

Fig. 830. A portion of the thallus or thalloid stem of *Marchantia polymorpha*. *r*. Receptacle, supported on a stalk, *s*. In the upper surface of the receptacle the antheridia are imbedded.——*Fig.* 831. Antheridium of *Marchantia*, discharging its small cellular contents (*sperm-cells*).

archegonia or *pistillidia*, and both kinds may be found on the same plant, or on different plants; hence these plants are either *monœcious* or *diœcious*.

The *antheridia* or male organs are variously situated in the different genera of this order; thus, in the leafy plants they are placed in the axils of leaves, as in some species of *Jungermannia*; in other plants they occur in the substance of the frond or thalloid expansion, as in *Riccia* and *Fimbriaria*; and in others, as in *Marchantia*, they are found imbedded in the upper surface of peltate or discoid-stalked receptacles (*fig*. 830, *r*). The *antheridia* are small, generally shortly stalked, cellular sacs, of an oval (*fig*. 831) or somewhat flask-shaped form, in which are contained a number of small sperm-cells; and their walls are usually formed of a double layer of cells. When ripe the antheridium bursts and discharges its contents; the sperm-cells also burst, and each emits a single *antherozoid*, in the form of a spiral thread with two or three coils, somewhat like those of *Chara* (*fig.* 857).

The *archegonia* or female organs, like the antheridia, are differently arranged in different genera; thus in *Riccia* they are imbedded in the substance of the frond, while in *Jungermannia* and *Marchantia* (*fig.* 832) they are imbedded in the under sur-

FIG. 832.

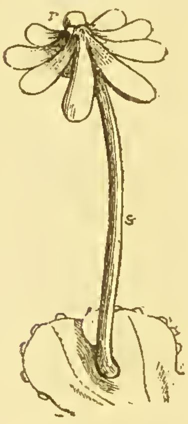


FIG. 833.

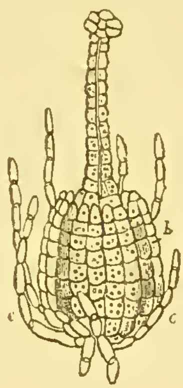


FIG. 834.

Fig. 832. A portion of the thallus or thalloid stem of *Marchantia polymorpha*. *r*. Receptacle supported on a stalk, *s*. On the under surface of the receptacle the archegonia are imbedded. —— *Fig.* 833. Archegonium of *Marchantia*. *b*. *Perigone*, open at its apex and surrounding an inner cellular case or *epigone*. *c*, *c*. *Paraphyses*.——*Fig.* 834. Elaters, *e*, of *Marchantia*. *s*, *s*. *Spores*.

face of the receptacles, *r*, which are elevated above the thallus on stalks, *s*. They are usually small flask-shaped bodies, each of which consists of a cellular case or *epigone* (*fig.* 833), having a canal in its upper elongated portion which leads to a cavity, at the bottom of which a single free cell, called the *germ* or *embryonal cell*, is developed. The germ-cell is doubtless fertilised, as in Ferns and Mosses, by the passage of the antherozoids down the canal until they come in contact with it. The fully-developed archegonia, like those of Mosses, have also at times an additional covering surrounding the epigone, called the *perigone*, which frequently grows up so as to form a sort of cup-shaped covering (*fig.* 833, *b*). At the base of the perigone, a number of cellular filaments, perichætial leaves, or paraphyses, are also occasionally to be found (*fig.* 833, *c*, *c*).

As in the case of Mosses, the fertilised germ-cell does not directly develop a new plant like its parent, but after fertilisation the germ-cell enlarges and bursts through the epigone, and forms a *sporangium* or *capsule*; the epigone either remaining as a sort of sheath round the base of the sporangium, which is called the *vaginule*, or its upper part is carried upwards as a sort of hood or styloid *calyptra*.

The sporangia vary much in different genera. In *Marchantia* they are formed of two layers of cells: one external, called the *cortical* or *peripheral* layer; and one internal, in which the spores, &c., are developed. The cells of the cortical layer exhibit spiral fibres, like the cells constituting the inner lining of the anthers in Flowering Plants. The cells forming the internal layer are thus described by Henfrey:—'At an early period the cells of the internal mass present the appearance of a large number of filaments radiating from the centre of the sporangium to the wall. These soon become free from each other, and it may then be perceived that some are of very slender diameter, and others three or four times as thick. The slender ones are developed at once into the long *elaters* (*fig.* 834, *c*) characteristic of this genus, containing a double spiral fibre, the two fibres, however, coalescing into one at the ends. The thicker filaments become subdivided by cross partitions, and break up into squarish free cells, which are the parent cells of the spores, four of which are produced in each.' The sporangia in this genus are situated on the under side of the receptacle (*fig.* 832, *r*), and vary in form; they burst by valves.

In *Jungermannia* the sporangia are elevated upon stalks arising out of a vaginule; they are more or less oval in form, and open by four valves which spread in a cross-like form; they contain spore-cells and *elaters* with a single spiral filament (*fig.* 8). In *Anthoceros* the sporangia open by two valves, and have a central axis or *columella*; they are of an elongated, tubular, or conical form, and are situated on a short stalk, and contain spore-cells and elaters, but the latter have no spiral fibres in their interior, and are much simpler in their structure than those just described as found in *Marchantia*. In *Riccia* the sporangia are imbedded in the substance of the frond, and have neither elaters nor columella. They have no regular dehiscence.

The spores have usually two coats, like pollen-cells; and the outer coat also frequently presents markings of different kinds; but in *Marchantia* the spores have but one coat. They mostly germinate without any well-marked intermediate prothallium, although some produce a kind of prothallium in the form of a confervoid mass or *protonema*, like a Moss (see page 375).

Section 2. Reproductive Organs of Thallophytes.

The Thallophytes may be divided into four large groups, called respectively, Fungi, Lichenes, Characeæ, and Algæ, in each of which again several subordinate divisions have been made. The general characters of the larger groups will be described hereafter in Systematic Botany. At present we have only to examine their reproductive organs, and of these even we can only give a general sketch ; but for fuller information on this subject the student is more especially referred to Sachs's 'Text Book of Botany,' as printed at the Clarendon Press of the University of Oxford.

1. Fungi or Mushrooms.—To give a detailed description of the various modes of reproduction occurring in the different sub-divisions of this order would be beyond the scope of this volume, and we will therefore simply choose a few examples as types of the different methods by which reproduction may take place. For this purpose we will adopt the classification proposed by De Bary, according to which the Fungi are divided into the following groups, viz. :—(i) Phycomycetes, (ii) Hypodermiæ, (iii) Basidiomycetes, (iv) Ascomycetes, after which we shall give a short notice of the *Bacteria*, which are now generally regarded as an order of the Fungi, called Schizomycetes.

(i) *Phycomycetes.*—As an example of this group we will briefly describe the life history of *Cystopus candidus*, a fungus which is commonly found growing upon Cruciferous plants. It resembles closely in its morphological phenomena *Vaucheria* (the life history of which is described under 'Algæ,' page 394), not only in respect to its unicellular mycelium, but also in its formation of oogonia and antheridia.

On examining a plant infested by *Cystopus*, it will be seen that the greatly elongated one-celled branched mycelium of the fungus (*fig.* 835, A), is interwoven, as it were, among the cells of its host, and draws nourishment from the latter by means of little rounded projections or bladders, known as *haustoria*, which penetrate the cell-walls of the host-plant. After vegetating for some time in this manner, erect branches grow out beyond the surface of the epidermis, from which conidia are formed by a process of budding. (The term *conidia*, when used by us, indicates in all cases reproductive cells which are thus produced asexually.) From these conidia, when moistened with dew, rain, &c., zoospores are formed, and these settling down upon a similar plant will, under favourable circumstances, again develop the *Cystopus* mycelium.

But *Cystopus* can also produce zoospores by means of a sexual process, which takes place in the interior of its host. The ends of certain filaments of the mycelium swell up, forming *oogonia* (*fig.* 835, A, *og*, *og*); whilst two club-shaped bodies, the *anthe-*

ridia (*fig.* 835, B, *an*), are formed by branches which arise from near the base of the oogonium. In the course of its development, the *oogonium* becomes of a more or less spherical form, and at its base a septum is formed separating it from the general cavity of the *Cystopus* mycelium, whilst the greater part of the protoplasm contained in the oogonium arranges itself so as to form a rounded mass known as the *oosphere* (*fig.* 835, B, *os*).

FIG. 835.

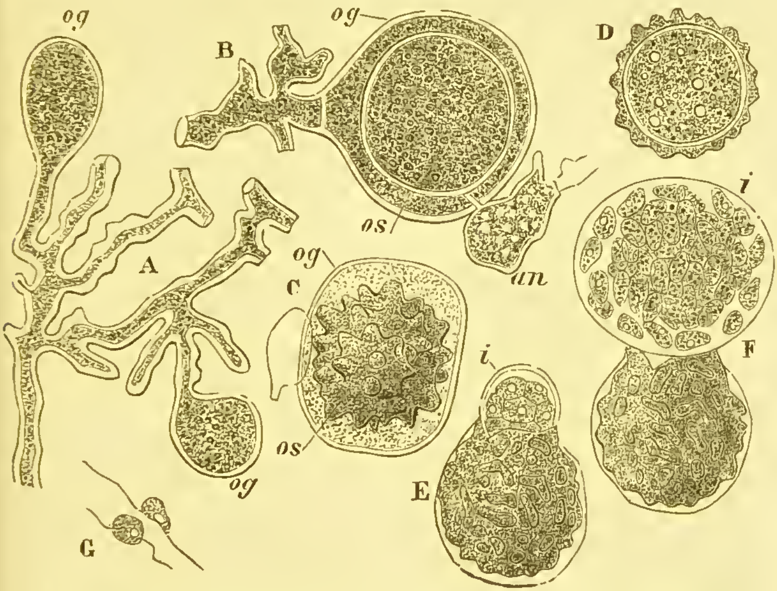


Fig. 835. A. Branched mycelium of *Cystopus* with young oogonia, *og*, *og*. B. Portion of mycelium bearing oogonium, *og*, with the oosphere, *os*; and antheridium, *an*. C. Mature oogonium, with *os*, the oospore. D. Mature oospore. E, F. Formation of swarm-spores or zoospores, G, from the oospores. *i*, *i*. Protruded endospore. After De Bary.

When fertilisation is about to take place, one or other of the antheridia comes in contact with the oogonium (*fig.* 835, B, *an*), and subsequently the protoplasm of the antheridium reaches that of the oogonium by penetrating the membrane of the latter (*fig.* 835, B). An *oospore* is thus formed (*fig.* 835, C, *os*), which becomes surrounded by a rough dark brown coat or *exospore*, and contains numerous starch granules (*fig.* 835, D). After lying dormant during the winter, the protoplasm of the oospore becomes divided into numerous segments, the whole being covered by a thin membrane known as the *endospore* (*fig.* 835 E, *i*, and F, *i*); and from each of the little segments of protoplasm is formed a *zoospore* or *swarm-spore* (*fig.* 835, G). The endospore ultimately forces itself like a bladder (*fig.* 835, E, *i*, F, *i*) through the exospore, and then bursting, the zoospores, G, are set free, each of which, like those from the conidia, may settle down and produce a new *Cystopus* mycelium.

(ii) *Hypodermiæ.—Puccinia graminis*, which we will take as the type of this group, is remarkable not only in showing a distinct alternation of generations, but also in the fact that each generation is developed upon a different host, and thus affording a good example of what has been called *heterœcism*, or changing from host to host during different changes of development.

Thus in the spring, the fungus (*fig.* 836) may be seen in one phase of its existence growing on the Barberry (*Berberis vulgaris*), whilst in the summer, upon certain Grasses fungous growths (*figs.* 837 and 838) may be seen which have been developed from spores formed whilst the *Puccinia* was inhabiting the Barberry, and which in fact constitute the second generation.

Fig. 836.

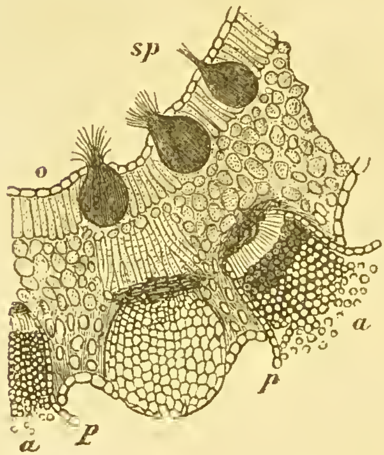


Fig. 836. Section through leaf of the Barberry infested with *Puccinia graminis*. *o*. Epidermis of upper surface of leaf. *sp*. Spermogonia. *p, p*. Layers of cells (*peridium*), surrounding, *a, a*, the æcidium fruits. After Sachs.

If a section be made through one of the yellowish swellings seen on the leaf of a Barberry plant which is affected by the fungus, the whole tissue of the leaf at the spot in question will be found to be permeated by the mycelium of the *Puccinia*, whilst two kinds of fructification may be noticed, one on either side of the leaf. On the upper surface (*fig.* 836, *o*) are somewhat rounded spaces, termed *spermogonia*, *sp*, full of very delicate hair-like bodies, and from the floor of the cavity very small spore-like structures, the *spermatia*, are formed. On the under surface are the much larger *æcidium fruits* or *æcidia*, *a*, *a*. These consist of closely packed vertical hyphæ, from which, by a process of continuous budding, a great number of conidia-like spores are detached. It is by the germination of these spores and their growth on Grasses, that what are known as the *uredo-fruits* are produced.

These uredo-fruits consist of a dense mycelium (*fig.* 837, *sh*), interwoven among the cells of the Grass leaf, from which vertical branches shoot upwards bearing at their extremities oval granular spores, the *uredospores*, *ur*. These uredospores, germinating in other Grasses, again produce *uredo-fruits*, and this process may be carried on throughout the summer. But towards autumn some of the older uredo-fruits produce what are known as the *teleutospores* (*figs.* 837, *t*, and 838, *t*, *t*). These are two-celled, somewhat elongated spores, which, germinating upon the Barberry leaf, give rise to the æcidium fruits which we have already described.

It will be noticed that as yet no sexual process has been discovered to occur during the life history of *Puccinia*. Should such be hereafter demonstrated, it will probably be found that the æcidia are formed in consequence of the fertilisation of female organs by the spermatia.

FIG. 837.

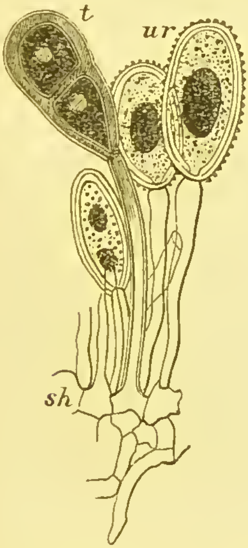


FIG. 838.

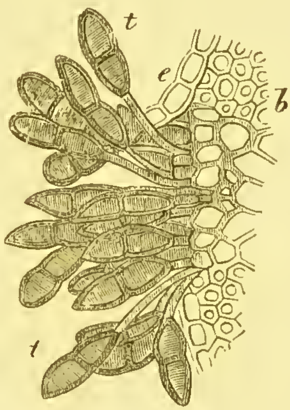


Fig. 837. Part of a layer of uredospores. *sh.* Hyphæ or mycelium ramifying among the cells of a leaf of the Couch Grass. *ur.* Uredospores. *t.* A teleutospore.——*Fig.* 838. *e.* Epidermal, and *b*, inner layer of cells of the infested leaf. *t*, *t*. Teleutospores. After De Bary.

(iii) *Basidiomycetes.*—As an example of this group we will briefly describe what is known of the life history of the common Mushroom (*Agaricus campestris*). That which is ordinarily known as the Mushroom is in reality the *receptacle* (*fig.* 6), *fructification*, or *spore-producing structure*, growing from a mycelium, *my*, which is vegetating underneath the surface of the ground or other substance upon which the fungus may be growing. The *receptacle*, in the case which we are considering, consists of two parts (*fig.* 839, A), viz. :—the *cap* or *pileus*, *p*, and the *stalk* or *stipe*, *st*. The former may be regarded as the essential part of the receptacle, the spores being produced on its under surface, whilst the stalk simply serves the purpose of raising the cap some distance above the ground.

In the earlier stages of development the young receptacle consists of small, somewhat pear-shaped bodies (*fig.* 839, B), made up of a dense mass of hyphal tissue continuous with that of the mycelium, *m.* As growth proceeds in these bodies, an annular air cavity is formed near the upper part, the roof of which forms the under side of the pileus, and, growing rapidly in a transverse direction, ultimately becomes covered by a number of closely set vertical folds placed in a radiating direction from the centre to the margin; these are the *lamellæ* or *gills*, and collectively constitute the hymenium (*fig.* 6, *b*), upon which the spores are produced in a manner to be presently described. The growth of the cap gradually causes the floor of the cavity,

FIG. 839.

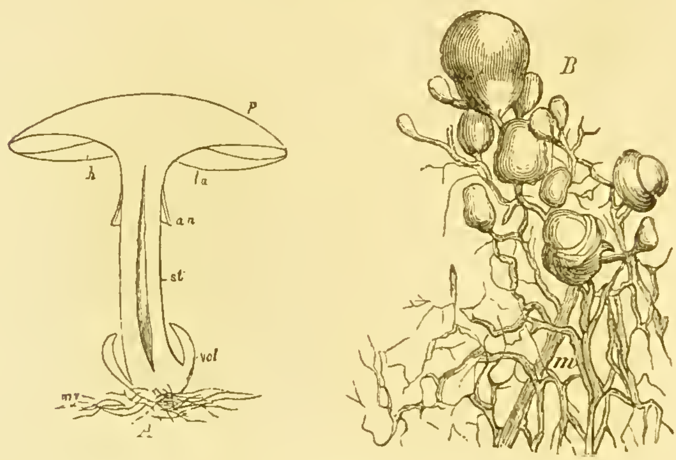


Fig. 839. A. Vertical section of the common Mushroom (*Agaricus campestris*). *my.* Mycelium. *vol.* Remains of volva. *st.* Stipe. *an.* Annulus. *h.* Hymenium with its gills or lamellæ, *la.* *p.* The pileus.—B. *m.* Mycelium of *Agaricus*, bearing numerous young receptacles in different stages of development. After Sachs.

known as the *veil* or *indusium*, to give way from the margin, so that it comes at last to hang from the stalk in the form of a fringe or *annulus* (*figs.* 6, *c*, and 839, A, *an*).

In some species of Agaricus, as the present, the whole plant is entirely enclosed at first in a kind of veil or covering (*fig.* 6), called the *volva*, which ultimately becomes ruptured, and free from the tissue forming the membrane on the upper surface of the pileus; but its remains may be seen at the base of the stalk (*fig.* 839, A, *vol*).

If a transverse section of one of the lamellæ of a mature hymenium be made, it will be seen to consist of cells, greatly elongated in the centre, constituting the *trama* (*fig.* 840, *t*), but being smaller and more or less rounded towards the periphery, where they form what is known as the *sub-hymenial layer*, *sh*. Placed upon and derived from this layer are the densely crowded club-shaped cells known respectively as the *basidia*, *s′*, *s″*, *s‴*, *s⁗*, or *paraphyses*, *q*, according as they produce spores or remain sterile.

From each basidium, in this species, two spores are produced, the process of their development being as follows :—On the free rounded surface of the basidial cell there first appear two little processes, *s′*, which quickly become swollen at their extremities, *s″*. The swelling in each instance increases, and finally a protoplasmic cell is produced, *s‴*, which becomes separated from the little stalk, *s⁗*, and forms a spore. The

FIG. 840.

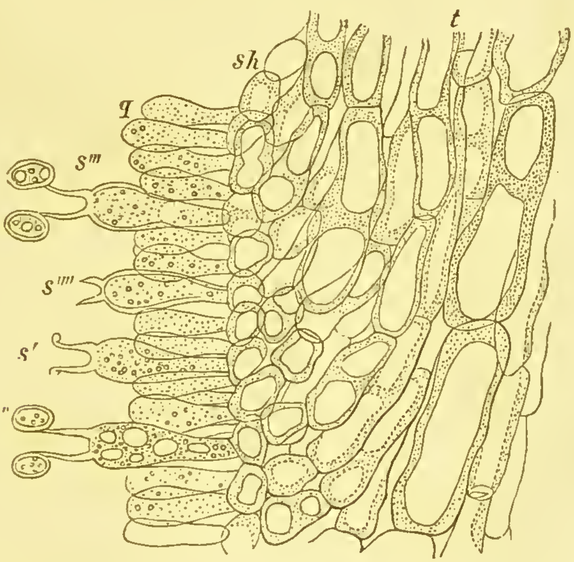


Fig. 840. Transverse section of a lamella of the mature hymenium of *Agaricus campestris*. *t*. Trama. *sh*. Sub-hymenial layer. *q*. Paraphyses. *s′*, *s″*, *s‴*. Basidia in different stages of development, showing formation of spores. *s⁗*. Basidium after the spores have fallen off. After Sachs.

spores, thus formed, when placed under favourable circumstances are capable of producing the mycelium, or dense network of hyphæ, from which again the fructification or receptacle is developed. Judging from analogy, we would have expected the fructification to be the result of a sexual process taking place in the mycelium, thus giving rise to an alternation of generations, but from the latest researches on the subject this does not seem to be the case.

(iv) *Ascomycetes.*—From this division of Fungi two examples may be selected for description.

The first which we will consider is *Claviceps purpurea*, or the *Ergot Fungus*. If we trace the development of this Fungus upon the ovary of the affected Grass (Rye being the one more commonly selected), we find that it first produces what is known as the *sphacelia* (*fig.* 842). On examining a section of an ovary in this condition, it is seen to be almost completely surrounded by a dense mass of hyphal tissue, which also penetrates more or less into its interior, and gradually, in fact almost entirely, takes the place of the proper structure of the ovary—this being more particularly the case towards the base of the organ.

FIG. 841.

FIG. 842.

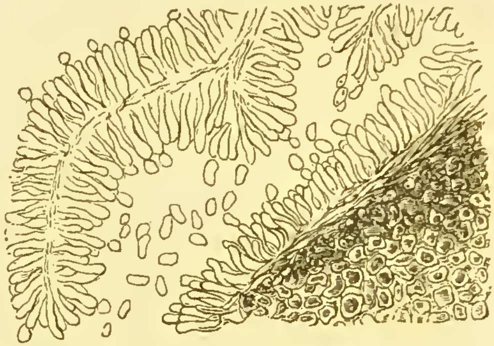


Fig. 841. Young sclerotium, *c*, of *Claviceps* growing up and supplanting the old sphacelia, *sph.* —— *Fig.* 842. Section through the junction of the sphacelia with the sclerotium of *Claviceps*, showing formation of conidia.

FIG. 843.

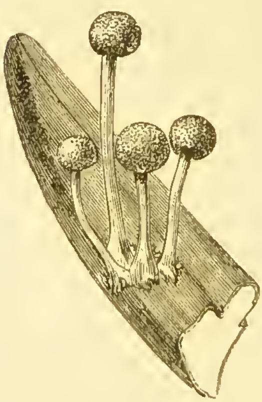


FIG. 844.

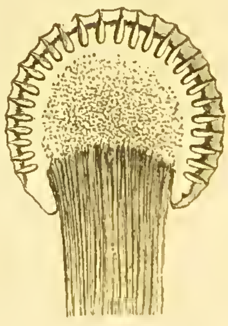


Fig. 843. Portion of the horn-shaped sclerotium of *Claviceps purpurea*, or the Ergot Fungus, bearing four stalked receptacles.——*Fig.* 844. Longitudinal section of a receptacle of the same, magnified, showing the perithecia. After Tulasne.

From the free ends of the outer hyphæ great numbers of conidia (*fig.* 842) are produced by budding, which appear to have the power of again producing sphacelia in other Grasses. Finally, the hyphal tissue becomes much more dense, this taking place gradually from the base to the apex, until the *sclerotium* (*fig.* 841) or *ergot*, which is ultimately (*fig.* 843) a somewhat horn-shaped body of a dark purple colour, is formed.

After remaining dormant during the winter, the *Ergot* or *Sclerotium* produces spores (from which the sphacelia can again be formed) in the following manner. Stalked receptacles (*fig.* 843) grow up from the tissue of the Ergot, in which are developed a number of *perithecia* (*fig.* 844). These *perithecia* are somewhat flask-shaped cavities (*fig.* 845), which are filled with *asci*; the latter containing long slender spores (*fig.* 846), termed *ascospores*, which again, by germinating on the Rye or allied Grasses, give rise to the sphacelia.

Peziza, our second example of the Ascomycetes, is a genus of Fungi containing a great number of species, many of which

FIG. 845.

FIG. 846.

Fig. 845. A single perithecium of *Claviceps purpurea*, magnified, showing the contained asci. After Tulasne.——*Fig.* 846. Asci of the same, containing the long slender ascospores. After Tulasne.

are very common, and may be seen growing upon the dead trunks of trees, &c. *Peziza* is recognised as a small disc-shaped body, slightly cupped on the upper surface and of a reddish-purple colour. On close examination it is found that this structure (which is in fact the fructification) is growing from, and continuous with, a mycelium vegetating under the surface of the wood, &c., upon which the Fungus is situated. On examining a vertical section under the microscope, it is seen to consist of numbers of elongated cells closely packed side by side. Of these the greater number are very narrow and somewhat club-shaped at the extremities, whilst the others are broader (*fig.* 847, *a–f*) and each contains eight oval spores in a greater or less state of development. These latter cells are known as the *asci* (the spores they produce being termed *asco-*

spores); whilst the former very narrow elongated cells are sterile branchlets, which are known as the *paraphyses*. The *ascospores* are produced by the process of free cell-formation.

That which we have been describing, however, is merely one phase of the life-history of *Peziza*, as this is one of the Fungi in which a clearly marked alternation of generations exists. Thus at a certain period of the year there appear on the *Peziza* mycelium branches directed vertically upwards, which, after branching and rebranching, produce structures by means of which a sexual process takes place. These consist of *antheridia* (*fig.* 848, *i*), and what may be termed *oogonia*, *a*, the latter being

Fig. 847.

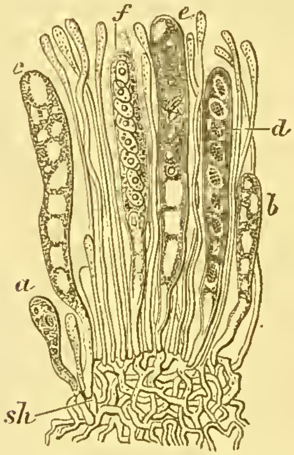


Fig. 848.

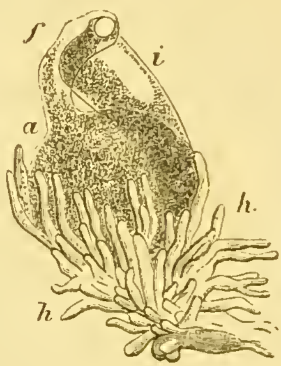


Fig. 847. *sh.* Sub-hymenial layer of the mycelium or hyphæ of *Peziza convexula*. *a, b, c, d, e, f.* Successive stages of development of the asci and ascospores intermixed with slender paraphyses. After Sachs.——*Fig.* 848. *h, h.* Mycelium or hyphæ of *Peziza confluens*. *a.* Oogonium with hooked process, *f*. *i.* Antheridium. After Tulasne.

ovoid vesicles placed at the extremities of the branchlets; whilst the former is an elongated club-shaped body rising from below the base of the oogonium. The antheridium, *i*, finally unites with the oogonium, *a*, through the interposition of a hook-shaped process, *f*, on the latter, and as a result of the fertilisation a number of hyphæ, *h*, *h*, shoot up from the base of the oogonium, which ultimately develop so as to form the fructification which we have already examined.

Bacteria.—A very large and important group of organisms is that of the *Bacteria*. Where these should be placed is still somewhat a matter of doubt; but they are more commonly arranged among the Fungi, forming the order Schizomycetes of the group Protomycetes. Cohn includes them amongst the Algæ, though they differ materially from Algæ in the fact that they will not live in clean water, but require decomposable substances for their nutrition; in this, and in that they do not contain chlorophyll, they resemble Fungi, and should doubtless be considered as Fungi, unless, indeed, they belong to the lowest group of animals, viz., Monads, as is maintained by some observers. Whether all *Bacteria* have an envelope of cellulose is questionable, for as their structure cannot be made out except under the highest powers of the microscope, what appears to be cellulose may really be nothing more than a halo produced by improper illumination, indifferent staining, and other causes. The forms of *Bacteria* vary considerably, some being small spherical bodies, which may exist singly, or in chains, or in masses, *Micrococci* (*fig.* 850, 5, 6, and 7); others are somewhat oval in form, *Bacteria* (*fig.* 850, 2); others, again, rod-shaped, *Bacilli* (*fig.* 849); while some have the form of a cork-screw of one or more turns, *Spirilla* (*fig.* 850, 3 and 4), &c. Most of the *Bacteria* are motile, the source of movement in many forms

FIG. 849.

Fig. 849. Bacilli, showing development from spores. After Klein.

FIG. 850.

Fig. 850.
1. Sarcinæ.
2. Bacteria.
3. Spirilla.
4. Spirillum, showing flagella.
5. 6. 7. Micrococci in strings, singly and in groups. After Cohn and Sachs.

being flagella, generally one at each end (*fig.* 850, 4), while in others the cause of movement has not yet been discovered. *Bacteria* may be divided according to their morphology or their physiology, some producing coloured secretions, *chromogenous*, although they themselves are colourless; others causing fermentation, *zymogenous*; while others are most probably the cause of disease, *pathogenous*. It is this last group which has been creating so much interest lately in connexion with phthisis, cholera, hydrophobia, anthrax, &c. The methods of reproduction are fission, and in some cases the production of spores, though both methods are most probably *agamogenic*.

2. Lichenes or Lichens.—Of late years Lichens have been regarded by many botanists as, in reality, Ascomycetous Fungi, parasitic upon Algæ. But as the recent researches of Crombie and others have shown that this view of their nature is highly improbable, and as moreover Lichens present so many characteristics peculiar to themselves, we shall describe them and their modes of reproduction under a separate head. According to the view that Lichens are species of Fungi, parasitic upon Algæ, the chlorophyll-containing cells or *gonidia* (*figs.* 853,

Fig. 851.

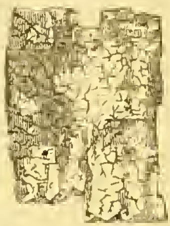


Fig. 852.

Fig. 853.

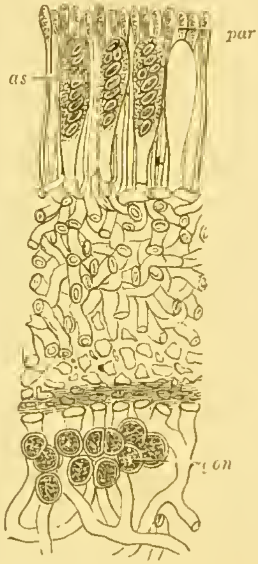


Fig. 851. Thallus of *Opegrapha atra*, showing linear apothecia, termed lirellæ.——*Fig.* 852. Portion of the thallus of *Parmelia parietina*, with young round *apothecia*, *ap*, and *spermogonia*, *sp*. After Henfrey.——*Fig.* 853. Section of the thallus through an apothecium of *Cetraria islandica*. *as.* Asci, three of which contain ascospores. *par.* Paraphyses. *gon.* Gonidia. After Berg and Schmidt.

gon, and 855, *gon*), found within the substance of their thallus, and which used formerly to be regarded as special asexual reproductive organs, are in reality Algæ upon which the Fungus is parasitic. Thus the thallus of a Lichen is a compound structure, consisting of two elements, the *fungal* and the *algal*.

The reproductive organs of Lichens are of three kinds :—(1) Apothecia ; (2) Spermogonia ; and (3) Pycnidia.

The *apothecia* are of various forms, and have received different names accordingly ; the more usual are the round (*fig.* 852, *ap*) and linear (*fig.* 851) ; the latter are commonly termed *lirellæ*.

The apothecia may be either sessile or stalked ; the stalk, when present, is termed the *podetium*. The apothecium is either composed of two parts, called the *thalamium* and *excipulum*, or, of the former only ; when the latter is found, it forms a partial or entire covering to the thalamium. The body of the apothecium constitutes the *thalamium*, and the layer of cells at the bottom of this, upon which the thecæ and paraphyses are placed, is termed the *hypothecium*. When the apothecium is divided by a vertical section, it is seen to contain a number of spore-cases called *asci* (*fig.* 853, *as*), surrounded by thread-like or somewhat club-shaped filaments, called *paraphyses*, *par*, which are usually regarded as abortive asci ; the asci and the paraphyses are placed perpendicularly upon the hypothecium. The apothecia are frequently of a different colour from the surrounding thallus ; this is due either to the paraphyses or the excipulum. Each of the asci, *as*, generally contains eight spores, but in some cases only four, and in others sixteen ; thus the spores are commonly a multiple of two, and the number is always constant for each species. In rare cases the asci have a large number of spores, and are hence said to be polysporous. The spores themselves are usually termed *ascospores*. Some of these spores are of a very complex structure, being divided into two, four, or many cells. They are frequently coloured, and form beautiful objects under the microscope.

In a very few genera of Lichens, as *Abrothallus* and *Scutula*, certain structures have been discovered by Tulasne, called *stylospores*. 'They consist of isolated spores borne upon shortish simple stalks. They are produced in conceptacles to which is applied the name of *pycnidia*.'

The *spermogonia* were first discovered by Tulasne, but they have now been found in a great number of Lichens, and probably exist in all. They generally appear as little black specks near the margins of the thallus, in the tissue of which they are usually more or less imbedded (*fig.* 852, *sp*) ; but rarely, they are quite free and above the thallus. The *spermogonium* varies in form, and has one or more cavities, with a small orifice at the top termed the *ostiole* or *pore* (*fig.* 854, *os*), with which all the cavities communicate. The spermogonium, when mature, has its interior filled with a number of bodies called *spermatia* (*figs.* 854, *s*, and 855, *s*), raised on stalks, termed *sterigmata* or *spermatophores* (*figs.* 854, *sp*, and 855, *sp*). The form of the spermatophores varies much : according to Henfrey, 'The simplest are short slender stalks, simple or branched ; or they are articulated branches composed of a great number of cylindroid or globular cells (*fig.* 855, *sp*) ; or the branches are reduced to two or three elongated cells. The *spermatia* (*fig.* 855, *s*), are terminal on the spermatophores, and consist of exceedingly minute bodies, ordinarily linear, very thin, short or longish, straight or curved, without appendages, and motionless, and lie in a mucilage of extreme transparency. The spermatia are commonly regarded as the analogues of the spermatozoids produced in the antheridia of the higher Cryptogams.' When the spermogonium is mature, the spermatia (*fig.* 854, *s*), are discharged through the pore or ostiole, *os*, in vast numbers.

FIG. 854.

FIG. 855.

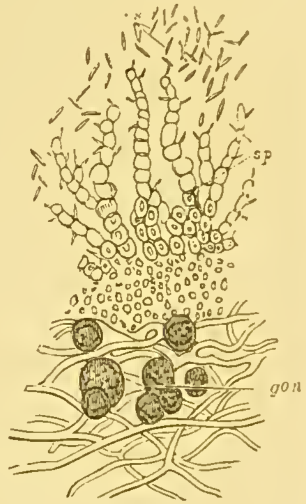


Fig. 854. Vertical section of a spermogonium of *Cladonia rangiferina*. *sp.* Spermatophores. *os.* Ostiole or pore, from which the spermatia, *s*, are escaping. ——*Fig.* 855. Highly magnified fragment from the wall of a spermogonium of *Parmelia parietina*. *sp.* Articulated sterigmata or spermatophores. *s.* Spermatia. *gon.* Gonidia. After Henfrey.

Lichens may also be reproduced in a vegetative manner by means of little detached portions of the thallus known as *soredia*. These are regarded by those who maintain the compound nature of Lichens as consisting of some of the Algæ, through which the Lichen derives its nutrition, connected and intermingled with a weft of fine fungal hyphæ. Such a soredium when placed under favourable conditions is capable of growing into a Lichen of the same nature as that from which it derived its origin.

3. CHARACEÆ OR CHARAS.—By many botanists the Charas are classed among the Algæ, but as they present in their structure and mode of reproduction many points of difference from the latter, we have placed them in a separate group immediately preceding them. They may be regarded as a link connecting the Algæ with Cormophytes.

The reproductive organs are of two kinds, both of which grow at the base of the branches, and either on the same or on different branches of the same plant, or on different plants. These organs are called respectively, *globules* and *nucules*.

The *globule* (*fig.* 856, *a*), which is regarded as an antheridium, or male organ, is a globular body, usually placed immediately below the nucule, *s*, but occasionally by its side. Of a green colour whilst young, it turns to a deep brick-red as it becomes mature. It consists of eight valves, or, as they have been termed, *shield-cells*, each of which is a flattened triangular cell, curved so as to present a convexity to the outer surface of the globule, and having its margins crenate or toothed, so as to dovetail, as it were, with the adjoining shield-cells. From the centre of each shield an oblong cell (*fig.* 858, *c*), the manubrium, is given off in a perpendicular direction. The

FIG. 856.

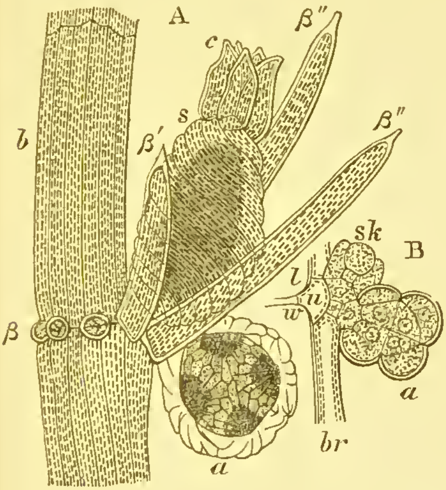


FIG. 857.

FIG. 858.

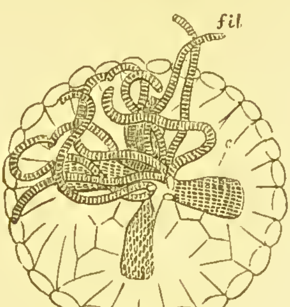


Fig. 856. A. Portion of the axis of *Chara fragilis*. *s.* Nucule or pistillidium. *a.* Globule or antheridium. *b.* Internode. *c.* Crown or corona of nucule. β. Abortive leaves. β', β'', β'', Sterile leaflets. B. *sk.* nucule, and *a*, globule, both in an early stage of development. *w.* Nodal cell of leaf. *u.* Union cell between it and basal node of globule. *l.* Cavity of internode of leaf. *br.* Cells of leaf covered with cortex. After Sachs.——*Fig.* 857. A portion of a filament, *fil*, of *fig.* 858, in the cells of which the antherozoids are developed; with a 2-ciliated *antherozoid* by its side.——*Fig.* 858. A globule cut in half to show the oblong cells or manubria, *c*, and the septate filaments, *fil*. After Henfrey.

eight cells from the eight shields converge in the centre of the globule. A ninth cell of a similar form, but larger than the others, also penetrates into the centre of the globule between the four lower shield-cells; this is the stalk which fixes the globule to the branch upon which it is placed. At the central end of each manubrium is a rounded cell, which supports in turn four other smaller cells, and from each of these latter four confervoid filaments are given off (*fig.* 858, *fil*), in each cell of which is produced a single spiral *antherozoid* (*fig.* 857), which is furnished with two very long ciliæ of excessive fineness. These antherozoids ultimately escape from the cell by a sudden movement resembling the action of a spring, and may then be seen to exhibit active movements in water.

The *nucule* is regarded as a pistillidium, archegonium, or female organ. It is an oval sessile body, situated in the axil of a branch (*fig.* 856, *s*); it consists of a central cell with a double coat (*fig.* 860), surrounded by five cells, which are wound spirally round it, and terminating above in five or ten smaller cells the ends of which remain free (*fig.* 859, *a*), and thus form a kind of crown at the apex of the nucule (*figs.* 856 A, C, and 859, *a*). At an early stage of growth the cells are separated from each other, and a canal is thus left between them extending from the crown towards the central cell. This canal is supposed to form a passage, by means of which the antherozoids reach the central cell of the nucule, by which its contained oosphere is fertilised. Ultimately the nucule drops off from its parent, remains at rest until the following season, and when it germinates first produces a single axial row of cells, forming a pro-embryo or pro-thallus from which the leaf-bearing sexual plant ultimately grows.

Fig. 859.

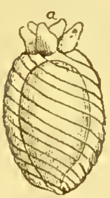


Fig. 860.

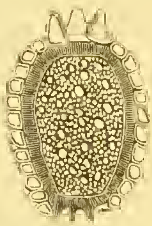


Fig. 859. Nucule or archegonium of *Chara*. *a*. Apices of the spirally wound cells.——*Fig.* 860. Vertical section of a nucule.

4. Algæ or Seaweeds.—This order of plants, like the Fungi, comprises a very large number of species, which vary exceedingly in form, size, colour, and other peculiarities. They are all either inhabitants of water salt or fresh, or live on moist surfaces; and may be microscopic plants, or growths of enormous size. Adopting no special classification of the Algæ, we will simply describe the processes of reproduction occurring in certain examples as types of the rest.

Fig. 861.

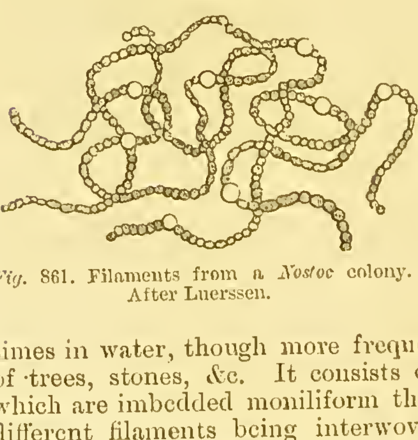


Fig. 861. Filaments from a *Nostoc* colony. After Luerssen.

Nostoc, a very common Alga, is found living sometimes in water, though more frequently on the damp surfaces of trees, stones, &c. It consists of a jelly-like substance, in which are imbedded moniliform threads of cells (*fig.* 861), the different filaments being interwoven with one another. The greater number of the constituent cells contain chlorophyll;

but usually there are also placed at definite distances from one another larger colourless cells, which are not, like the others, capable of division, and are ordinarily known as *heterocysts* (*fig.* 861). By means of the growth and subsequent division of the smaller cells, the *Nostoc* colony may become increased in size, and new colonies also at certain times become formed in the following manner. By means of the imbibition of water the jelly of the old colony swells up and allows the *Nostoc* filaments or rows of cells to become free. Each cell subsequently grows rapidly in a transverse direction till the appearance is presented by each filament of a number of disc-like bodies placed side by side. Cell-division next takes place in a direction parallel to the axis of the filament, so that a number

FIG. 862.

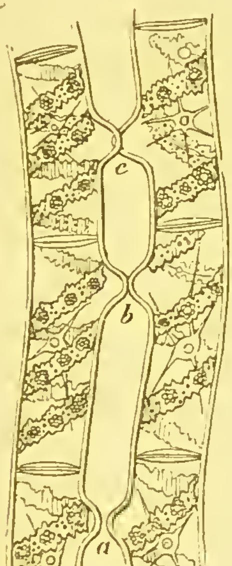


FIG. 863.

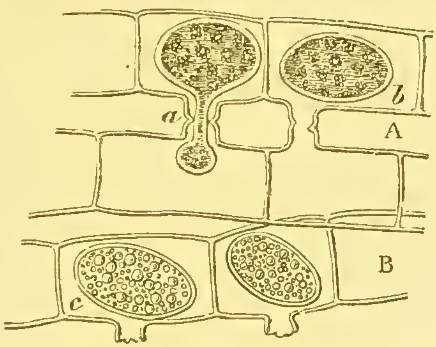


Fig. 862. Two filaments of *Spirogyra* about to conjugate; each cell is seen to contain chlorophyll arranged in spiral bands with grains of starch, oil globules, and a central nucleus, surrounded by protoplasmic threads which extend to the cell-wall. *a*, *b*, *c*. Lateral protrusions of the cell-walls of adjoining cells. After Sachs.——*Fig.* 863. A. Filaments of *Spirogyra* conjugating. *a*. Formation of zygospore. *b*. Formed zygospore. B. A filament in which are young zygospores, *c*, and which contain drops of oil. After Sachs.

of septate thread-like bodies are produced, which, joining by their ends, grow so as to ultimately produce a new *Nostoc* colony. At the same time the heterocysts are developed from cells which previously differed in no apparent respect from the rest, and the jelly-like envelope of the colony becomes also gradually formed.

Spirogyra, our next example of this order of plants, is one in which the process of reproduction known as conjugation very commonly takes place. *Spirogyra* is an Alga which may be found in great quantities in most ponds towards the end of summer, and is one of the prettiest objects which can be examined under the microscope. Seen with the naked eye, it consists of a mass of long, very slender green threads or filaments, which float in the water where they are growing. Examined with the microscope, each filament is seen to be more or less cylindrical, and composed of a great number of similar cells placed end to end (*fig.* 862). The chlorophyll is arranged in the parietal layer of protoplasm of the cell in a definite spiral manner; the name of some of the species being determined by the number of such spirals in a single cell. Each cell is capable of growth and division, and by this means the bulk of the entire plant is increased.

When conjugation is about to take place, two filaments approach each other, and from the sides of contiguous cells (*fig.* 862, *a*, *b*, *c*), protrusions of the wall occur which meet in the centre. The protruding ends of the wall then intervening between the cavities of the two conjugating cells next become absorbed (*fig.* 863, A, *a*), and the protoplasm of one cell separates itself from its cell-wall, and gradually travels into the other cell, where it becomes intimately mixed with the protoplasm existing there; the whole mass then becomes of a somewhat oval shape, surrounds itself with a cell-wall, *b*, and in fact constitutes what is called a *zygospore*. Later on its colour changes from green to that of a deep red, and after remaining dormant during the winter the zygospore germinates at the beginning of spring, and so gives rise to a new *Spirogyra* plant.

Vaucheria, which we will now consider, exhibits true sexual reproduction, in addition to the formation of asexual spores. An irregular kind of alternation of generations exists in this genus, inasmuch as asexual spores are usually produced by a certain number of successive generations, the sexual process only taking place in generations separated by a considerable interval from one another. At the same time it must be noticed that asexual spores may be formed in the same plant as that in which sexual reproduction takes place.

Vaucheria may be found growing either in water or on moist surfaces. Its thallus consists of one very elongated and greatly branched cell, attached to some fixed object by means of a portion of its thallus, which is much branched and perfectly transparent (*fig.* 864, D, *w*). The other, or non-transparent portion of the cell contains protoplasm, chlorophyll grains, and frequently numbers of small oil globules. The asexual spores are formed in various ways in the different species, the more common method being that in which a small branch becomes separated from the parent cell by division, the protoplasm thus shut off secreting a cell-wall round itself, and thus forming a spore, which ultimately germinating gives rise to a new *Vaucheria* thallus. (M. C. Cooke and Bates have described the main filaments or threads as much divided off by septa into cells at the period of fructification; and Cooke believes, from this circumstance and others, that zoogonidia may be produced in *Vaucheria* in cells divided off for that purpose.)

Zoospores or *Zoogonidia* are also not unfrequently formed as follows :—The contents of the branch, which has swollen into a sporangium, contract, and escape as a primordial cell, or one without a cell-wall, from a fissure at the apex (*fig.* 864, A, *sp*). This primordial cell is densely covered by short cilia, and is termed a *zoospore* or *zoogonidium*, which at first rapidly rotates ; but it soon comes to rest, when the cilia disappear, and a cellulose wall is produced (*fig.* 864, B). This spore then germinates by putting out one (*fig.* 864, C) or two tubes ; or it forms on the other side, at the same time, a branched root-like organ (*fig.* 864, D, *w*).

FIG. 864.

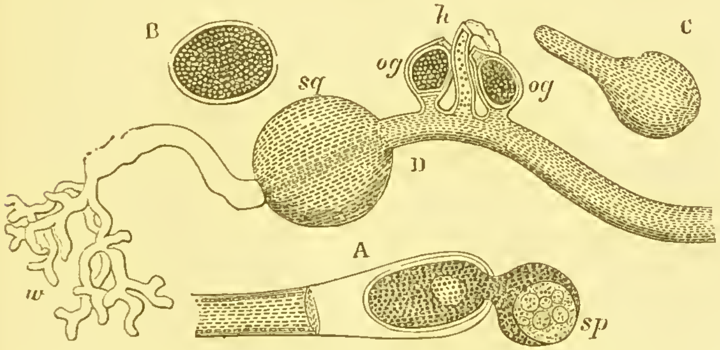


Fig. 864. A. *sp*. Newly formed zoospore or zoogonidium of *Vaucheria sessilis* escaping. B. Zoospore at rest after having lost its cilia. C. First stage of germination. D. Filament of *Vaucheria sessilis* producing oogonia, *og*, *og*, and antheridium, *h*. *w*. Hyaline root-like process, forming a sort of mycelium. *sq*. Zoospore, which by germinating has formed the filament. After Sachs.

When sexual reproduction takes place, short branches of the thallus or filament, which are in close proximity to each other, become transformed into *antheridia*, *h*, and *oogonia*, *og*, *og* (*fig.* 864, D). The branch which is to form the antheridium is longer than that which forms the oogonium, and generally becomes more or less curved, and a division is made about halfway from its base. The protoplasm in the upper part becomes differentiated into antherozoids, which by means of the bursting of the antheridium become free at the same time as the rupture of the oogonium takes place.

The *oogonia* (*fig.* 864, D, *og*, *og*), of which there are frequently two near to each other, are somewhat ovoid ; they differ from the antheridia in containing a good deal of chlorophyll, and are separated from the cavity of the thallus or filament by a septum situated at their base. The green and granular contents finally collect in the centre of the oogonium, and colourless protoplasm is to be seen at its end ; the cell-wall then opens at this point, and the contents at the same time retract from the cell-wall and what is termed the *oosphere* is formed. The antheridium opens at the same time as the oogonium, and the antherozoids escape, reach the oosphere, mix with it, and then disappear ; and the oosphere is transformed into an *oospore*. The *oospore* thus formed acquires a distinct cell-wall of its own, and its colour also changes to a reddish hue. By the germination of the oospore, a new *Vaucheria* thallus may be formed.

Fucus.—This genus includes numerous species, which form the various plants commonly known as Seaweeds. The thallus (*fig.* 5) is usually long, very much branched, and of a greenish brown colour. In structure, it is made up at the surface of closely packed small cells, but towards the interior the cells are more elongated, and joined end to end, so as to form filaments

FIG. 865.

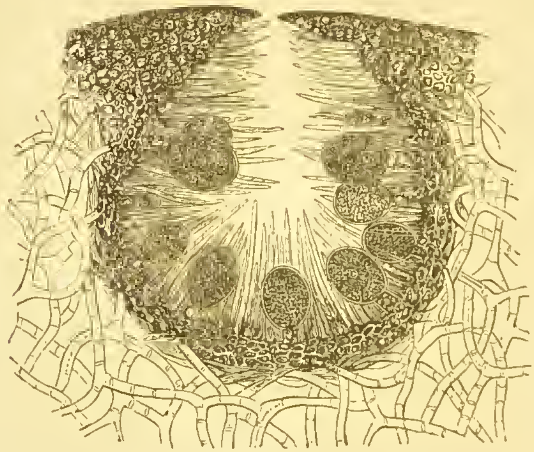


Fig. 865. Vertical section of a female conceptacle of *Fucus vesiculosus* containing oogonia and paraphyses. After Thuret.

which are interwoven amongst one another (*fig.* 865). The walls of the constituent cells are peculiar in consisting of two parts, an inner firm layer, and an outer one which is generally more or less swollen by imbibition of water. (See page 73.)

Reproduction is effected by a sexual process, which takes place in the following way :—Numerous little cavities, known as *conceptacles*, appear sunk in the surface of large swollen *receptacles* (*fig.* 5, *t*, *t*), on the ends of the longer forked branches of the Fucus, and in these are contained the *antheridia*, or *oogonia* ; or both of these organs, together with abortive filaments or *paraphyses*. Some species, as *Fucus platycarpus*, are monœcious, i.e. contain both antheridia and oogonia in the same conceptacle; but in others, as *Fucus vesiculosus*, either only antheridia or oogonia conceptacles are produced in the same plant; such species therefore are diœcious.

Taking *Fucus vesiculosus* as an example of the diœcious species, on making a section through a female conceptacle, its cavity is found to be of a more or less spherical form, and marked off from the loose tissue of the interior of the thallus by a thin layer of denser tissue resembling, and in fact being a continuation of, that of the surface, which may be called the *epidermal layer* (*fig.* 865). Springing from all parts of the wall of the conceptacle are slender jointed filaments, the *paraphyses.* Amongst these paraphyses are the *oogonia*, which are produced from certain cells of the lining, or epidermal layer of cells.

The *antheridia* in the monœcious species, as *Fucus platycarpus*, are developed in the same conceptacle as the *oogonia*; and

FIG. 866.

FIG. 867.

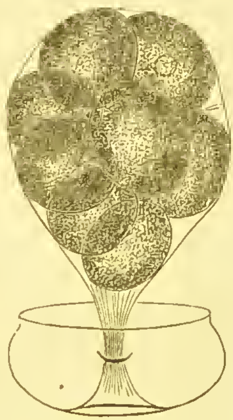


FIG. 868.

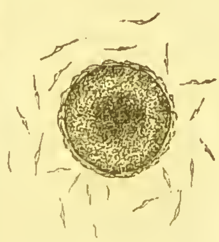


Fig. 866. Antheridia. *a*, *a*, on the branched hairs of the male conceptacle. After Thuret.——*Fig.* 867. Oogonium with the oospheres fully separated, and disengaging themselves from their coverings. After Thuret.——*Fig.* 868. An oosphere without a cellulose coat being fertilised by antherozoids so as to form an oospore.

in diœcious species in separate conceptacles, then termed *male conceptacles.* These *antheridia* (*fig.* 866) are somewhat elliptical bodies, *a*, *a*, formed on branched hair-like cells. When mature the antheridium becomes a bright red colour, and contains a number of small antherozoids (*fig.* 868), each of which is furnished with a pair of cilia.

The *oogonia* are globular bodies borne upon a short one-celled stalk, in which are produced eight oospheres by means of the division of the contained protoplasm (*fig.* 867). These, which are at first angular, become rounded off, and are ultimately set free by the bursting of the oogonium membrane. The antherozoids, which escape almost simultaneously with the oospheres, gather round the latter and appear to become finally blended with their substance (*fig.* 868). The *oospore* thus formed secretes around itself a cell-wall and very soon begins to germinate. Growth and division proceed, and so a new Fucus thallus is built up.

Œdogonium.—The thallus of *Œdogonium* consists of a long, unbranched row of cells; and each cell is nucleated, and contains chlorophyll granules imbedded in the parietal protoplasmic layer. Reproduction is effected either asexually by means of *zoospores*; or in a sexual manner by *antheridia* and *oogonia*. The former are produced by means of the bursting of a cell and the consequent escape of the cell contents in the form of an ovate mass with a tuft of fine cilia at the more pointed extremity.

Fig. 869.

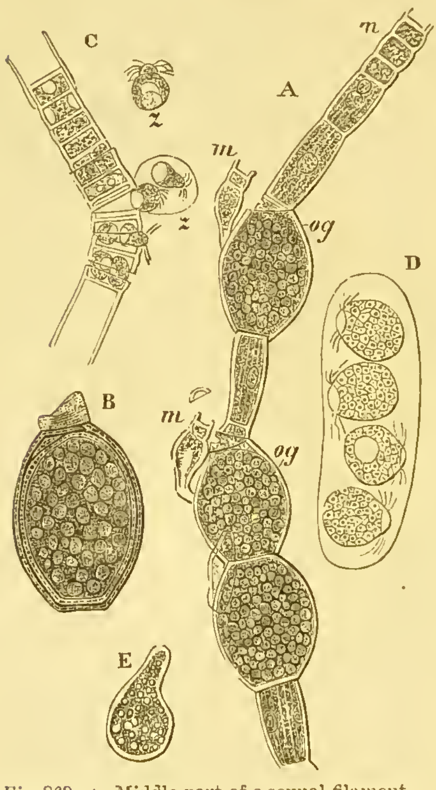


Fig. 869. A. Middle part of a sexual filament of *Œdogonium ciliatum*. *og*, *og*. Oogonia fertilised by the dwarf male plants, *m*, *m*, developed from zoospores formed in the cells, *n* (antheridium), at the upper part of the filament. B. Ripe oospore. C. Piece of male filament of a species of *Œdogonium*, with production of antherozoids, *z*, *z*. D. The four swarm-spores resulting from an oospore. E. Swarm-spore at rest. After Pringsheim.

In the latter case the *antherozoids* are formed in special cells, and either on the same filament as the *oogonia* (*fig.* 869, A, *n*, *og*); which is then termed a *sexual filament*; or on another filament (*fig.* 869, C, *z*, *z*), then called a *male filament*. The antherozoids resemble the zoospores or zoogonidia, but are smaller. The *oogonia* (*fig.* 869, A, *og*, *og*) are oval bodies containing a great deal of chlorophyll, and are formed by the enlargement of any of the individual cells of the filament. The contained protoplasmic mass, or *oosphere*, may be fertilised in two different ways. Either the oosphere is directly fertilised by contact with the antherozoids above described (*fig.* 869, C, *z*, *z*); or by means of an antherozoid produced from a peculiar form of swarm-spore known as an *androspore* (*fig.* 869, A, *n*). The androspore, which is produced from cells resembling those of the antheridia, becomes attached to the oogonium, forming what is known as a dwarf male plant (*fig.* 869, A, *m*, *m*), and subsequently discharges its protoplasm in the form of an antherozoid, by which the oosphere may be fertilised, and become transformed into an *oospore.*

In either case the oospore after a short period of rest gives rise to four swarm-spores (*fig.* 869, D), each of which (*fig.* 869, E) subsequently grows into a swarm-spore-producing plant, so that in *Œdogonium* we have another example of alternation of generations, similar to that which occurs in *Vaucheria* (page 394), viz., one in which a series of generations consists of the swarm-spore-producing plant, whilst at more or less regular intervals a sexual generation takes place. It should be noted however that zoospores may be also produced in the same individual plant as that in which the sexual process takes place.

BOOK II.

SYSTEMATIC BOTANY, OR THE CLASSIFICATION OF PLANTS.

CHAPTER 1.

GENERAL PRINCIPLES OF CLASSIFICATION.

Section 1.—Species, Genera, Orders, and Classes.

Our attention has been hitherto directed to the examination of the structure and forms of the various organs and parts of plants. In doing so, we cannot but have noticed the almost infinite varieties of forms which have thus been presented to us, and also at the same time observed that, notwithstanding such variations, there are some striking resemblances in the structure of the organs of certain plants, by which a close relationship is thus clearly indicated between them. It is the object of Systematic Botany to take notice of such relationships, and thus to bring plants together which are allied in their forms and structure, and to separate those that are unlike; and in this way to take a comprehensive view of the whole Vegetable Kingdom. In its extended sense, Systematic Botany has for its object the naming, describing, and arranging of plants in such a manner, that we may readily ascertain their names, and at the same time get an insight into their affinities and general properties.

At the present time there are at least 120,000 species of plants known to exist on the earth. It is absolutely necessary therefore, for the purpose of study, or in order to obtain any satisfactory knowledge of such a vast number of plants, that we should arrange them according to some definite and fixed rules; but before we proceed to describe the systems that have been devised at various times for their arrangement, it will be necessary to define the principal terms which are in common use in such systems.

1. Species.—By the term species we understand a collection of individuals which resemble each other more nearly than they

resemble any other plants, and which, taking Flowering Plants as illustrations, can be reproduced by seed; so that we may from analogy infer that they have all been derived originally from one common stock. Thus, if we walk into a field of Beans, Peas, or Clover, we observe thousands of individuals, which, although differing to a certain extent in size, and in some other unimportant characters, we at once associate together under a common name. In like manner we commonly observe around us, in the gardens and fields, similar collections of individuals. Such collections of plants, thus seen to resemble one another in all their important parts, constitute our first idea of a species; and that idea is at once confirmed if, by taking the seeds of such plants and sowing them, we obtain other plants exactly resembling those from which such seeds have been derived. Species are, however, under special conditions, liable to variations, and we have then formed what are termed *varieties* and *races*.

a. *Varieties or Sub-species.*—It has just been observed, that if the seed of a species be sown, it will reproduce its parent, or, in other words, produce a plant resembling its parent in all its important parts. But this will only happen, when the new individual has been exposed to similar influences of soil, heat, light, moisture, and other conditions, as its parent; and hence we find that variations in such particulars will lead to certain peculiarities in form, colour, size, and other minor characters, in plants raised from the seeds of the same species. In this manner we have produced what are termed *varieties*. In some cases such variations are merely transient, and the individuals presenting such peculiarities will in time return to their original specific type, or perish altogether; while in other instances they are permanent and continue throughout the life of the individual, the whole plant being, as it were, impregnated with the particular variations thus impressed upon it, and hence such variations may be perpetuated by the gardener in the operations of Budding, Grafting, &c. (see page 107), as is the case with many of our fruit trees and flowers. But even these varieties cannot be propagated by seed; for if their seeds be sown, the individuals which will be produced will have a tendency to revert to the original species from which such varieties have been obtained, so that the nature of the plant raised will depend upon the character of the soil in which it is placed, and the other external conditions to which it is exposed. Thus, if we sow the seeds of a number of different varieties of Apples, the fruit subsequently produced by the new generation of Apple trees will, instead of resembling that of their parents, have a tendency to revert to that of the common Crab, from which species all such varieties have been originally derived. Hence a variety differs essentially from a species in the fact that it cannot be propagated by seed.

b. *Races.*—Besides the varieties just alluded to there are others, which are called *permanent varieties* or *races*, because their peculiarities can be transmitted by seed. Familiar examples of such races are afforded by our Cereal grains, as Wheat, Oats, and Barley ; and also by our culinary vegetables, as Peas, Lettuces, Radishes, Cabbages, Cauliflowers, and Broccoli. How such races of plants have originated, it is impossible to say with any certainty. In the first case they probably arose in an accidental manner, for it is found that plants under cultivation are liable to produce certain variations or abnormal deviations from their specific type, or to *sport*, as it is termed. By further cultivation under the care of the gardener, such variations are after a time rendered permanent, and can be propagated by seed, These so-called permanent varieties, however, if left to themselves, or if sown in poor soil, will soon lose their peculiarities, and either perish, or return to their original specific type ; it will be seen, therefore, that races present well-marked characters by which they are distinguished from true species. Hence, although our cereal grains and culinary vegetables have become permanent varieties by ages of cultivation and by the skill of the cultivator, they can only be made to continue in that state by a resort to the same means, for if left to themselves they would, as just observed, either perish or revert to their original specific type ; and hence we see also, how important is the assistance of the agriculturist and gardener in perpetuating and improving such variations.

Another cause which leads to constant variations from the specific type is *hybridisation*. The varieties thus formed, which are called *hybrids* and *cross-breeds*, are, however, rarely transmitted by seed—although, in some instances, such is the case for a few generations—but they gradually revert to one or the other parent stock. (See *Hybridisation.*)

We have now seen that species, under certain circumstances, are liable to variations, but that all such varieties have a tendency to revert to their original specific type. Hence, in a practical point of view, species must be considered as permanent productions of Nature, which are capable of varying within certain limits, but in no cases capable of being altered so as to assume the characters of another species. There is not the slightest foundation for the theory, which has been advocated by some naturalists, of a transmutation of species. All such statements, therefore, that have been made, of the conversion of Oats into Rye, or of any species whatever into another, are entirely without foundation, and have arisen from imperfect observation.*

* The above views as to the origin and nature of species and varieties must be understood, as we have stated above, in a practical point of view, although until the last few years they were, in every sense, almost universally entertained by naturalists ; but they are opposed to those now far more generally adopted, and which were first developed in Darwin's great

In practice it is important that we should distinguish varieties from true species, for nothing is so calculated to lead to confusion in Descriptive Botany as the raising of mere varieties to the condition of species. No individuals should be considered as constituting a species unless they exhibit important and permanent distinctive characters in a wild state, and which can be perpetuated by seed. Great uncertainty still prevails in our systematic works as to what is a species and what is a variety; and hence we find different authors, who have written on British and other plants, estimate the number of species contained in such genera as *Rosa*, *Rubus*, *Saxifraga*, *Hieracium*, *Salix*, *Smilax*, and others, very differently.

2. Genera.—The most superficial observer of plants will have noticed that certain species are more nearly allied to each other than to other species. Thus, the different kinds of Roses, Brambles, Heaths, Willows, may be cited as familiar examples of such assemblages of species; for, although the plants comprehended under these names present certain well-marked distinctive characters, yet there are at the same time also striking resemblances between them. Such assemblages of species are called *genera*. A *genus*, therefore, is a collection of species which resemble each other in general structure and appearance more than they resemble any other species. Thus, the various kinds of Brambles constitute one genus, the Roses another, the Willows, Heaths, Clovers, and Oaks form also, in like manner, as many different genera. The characters of a genus are taken *exclusively* from the organs of reproduction, while those of a species are derived *generally* from all parts of the plant; hence a genus is defined as a collection of species which resemble each other in the structure and general characters of their organs of reproduction. It is not necessary, however, that a genus should contain a number of species, for, if a single species presents peculiarities of a marked kind, it may of itself constitute a genus.

It frequently happens that two or more species of a genus have a more striking resemblance to each other in certain important characters than to other species of the same genus, in which case they are grouped together into what is termed a *sub-genus*, and further subdivisions of more nearly allied species, such as *sections*, *sub-sections*, &c., may be made.

3. Orders or Natural Orders.—If we regard collections of genera from the same point of view as we have just done those of species,—that is, as to their close resemblances,—

work 'On the Origin of Species,' and in other volumes by the same gifted observer. This author contends that species, so far from being immutable, are liable to change of almost any extent—in fact, that plants, by the operation of causes acting over a long period of time, may become so altered, that they preserve scarcely any apparent resemblance to those from which they were originally derived.

we shall find that some of them also resemble each other more than they do other genera. Thus, Mustards, Turnips, Radishes, and Cabbages have a strong common resemblance, while they are unlike Strawberries and Brambles ; and even less so to Hazels, Oaks, and Beeches ; and still more unlike Larches, Pines, Firs, and Cedars. Proceeding in this way throughout the Vegetable Kingdom, we collect together allied genera, and form them into groups of a higher order called *Orders* or *Natural Orders* ; hence, while genera are collections of related species, orders are collections of allied genera. Thus, Turnips, Radishes, and Cabbages, all belong to different genera, but they agree in their general structure, and are hence included in the order *Cruciferæ* ; while Strawberries, Brambles, Roses, Apples, and Plums, are all different genera, but from the general resemblance they bear to each other in their structure, they are placed in one order, called *Rosaceæ*. Again : Oaks, Beeches, and Hazels are different genera, but they belong to one order ; also the Pines and Cedars are different genera, but as the fruit of them all is a *cone*, they are grouped together in one order, which is termed the *Coniferæ*.

We find also that certain genera of an order, like certain species of a genus, have a more striking resemblance to each other than to other genera of the same order ; hence such are grouped together into what are called *Sub-orders*. Thus the Chicory, Dandelion, Sow-thistle, Lettuce, Thistle, Burdock, and Chamomile, all belong to the same order, but there is a greater resemblance in the Chicory, Dandelion, Sow-thistle and Lettuce to each other than to the remaining genera. Hence, while all the above genera belong to the order *Compositæ*, they are at the same time placed in two different sub-orders. Thus, one sub-order, called the *Liguliflorœ*, includes the Chicory, Dandelion, Sow-thistle, and Lettuce ; and the other sub-order, the *Tubuliflorœ*, that of the Thistle, Burdock, and Chamomile. In like manner, while we find the Plum, Strawberry, Raspberry, Rose, and Apple, all belonging to the same order *Rosaceæ*, some of them have more resemblance to each other than to others. Thus, the Plum has a drupaceous fruit, and is therefore placed in a distinct sub-order, which is called *Drupaceæ* ; the Strawberry, Raspberry, and Rose are much more like each other than they are to the Plum or Apple, hence they are put in a sub-order called *Roseæ* ; while the Apple, from the character of its fruit, is placed in a sub-order termed *Pomeæ*.

It is also found convenient to subdivide sub-orders into *Tribes*, *Sub-tribes*, &c., by collecting together into groups certain very nearly allied genera, but it is not necessary for us to illustrate such divisions further, as the principles upon which they depend have been now sufficiently treated of.

4. Classes.—By a class, we understand a group of orders possessing some very important structural characters in common.

Thus we have the classes Monocotyledones and Dicotyledones, which possess certain distinctive characters in their respective embryos, &c.

The Classes are also divided into *Sub-classes*, *Series*, *Cohorts* or *Alliances*, and other divisions, in the same manner as the orders, genera, and species are subdivided; but as the names of such divisions vary in different systems, and are all more or less artificial, it is not necessary for us, in this place, to dwell upon them further. The classes themselves, in different systems, are also generally arranged in more comprehensive groups, which have been variously named *Sub-kingdoms*, *Groups*, *Divisions*, *Regions*, *Sub-divisions*, &c. But as these are also of different extent and variously defined by botanists, we must refer to the several systems for particulars respecting them.

The following table will include all the more important groups we have alluded to; those in more general use being indicated by capitals.

1. SUB-KINGDOMS OR DIVISIONS.
    - Sub-divisions.
2. CLASSES.
    - Sub-classes.
        - Series.
            - Cohorts or Alliances.
3. ORDERS.
    - Sub-orders.
        - Tribes.
            - Sub-tribes.
4. GENERA.
    - Sub-genera.
        - Sections.
5. SPECIES.
    - Varieties.
        - Races.

Section 2. CHARACTERS, NOMENCLATURE, ABBREVIATIONS, AND SYMBOLS.

DESCRIPTIVE BOTANY is the art of describing plants in technical language, so that they may be readily recognised when met with by those to whom they were previously unknown, who possess a knowledge of the technical names of the different parts and organs of plants and of their various modifications. This subject is too extensive to be treated of here; reference must be made to special treatises for this purpose; but it is necessary for us to refer briefly to the Characters, Nomenclature, Abbreviations, and Symbols of Plants.

1. CHARACTERS.—By the term character, we mean a list of

all the points by which any particular *variety*, *species*, *sub-genus*, *genus*, *sub-tribe*, *tribe*, *sub-order*, *order*, *sub-class*, or *class*, &c., is distinguished from another. We have also two kinds of characters, which are called respectively *essential* and *natural*. By an essential character, we understand an enumeration of those points only, by which any division of plants may be distinguished from others of the same nature; such may be also called *diagnostic* characters. A *natural character*, on the other hand, is a complete description of a given species, genus, order, class, &c., including an account of every organ from the root upwards, through the stem, leaves, flowers, fruit, and seed. Such characters are necessarily of great length, and are not required for general diagnosis, although of great value when a complete history of a plant or group is required. Those characters, again, which refer to a species are called *specific*, and are taken generally from all the organs and parts of the plant, and relate chiefly to their *form*, *shape*, *surface*, *division*, *colour*, *dimension*, and *duration*; or, in other words, to characters of a superficial nature, and without reference to their internal structure. The characters of a genus are called *generic*, and are taken from the organs of reproduction. The characters of an order are termed *ordinal*, and are derived from the general structure of the plants in such groups, more especially of the organs of reproduction. While the characters of a class, &c., as already mentioned, are derived from certain important structural peculiarities which the plants of such divisions exhibit. The essential character of a genus, when indicated in Latin, is put in the nominative case, while that of a species is placed in the ablative.

2. Nomenclature.—It is the object of nomenclature to lay down rules for naming the various kinds of plants and the different groups into which they are arranged in our systems of classification; in the same manner as it is the object of terminology to find names for the different organs of plants, and the modifications which those organs present.

a. *Species.*—The names of the species are variously derived. Thus the species of the genus *Viola*, as shown by Gray in the following paragraphs, exhibit the origin of many such names. 'Specific names sometimes distinguish the country which a plant inhabits: for example, *Viola canadensis*, the Canadian Violet; or the station where it naturally grows, as *Viola palustris*, which is found in swamps, and *Viola arvensis*, in fields; or they express some obvious character of the species, as *Viola rostrata*, where the corolla bears a remarkably long spur, *Viola tricolor*, which has tri-coloured flowers, *Viola rotundifolia*, with rounded leaves, *Viola lanceolata*, with lanceolate leaves, *Viola pedata*, with pedately-parted leaves, *Viola primulæfolia*, where the leaves are compared to those of a Primrose, *Viola asarifolia*, where they are likened to those of *Asarum*, *Viola pubescens*, which is hairy throughout, &c. Frequently the species bears the name of its discoverer or describer, as *Viola Muhlenbergii*, *Viola Nuttallii*, &c.

Specific names are written after the generic, as indicated above in the different species of the genus *Viola*, and these together constitute the proper appellation of a plant, in the same way as the surnames and Christian names designate the members of a family. The specific names should also in all cases be adjectives, or substantives used adjectively; in the former case they should agree in gender and case with the name of the genus. Thus when a species is named after its discoverer or describer, it is usually placed in the genitive case, as *Viola Muhlenbergii* and *V. Nuttallii*; but when such names are merely given in honour of botanists who have had nothing to do with their discovery or description, the specific names are generally put in the adjective form, as *Carex Hookeriana*, *Veronica Lindleyana*: such a rule is, however, frequently departed from. Sometimes the specific name is a noun, in which case it does not necessarily agree with the genus in gender; such specific names are often old generic ones, as *Dictamnus Fraxinella*, *Rhus Cotinus*, *Lythrum Salicaria*, *Rhus Coriaria*, *Dianthus Armeria*, *Rhamnus Frangula*. In such cases the specific name should begin with a capital letter: a similar rule should also be adopted when it is derived from a person; but in all other instances it is better that the specific name should begin with a small letter. The specific name was called by Linnæus the *trivial* name; thus, in the particular kind of Violet called *Viola palustris*, *Viola* is the generic, and *palustris* the specifie or trivial name.

b. *Genera.*—The names of the genera are substantives, in accordance with the rule laid down by Linnæus as follows:—Every species shall have a particular name, compounded of a substantive and an adjective, whereof the former indicates the genus, and the latter the species. This has already been referred to under the head of Species. The names of the genera are derived in various ways: thus, either from the name of some eminent botanist, as Linnæa after Linnæus, Smithia after Smith, Hookeria after Hooker, Jussiæa after Jussieu, Tournefortia after Tournefort, Lindleyana after Lindley; or from some peculiarity of structure or habit of the plants comprised in them, and from various other circumstances. Thus, *Crassula* is derived from the genus comprising plants with succulent or thickened leaves; *Sagittaria*, from its arrow-shaped leaves; *Arenaria*, from growing in sandy places; *Lithospermum*, from its fruits (which were formerly regarded as seeds) having a stony hardness; *Campanula*, from its corolla being in the form of a bell; *Lactuca*, from its milky juice; and so on. Others, again, have derived their generic names from supposed medicinal properties, such as *Scrophularia*, from its former use in scrofula; *Pulmonaria*, from its employment in pulmonary disease, &c.

c. *Orders.*—The names of the orders in the Artificial

System of Linnæus are chiefly derived from the various characters of the gynœcium and fruit. Those of Natural Systems are usually taken from some well-known genus which is included in any particular order, and which may be regarded as the type of that order. Thus, the genus *Ranunculus* gives the name *Ranunculaceæ* to the order to which it belongs; the genera *Papaver*, *Malva*, *Hypericum*, *Geranium*, *Rosa*, *Lilium*, *Orchis*, and *Iris*, in like manner, give names respectively to the orders *Papareraceæ*, *Malvaceæ*, *Hypericaceæ*, *Geraniaceæ*, *Rosaceæ*, *Liliaceæ*, *Orchidaceæ*, and *Iridaceæ*. At other times the names of the orders are derived from some characteristic feature which the plants included in them present. Thus, the order *Cruciferæ* is so named because its plants have cruciate corollas; the order *Leguminosæ* comprises plants whose fruit is a legume; the *Umbelliferæ* are umbel-bearing plants; the *Labiatæ* have a labiate corolla; the *Coniferæ* are cone-bearing plants; and so on.

d. *Classes.*—The names of the classes are derived from some important and permanent characters which the plants comprised in them possess, relating either to their structure or mode of development. Such names vary, however, according to the views of different systematic botanists. Those which have been more commonly used in this country are, *Acotyledones*, *Monocotyledones*, and *Dicotyledones*—terms which are derived from the structure and characters of the reproductive bodies in the three classes respectively. Others, also in common use, are derived from the mode of development and structure of the stem: such are *Exogens*, *Endogens*, and *Acrogens*. The above names are used especially in Natural Systems of Classification; while the names of classes in the Artificial System of Linnæus are derived chiefly from the number and other characters presented by the andrœcium.

e. *Sub-kingdoms, Divisions, &c.*—The names of these are generally derived from the presence or otherwise of evident flowers or reproductive organs, as those of *Phanerogamia* and *Cryptogamia*. The names of *Cotyledones* and *Acotyledones*, indicating the presence or absence of an embryo, have been also in common use. Others, again, have been employed, having reference to their elementary structure, as *Vasculares* and *Cellulares*; or to the presence or absence of a stem, as *Cormophyta* and *Thallophyta*. The other sub-divisions are variously named according to the views of different botanists.

3. Abbreviations and Symbols.—It is usual in botanical works to use certain abbreviations and symbols. A few of the more important need alone be mentioned here.

a. *Abbreviations.*—The names of authors, when of more than one syllable, are commonly abbreviated by writing the first letter or syllable, &c., as follows:—

L. or *Linn.* means Linnæus; *Juss.* is the abbreviation for Jussieu; *DC.* or *De Cand.* for De Candolle; *Br.* for Brown;

Lindl. for Lindley ; *Rich.* for Richard ; *Willd.* for Willdenow ; *Hook.* for Hooker ; *With.* for Withering ; *Endl.* for Endlicher ; *Bab.* for Babington ; *Berk.* for Berkley, &c., &c.

It is common to put such abridged names after that of the genus or species which has been described by them respectively. Thus *Eriocaulon, L.* indicates that the genus *Eriocaulon* was first described by Linnæus ; *Miltonia, Lindl.* is the genus *Miltonia* as defined by Lindley ; *Nuphar pumila, DC.* is the species of *Nuphar* defined by De Candolle, &c., &c.

Other abbreviations in common use are *Rad.* for root ; *Caul.* for stem ; *Fl.* for flower ; *Cal.* for calyx ; *Cor.* for corolla ; *Per.* for perianth ; *Fr.* for fruit ; *Ord.* for order ; *Gen.* for genus ; *Sp.* or *Spec.* for species ; *Var.* for variety ; *Hab.* for habitat ; *Herb.* for herbarium, &c. Again—

V. v. c. (*Vidi vivam cultam*) indicates that the author has seen a living cultivated plant as described by him.
V. v. s. (*Vidi vivam spontaneam*) indicates that the author has seen a living wild plant.
V. s. c. (*Vidi siccam cultam*) indicates that a dried specimen of the cultivated plant has been examined.
V. s. s. (*Vidi siccam spontaneam*) indicates that a dried specimen of the wild plant has been examined.

b. *Symbols.*—The more important symbols are as follow :—

⊙, ○, ①, or A, signifies an annual plant.
⊙ ⊙, ②, or B, means a biennial plant.
♃, △, or P, signifies a perennial.
♄ or Sh. means a shrub.
T signifies a tree.
(twining to the right ;) twining to the left.
♂ a staminate flower.
♀ a pistillate flower.
☿ an hermaphrodite flower.
♂ - ♀ a monœcious plant.
♂ : ♀ a diœcious species.
☿ ♂ ♀ a polygamous species.
○ = signifies that the cotyledons are accumbent, and the radicle lateral.
○ || Cotyledons incumbent, radicle dorsal.
○ ≫ Cotyledons conduplicate, radicle dorsal.
○ || || Cotyledons twice folded, radicle dorsal.
○ || || || Cotyledons three times folded, radicle dorsal.
? The note of interrogation is used to indicate doubt or uncertainty as to the genus, species, locality, &c.
! The note of exclamation indicates certainty in the above particulars.
* The asterisk indicates that a good description is to be found at the reference to which it is appended.

CHAPTER 2.

SYSTEMS OF CLASSIFICATION.

We have already stated that Systematic Botany has for its object the naming, describing, and arranging of plants in such a manner that we may readily ascertain their names, and at the same time get an insight into their affinities and general properties. Every system that has been devised for the arrangement of plants does not, however, comprise all the above points: for, while some systems are of value simply for affording us a ready means of ascertaining their names: others not only do this, but at the same time give us a knowledge of their affinities and properties. Hence we divide the different systems of Classification under two heads; namely, Artificial and Natural,—the former only necessarily enabling us to ascertain readily the name of a particular plant; while the latter, if perfect, should comprise all the points which come within the object of Systematic Botany. The great aim of the botanist, therefore should be the development of a true Natural System; but in past times, Artificial Systems, more particularly that of Linnæus, have been of great value. Linnæus himself never devised his system with any expectation or desire of its serving more than a temporary purpose, or as an introduction to the Natural System, when the materials for its formation had been obtained.

In both artificial and natural systems, the lower divisions—namely, the genera and species—are the same, the difference between the systems consisting in the manner in which these divisions are grouped into orders, classes, and other higher groups. Thus in the Linnæan and other artificial systems, one, or, at most, a few characters are arbitrarily selected, and all the plants in the Vegetable Kingdom are distributed under classes and orders according to the correspondence or difference of the several genera in such respects, no regard being had to any other characters. The plants in the classes and orders of an artificial system have, therefore, no necessary agreement with each other except in the characters selected for convenience as the types of those divisions respectively. Hence such a system may be compared to a dictionary, in which words are arranged, for convenience of reference, in an alphabetical order, adjacent words having no necessary agreement with each other, except in commencing with the same letter. In the Natural System, on the contrary, all the characters of the genera are taken into consideration, and those are grouped together into orders which correspond in the greatest number of important characters; and the orders are again united, upon the same principles, into groups of a higher order, namely, the classes and other divisions. While it must be evident, therefore, that all the knowledge we necessarily gain by an artificial system is the name of an unknown plant; on the other hand, by the natural system, we learn not only the name, but also its relations to the plants by which it is surrounded, and hence get a clue to its structure, properties, and history. Thus, supposing we find a plant, and wish to ascertain its name, if we turn to the Linnæan System, and find that such a plant is the *Menyanthes trifoliata*, this name is the whole amount of the knowledge we have gained; but by turning to the Natural System instead, and finding that our plant belongs to the order *Gentianaceæ*, we ascertain at once from its affinities that it must have the tonic and other properties which are possessed by the plants generally of that order, and, at the same time, we also learn that it accords in its structure with the same plants; and hence, by knowing the name of a plant by the Natural System, we may at once learn all that is most important in its history. It is quite true that all the orders, as at present constituted, are by no means so natural as that of the Gentianaceæ, but this arises from the present imperfection of our systems, and can only be remedied as our knowledge of plants extends; even a system, devised as perfectly as possible one day, may be deficient the next, in consequence of new plants being discovered which might compel us to alter our views, for at present the Floras of many regions of the globe are imperfectly known, and those of others almost entirely unknown. Sufficient, however, is now known of plants to enable us to establish certain great divisions according to a natural method, and which after discoveries are not likely to affect to any important extent. The present imperfections of the Natural System are, therefore, comparatively unimportant, and will no doubt disappear as our knowledge of the Flora of the globe becomes extended.

Having now described the general characters upon which the artificial and natural systems depend, and the particular merits and disadvantages of the two kinds of systems respectively, we proceed in the next place to describe the special characters upon which such systems are founded, commencing with those of an artificial nature, which, however, will be only treated of very briefly.

Section 1. Artificial Systems of Classification.

The first artificial system of any importance, of which we have any particular record, is that of Cæsalpinus, which was promulgated in 1583. Only 1520 plants were then known; and these were distributed into fifteen classes, the characters of which were chiefly derived from the fruit. The next systematic arrangement of an artificial character was that of Morison, about the year

TABULAR VIEW OF THE LINNÆAN ARTIFICIAL SYSTEM.

					Classes.	*Orders.*
Stamens and pistil in the same flower.	Stamens separate from the pistil.	Stamens not connected with each other.	Stamens of equal length, or at all events neither didynamous nor tetradynamous.	1 Stamen	1. MONANDRIA.	1. MONOGYNIA, 1 free style or stigma
				2 Stamens	2. DIANDRIA.	2. DIGYNIA, 2 free styles or stigmas
				3 „	3. TRIANDRIA.	3. TRIGYNIA, 3 „ „
				4 „	4. TETRANDRIA.	4. TETRAGYNIA, 4 „ „
				5 „	5. PENTANDRIA.	5. PENTAGYNIA, 5 „ „
				6 „	6. HEXANDRIA.	6. HEXAGYNIA, 6 „ „
				7 „	7. HEPTANDRIA.	7. HEPTAGYNIA, 7 „ „
				8 „	8. OCTANDRIA.	8. OCTAGYNIA, 8 „ „
				9 „	9. ENNEANDRIA.	9. ENNEAGYNIA, 9 „ „
				10 „	10. DECANDRIA.	10. DECAGYNIA, 10 „ „
				12 to 19„	11. DODECANDRIA.	11. DODECAGYNIA, 12 to 19 „ „
				20 or more, perigynous	12. ICOSANDRIA.	12. POLYGYNIA, 20 or more „ „
				20 or more, hypogynous	13. POLYANDRIA.	
			Of unequal length.	Two long and two short stamens.	14. DIDYNAMIA.	1. GYMNOSPERMIA, Fruit achænia, with one seed. 2. ANGIOSPERMIA, Fruit capsular, with many seeds.
				Four long and two short stamens.	15. TETRADYNAMIA.	1. SILICULOSA, Fruit a Silicula. 2. SILIQUOSA, Fruit a Siliqua.
		Connected with each other.		By their filaments in one bundle.	16. MONADELPHIA.	1. TRIANDRIA, 3 stamens.
				By their filaments in two bundles.	17. DIADELPHIA.	2. PENTANDRIA, 5 stamens.
				By their filaments in more than two bundles.	18. POLYADELPHIA.	3. HEXANDRIA, 6 stamens. &c., &c., as in first 13 classes.
				By their anthers	19. SYNGENESIA.	1. POLYGAMIA ÆQUALIS. Florets in capitula, and all perfect. 2. POLYGAMIA SUPERFLUA. Florets in capitula; florets of the disk hermaphrodite, of the ray pistillate. 3. POLYGAMIA FRUSTRANEA. Florets in capitula; those of the disk hermaphrodite, and those of the ray neuter. 4. POLYGAMIA NECESSARIA. Florets

in capitula; those of the disk staminate, and those of the ray pistillate.
5. POLYGAMIA SEGREGATA. Florets in capitula; each with a separate involucre.

Plants having — Stamens and pistil evident.

Stamen or stamens adherent to the pistil . . . 20. GYNANDRIA.
1. MONANDRIA, 1 stamen.
2. DIANDRIA, 2 stamens: and so on according to the number of stamens, as in the first 13 classes.

In separate flowers . . . . .

On the same plant . 21. MONŒCIA.
On separate plants . 22. DIŒCIA.
1. MONANDRIA, 1 stamen.
2. DIANDRIA, 2 stamens.
3. HEXANDRIA, 6 stamens.
4. POLYANDRIA, numerous stamens; and so on, as in the first 13 classes.
5. MONADELPHIA, stamens united into one bundle by their filaments.
6. POLYADELPHIA, stamens united into several bundles by their filaments.

Stamens and pistil separate in some flowers, and united in others, either on the same or on two or three different plants. 23. POLYGAMIA.
1. MONŒCIA, with staminate, pistillate, and hermaphrodite flowers on the same plant.
2. DIŒCIA. With hermaphrodite flowers on one plant, and staminate and pistillate flowers on another plant of the same species.
3. TRIŒCIA, where one plant bears hermaphrodite, another staminate, and a third pistillate flowers.

Plants with organs of reproduction concealed or inconspicuous . . . . 24. CRYPTOGAMIA.
1. FILICES. Ferns.
2. EQUISETACEÆ. Horsetails.
3. LYCOPODIACEÆ. Club-mosses.
4. SELAGINELLACEÆ. Selaginellas.
5. MARSILEACEÆ. Pepperworts.
6. MUSCI. Mosses.
7. HEPATICACEÆ. Liverworts.
8. FUNGI. Mushrooms.
9. LICHENES. Lichens.
10. CHARACEÆ. Charas.
11. ALGÆ. Seaweeds.

1670. He divided plants into eighteen classes, which were constructed according to the nature of the flower and fruit, and the external appearance of the plants. The systems of Hermann and others were also constructed upon somewhat similar principles, while that of Camellus was framed from the characters presented by the valves of the pericarp, and their number. In the system of Rivinus, which was promulgated in the year 1690, plants were divided into eighteen classes ; these were founded entirely upon the corolla—its regularity or irregularity, and the number of its parts being taken into consideration. The system of Christian Knaut was but a slight alteration of that of Rivinus. That of Tournefort, which was promulgated about the year 1695, was for a considerable time the favourite system of all botanists. About 8,000 species of plants were then known, which were distributed by Tournefort into twenty-two classes. He first arranged plants in two divisions, one of which comprised *herbs* and *under-shrubs*, and the other *trees* and *shrubs* ; and each of these divisions was then divided into *classes*, which were chiefly characterised according to the form of the corolla. Many other systems were devised which were simply alterations of the foregoing, as that of Pontedera. Magnolius, however, framed a system entirely on the calyx ; while Gleditsch attempted one in which the classes were founded on the position of the stamens. All the above systems were, without doubt, useful in their day, and paved the way for the more comprehensive one of Linnæus, which we now proceed to notice.

Linnæan System.—This celebrated system was first promulgated by Linnæus in his 'Systema Naturæ,' published in the year 1735 ; and although it was somewhat altered by subsequent botanists, the Linnæan System, in all its essential characters, was that devised by Linnæus himself ; and although now superseded by natural systems, it will be advisable for us to give a general sketch of its principal characteristics.

The classes and orders in the Linnæan System are taken exclusively from the essential organs of reproduction, the sexual nature of which Linnæus had clearly established : hence this artificial scheme is commonly termed the Sexual System.

The table (pp. 412 and 413) of the Classes and Orders of the Linnæan System will show at a glance their distinctive characteristics so far as the Phanerogamia are concerned ; but the Cryptogamia have been arranged according to the Natural System.

Section 2. Natural Systems of Classification.

The object of all natural systems, as already noticed (page 411), is to group together those plants which correspond in the greatest number of important characters, and to separate those that are unlike. The mode in which this has been attempted to be carried out varies according to the particular views of botanists as to the relative value of the characters furnished by the different organs of plants; but it must be evident to those who desire to arrange plants according to their natural affinities, that those systems of classification will be the most natural in which the organs of the highest value, and those least liable to change, are especially relied on in the determination of the affinities of plants.

Taking these principles as our guide, we should regard the organs of reproduction as of the highest importance, and we find accordingly that while some plants have flowers with evident sexes, others have no flowers, and their sexual organs are more or less concealed; hence the former are called Phanerogamous or Phænogamous, and the latter Cryptogamous. The former are also reproduced by true seeds containing an embryo, whilst the latter are reproduced by spores in which we have no such structure as an embryo; hence these characters are of the first importance.

Next in importance comes the presence or absence of an ovary, as such a difference is accompanied by essential structural and functional peculiarities, and we have thus the two great divisions of Angiospermous and Gymnospermous plants.

Next in value is the structure of the embryo itself, as it contains within itself in a rudimentary condition all the essential organs of a plant. Hence as the embryo varies in the number of its cotyledons, cotyledonous plants are further divided into two classes—those possessing one cotyledon being called Monocotyledonous, and those with two, Dicotyledonous.

Next in importance is the presence or absence of a stem, giving the names of Cormophytes and Thallophytes; whilst in those with stems the internal structure and development presents us with well-marked and important characters.

The characters founded upon the position and relation of the stamens and carpels to each other, as also to the floral envelopes; as well as the presence or absence of one or both of the floral envelopes, and the union or otherwise of their constituent parts, although not of the highest importance, are of much value in the subordinate divisions.

The leaf also is of some importance as regards its venation: thus, in Cormophytes the leaves or fronds have commonly a forked venation; those of Monocotyledonous plants are parallel-veined; while those of Dicotyledonous plants are net-veined or reticulated. Again, stemless plants have no true leaves, but produce a flattened cellular expansion or thallus, which has no true veins.

Such are the general principles which should be attended to by those who arrange plants according to their natural affinities; but it must be borne in mind, that even in the best devised natural systems there must be (at least at present) much that is artificial, so that all that we mean by a Natural System is, that it expresses, as far as is possible only, the arrangement of plants according to their natural affinities. (See page 411.) This imperfection of our natural systems necessarily arises from our incomplete knowledge of existing plants ; for as our acquaintance with new species is becoming every day extended, our views are liable to be modified or changed, and even supposing plants be ever so naturally arranged, we should be still unable to place them in a linear series, for 'Different groups touch each other at several different points, and must be considered as alliances connected with certain great centres. We find also that it is by no means easy to fix the limits of groups. There are constantly aberrant orders, genera, and species, which form links between the groups, and occupy a sort of intermediate territory. In this, as in all departments of natural science, there are no sudden and abrupt changes, but a gradual transition from one series to another. Hence exact and rigid definitions cannot be carried out. In every natural system there must be a certain latitude given to the characters of the groups, and allowances must be made for constant anomalies, in so far as man's definitions are concerned.'

Natural Systems.—We now proceed to give an abstract of the more important natural systems. The first attempt at arranging plants according to their natural affinities was by our celebrated countryman, John Ray, in the year 1682 ; and imperfect as any scheme must necessarily have been at that day, when the number of plants known was very limited, still his arrangement was in its leading divisions correct, and has formed the foundation of all succeeding systems. He divided plants thus :—

1. Flowerless.
2. Flowering ; these being again subdivided into
    a. Dicotyledons.
    b. Monocotyledons.

Ray still further grouped plants together into genera, which were equivalent to our natural orders, many of which indicated a true knowledge of natural affinities, and are substantially represented at the present day by such natural orders as the Fungi, Musci, Filices, Coniferæ, Labiatæ, Compositæ, Umbelliferæ, and Leguminosæ.

Next in order was the scheme propounded by the celebrated author of the most perfect artificial system ever devised for the arrangement of plants, namely, Linnæus, who, about the year 1751, drew up a sketch of the natural affinities of plants under the name of Fragments. Many of the divisions thus prepared by Linnæus are identical with natural orders as at present defined, among which we may mention Orchideæ, Gramina, Compositæ (nearly), Umbellatæ, Asperifoliæ, Papilionaceæ, Filices, Musci, and Fungi.

Jussieu's Natural System.—To Antoine Laurent de Jussieu, however, belongs the great merit of having first devised a comprehensive natural system. His method was first made known in the year 1789. It was founded upon the systems of Ray and Tournefort, to which he made some important additions, more especially in considering the position of the stamens with respect to the ovary. The following table, which requires no explanation, represents his arrangement.

			Class.
Acotyledons			1. Acotyledones.
Monocotyledons		Stamens hypogynous.	2. Monohypogynæ.
		Stamens perigynous.	3. Monoperigynæ.
		Stamens epigynous.	4. Monoepigynæ.
Dicotyledons.	Apetalæ	Stamens epigynous.	5. Epistamineæ.
		Stamens perigynous.	6. Peristamineæ.
		Stamens hypogynous.	7. Hypostamineæ.
	Monopetalæ	Corolla hypogynous.	8. Hypocorollæ.
		Corolla perigynous.	9. Pericorollæ.
		Corolla epigynous.	10. Epicorollæ Synantheræ (anthers coherent).
			11. Epicorollæ Corisantheræ (anthers distinct).
	Polypetalæ	Petals epigynous.	12. Epipetalæ.
		Petals hypogynous.	13. Hypopetalæ.
		Petals perigynous.	14. Peripetalæ.
	Diclines irregulares		15. Diclines.

Under these fifteen classes Jussieu arranged 100 natural orders or families. This was the first natural arrangement in which an attempt was made to assign characters to natural orders, but so admirably were these drawn up, that they have formed the basis of all succeeding systematists. Indeed, the limits of a great many of Jussieu's natural orders are identical with those of the present day.

De Candolle's Natural System.—The next system of note after that of Jussieu, was that of Augustin Pyramus de Candolle, which was first promulgated in 1813. This system, modified, however, in some important particulars, is that which is most in use at the present day, and which, generally, in its essential divisions, we shall adopt in this volume. In the first place, De Candolle divided plants into two great divisions or sub-kingdoms, called Vasculares or Cotyledoneæ, and Cellulares or Acotyledoneæ, the characters of which are as follows:—

Division 1. *Vasculares*, or *Cotyledoneæ*; that is, plants possessing both cellular (parenchymatous) tissue and vessels; and having an embryo with one or more cotyledons.

Division 2. *Cellulares*, or *Acotyledoneæ*; that is, plants composed of cellular (parenchymatous) tissue only; and whose embryo is not furnished with cotyledons.

The former division was again divided into two classes, called Exogenæ or Dicotyledoneæ, and Endogenæ or Monocotyledoneæ, the essential characters of which may be thus stated:—

Class 1. *Exogenæ*, or *Dicotyledoneæ*; that is, plants whose vessels are arranged in concentric layers, of which the youngest are the outermost and the softest; and having an embryo with opposite or whorled cotyledons.

Class 2. *Endogenæ*, or *Monocotyledoneæ*; that is, plants whose vessels are arranged in bundles, the youngest being in the middle of the trunk; and having an embryo with solitary or alternate cotyledons.

These classes were again divided into sub-classes or groups. Thus, under the Dicotyledoneæ were placed four groups, named Thalamifloræ, Calycifloræ, Corollifloræ, and Monochlamydeæ. Under the Monocotyledoneæ two groups were placed, called Phanerogamæ and Cryptogamæ. The latter group, which included the higher Cryptogamia, was placed under Monocotyledoneæ from a mistaken idea that the plants included in it possessed an embryo of a somewhat analogous character to that of monocotyledonous plants. The Acotyledoneæ were also divided into two groups, called Foliosæ and Aphyllæ.

The following is a tabular view of De Candolle's system.

Sub-kingdom 1. VASCULARES, OR COTYLEDONEÆ.

Class 1. *Exogenæ*, or *Dicotyledoneæ*.

Sub-class 1. *Thalamifloræ*	Petals distinct, inserted with the stamens on the thalamus.
2. *Calycifloræ*	Petals distinct or more or less united, and inserted on the calyx.
3. *Corollifloræ*	Petals united, and inserted on the thalamus.
4. *Monochlamydeæ*	Having only a single circle of floral envelopes, or none.

Class 2. *Endogenæ*, or *Monocotyledoneæ*.

Sub-class 1. *Phanerogamæ*	Fructification visible, regular.
2. *Cryptogamæ*	Fructification hidden, unknown, or irregular.

Sub-kingdom 2. CELLULARES, OR ACOTYLEDONEÆ.

Sub-class 1. *Foliosæ*	Having leaf-like expansions, and known sexes.
2. *Aphyllæ*	Having no leaf-like expansions, and no known sexes.

Under these sub-classes De Candolle arranged 161 Natural Orders. The enumeration of these is unnecessary in an elementary volume; we shall content ourselves with mentioning a few only, as examples of the different groups. Thus, as examples of *Thalamifloræ*—Cruciferæ, Caryophylleæ, and Malvaceæ; of *Calycifloræ*—Rosaceæ, Umbelliferæ, and Compositæ; of *Corollifloræ*—Convolvulaceæ, Solaneæ, and Labiatæ; of *Monochlamydeæ*—Polygoneæ, Urticeæ, and Amentaceæ; of *Phanerogamæ*—Orchideæ, Irideæ, and Gramineæ; of *Cryptogamæ*—Filices, Equisetaceæ, and Lycopodineæ; of *Foliosæ*—Musci and Hepaticæ; and of *Aphyllæ*—Lichenes, Fungi, and Algæ.

In this system it will be observed that De Candolle adopted the primary divisions of Jussieu, but he reversed the order of their arrangement; for instead of commencing with Acotyledons, and passing through Monocotyledons to Dicotyledons, he began with the latter, and proceeded by the Monocotyledons to Acotyledons.

Since the appearance of De Candolle's system numerous other arrangements have been proposed by botanists, as those of Agardh, Perleb, Dumortier, Bartling, Lindley, Schultz, Endlicher, and many others. As all these systems, with the exception of those of Lindley and Endlicher, were never much used, and are not adopted in great systematic works of the present day, it will be unnecessary for us to allude to them further. But the latter having been used in important systematic works, it will be advisable for us to give a general sketch of their leading characters.

ENDLICHER'S NATURAL SYSTEM.—The system of Endlicher is adopted in his 'Genera Plantarum,' published between the years 1836–1840. The following is a sketch of this system. He first divided plants into two great divisions, which he denominated Regions, and named Thallophyta and Cormophyta. These were again divided into Sections and Cohorts, as follows :—

Region 1. THALLOPHYTA. Plants with no opposition of stem and root; with no vessels and no sexual organs; and with germinating spores lengthening in all directions.

Section 1. *Protophyta.* Plants developed without soil; drawing nourishment from the element in which they grow; and having a vague fructification; as in Algæ and Lichens.

Section 2. *Hysterophyta.* Plants formed on languid or decaying organisms; nourished from a matrix; all the organs developing at once, and perishing in a definite manner; as in Fungi.

Region 2. CORMOPHYTA. Plants with stem and root in opposite directions; spiral vessels and sexual organs distinct in the more perfect.

Section 3. *Acrobrya.* Stem growing at the point only, the lower part being unchanged, and only used for conveying fluids.

Cohort 1. *Anophyta.* Having no spiral vessels; both sexes perfect; spores free in spore-cases. Examples, Hepaticæ and Musci.

Cohort 2. *Protophyta.* Having vascular bundles more or less perfect; male sex absent. Spores free in one- or many-celled spore-cases. Examples, Filices and Equisetaceæ.

Cohort 3. *Hysterophyta.* Having perfect sexual organs; seeds without an embryo, polysporous; parasitic. Example, Rhizantheæ.

Section 4. *Amphibrya.* Stem growing at the circumference. Examples, Gramineæ, Liliaceæ, Iridaceæ, Orchidaceæ, and Palmaceæ.

Section 5. *Acramphibrya.* Stem growing at both the apex and circumference.

Cohort 1. *Gymnospermæ.* Ovules naked, receiving impregnation immediately by the micropyle; as in Coniferæ.

Cohort 2. *Apetalæ.* Calyx absent, rudimentary, or simple, calycine or coloured, free or united to the ovary. Examples, Cupuliferæ, Urticaceæ, and Polygoneæ.

Cohort 3. *Gamopetalæ.* Both floral envelopes present, the outer calycine, the inner corolline, the latter being monopetalous; rarely abortive. Examples, Compositæ, Labiatæ, Scrophularineæ, and Ericaceæ.

Cohort 4. *Dialypetalæ.* Both floral envelopes present, the outer being monosepalous or polysepalous, free or united to the ovary, calycine or sometimes corolline; the inner being corolline with distinct petals, or rarely cohering by means of the base of the stamens, and with an epigynous, perigynous, or hypogynous insertion; rarely abortive. Examples, Umbelliferæ, Ranunculaceæ, Cruciferæ, Caryophylleæ, Rosaceæ, and Leguminosæ.

Under these divisions Endlicher included 277 Natural Orders. After Jussieu, he commenced with the simplest plants and gradually proceeded to the more complicated, placing those of the Leguminosæ at the highest point of the series.

LINDLEY'S NATURAL SYSTEM.—To Lindley especially belongs the merit of having been the first botanist who made any serious attempt to introduce a natural arrangement of plants into use in this country. The first system proposed by him in 1830 was but a slight modification of that of De Candolle. No attempt was made in this system to form minor groups or divisions of the tribes; but in 1833, in a new system, Lindley arranged the natural orders in groups subordinate to the higher divisions, which were called Nixus (tendencies). These primary divisions were again divided into Sub-classes, Cohorts, and Nixus or groups of nearly allied Natural Orders. In 1838, Lindley again altered his arrangement so far as regarded Exogens; and finally, in the year 1845, further modified his views, and proposed the following scheme, which was that adopted by him in his great work on 'The Vegetable Kingdom.'

LINDLEY'S NATURAL SYSTEM.

1. ASEXUAL, OR FLOWERLESS PLANTS.

Stem and leaves undistinguishable . Class 1. Thallogens.
Stem and leaves distinguishable . . Class 2. Acrogens.

2. SEXUAL, OR FLOWERING PLANTS.

Fructification springing from a thallus Class 3. Rhizogens.
Fructification springing from a stem.
Wood of stem youngest in the centre; cotyledon single.
Leaves parallel-veined, permanent; wood of the stem always confused . . . . Class 4. Endogens.
Leaves net-veined, deciduous; wood of the stem, when perennial, arranged in a circle with a central pith . . . Class 5. Dictyogens.
Wood of stem youngest at the circumference, always concentric; cotyledons two or more.
Seeds quite naked . . . Class 6. Gymnogens.
Seeds enclosed in seed vessels . Class 7. Exogens.

The Exogens were further divided into four sub-classes thus:—

Sub-class 1. *Diclinous Exogens*, or those with unisexual flowers, and without any customary tendency to form hermaphrodite flowers.

Sub-class 2. *Hypogynous Exogens*, or those with hermaphrodite or polygamous flowers; and stamens entirely free from the calyx and corolla.

Sub-class 3. *Perigynous Exogens*, or those with hermaphrodite or polygamous flowers, and with the stamens growing to the side of either the calyx or corolla; ovary superior, or nearly so.

Sub-class 4. *Epigynous Exogens*, or those with hermaphrodite or polygamous flowers, and with the stamens growing to the side either of the calyx or corolla; ovary inferior, or nearly so.

Neither of the other classes are divided into sub-classes, but of Endogens four sections are distinguished thus :—

1. Flowers glumaceous (that is to say, composed of bracts not collected in true whorls, but consisting of imbricated colourless or herbaceous scales).
2. Flowers petaloid, or furnished with a true calyx or corolla, or with both, or absolutely naked; unisexual (that is, having sexes altogether in different flowers, without half-formed rudiments of the absent sexes being present).
3. Flowers furnished with a true calyx and corolla; adherent to the ovary; hermaphrodite.
4. Flowers furnished with a true calyx and corolla, free from the ovary; hermaphrodite.

Under the above classes Lindley includes 303 Natural Orders, which are arranged in fifty-six groups subordinate to the sections, sub-classes, and classes, and which are termed Alliances.

Bentham and Hooker's System.—The essential features of this system for the arrangement of the Phanerogamia, which is adopted in their great work, 'Genera Plantarum,' are as follow :—

Division I. Phanerogamia.
  Sub-division 1. Angiospermia.
    Class 1. *Dicotyledones.*
      Sub-class 1. Polypetalæ.
        Series 1. Thalamifloræ.
          2. Discifloræ.
          3. Calycifloræ.
      Sub-class 2. Gamopetalæ or Monopetalæ.
        Series 1. Inferæ or Epigynæ.
          2. Superæ.
          3. Dicarpiæ.
      Sub-class 3. Monochlamydeæ or Incompletæ.
        Series 1. Curvembryæ.
          2. Multiovulatæ aquaticæ.

Series 3. Multiovulatæ terrestres.
4. Micrembryæ.
5. Daphnales.
6. Achlamydosporeæ.
7. Unisexuales.
8. Ordines anomali.

Class 2. *Monocotyledones.*
Series 1. Microspermæ.
2. Epigynæ.
3. Coronarieæ.
4. Calycinæ.
5. Nudifloræ.
6. Apocarpæ.
7. Glumaceæ.

Sub-division 2. GYMNOSPERMIA.

The series in the above system in the sub-classes Polypetalæ and Gamopetalæ are further divided into Cohorts as follows :—

Sub-class 1. POLYPETALÆ.

Series 1. Thalamifloræ.
Cohort 1. Ranales.
2. Parietales.
3. Polygalineæ.
4. Caryophyllineæ.
5. Guttifcrales.
6. Malvales.

Series 2. Discifloræ.
Cohort 1. Geraniales.
2. Olacales.
3. Celastralcs.
4. Sapindales.

Series 3. Calycifloræ.
Cohort 1. Rosales.
2. Myrtalcs.
3. Passiflorales.
4. Ficoidales.
5. Umbellales.

Sub-class 2. GAMOPETALÆ.

Series 1. Inferæ or Epigynæ.
Cohort 1. Rubialcs.
2. Astcrales.
3. Campanales.

Series 2. Superæ.
Cohort 1. Ericales.
2. Primulales.
3. Ebcnales.

Series 3. Dicarpiæ or Bicarpellatæ.
Cohort 1. Gentianales.
2. Polemoniales.
3. Personales.
4. Lamiales.

No division of the series is made in 'Genera Plantarum;' but in the English translation of Le Maout and Decaisne's 'Traité Général de Botanique,' which was edited by Sir. J. D. Hooker, the sub-class Monochlamydeæ and the class Monocotyledones are divided as follows:—

Sub-class 3. MONOCHLAMYDEÆ.
Division 1. Ovary superior (*Superæ*).
Cohort 1. Chenopodiales.
2. Laurales.
3. Daphnales.
4. Urticales.
5. Amentales.
6. Euphorbiales.
7. Piperales.
8. Nepenthales.

Division 2. Ovary inferior (*Inferæ*).
Cohort 1. Asarales.
2. Quernales.
3. Santalales.

Class 2. *Monocotyledones.*
Division 1. Ovary inferior (*Inferæ*).
Cohort 1. Hydrales.
2. Amomales.
3. Orchidales.
4. Taccales.
5. Narcissales.
6. Dioscorales.

Division 2. Ovary superior (*Superæ*).
Sub-division 1. Ovary apocarpous (*Apocarpæ*).
Cohort 1. Triurales.
2. Potamales.

Sub-division 2. Ovary syncarpous (*Syncarpæ*).
Cohort 1. Palmales.
2. Arales.
3. Liliales.
4. Pontederales.
5. Commelynales.
6. Restiales.
7. Glumales.

For full particulars in reference to this system, reference should be made to Bentham and Hooker's 'Genera Plantarum,' and to the English translation of Le Maout and Decaisne's 'Traité Général de Botanique,' edited by Sir J. D. Hooker. The essential characters of the various divisions are also described below under the head of 'Natural System adopted in this Manual,' and in the chapter describing the 'Arrangement, Characters, &c., of the Natural Orders.'

Besides the above systems, others are now much used in Germany, as those of A. Braun and Caruel of the Phanerogamia; and those of Sachs and others of the Cryptogamia.

NATURAL SYSTEM ADOPTED IN THIS MANUAL.—The natural arrangement adopted in this volume, which is founded, so far as the Phanerogamia are concerned, upon the systems of De Candolle and Bentham and Hooker,—that of De Candolle being the basis, is as follows:—

The Vegetable Kingdom is first divided into two sub-kingdoms, namely:—Phanerogamia or Flowering Plants; and Cryptogamia or Flowerless Plants.

Sub-kingdom 1. *Phanerogamia* or *Flowering Plants*.—This includes plants which have evident flowers; and which are reproduced by seeds containing an embryo with one or more cotyledons.

Sub-kingdom 2. *Cryptogamia* or *Flowerless Plants*.—This includes those plants which have no flowers; and which are reproduced by minute bodies termed spores, which have no embryo.

SUB-KINGDOM I. PHANEROGAMIA OF FLOWERING PLANTS. These are divided as follows:—

Division I. *Angiospermia*, in which the ovules are distinctly enclosed in an ovary; and are fertilised indirectly by the action of the pollen on the stigma. Endosperm formed after fertilisation. It is divided thus:—

Class 1. DICOTYLEDONES, in which the embryo is dicotyledonous; the germination exorhizal; the stem exogenous; the leaves with a reticulated venation; and the flowers commonly with a quinary or quaternary arrangement. In this class we have three sub-classes.

Sub-class 1. POLYPETALÆ, with usually bisexual flowers, which are commonly furnished with a calyx and corolla, and the latter composed of distinct petals. This is divided into three series as follows:—

Series 1. *Thalamifloræ*, that is, plants, the flowers of which have usually the calyx, corolla, and stamens distinct from one another; ovary superior; and the stamens hypogynous.

Series 2. *Discifloræ.*—Thalamus furnished with a disk, which is hypogynous or adnate to the calyx or ovary; or bearing a series of glands; stamens arising from the disk and either hypogynous or perigynous; ovary superior, placentation usually axile.

Series 3. *Calycifloræ.*—Calyx usually gamosepalous; petals arising from the calyx or from a perigynous disk; stamens perigynous or epigynous, ovary superior or inferior.

Sub-class 2. GAMOPETALÆ or COROLLIFLORÆ, with usually bisexual flowers; calyx commonly gamosepalous; corolla gamopetalous; stamens inserted on the corolla or ovary, or rarely separate from the corolla, and arising directly from the thalamus; ovary superior or inferior. Of this sub-class we have three series, as follows:—

Series 1. *Inferæ* or *Epigynæ*, in which the calyx is adherent and the ovary consequently inferior; stamens epigynous.

Series 2. *Superæ*, in which the calyx is inferior; the stamens inserted on the corolla, or rarely on the thalamus; ovary superior (except in *Vacciniaceæ*), and usually more than 2-celled.

Series 3. *Dicarpiæ* or *Bicarpellatæ*, in which the ovary is usually superior, and composed of 2 carpels, or rarely 1-3; stamens inserted on the corolla.

Sub-class 3. MONOCHLAMYDEÆ or INCOMPLETÆ.—Flowers either have a calyx only (monochlamydeous), or without both calyx and corolla (achlamydeous); often unisexual. Of this sub-class we have two series, thus:—

Series 1. *Superæ*, in which the ovary is superior.

Series 2. *Inferæ* or *Epigynæ*, in which the ovary is inferior.

Class 2. MONOCOTYLEDONES, in which the embryo is monocotyledonous; the germination endorhizal; the stem endogenous; the leaves usually with a parallel venation; and the flowers with a ternary arrangement. This class may be divided into two sub-classes as follows:—

Sub-class 1. *Petaloideæ.*—Leaves with a parallel venation, or rarely reticulated, permanent or occasionally deciduous; floral envelopes (perianth) verticillate and usually coloured, rarely green or scaly, and sometimes absent. This sub-class may be divided into two series:—

Series 1. *Inferæ* or *Epigynæ*, in which the ovary is inferior, or rarely superior, as in some Bromeliaceæ and Hæmadoraceæ. Perianth usually in two whorls and both coloured.

Series 2. *Superæ*, in which the ovary is superior. Of this we have two sub-series.

Sub-series 1. *Apocarpæ*, in which the gynœcium is usually apocarpous, or rarely of one carpel (*simple*).

Sub-series 2. *Syncarpæ*, where the gynœcium is syncarpous, or in some Palms apocarpous.

Sub-class 2. *Glumaceæ.*—Leaves parallel-veined, permanent; flowers glumaceous, that is, having no proper perianth, but imbricate bracts instead.

Division II. *Gymnospermia*, in which the ovules are naked or not enclosed in an ovary, and are fertilised directly by the action of the pollen. Endosperm formed before fertilisation.

Sub-kingdom II. Cryptogamia or Flowerless Plants are those which have no proper flowers, that is, having no floral envelopes, stamens, or carpels, and which are reproduced by minute bodies termed spores, which have no embryo. This may be divided as follows:—

Division I. *Cormophyta.*—Plants with commonly roots, stems, and leaves, and with vascular tissue; or the latter is imperfect or entirely absent. This may be divided thus:—

Class 1. Vasculares or Vascular Cryptogams, or those containing evident vascular tissue. Of this we have two sub-classes as follows:—

Sub-class 1. *Isosporia*, producing spores of one kind only, from which prothallia free from the spores are developed, and containing both antheridia and archegonia.

Sub-class 2. *Heterosporia*, producing spores of two kinds, namely, *megaspores* or *macrospores*, and *microspores.* The megaspores develop a prothallium which remains attached to the spores, and which produces archegonia (female prothallium); and the microspores form a small rudimentary prothallium also confluent with the spores, which produces only antherozoids (male prothallium).

Class 2. Muscineæ, or Cormophytal Cryptogams without vascular tissue, or in which the latter is imperfect.

Division II. *Thallophyta.*—Plants without any distinction of roots, stems, and leaves, and which are entirely composed of parenchymatous tissue. This division has been variously divided by botanists; but as their arrangement at present is very transitional, reference must be made for full particulars to special treatises.

The following is a tabular arrangement of the above system:—

Sub-kingdom I. Phanerogamia or Flowering Plants.

- Division 1. Angiospermia.
  - Class 1. Dicotyledones.
    - Sub-class 1. Polypetalæ.
      - Series 1. Thalamifloræ.
      - 2. Discifloræ.
      - 3. Calycifloræ.
    - Sub-class 2. Gamopetalæ or Corollifloræ.
      - Series 1. Inferæ or Epigynæ.
      - 2. Superæ
      - 3. Dicarpiæ or Bicarpellatæ.
    - Sub-class 3. Monochlamydeæ or Incompletæ.
      - Series 1. Superæ.
      - 2. Inferæ or Epigynæ.
  - Class 2. Monocotyledones.
    - Sub-class 1. Petaloideæ.
      - Series 1. Inferæ or Epigynæ.
      - 2. Superæ.
        - 1. Apocarpæ.
        - 2. Syncarpæ.
    - Sub-class 2. Glumaceæ.
- Division 2. Gymnospermia.

Sub kingdom II. Cryptogamia or Flowerless Plants.

- Division 1. Cormophyta.
  - Class 1. Vasculares.
    - Sub-class 1. Isosporia.
    - 2. Heterosporia.
  - Class 2. Muscineæ.
- Division 2. Thallophyta.

CHAPTER 3.

ARRANGEMENT, CHARACTERS, DISTRIBUTION, PROPERTIES AND USES OF THE NATURAL ORDERS.

Having now given a general sketch of the more important Natural Systems—especially of that one which we propose to follow in this volume—and described the characters of its divisions, we proceed to the description of the various natural orders arranged under those divisions. Our attention will be chiefly directed to the principal orders, and especial importance will be given to their diagnostic characters,—or those only which are necessary for their distinction. In our notice of the natural systems, we have seen that some authors, as Jussieu, Endlicher, and Lindley, commence with the simplest forms of plants, and end with the most complicated; while others, as Ray, De Candolle, and Bentham and Hooker, take an opposite course, and proceed from the most highly developed plants to the simplest. We have adopted the latter plan here, because the more highly developed plants are much better known than those of lower organisation, and are of more general interest to the majority of our readers.

Sub-kingdom I.

PHANEROGAMIA OR FLOWERING PLANTS.

Division I. ANGIOSPERMIA.

Class I. Dicotyledones.

Sub-class I. *Polypetalæ.*

Series 1. Thalamifloræ.

Cohort 1. *Ranales.*—Gynœcium apocarpous, or very rarely syncarpous, or simple. Seeds usually albuminous.

Order 1. Ranunculaceæ, the Buttercup Order. — Character.—*Herbs*, or rarely climbing *shrubs*, with a watery, colourless, usually acrid juice. *Leaves* alternate or opposite, generally much divided (*figs.* 333, 334, and 371), or sometimes entire, with usually dilated and amplexicaul petioles. *Stipules* generally absent, but rarely present, and then adnate. *Inflorescence* definite (*fig.* 432) or indefinite. *Calyx* of 3–6, usually 5 (*fig.* 870) distinct sepals, regular (*figs.* 432 and 870) or irregular (*fig.* 457), green or rarely petaloid, deciduous or very rarely persistent; æstivation generally imbricate (*fig.* 870), sometimes valvate (*fig.* 792) or induplicate. *Corolla* of 3–15, usually 5 (*fig.* 870) distinct petals, regular (*fig.* 870) or irregular (*fig.* 496); æstivation imbricate (*fig.* 870), sometimes absent (*fig.* 792). *Stamens* numerous (*figs.* 792 and 870), or very rarely few, hypogynous (*figs.* 542 and 871, *e*); *anthers* adnate (*fig.* 872), bursting longitudinally. *Carpels* generally numerous (*figs.* 542 and 871, *p*), or rarely few or only 1, usually distinct and one-celled (*fig.* 875, *o*), or very rarely united so as to form a compound many-celled ovary; *ovary* with one (*fig.* 875, *g*) or many ovules; *ovules* anatropous, attached to the ventral suture (*fig.* 875); *styles* simple (*fig.* 871, *p*). *Fruit* various, either consisting of a number of dry achenes, or of one or more whorls of follicles (*fig.* 873), which are sometimes united below, or sometimes

FIG. 870.

FIG. 871.

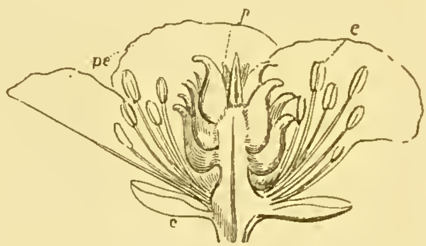


FIG. 872.

FIG. 873.

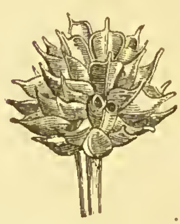


FIG. 874.

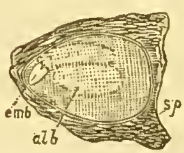


FIG. 875.

Fig. 870. Diagram of the flower of a species of *Ranunculus*.——*Fig.* 871. Vertical section of the flower of *Ranunculus acris*. *c.* Calyx. *pe.* Petals. *e.* Stamens. *p.* Carpels.——*Fig.* 872. Adnate anther of a Ranunculaceous plant.——*Fig.* 873. Numerous follicles of *Trollius europæus*.——*Fig.* 874. Vertical section of the seed of the Monkshood (*Aconitum*). *sp.* Coverings of the seed. *emb.* Embryo. *alb.* Albumen.——*Fig.* 875. Vertical section of a carpel of *Ranunculus acris*. *o.* Ovary. *g.* Ovule. *s.* Stigma.

there is only one follicle; or very rarely the fruit is baccate, with one or more seeds. *Seeds* solitary or numerous, when solitary, erect or pendulous; *embryo* minute (*fig.* 874, *emb*), at the base of homogeneous horny albumen, *alb*.

Diagnosis.—Herbs or rarely shrubs, with a colourless, watery, and usually acrid juice. Sepals, petals, and stamens distinct. hypogynous. Corolla with an imbricate æstivation. Stamens usually numerous; anthers adnate, bursting longitudinally. Carpels, except in a very few instances, more or less distinct.

Seeds with a minute embryo, and homogeneous horny albumen, anatropous.

Division of the Order and Illustrative Genera.—The order may be divided into five tribes as follows :—

Tribe 1. *Clematideæ.* Calyx valvate (*fig.* 792) or induplicate. Fruit consisting of a number of achenes. Seed pendulous. *Illustrative Genus* :—Clematis, *Linn.*

Tribe 2. *Anemoneæ.* Calyx imbricate, usually coloured. Fruit consisting of a number of achenes. Seed pendulous. *Illustrative Genus* :—Anemone, *Haller.*

Tribe 3. *Ranunculeæ.* Calyx imbricate (*fig.* 870). Fruit consisting of a number of achenes. Seed erect. *Illustrative Genus* :—Ranunculus, *Linn.*

Tribe 4. *Helleboreæ.* Calyx imbricate. Petals irregular or none. Fruit consisting of one or more whorls of many-seeded follicles (*fig.* 873), which are sometimes united below; or rarely baccate. *Illustrative Genera* :—Aconitum, *Linn.* ; Cimicifuga, *Elliott.*

Tribe 5. *Pæonieæ.* Calyx imbricate. Fruit consisting of from 2–5 follicles, which are more or less surrounded at the base by a cup-shaped disk (*fig.* 580). *Illustrative Genus* :—Pæonia, *Linn.*

Distribution and Numbers.—These plants occur chiefly in cold damp climates, and are almost unknown in the tropics, except on mountains. The order includes about 600 species.

Properties and Uses.—The plants of this order generally abound in an acrid principle, which in some is even vesicant. This acridity is, however, very volatile, so that in most cases it is dissipated by drying, or by infusing them in boiling, or even sometimes in cold water ; it varies also in different parts of the same plant, and even in the same parts at different seasons. Some plants contain in addition a narcotic principle ; and when these principles are in excess they are virulent poisons. Generally the plants of this order are to be regarded with suspicion, although some are simply bitter and tonic.

Aconitum.—Some species of this genus are very virulent poisons. The dried root of *Aconitum ferox*, which is known as Nepal or Indian aconite, has been usually considered to be the sole source of the celebrated Indian drug and poison, 'Bikh' or 'Bish' but this is also obtained indifferently from *A. Napellus, A. uncinatum, A. palmatum*, and probably others.—*Aconitum Napellus*, a European species, commonly called Monkshood, is the official plant of the British Pharmacopœia. The leaves, flowering tops, and root (more especially the latter), are poisonous, but when used in proper doses they are sedative, anodyne, and diuretic. Several fatal cases of poisoning have occurred from the root having been mistaken for Horse-radish. The other European species are almost inert. The properties of the above species are especially due to at least two powerful alkaloids, called *aconitine* and *pseud-aconitine*. The official *aconitine* is a mixture of these alkaloids, and probably others, in varying proportions, and has been much used externally in neuralgia and chronic rheumatism, and also occasionally internally in rheumatism and other diseases, but it is a dangerous remedy for internal use. The fresh leaves and flowering tops, the dried root, and aconitine, are official in the British Pharmacopœia. Other species have similar properties, as, for instance, the species yielding Japanese aconite roots or tubers, now supposed to be *A. Fischeri.* These roots contain a very powerful alkaloid named *japaconitine.* It is said to exceed in poisonous properties both aconitine and pseud-aconitine. The *Aconitum ferox* contains the largest amount of alkaloids of any known species. The root or rhizome of *Aconitum heterophyllum* has no poisonous properties; it is official in the Pharmacopœia of India, and has a reputation in India as a tonic and antiperiodic medicine. It is known in the Indian bazaars as *Atis* or *Atees.*

Actæa spicata, Baneberry.—The rhizome of this plant, as shown by the author, is a frequent adulteration in this country of Black Hellebore rhizome. The same adulteration has also been noticed on the Continent, and in America. The fruits are poisonous. (See *Cimicifuga*).

Cimicifuga.—The rhizome with the attached rootlets of *Cimicifuga* (*Actæa*) *racemosa* has been long used in the United States as a remedy in acute rheumatism, chorea, and various anomalous forms of nervous diseases. It has been introduced into this country, and employed with some success in similar diseases; and is now official in the British Pharmacopœia. In the form of a tincture it is also reputed to be a valuable external application for reducing inflammation; indeed, in such cases, it is said to be far more efficacious than tincture of arnica. It is the source of the eclectic remedy known in the United States as *cimicifugin.*

Clematis erecta and *C. Flammula.*—The leaves of these plants have been used as rubefacients and vesicants. Some other species possess analogous properties.

Coptis.—The root of *Coptis trifoliata*, Goldthread, which is a native of North America, is a pure and powerful bitter, and is used as a stomachic and tonic. The root of *Coptis Teeta*, commonly known in India as Coptis or Tita root, is found in the bazaars of India; and is official in the Pharmacopœia of India. It is also known under the name of Mishmi Bitter or Mahmira. It is intensely and powerfully bitter, and is a valuable tonic. Both these drugs contain *berberine.*

Delphinium Staphysagria.—The seeds of this plant were formerly employed for their emetic, purgative, and anthelmintic properties; but their violent action has led to their internal disuse. They are commonly known under the name of Stavesacre seeds. They contain an alkaloid, called *delphinine.* They are, however, still much used externally in various skin diseases, and are now official in the British Pharmacopœia; they are also employed externally for destroying vermin. Delphinine has also been used externally in neuralgia and rheumatism.—*D. Consolidum.*—The root and seeds contain *delphinine*, and have similar properties to Stavesacre seeds.

Helleborus.—The rhizome and rootlets of *Helleborus officinalis* constituted the Black Hellebore of the ancients, which was much used by them as a drastic hydragogue purgative.—*Helleborus niger* is the Black Hellebore of the present time; it is still occasionally employed in this country and elsewhere, and possesses similar properties to the former (see *Actæa*).—*Helleborus viridis* and *H. fœtidus* are also of a like nature, and may be used as efficient substitutes; indeed that of *H. viridis* is more powerful in its action.

Hydrastis canadensis.—The rhizome and rootlets, under the names of Yellow Root and Golden Seal, are used in the United States for their tonic properties; and are also reputed to exercise an especial influence over mucous surfaces. Their action is due to the presence of *berberine* and a peculiar alkaloid called *hydrastine.* The drug used by the eclectic practitioners in the United States under the name of *hydrastine* is obtained from it. Hydrastis is also used by the Indians of the Western States of North America to dye various shades of yellow.

Nigella sativa.—The seeds were formerly employed instead of pepper. They are regarded in India as carminative. It is supposed that these seeds, or those of another species used by the Afghans for flavouring curries, form the Black Cummin of Scripture (Isaiah xxviii. 25, 27).

Ranunculus.—*R. sceleratus* and *R. Flammula* are very acrid, which property is also possessed to a certain extent by many other species.—*R. Ficaria* has thickened roots which contain a good deal of starch; hence they have been used as food.

Xanthorrhiza apiifolia.—The root has a pure bitter taste, and possesses well-marked tonic properties. It is also used by the Indians in the southern parts of the United States as a yellow dye. It contains *berberine* as a constituent.

Many plants of the order are commonly cultivated in our gardens; as various species of *Clematis*, *Anemone*, *Ranunculus*, *Eranthis* (Winter Aconite), *Helleborus* (Christmas Rose), *Aquilegia* (Columbine), *Delphinium* (Larkspur), *Aconitum* (Monkshood), *Pæonia* (Pæony). *Pæonia Moutan* or *Moutan officinalis* is the Tree Pæony of China, which is remarkable for its very large showy flowers, and for the number of its blossoms: thus, Fortune mentions a plant in the neighbourhood of Shanghai which yearly produced from 300 to 400 flowers.

Order 2. DILLENIACEÆ, the Dillenia Order. — Character. —*Trees, shrubs*, or rarely *herbs*. *Leaves* usually alternate, very rarely opposite, generally *exstipulate*. *Sepals* 5, persistent, in two rows. *Petals* 5, deciduous, hypogynous, imbricate. *Stamens* numerous, hypogynous. *Carpels* 2—5, rarely 1, more or less distinct. *Fruit* formed of from 2—5 distinct or adherent carpels, rarely 1. *Seeds* numerous, or 2 or 1 by abortion, anatropous, arillate; *albumen* homogeneous, fleshy; *embryo* minute.

Diagnosis.—Stipules absent, except in rare cases. Sepals and petals 5 each, hypogynous; the former persistent in two rows, the latter with an imbricate æstivation. Carpels more or less distinct. Seeds numerous, arillate; albumen fleshy, homogeneous.

Distribution and Numbers.—The plants of this order occur chiefly in Australia, India, and equinoctial America; a few species have been also found in equinoctial Africa; none occur in Europe. *Illustrative Genera*:—Dillenia, *Linn.*; Candollea, *Labill.* There are nearly 200 species belonging to this order.

Properties and Uses.—These plants have generally astringent properties; they have been used as vulneraries, and for tanning in Brazil.

Dillenia.—The young calyces of some species have an acid taste and are employed as an ingredient of curries in some parts of India. Some species of *Dillenia* grow to a large size, and form hard durable timber.

Most of the Indian species belonging to the genus *Dillenia* are remarkable not only for their evergreen foliage, but also for the beauty of their flowers. They are sometimes cultivated as stove or greenhouse plants in this country.

Order 3. CALYCANTHACEÆ, the Calycanthus Order.—*Diagnosis.*—These are shrubby plants resembling the *Rosaceæ*, but they differ in having opposite leaves, which are always simple, entire, and exstipulate; in their sepals and petals being numerous, and similar in appearance; in having stamens whose anthers are adnate, and turned outwards; and by having convolute cotyledons. *They are placed here in accordance with the views of Bentham and Hooker.*

Distribution and Numbers.—They are natives of Japan and North America. *Illustrative Genera:*—Calycanthus, Chimonanthus. These are the only 2 genera, which include 6 species.

Properties and Uses.—The flowers generally are fragrant and aromatic; and the bark of *Calycanthus floridus*, Carolina All-spice, is sometimes used in the United States as a substitute for Cinnamon bark.

Order 4. MAGNOLIACEÆ, the Magnolia Order.—Character.—*Trees* or *shrubs*, with alternate leathery *leaves* (*fig.* 336), and with usually large convolute *stipules* which enclose the leaf-bud and fall off as it expands. *Sepals* usually three to six, deciduous. *Petals* three or more, hypogynous, in two or more rows. *Stamens* numerous, hypogynous (*fig.* 604, *e*). *Carpels* several, one-celled, often arranged upon an elongated thalamus (*fig.* 604, *c*). *Fruit* consisting of numerous dry or succulent, dehiscent (*fig.* 667) or indehiscent carpels, which are distinct or united at the base. *Seeds* anatropous, with or without an aril, solitary or several, often suspended from the fruit by a long funiculus (*fig.* 667); *embryo* minute; *albumen* fleshy, homogeneous.

Diagnosis.—Trees or shrubs. Leaves alternate, leathery. Stipules usually present, and then large and enveloping the leaf-bud, deciduous. Sepals and petals with a ternary arrangement of their parts, hypogynous, the former deciduous, the latter with an imbricate æstivation. Carpels distinct or coherent at the base. Albumen homogeneous.

Division of the Order.—The order may be divided into two tribes:—

Tribe 1. *Magnolieæ.*—Carpels distinct, arranged upon an elongated thalamus in a cone-like manner (*fig.* 604, *e*). Leaves not dotted or scarcely so. *Illustrative Genera:*—Liriodendron, *Linn.*; Magnolia, *Linn.*

Tribe 2. *Wintereæ.*—Carpels united at the base, and forming but one whorl. Leaves dotted and often exstipulate. *Illustrative Genera:*—Drimys, *Forst.*; Illicium, *Linn.*

Distribution and Numbers.—The majority of the plants of this order are found in North America. Some also occur in the West Indies, Japan, China, India, South America, Australia, and New Zealand. None have been found in Africa or any of the adjoining islands, or in Europe. The order contains about 170 species.

Properties and Uses.—These plants are chiefly remarkable for bitter, tonic, and aromatic properties.

Drimys Winteri.—The bark, which was formerly known under the name of Winter's Bark, has tonic, aromatic, antiscorbutic, and stimulant properties. It was often confounded with Canella Bark, which has been termed Spurious Winter's Bark. It was formerly much employed in this country, but at present it is very rarely or ever used. The Winter's Bark, as now found in commerce, is commonly obtained from *Cinnamodendron* *corticosum* (see *Cinnamodendron*), a native of Jamaica.—*Drimys granatensis* possesses similar properties.

Illicium anisatum, Star-Anise.—The whole plant, particularly the fruit, has the flavour and odour of the European Anise plant (*Pimpinella Anisum*). Star-Anise fruit is used by the Chinese as an aromatic and carminative, and also as a spice. A large portion of the Oil of Anise of commerce is now derived from this fruit. This oil and the fruit from which it is obtained, are official in the British Pharmacopœia; it is regarded as a superior oil to that obtained in Europe from the fruit of *Pimpinella Anisum*, which is also official, and was formerly the sole botanical source of Oil of Anise. The species of *Illicium* which grows in Japan is regarded as distinct by Siebold, and named *I. religiosum*, but more generally it is included by botanists under *I. anisatum*. Husemann, Holmes, and others, however, have recently given reasons for believing them distinct. The fruits of *I. religiosum* are occasionally imported; they have a faint aromatic odour and taste, which have been regarded as resembling bay leaves or camphor, but are entirely devoid of the characteristic anise taste and odour of the Chinese fruits. In Japan they are termed *Skimi*, *shikmi*, or *shikimi fruits*; and the recent observations of Geerts and others have shown that they are poisonous, as well as the oil which is obtained by expression from the seeds. This oil is used in Japan as a cheap lighting material and for lubricating purposes.

Liriodendron tulipifera, Tulip-tree.—The bark possesses bitter and tonic properties.

Magnolia.—*M. glauca*, Swamp Sassafras or Beaver Tree. The bark is tonic and aromatic, somewhat resembling that of Cinchona in its action. The unripe fruits of other species, as *Magnolia Frazeri* and *M. acuminata*, have similar properties.

Michelia Champaca.—The flowers of this plant, which is a native of India, yield a fragrant oil. (See *Cananga*, p. 436.)

Tasmannia aromatica.—The fruit is used in New Holland as a substitute for pepper.

The plants of this order are also remarkable for the fragrance and beauty of their flowers and foliage; hence they are favourite objects of culture in this country, either as hardy plants, such as several Magnolias and the Tulip-tree; or as stove and greenhouse plants, such as species of *Illicium*.

Order 5. SCHIZANDRACEÆ, the Schizandra Order.—Character.—Trailing *shrubs*. *Leaves* alternate, exstipulate, simple, often dotted. *Flowers* unisexual. *Calyx* and *corolla* with a ternary arrangement of their parts, hypogynous, imbricate. *Barren flower*:—*Stamens* numerous, monadelphous or distinct, hypogynous; *anthers* 2-celled, extrorse, with a thickened connective. *Fertile flower*:—*Carpels* numerous, 1-celled, distinct or united; *ovules* 2, pendulous. *Fruits* numerous, collected into a cluster, baccate. *Seeds* with abundant homogeneous fleshy albumen; *embryo* very minute. *This order is made a tribe of Magnoliaceæ by Bentham and Hooker.*

Diagnosis.—Trailing shrubs. Leaves alternate, exstipulate, simple. Flowers unisexual. Sepals and petals imbricate. Stamens numerous, hypogynous. Ovules pendulous; embryo very minute, with abundant homogeneous albumen.

Distribution and Numbers.—This small order only contains 12 species. These species occur in India, Japan, and the southern parts of the United States. *Illustrative Genera*:—Schizandra, *L. C. Rich.*; Hortonia, *Wight*.

Properties and Uses.—The plants of this order are insipid and mucilaginous. Some have edible fruits.

Order 6. ANONACEÆ, the Custard-apple Order.—Character.—*Trees* or *shrubs*. *Leaves* alternate, simple, exstipulate. *Calyx* of three sepals, generally united at the base, persistent. *Corolla* of six petals, in two whorls, leathery; *æstivation* usually valvate, hypogynous, rarely united, or more rarely altogether absent. *Stamens* usually numerous, and inserted on a large hypogynous thalamus; *connective* enlarged, 4-angled; *anthers* adnate. *Carpels* usually numerous, distinct or united, or very rarely solitary, with one or more anatropous *ovules*. *Fruit* composed of a number of dry or succulent carpels, which are distinct, or united so as to form a fleshy mass; or rarely simple. *Seeds* one or more, anatropous; *embryo* minute; *albumen* ruminated.

Diagnosis.—Trees or shrubs. Leaves alternate. No stipules. Calyx of 3 sepals, persistent. Petals 6, in two rows, hypogynous, usually valvate. Anthers adnate, with an enlarged 4-cornered connective. Albumen ruminated.

Distribution and Numbers.—The plants of this order are almost entirely confined to the tropical regions of Asia, Africa, and America. None are found in Europe. *Illustrative Genera*:—Xylopia, *Linn.*; Anona, *Linn.*; Monodora, *Dunal.* There are nearly 400 species in this order.

Properties and Uses.—Generally aromatic and fragrant in all their parts. Some have edible fruits, which are much esteemed.

Anona squamosa and *A. muricata* yield the agreeable succulent fruits of the East and West Indies, called Custard-apples: the fruit of *A. squamosa* is called Sweet-sop: that of *A. muricata*, Sour sop. They are now frequently imported into this country. Other species are also esteemed for their fruits, as *Anona reticulata*, which yields the netted Custard-apple, and *A. Cherimolia*, which produces the Cherimoyer of Peru. Another species, namely, *A. palustris*, is the source of West Indian Cork-wood, so called from its elasticity and lightness; the fruit is termed the Alligator Pear, but in consequence of the presence of a narcotic principle it is not eaten. This must not be confounded with the true *Avocado* or *Alligator Pear*, which is in much repute in the West Indies, and is derived from *Persea gratissima*. (See *Persea*.)

Cœlocline (*Unona*) *polycarpa*, DC.—The Berberine or Yellow-dye tree of Soudan.—The bark of this tree yields a beautiful yellow colour, which is much used as a dyeing material in certain parts of Africa. When reduced to a coarse powder, it is also a topical remedy of great repute in the treatment of indolent ulcers, and chronic leprous sores of the extremities. It contains *berberine*, to which its medicinal virtues are probably due.

Cananga (*Unona*) *odorata*.—The flowers yield a very fragrant oil, which is known under the names of *Ilang-ilang*, *Alanguilan*, *Oleum Unonæ*, and *Oleum Anonæ*. According to Guibourt, the oil known as *Macassar Oil* is Cocoa-nut oil digested with the flowers of *Michelia Champaca* (see *Michelia*, p. 435) and *Cananga odorata*, coloured yellow by means of turmeric.

Duguetia quitarensis.—According to Schomburgk, the strong elastic wood called Lance-wood, chiefly used by coachmakers, is furnished by this plant, which is a native of Guiana.

Monodora Myristica, the Calabash Nutmeg, has somewhat similar aromatic qualities to the true Nutmeg of commerce. These nutmegs are also commonly known as Jamaica or American nutmegs.

Uvaria febrifuga.—The fruit of this species is supposed to be the one which is used as a febrifuge by the Indians on the Orinoco; according to Martius, however, that is obtained from the *Xylopia grandiflora.*

Xylopia.—*X. aromatica* (*Habzelia æthiopica*), DC., is commonly known as *Piper æthiopicum.* The dried fruit is used by the African negroes on account of its stimulant and carminative effects, and also as a condiment.—*Xylopia undulata* has nearly similar properties.—*Xylopia glabra* yields the Bitter wood of the West Indies, which has tonic properties. The fruits of *X. longifolia* are used as a febrifuge throughout the valley of the Orinoco.

Order 7. MENISPERMACEÆ, the Moon-seed Order.—Character. — Climbing or trailing *shrubs. Leaves* alternate, simple, exstipulate, usually entire. *Flowers* generally diœcious, but sometimes imperfectly unisexual, rarely perfect or polygamous. *Barren flower*:—*Calyx* and *corolla* with a ternary arrangement of their parts, generally in two whorls, imbricate or valvate. *Stamens* usually distinct, sometimes monadelphous. *Carpels* rudimentary or wanting. *Fertile flower*:—*Sepals* and *petals* usually resembling those of the barren flower. *Stamens* imperfectly developed, or wanting. *Carpels* usually 3, sometimes 6, commonly supported on a gynophore, distinct, 1-celled, each containing one curved ovule. *Fruits* drupaceous, curved around a central placental process, 1-celled. *Seeds* 1 in each cell, and curved so as to assume the form of that cell; *embryo* curved; *albumen* present or absent; when present homogeneous, or partially divided into plates or convolutions by the projection inwards of the inner membranous covering of the seed.

Diagnosis.—Trailing or climbing shrubs. Leaves alternate, simple, exstipulate. Flowers usually diœcious. Sepals, petals, stamens, and carpels with a ternary arrangement, hypogynous. Carpels distinct. Fruits 1-celled, curved. Seed solitary, curved; embryo curved; albumen absent, or usually small in amount, and then either homogeneous or somewhat ruminated.

Miers remarks, 'that there is probably no family so completely heteromorphous as the Menispermaceæ, or which presents such extreme and aberrant features at variance with its normal structure.' Hence there is great difficulty in drawing up a satisfactory diagnosis of this order.

Distribution and Numbers.—The plants of this order are chiefly found in the forests of the tropical parts of Asia and America. None occur in Europe. *Illustrative Genera*:—Jateorhiza, *Miers*; Menispermum, *Tourn.* There are, according to Lindley, about 300 species included in this order; but some other botanists much reduce this number.

Properties and Uses.—These plants are chiefly remarkable for their narcotic and bitter properties. A few are mucilaginous. When the narcotic principle is in excess they are very poisonous. Some are valuable tonics.

Anamirta paniculata.—The fruit of this plant, which is known as *Cocculus indicus*, is poisonous. It has been extensively employed for a long period as a poison for taking fish and game, which it stupefies. It is also reputed to be used to a great extent (chiefly by publicans) to impart a bitter taste to malt liquor, and to increase its intoxicating effects; but it must be admitted that we have no very satisfactory evidence on this point. The average annual imports of *Cocculus indicus* from India are about 50,000 lbs., a quantity, it is said, sufficient to drug 120,000 tuns of beer. It has been also employed externally to destroy vermin, and for the cure of some skin diseases. It owes its active properties to a poisonous neutral principle contained in the seed, called *picrotoxin*. The pericarp also contains two isomeric alkaloids in minute quantity, which have been named *menispermine* and *paramenispermine*, of which but little is known.

Chondrodendron tomentosum.—The root of this plant, which is a native of Brazil, as shown by Hanbury, is the original *Pareira brava*, and is the drug on which its reputation was founded. It is official in the British Pharmacopœia. (See *Cissampelos.*) The stem possesses similar but less powerful properties; it is, however, frequently mixed with the root. Pareira root contains an alkaloid which has been named *cissampeline* or *pelosine*, but which Flückiger has proved to be identical with *beberine*, the active principle of Bebeeru bark. (See *Nectandra.*)

Cissampelos.—C. Pareira was official in the British Pharmacopœia as the botanical source of Pareira root. It possesses tonic and diuretic properties. The true Pareira root of commerce is not, however, derived from *Cissampelos Pareira*, but from *Chondrodendron tomentosum*, as noticed above in referring to that plant. Other spurious kinds of *Pareira brava* are derived from *Abuta rufescens*, which yields White Pareira brava; from *Abuta amara*, Yellow Pareira brava; and also from other Menispermaceous plants.

Coscinium fenestratum.—The wood and bark of the stem possess tonic and stomachic properties. The stems have been imported into this country from Ceylon, and sold as true Calumba root; they contain much *berberine.*

Jateorhiza.—Jateorhiza Calumba is now official in the British Pharmacopœia as the botanical source of Calumba root, so well known as a valuable stomachic and tonic. The tonic and stomachic properties of Calumba root are especially due to a peculiar neutral principle, called *calumbin*. It also contains *berberine* and *calumbic acid*, to the presence of which its properties are also, to some extent at least, due.

Menispermum canadense, Yellow Parilla or Moonseed.—The root yields the eclectic remedy called *menispermin*, which is reputed to be alterative, tonic, laxative, diuretic, and stimulant; and to be especially useful in syphilitic, cutaneous, and rheumatic affections. This root has also been sold in the United States under the name of Texas Sarsaparilla.

Tinospora cordifolia.—The root and stems are official in the Pharmacopœia of India, and are known under the name of Gulancha; they possess well-marked tonic, antiperiodic, and diuretic properties.

Order 8. BERBERIDACEÆ, the Barberry Order.—Character.—*Shrubs* or *herbaceous* perennial plants. Leaves alternate (*fig.* 383), compound, usually exstipulate. The leaves are frequently apparently simple, but in such cases it will be found that the blade is articulated to the petiole, which is evidence of their compound nature. The stem is generally free from hairs and other appendages of a similar character, but it is often spiny (*fig.* 383). These spines are nothing more than the hardened veins of some of the leaves, between which the parenchyma is not developed. *Sepals* 3, 4, or 6, deciduous, in two whorls (*fig.* 876). *Petals* equal to the sepals in number and opposite to them, or twice as many, hypogynous. *Stamens* hypogynous (*fig.* 878), equal to the petals in number, and opposite to them (*fig.* 876); *anthers* 2-celled, each opening by a valve from the bottom to the top (*figs.* 540 and 585), except in *Podophyllum* where they dehisce longitudinally. *Carpels* solitary, 1-celled (*figs.* 877 and 878); *style* somewhat lateral (*fig.* 877); *stigma* orbicular (*fig.* 878); *ovules* anatropous, attached to a marginal *placenta* (*figs.* 877 and 878). *Fruit* baccate, or dry and capsular. *Seeds* (*fig.* 879) usually with a minute *embryo*; *albumen* between fleshy and horny.

FIG. 876.

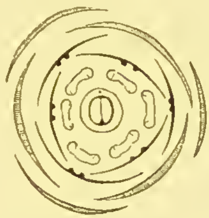


FIG. 877.

FIG. 878.

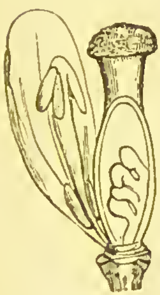


FIG. 879.

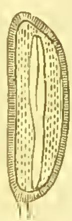


Fig. 876. Diagram of the flower of the Barberry (*Berberis*).——*Fig.* 877. Vertical section of the flower of *Epimedium*.——*Fig.* 878. Vertical section of the ovary of *Berberis*.——*Fig.* 879. Vertical section of the seed of *Berberis*, with the embryo in the axis surrounded by albumen.

Diagnosis.—Leaves alternate, very often spiny. Sepals 3, 4, or 6, deciduous. Petals hypogynous, and opposite to the sepals when equal to them in number. Stamens definite, hypogynous, opposite to the petals; anthers 2-celled, each opening by a recurved valve, except in *Podophyllum* where they dehisce longitudinally. Carpel solitary; placenta marginal; ovules anatropous. Seeds with albumen.

Distribution and Numbers.—They are found in the temperate parts of Europe, America, and Asia, and are very common in the mountainous parts of the North of India. *Illustrative Genera*:—Berberis, *Linn.*; Epimedium, *Linn.*; Leontice, *Linn.* The order includes about 100 species.

Properties and Uses.—These plants are generally acid, astringent, and bitter; but some are purgative. Their acid properties are due to the presence of oxalic acid.

Berberis vulgaris, the common Barberry.—The fruits of this and other species are acid and astringent, and form a refreshing preserve. Its bark and stem are very astringent, and are occasionally used by dyers in the preparation of a yellow dye. The common Barberry bark is sometimes employed to adulterate Pomegranate root-bark. It is said to be tonic in small doses, and cathartic in large ones. It owes its properties more especially to *berberine*. The root-bark of *B. Lycium*, *B. asiatica*, and *B. aristata*, forms Indian Barberry bark. This bark, which is official in the Pharmacopœia of India, possesses tonic, anti-periodic, and diaphoretic properties; and its extract, under the name of *Rusot*, is employed in India as a local application in ophthalmia and other affections of the eyes. The properties of Indian Barberry bark are especially due to the presence of the alkaloid *berberine*.

Caulophyllum thalictroides, Blue Cohosh.—The root (rhizome) has a reputation among the eclectic practitioners in the United States in certain uterine affections. It is regarded as a stimulating tonic and slight narcotic. The eclectic remedy termed *caulophyllin* which is obtained from it, is reputed to be antispasmodic, alterative, tonic, diuretic, and vermifuge.

Jeffersonia diphylla.—The root (rhizome) is popularly known as *rheumatism-root* in the United States, from its reputed value in rheumatism. It is commonly said to resemble senega root in its action, and to possess emetic, tonic, and expectorant properties.

Podophyllum peltatum, May-apple.—The rhizome and rootlets possess hydragogue cathartic properties, owing especially to the presence of a resin, which is frequently termed incorrectly *podophyllin*. The rhizome is official in the British Pharmacopœia as the source of the official *Resin of Podophyllum*, which is now largely used as a cholagogue, &c., in this country.

Order 9. LARDIZABALACEÆ, the Lardizabala Order.—Character.—*Shrubs* of a twining habit. *Leaves* alternate, exstipulate, compound. *Flowers* unisexual. *Barren flower*:—*Calyx* and *corolla* with a ternary arrangement of their parts, each in one or two whorls, deciduous. *Stamens* 6, opposite the petals, usually monadelphous, sometimes distinct. *Rudimentary carpels* 2 or 3. *Fertile flower*:—*Calyx* and *corolla* as before, but larger, hypogynous. *Stamens* 6, very imperfect and sterile. *Carpels* distinct, generally 3, rarely 6 or 9, 1-celled; *ovules* usually numerous, rarely 1, imbedded on the inner surface of the ovary. *Fruit* baccate, or sometimes follicular. *Seed* with usually a minute embryo in a large quantity of homogeneous albumen. *This order is placed in Berberidaceæ by Bentham and Hooker, and by Baillon; and by De Candolle in Menispermaceæ.*

Diagnosis.—Twining shrubs. Leaves alternate, exstipulate, compound. Unisexual flowers. Carpels distinct, superior. Seeds parietal, imbedded; embryo usually minute, with abundant homogeneous albumen.

Distribution and Numbers.—There are about 15 species belonging to this order. According to Lindley, two genera inhabit the cooler parts of South America; one is a tropical form, and the remainder are from the temperate parts of China. *Illustrative Genera*:—Stauntonia, *DC.*; Lardizabala, *Ruiz et Par.*

Properties and Uses.—The plants of this order appear to be without any active properties. Some have edible fruits. Others have been introduced into our greenhouses as evergreen climbers.

Order 10. CABOMBACEÆ, the Water-shield Order.—Character.—*Aquatic plants*, with floating peltate leaves. *Sepals* and *petals* 3 or 4, alternating with each other. *Stamens* definite or numerous. *Thalamus* flattened, small. *Carpels* 2 or more, distinct. *Fruit* indehiscent. *Seeds* few; *embryo* minute, enclosed in a vitellus, and outside of abundant fleshy albumen.

Diagnosis.—The only orders likely to be confounded with this, are the Nymphæaceæ and Nelumbiaceæ. The plants belonging to the Cabombaceæ are distinguished from the Nymphæaceæ, by having *distinct carpels, marginal placentas, few seeds, no evident thalamus*, and by the *presence of fleshy instead of farinaceous albumen*; and from the Nelumbiaceæ, by their *small thalamus*, by having *more than one seed in each carpel*, by their *minute embryo*, and their *abundant albumen*. *Both Cabombaceæ and Nelumbiaceæ are included in Nymphæaceæ by Bentham and Hooker.*

Distribution and Numbers.—There are but 3 species belonging to this order. They occur in America, Australia, and India. *Illustrative Genera*:—Cabomba, *Aubl.*; and Brasenia, *Pursh*, are the only genera.

Properties and Uses.—They have no important properties. *Brasenia (Hydropeltis) purpurea* is said to be nutritious.

Order 11. NYMPHÆACEÆ, the Water-lily Order.—Character.—*Aquatic perennial herbs. Leaves* usually floating, peltate or cordate. *Flowers* solitary, large and showy. *Sepals* inferior,

FIG. 880.

FIG. 881.

FIG. 882.

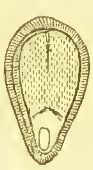


Fig. 880. Flower of Yellow Water-lily (*Nuphar luteum*).——*Fig.* 881. Ovary of *Nuphar* with numerous radiating stigmas.——*Fig.* 882. Vertical section of the seed of *Nymphæa alba*, showing the embryo enclosed in a vitellus, and on the outside of albumen.

usually 4 (*fig.* 453, *c, c, c, c*), or rarely 5 (*fig.* 880), persistent, generally petaloid on their inside. *Petals* numerous (*fig.* 453, *p, p, p, p*), deciduous, often passing by gradual transition into the stamens (*fig.* 453, *p, e*), in the same way as the sepals pass into the petals; inserted on a fleshy disk-like expansion of the thalamus below the stamens (*fig.* 522). *Stamens* numerous, placed upon the thalamus; *filaments* petaloid (*fig.* 453, *e*, 1, 2, 3, 4, 5); *anthers* adnate. *Thalamus* large, forming a disk-like expansion more or less surrounding the ovary, and having inserted upon it the petals and stamens (*fig.* 522). *Carpels* numerous, united so as to form a compound ovary (*fig.* 869); *ovary* many-celled (*fig.* 790); *styles* absent; *stigmas* radiating on the top (*figs.* 522 and 881), and alternate with the dissepiments. *Fruit* indehiscent, many-celled. *Seeds* numerous, attached all over the spongy dissepiments; *embryo* minute, enclosed in a separate sac or vitellus, and on the outside of farinaceous albumen (*fig.* 882).

Diagnosis.—Aquatic perennial herbs with cordate or peltate usually floating leaves. Thalamus large, and forming a disk-like expansion more or less surrounding the ovary, and having inserted upon it the petals and stamens. Sepals inferior, persistent; petals numerous; stamens numerous, with petaloid filaments and adnate anthers; carpels united so as to form a compound many-celled ovary; stigmas radiating on the top, and alternate with the dissepiments; ovules numerous, and attached all over the dissepiments. Embryo minute, on the outside of farinaceous albumen, enclosed in a vitellus.

Distribution and Numbers.—The plants of this order are chiefly found in quiet waters, throughout the whole of the northern hemisphere; they are, generally speaking, rare in the southern hemisphere. *Illustrative Genera*:—Victoria, *Lindl.*; Nymphæa, *Linn.* There are about 40 species.

Properties and Uses.—These plants have bitter and astringent properties. They have been also considered as sedative and narcotic; but there does not appear to be any foundation for such an opinion. Many contain a large quantity of starch both in their rhizomes and seeds; hence, such parts are used for food in some countries.

Victoria Regia.—This plant is a native of Equatorial America, and has been introduced into this country, where it has excited much interest, both on account of the beauty and size of its flowers, and its enormous and singularly constructed leaves. The flowers when fully expanded are more than a foot in diameter; and the leaves, which are turned up at their margins, vary from four to eight feet in diameter. The plant is commonly known in this country as the Victoria Water-lily, and in South America under the name of Water-maize, as the seeds are there used for food, for which purpose they are commonly roasted with Maize or Indian Corn. The rhizomes also contain a large quantity of starch.

Order 12. NELUMBIACEÆ, the Water-bean Order.—Character.—*Aquatic herbs. Leaves* peltate, rising above the water. *Flowers* large and showy. *Sepals* 4 or 5. *Petals* numerous, in several whorls. *Stamens* numerous, in several whorls; *filaments* petaloid. *Thalamus* very large (*fig.* 654, *thal*), flattened at the top, and excavated so as to present a number of cavities, each of which contains a single *carpel* (*fig.* 654, *carp*). *Fruit* consisting of the ripened nut-like carpels, which are half-buried in the cavities of the thalamus. *Seed* solitary, or rarely 2; without *albumen*; *embryo* large, enclosed in a membrane, with two fleshy cotyledons, and a much-developed plumule. *This order,* *as we have already stated, is included in Nymphæaceæ by Bentham and Hooker.*

Diagnosis.—Aquatic herbs with peltate leaves. Thalamus very large, flattened at the top, and excavated so as to present a number of cavities. Carpels distinct, and partially imbedded in the large honeycombed thalamus. Fruit of numerous, usually 1-seeded, nut-like bodies. Albumen none; plumule very large.

Distribution and Numbers.—These beautiful water plants are natives of stagnant or quiet waters of temperate and tropical regions in the northern hemisphere; they are most abundant in the East Indies. *Illustrative Genus:*—There is but 1 genus, *Nelumbium*; which includes 3 species.

Properties and Uses.—The nut-like fruits of all the species are edible, as well as their rhizomes, which contain starch like those of Nymphæaceous plants.

Nelumbium speciosum.—The fruit of this plant is commonly considered to have been the Egyptian Bean of Pythagoras; and the flower the sacred Lotus so often represented on the monuments of Egypt and India. The plant, however, is no longer found in Egypt, but it is common in India. The leaves and peduncles contain a large number of spiral vessels; these, when extracted, are used for wicks, 'which on great and solemn occasions are burnt in the lamps of the Hindoos placed before the shrines of their gods.'

Cohort 2. *Parietales.*—Gynœcium syncarpous; placentation parietal, or very rarely axile.

Order 1. SARRACENIACEÆ, the Side-saddle-flower Order.—Character.—*Perennial herbs*, growing in boggy places, with radical hollow leaves, which are pitcher- or trumpet-shaped (*figs.* 391 and 392). *Sepals* 4—6, usually 5, persistent, imbricate. *Petals* 5, hypogynous, sometimes absent. *Stamens* numerous, hypogynous; *anthers* adnate, 2-celled. *Carpels* 3—5, united so as to form a compound 3—5-celled ovary; *ovules* numerous; *placentas* axile; *style* simple and truncate, or expanded at its top into a large shield-like angular process with one stigma beneath each of its angles. *Capsule* 3—5-celled, dehiscing loculicidally. *Seeds* numerous, attached to large axile placentas; *albumen* abundant.

Diagnosis.—Perennial boggy plants, with pitcher or trumpet-shaped leaves. Calyx permanent, imbricate. Carpels united so as to form a compound ovary, and a 3—5-celled dehiscing fruit, with large axile placentas; albumen abundant.

Distribution and Numbers.—There are 8 species, of which 6 are confined to the bogs of North America, 1 occurs in Guiana, the other species is found in California. *Illustrative Genera:*—Sarracenia, Heliamphora.

Properties and Uses.—The pitchers are lined by glandular hairy appendages; these secrete a peculiar digestive fluid which dissolves any insects that find their way into them. The solution thus formed is ultimately absorbed, and appears to be necessary for the healthy condition of these plants.

Sarracenia.—The rhizome, rootlets, and leaves of *Sarracenia purpurea* were formerly vaunted as a specific in small-pox, but from extensive trials in the hospitals of this and other countries, they have been found to be entirely useless.—*S. variolaris* and *S. flava* are reputed to be diuretic and mildly purgative, and useful in dyspepsia, headache, &c. The properties, however, of all the species seem to be unimportant.

Order 2. PAPAVERACEÆ, the Poppy Order.—Character.—*Herbs* or *shrubs*, usually with a milky juice (white or coloured). *Leaves* alternate, exstipulate. *Sepals* usually 2 (*fig.* 883) or rarely 3, caducous (*fig.* 471). *Petals* 4 (*figs.* 883 and 884), or rarely 6, or some multiple of 4, or very rarely wanting ; usually crumpled in æstivation (*fig.* 883), hypogynous. *Stamens* generally numerous (*figs.* 883 and 884), hypogynous (*figs.* 32 and

FIG. 883.

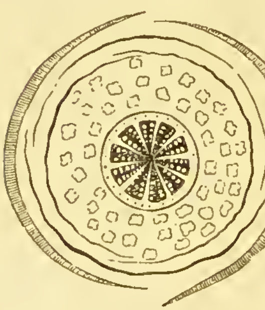


FIG. 884.

FIG. 885.

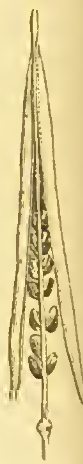


Fig. 883. Diagram of the flower of the Poppy, with two sepals, four crumpled petals, numerous stamens, and a compound one-celled ovary with several parietal placentas projecting into its interior so as to nearly divide it into several cells.——*Fig.* 884. Flower of Celandine (*Chelidonium majus*). *sti.* Two stigmas on the apex of a lengthened or pod-like ovary.——*Fig.* 885. Siliquæform or pod-shaped capsule (*ceratium*) of Celandine.

884) ; *anthers* 2-celled, innate (*fig.* 32). *Ovary* 1-celled, with 2 or more (*figs.* 623 and 883) parietal placentas, which project more or less from the walls into its cavity, and in *Romneya* actually adhere in the axis ; *styles* absent (*fig.* 32) or very short ; *stigmas* 2 (*fig.* 884, *sti*), or many (*fig.* 32, *sti*), alternate with the placentas, and opposite the imperfect dissepiments ; when numerous, they form a star-like process on the top of the ovary (*fig.* 32); *ovules* numerous (*fig.* 623). *Fruit* 1-celled, and either pod-shaped with 2 parietal placentas (*fig.* 885), or capsular with several placentas ; dehiscing by valves (*fig.* 885) or pores, or sometimes indehiscent. *Seeds* usually numerous ; *embryo* in fleshy-oily albumen (*fig.* 775).

Diagnosis.—Usually herbs with a milky juice. Leaves alternate and exstipulate. Peduncles 1-flowered ; flowers regular and symmetrical. Calyx and corolla with a binary or ternary arrangement of their parts, deciduous, hypogynous. Stamens numerous, hypogynous; anthers 2-celled, innate. Ovary compound, 1-celled, with parietal placentas, stigmas alternate to the placentas. Fruit 1-celled, except in *Romneya*. Seeds numerous, albuminous.

Distribution and Numbers.—Nearly two-thirds of the plants of this order are natives of Europe, and are mostly annuals. They are almost unknown in tropical regions, and are but sparingly distributed out of Europe in a wild condition. *Illustrative Genera:*—Papaver, *Linn.*; Chelidonium, *Linn.* The order includes above 130 species.

Properties and Uses.—The plants of this order are in almost all cases characterised by well-marked narcotic properties. Some are acrid, while others are purgative. In a medicinal point of view, this order must be regarded as the most important in the Vegetable Kingdom, from its yielding Opium, undoubtedly the most valuable drug of the Materia Medica.

Argemone mexicana, Mexican or Gamboge Thistle.—The seeds have narcotico-acrid properties. An oil may be obtained from them by expression, which possesses aperient and other properties, and has been recommended as a remedy in cholera. In the West Indies, the seeds are also used as a snbstitute for Ipecacuanha. In the East Indies, the oil is likewise employed as an external application in certain skin diseases.

Chelidonium majus, Celandine.—The Celandine is a native of this country, growing especially in the neighbourhood of towns and villages. It has an orange-colonred juice of a poisonons nature, which is a popular external application for the cure of warts, and has been used successfully in opacities of the cornea. It has been also administered internally, and is reputed aperient, dinretic, and stimulant.

Papaver.—*P. somniferum*, Opium Poppy.—Opinm is the juice obtained by incisions from the unripe capsules of this plant, inspissated by spontaneons evaporation. It has been known from early times, having been allnded to by Hippocrates, Diagoras, and Dioscorides. Various kinds of opium have been described under the names of Turkey, Smyrna, or Asia Minor, Egyptian, Persian, European, Indian, Chinese, and others. Opium which is produced in Asia Minor is that most commonly nsed in this country, and is alone official for all the preparations of the British Pharmacopœia, except the alkaloids which may be obtained from other kinds of opium. Its consumption is largely on the increase; thus, in 1839, the quantity imported into Great Britain was 41,000 pounds, and in 1852, 114,000 pounds, and it is very much greater at the present time. Thus the average annual exports of opium from Smyrna alone are now probably more than 300,000 pounds. But India is the great opium producing country, for here the quantity of opium produced annually is nearly 12,000,000 pounds. Of this enormous quantity at least 8,000,000 pounds are exported to and consumed in China, representing a market value of about as many pounds sterling. Opium is also now largely produced in China. Opium possesses in a marked degree the narcotic properties of the plants of the order from which it is obtained. In large doses it is a narcotic poison. It is also regarded as soporific, anodyne, and antispasmodic. Its narcotic properties are chiefly due to a peculiar alkaloid called *morphine*, which is combined with *meconic acid*. Its properties are also due, to some extent at least, to other peculiar principles which it contains, as *codeine*, *narcotine*, *narceine*, *thebaine*, *meconine*, and a number of others, the properties of which are but little known. The alkaloids *codeine* and *morphine* in the form of some of its salts, and *meconic acid*, are official in the British Pharmacopœia. While the juice obtained from the unripe pericarp has been proved to possess such active properties, the seeds are bland and wholesome. They yield by expression an oil which is much used on the Continent and in this country, as a substitute for olive oil and for other purposes. It is one of the oils employed for the purpose of adulterating olive oil. The cake left after the oil has been extracted may be used for fattening cattle. The dark-coloured seeds are known as *Maw seeds*, and are largely eaten by birds. They are also used as a medicine for them.—*Papaver Rhœas*, the common Red or Corn Poppy, has scarlet or red petals, as its name implies. A syrup prepared from the fresh petals (which are official in the British Pharmacopœia) is used as a colouring ingredient by the medical practitioner. The fresh petals are also supposed to possess slight narcotic properties.

Sanguinaria canadensis, Puccoon.—The rhizome and rootlets of this plant, which is a native of North America, contain a red juice, from which circumstance it is commonly termed Blood-root. This so-called root is used internally in large doses as an emetic and purgative, and in smaller doses as a stimulant, diaphoretic, and expectorant. It is also said by Eberle to exercise a sedative influence on the heart, as certain as that of Digitalis. When applied externally, it has been stated to have well-marked escharotic properties, and has been used, combined with chloride of zinc, as an external application for the destruction of cancerous growths; but from trials in this country it has been proved valueless for such a purpose.

Many genera belonging to this order are commonly cultivated in our gardens, as *Papaver*, *Argemone*, *Rœmeria*, *Platystemon*, *Eschscholtzia*, &c.

Order 3. FUMARIACEÆ, the Fumitory Order.—Character.—*Smooth herbs* with a watery juice. *Leaves* alternate, much divided, exstipulate. *Sepals* 2 (*fig.* 886), deciduous. *Petals* 4,

FIG. 886.

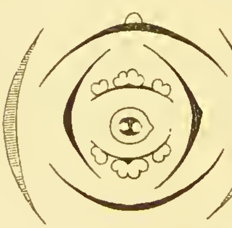


FIG. 887.

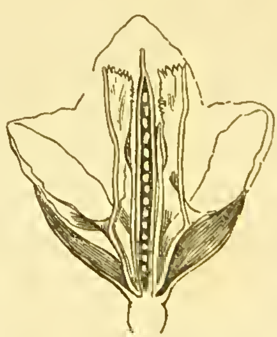


FIG. 888.

FIG. 889.

Fig. 886. Diagram of the flower of *Corydalis*, with two sepals, four petals in two whorls, six stamens in two bundles, and a one-celled ovary with two parietal placentas.——*Fig.* 887. Vertical section of the flower of *Hypecoum*.——*Fig.* 888. Upper or posterior petal of *Corydalis*, spurred at the base, and a bundle of three stamens.——*Fig.* 889. Vertical section of the seed of *Fumaria*.

cruciate, very irregular, in two whorls (*fig.* 886); one or both of the outer petals being gibbous or spurred (*figs.* 886 and 888), and the two inner frequently united at the apex. *Stamens* hypogynous, usually 6, diadelphous, the two bundles being opposite the outer petals, and containing an equal number of stamens (*fig.* 886), the middle stamen of each bundle having a 2-celled anther (*fig.* 886), the two outer with 1-celled anthers (*fig.* 886); in rare cases there are four stamens, which are then distinct and opposite the petals. *Ovary* superior (*fig.* 887), 1-celled, with parietal placentas (*figs.* 886 and 887); *style* short, or long and filiform; *stigma* obtuse or lobed; *ovules* amphitropous. *Fruit* indehiscent and 1- or 2-seeded, or two-valved and dehiscent, or a succulent indehiscent pod-like fruit; in the two latter cases containing a number of seeds. *Seeds* shining, crested; *embryo* abaxial, minute (*fig.* 889); *albumen* fleshy. *This order is included in Papaveraceæ by Bentham and Hooker.*

Diagnosis.—Smooth herbs, with a watery juice, and alternate exstipulate much-divided leaves. Flowers very irregular and unsymmetrical, and either purple, white, or yellow. Sepals 2, deciduous. Stamens hypogynous, usually 6, diadelphous, or 4, distinct; always opposite to the petals. Ovary superior with parietal placentas; ovules amphitropous. Embryo minute, abaxial, in fleshy albumen.

Distribution and Numbers.—The plants of this order principally occur in thickets and waste places in the temperate latitudes of the northern hemisphere. *Illustrative Genera*:—Dicentra, *Borkh.*; Fumaria, *Tourn.* There are about 110 species.

Properties and Uses.—These plants possess slightly bitter, acrid, astringent, diaphoretic, emmenagogue, and aperient properties. The rhizomes or tubers of *Dicentra* (*Corydalis*) *formosa* are the source of *corydalin*, which is used by the eclectic practitioners in the United States of America in syphilis, scrofula, &c.; but the properties of this and other plants of the order appear to be unimportant. Some species are cultivated in our gardens and greenhouses. The most important of these is *Dicentra* (*Dielytra*) *spectabilis*, which has very showy flowers, but, like all other plants of the order, it is scentless.

Order 4. Cruciferæ, the Cruciferous Order.—Character.—*Herbs*, or very rarely shrubby plants. *Leaves* alternate, exstipulate. *Flowers* usually yellow or white, rarely purple, or some mixture of these colours; *inflorescence* racemose (*fig.* 891) or corymbose; usually ebracteated. *Sepals* 4 (*fig.* 890), deciduous; *æstivation* imbricate or rarely valvate. *Petals* 4 (*figs.* 25, *p*, and 890), hypogynous, arranged in the form of a Maltese cross, alternate with the sepals, deciduous. *Stamens* 6, tetradynamous (*fig.* 892, *ee*), hypogynous. *Thalamus* furnished with small green glands (*fig.* 892, *gl*) placed between the stamens. *Ovary* superior (*fig.* 892), with two parietal placentas (*fig.* 615 and 893), 1-celled, or more usually 2-celled (*fig.* 890) from the formation of a spurious dissepiment called the *replum* (*fig.* 615, *cl*); *ovules* generally numerous, arranged alternately on two parietal placentas so as to form a single row, amphitropous or campylotropous ; *style* none (*fig.* 892), or very short ; *stigmas* 2 (*fig.* 893), opposite the placentas. *Fruit* a siliqua (*figs.* 682 and 893), or silicula (*figs.* 714, 894, and 895), 1- or 2-celled, 1- or many-seeded. *Seeds* stalked, generally pendulous (*figs.* 893 and 894) ; *embryo* with the radicle variously folded upon the cotyledons (*figs.* 776, 777, 778, 896, and 897) ; *albumen* none.

Diagnosis.—Generally ebracteated herbs. Inflorescence indefinite ; racemose or corymbose. Sepals and petals 4, deciduous, regular, the latter cruciate. Stamens tetradynamous. Ovary with two parietal placentas ; stigmas 2. Fruit a siliqua or silicula. Seeds stalked, without albumen, and with the radicle variously folded upon the cotyledons. *No other order is likely to be confounded with this if ordinary care be taken, as tetradynamous stamens only occur here, except in a very few plants belonging to the order Capparidaceæ.*

FIG. 890.

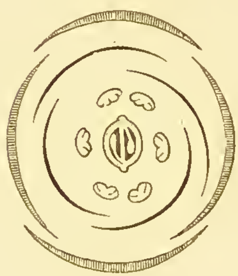


FIG. 891.

Fig. 890. Diagram of a Cruciferous flower.——*Fig.* 891. Portion of the flowering branch of the Wallflower.

Division of the Order and Illustrative Genera.—This large and truly natural order has been divided into sub-orders according to the nature of the fruit, and also as to the mode in which the embryo is folded. The latter is the most natural arrangement.

The sub-orders founded on the nature of the fruit are as follows :—

Sub-order 1. *Siliquosæ.*—Fruit a siliqua (*fig.* 682), opening by valves longitudinally. *Illustrative Genera :*—Cheiranthus, *Linn.* ; Brassica, *Linn.*

Sub-order 2. *Siliculosæ latiseptæ.*—Fruit a silicula opening by valves ; the replum in its broader diameter (*fig.* 895). *Illustrative Genus :*—Cochlearia, *Linn.*

Sub-order 3. *Siliculosæ angustiseptæ.*—Fruit a silicula opening by valves ; the replum in its narrower diameter (*fig.* 894). *Illustrative Genera* :—Capsella, *Mœnch* ; Iberis, *Linn.*

Sub-order 4. *Nucumentaceæ.*—Fruit an indehiscent silicula ; often 1-celled, owing to the absence of the replum. *Illustrative Genus* :—Isatis, *Linn.*

Fig. 892.

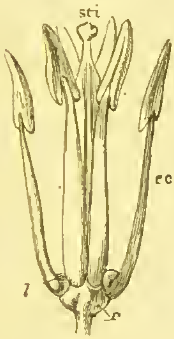
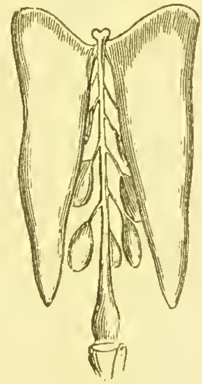


Fig. 893.

Fig. 894.



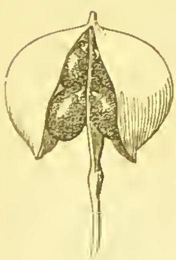


Fig. 895.

Fig. 896.

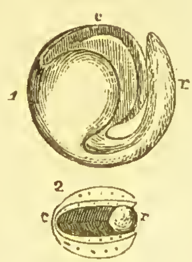


Fig. 897.

Fig. 892. Essential organs of the Wallflower (*Cheiranthus Cheiri*). *r.* Thalamus. *gl.* Glands. *ec.* Tetradynamous stamens. *sti.* Stigmas.——*Fig.* 893. An unripe siliqua of the Wallflower, with one of the valves removed to show the replum, and the stalked pendulous seeds.——*Fig.* 894. The silicula of Shepherd's Purse (*Capsella Bursa-pastoris*) in the act of dehiscing, showing the stalked pendulous seeds.——*Fig.* 895. Silicula of the Scurvy-grass (*Cochlearia officinalis*) in the act of dehiscing.——*Fig.* 896. The embryo of *Bunias orientalis.*——*Fig.* 897. The embryo of the Cabbage plant (*Brassica oleracea*). 1. Undivided. 2. Horizontal section. *r.* Radicle. *c.* Cotyledons.

Sub-order 5. *Septulatæ.*—The valves of the fruit opening longitudinally and bearing transverse septa in their interior. There are no examples among British plants.

Sub-order 6. *Lomentaceæ.*—Fruit a siliqua or silicula, dividing transversely into 1-seeded portions, the true siliqua sometimes barren ; the beak placed above it containing one or two seeds. *Illustrative Genera* :—Cakile, *Gaert.* ; Raphanus, *Linn.*

The arrangement of Bentham and Hooker is essentially the same as the above.

The sub-orders founded on the mode in which the embryo is folded are as follows :—

Sub-order 1. *Pleurorhizeæ* (O =) (*fig.* 778).—Cotyledons accumbent, flat; radicle lateral. *Illustrative Genera*:—Cheiranthus, *Linn.*; Arabis, *Linn.*

Sub-order 2. *Notorhizeæ* (O ||) (*fig.* 777).—Cotyledons incumbent, flat; radicle dorsal. *Illustrative Genera*:—Hesperis, *Linn.*; Isatis, *Linn.*

Sub-order 3. *Orthoploceæ* (O ≫) (*fig.* 897).—Cotyledons conduplicate, longitudinally folded in the middle; radicle dorsal, within the fold. *Illustrative Genera*:—Brassica, *Linn.*; Raphanus, *Linn.*

Sub-order 4. *Spirolobeæ* (O || ||) (*figs.* 776 and 896).—Cotyledons twice folded, linear, incumbent. *Illustrative Genus*:—Bunias, *Linn.* There are no examples among British plants.

Sub-order 5. *Diplecolobeæ* (O || || ||).—Cotyledons thrice folded, linear, incumbent. *Illustrative Genera*:—Senebiera, *DC.*; Subularia, *Linn.*

Distribution and Numbers.—The plants of this order chiefly inhabit temperate climates. A large number are also found in the frigid zone, and a few in tropical regions, chiefly on mountains. The order includes about 1,600 species.

Properties and Uses.—This order is generally characterised by antiscorbutic and pungent properties, frequently combined with acridity; it is one of the most natural in the Vegetable Kingdom, and does not contain a single poisonous plant. The seeds frequently contain a fixed oil. Many of our commonest culinary vegetables are derived from this order.

Anastatica hierochuntina, Rose of Jericho.—This plant, which is found wild in the deserts of Egypt and Syria, is remarkable for its hygrometric properties. Thus, when it is full grown, and its branches have become dry and withered, it contracts and coils up, so as to assume the form of a ball, and in this state it is blown about by the winds from place to place: but if it be then exposed to moisture, it uncoils, and the branches expand again as if restored to life. 'Some superstitious tales are told of it, among which, it is said to have first bloomed on Christmas Eve to salute the birth of the Redeemer, and paid homage to His resurrection by remaining expanded till Easter.' In Palestine it is termed 'Kaf Maryam,' Mary's Flower.

Brassica.—This genus contains several species which are commonly cultivated as food for man and cattle.—*Brassica Rapa* is the common Turnip; and the Swedish Turnip is probably a hybrid between *Brassica campestris* and *B. Rapa* or *B. Napus*, but according to some it is derived from *B. campestris*.—*B. Napus* yields Rape, Cole, or Colza seeds, from which may be expressed a large quantity of bland fixed oil, which is much employed for burning and other purposes. The cake left after the expression of the oil is also used as food for cattle, &c., under the name of Oil-cake. The seeds of *B. chinensis* yield Shanghai Oil.—*B. oleracea*, the Wild Cabbage, is supposed to be the original species from which have been derived, by cultivation, all the varieties of Cabbages, Kohl-Rabi, Greens, Broccoli, and Cauliflowers. The Kohl-Rabi is produced by the stem enlarging above the ground into a fleshy knob, resembling a turnip. Broccoli and Cauliflowers are deformed inflorescences.—*B. nigra* and *B. alba* were formerly placed under the genus *Sinapis*, L.; but this genus is now commonly included in *Brassica*. The seeds of these two species are in common use in medicine and for culinary purposes, and the seedlings are also employed as salads; those of the former are dark-coloured, and are known as Black Mustard seeds; those of the latter have a yellowish colour, and are termed White Mustard seeds—both kinds are official. Flour of mustard, so extensively used as a condiment, is prepared from a mixture of commonly two parts of powdered Black and three of White Mustard seeds: the proportions, however, used by different manufacturers vary. Both the Black and White Mustard seeds contain a large quantity of fixed oil, which is readily obtained by submitting them to pressure; this expressed oil is called *fixed oil of mustard*. It is remarkable that we do not find ready formed in either Black or White Mustard seeds the pungent acrid principle or principles for which mustard is especially distinguished. But when Black Mustard seeds are distilled with water, they yield a very acrid and pungent volatile oil, on which their virtues essentially depend. The elements of this oil exist in the seed, in the forms of *myronate of potash* or *sinigrin* and *myrosin*. These substances, when mixed through the medium of water, cause the formation of the volatile oil of mustard, which is official in the British Pharmacopœia. But the active properties of White Mustard seeds are not due to the presence of a volatile oil, as no such oil can be obtained from them by distillation with water, or otherwise; but they are owing to a fixed acrid oily principle, which is developed under the influence of water, by the action of *myrosin*, one of its constituents, on a crystalline principle which it also contains, called *sinalbin* or *sulpho-sinapisin*. Flour of mustard is given internally as a stimulant, diuretic, and emetic; and externally applied, it is irritant, rubefacient, &c. The volatile oil is a powerful vesicant. White Mustard seeds are also taken in an entire state as a stimulant in dyspepsia. The seeds of *Sinapis juncea*, a native of India, possess similar properties to those of Black and White Mustard seeds; they are official in the Pharmacopœia of India, under the name of *Sinapis indica*.

Camelina sativa, Gold of Pleasure.—The seeds are stated to be valuable as food for cattle. They contain a large quantity of oil.

Cardamine pratensis, Cuckoo-flower.—The flowers were formerly much used for their stimulant and diaphoretic properties, and have long been a popular remedy for epilepsy in children.

Cochlearia.—*C. Armoracia* (*Armoracia rusticana*).—The root is the common Horseradish, so much used as a condiment. Several fatal cases of poisoning have occurred from the substitution of Aconite or Monkshood root for that of Horseradish, which it is supposed to resemble. Fresh Horseradish root is official in the British Pharmacopœia; it is used in medical practice—*externally*, as an irritant, rubefacient, and vesicant, and *internally* as a stimulant, diuretic, and masticatory. Its virtues depend upon the formation of a small quantity of volatile oil, under the influence of water, from the supposed presence of the same principles as those contained in Black Mustard seeds. (See *Brassica.*)—*C. officinalis*, Scurvy-grass, was long esteemed for its anti-scorbutic properties.

Crambe maritima, Sea-kale.—The stem and leaf-stalks of this plant, by cultivation under diminished light, form a much esteemed vegetable. In the wild state the plant possesses a good deal of acridity, but this is almost entirely removed by cultivation as above.

Isatis tinctoria, Woad.—This plant yields a dark-blue dye, which was formerly much used in this country and other parts of Europe, but it is now rarely or ever employed, having been superseded by Indigo. In China also, a blue dye is obtained from the fruits of *Isatis indigotica*.

Lepidium sativum, Garden Cress.—This is well known as a pungent salad; it is commonly used for that purpose mixed with the seedlings of the Mustard plants.

Nasturtium officinale.—This plant is the common Watercress, so well known as an excellent and wholesome salad. It has been highly spoken of as a remedial agent in the treatment of cachectic diseases. According to Mulder, it contains iodine.

Raphanus sativus.—This is the common Radish, so much employed as a salad, &c. The siliques of *Raphanus caudatus*, when about half-grown, are good as a boiled vegetable; and in a still younger state they form an agreeable salad, having a mild radish-like flavour.

Sinapis.—This genus is now commonly included in that of *Brassica* (which see).

Many plants of the order are favourite objects of culture in our gardens, such as the Stock (*Matthiola*), Wallflower (*Cheiranthus Cheiri*), Candytuft (*Iberis umbellata*), Honesty (*Lunaria biennis*), &c.

Order 5. CAPPARIDACEÆ, the Caper Order.—Character.—*Herbs, shrubs*, or rarely *trees*. *Leaves* alternate, exstipulate, or rarely with spiny stipulate appendages. *Sepals* 4 (*fig.* 656, *cal*), sometimes cohering more or less; *æstivation* imbricate or valvate, equal or unequal. *Petals* usually 4 (*fig.* 656, *cor*), cruciate, imbricate, generally unequal and unguiculate, rarely 8, or sometimes none. *Stamens* numerous or definite, if 6, very rarely tetradynamous, placed usually upon a prolonged thalamus or stalk by which they are raised above the calyx and corolla (*fig.* 656, *st*). *Ovary* (*fig.* 656, *ov*) placed on a gynophore or sessile, 1-celled; *placentas* 2 or more, parietal; *style* filiform or wanting; *ovules* amphitropous or campylotropous. *Fruit* 1-celled, usually many-seeded, very rarely 1-seeded, either pod-shaped and dehiscent, or baccate and indehiscent. *Seeds* generally reniform, without albumen; *embryo* curved; *cotyledons* leafy.

Diagnosis.—Herbs, shrubs, or trees, with alternate leaves. Sepals and petals 4 each, the latter cruciate, and generally unequal. Stamens usually numerous, very rarely tetradynamous, commonly inserted on a stalk, which raises them above the calyx and corolla. Ovary 1-celled, placentas parietal. Fruit dehiscent or indehiscent, 1-celled. Seeds generally reniform; embryo curved; no albumen.

Division of the Order and Illustrative Genera.—The order has been divided, according to the nature of the fruit, as follows:—

Sub-order 1. *Cleomeæ*.—Fruit capsular and dehiscent. *Illustrative Genera*:—Gynandropsis, *DC.*; Cleome, *DC.*

Sub-order 2. *Cappareæ*.—Fruit baccate and indehiscent. *Illustrative Genera*:—Cadaba, *Forsk.*; Capparis, *Linn.*

Distribution and Numbers.—The plants of the order are found in tropical and sub-tropical regions of the globe. In Africa they are especially abundant. The common Caper (*Cap-*

paris spinosa), which inhabits rocky places in the south of Europe, is the only European species, and also that one which is found farthest north. The order contains about 360 species.

Properties and Uses.—In their properties these plants resemble in many respects the Cruciferæ, being generally pungent, stimulant, and antiscorbutic. Others are aperient, diuretic, and anthelmintic. In some plants the pungent principle is highly concentrated, or probably is in itself deleterious, so that those in which it is found are very poisonous.

Cadaba indica.—The root is reputed to be aperient and anthelmintic.

Capparis.—The flower-buds of various species of this genus are used to form the well-known pickle called Capers. Thus, *Capparis spinosa* is that employed in the south of Europe, *C. Fontanesii* in Barbary, and *C. ægyptiaca* in Egypt. *C. ægyptiaca* is stated to be the Hyssop of Scripture. Capers are stimulant, antiscorbutic, and aperient. The fruit of *C. coriacea* has been lately recommended as a valuable remedy in epilepsy, and generally for nervous and hysterical affections.—*C. Sadada* has a small fruit which possesses an acrid peppery taste, and is an important article of food in some parts of Africa. The fruit of one species, said to be allied to *C. pulcherrima*, and which is found in the neighbourhood of Carthagena, is extremely poisonous.

Cleome.—Some species are very pungent, and are used as condiments like our mustard.

Cratæva religiosa is commonly employed amongst the natives in India as a stomachic and tonic. The root of *C. gynandra*, the Garlic Pear, is said to be vesicant.

Gynandropsis pentaphylla, a native of India, is reputed to be antispasmodic. The bruised leaves are rubefacient, and even vesicant; and its seeds are used as a substitute for mustard, and, like mustard seeds, contain a fixed oil.

Polanisia.—Some species of this genus are also employed like mustard. The root of *P. icosandra* is used internally as a vermifuge, and externally as a rubefacient, &c.

Order 6. Resedaceæ, the Mignonette Order.—Character.—*Herbs*, or rarely small *shrubs*. *Leaves* alternate, entire or divided, exstipulate, or with minute glandular stipules. *Calyx* with from 4—7 divisions. *Petals* 2—7, entire or with a deeply lobed or fringed limb (*fig.* 499), unequal. *Disk* fleshy, large, hypogynous, one-sided. *Stamens* definite, inserted on the disk. *Ovary* sessile, 1-celled (*fig.* 621); *ovules* amphitropous or campylotropous; *placentas* (*fig.* 621, *pl*) parietal; *stigmas* 3, sessile. *Fruit* usually opening at the apex long before the seeds are ripe (*fig.* 621), 1-celled. *Seeds* usually numerous, reniform; *embryo* curved, without albumen.

Diagnosis.—Usually herbs, with alternate leaves and unsymmetrical flowers. Disk large, hypogynous, one-sided. Stamens definite, not tetradynamous. Ovary sessile, 1-celled, with parietal placentation; stigmas 3, sessile. Fruit usually opening at the apex before the seeds are ripe. Seeds generally numerous, reniform, exalbuminous.

Distribution and Numbers.—They are chiefly natives of Europe and the adjoining parts of Africa and Asia. A few occur in the north of India, Cape of Good Hope, and California. *Illustrative Genera:*—Reseda, *Linn.*; Astrocarpus, *Neck.* There are about 45 species in this order.

Properties and Uses.—But little is known of their properties. The plants are generally somewhat acrid, and were formerly supposed to be sedative.

Reseda.—*Reseda odorata* is the Mignonette plant, which is so much esteemed for the fragrance of its flowers.—*Reseda luteola*, a common plant in this country, and known under the name of Weld, yields a yellow dye.

Order 7. CISTACEÆ, the Rock-rose Order.—Character.—*Shrubs* or *herbs*, often viscid. *Leaves* opposite or alternate, entire, stipulate or exstipulate. *Flowers* showy. *Sepals* usually 5 (*fig.* 898), sometimes 3, persistent, unequal; *æstivation* of the three inner twisted. *Petals* usually 5 (*fig.* 898), very rarely 3, caducous, hypogynous, frequently corrugated in the bud, and twisted in a reverse way to that of the sepals. *Stamens* (*fig.* 898) distinct, hypogynous, definite or indefinite. *Ovary* 1-(*fig.* 898) or

FIG. 898.

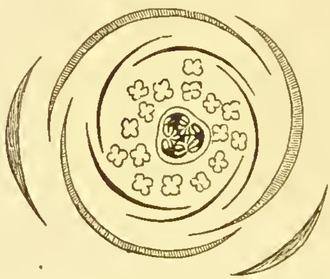


FIG. 899.

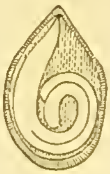


Fig. 898. Diagram of the flower of a species of *Helianthemum.*——*Fig.* 899. Section of the seed of a species of *Cistus*, the pointed end being its apex.

many-celled from parietal septa; *ovules* orthotropous; *style* single; *stigma* simple. *Fruit* capsular, usually 1-celled, with 3—5, or rarely 10 valves; or imperfectly 3—5—10-celled; *placentas* parietal (*fig.* 898). *Seeds* definite or numerous, albuminous (*fig.* 899); *embryo* (*fig.* 899) curved or spiral, with the radicle remote from the hilum.

Diagnosis.—Leaves entire. Sepals and petals with a ternary or quinary arrangement, twisted in æstivation; the former persistent, the latter caducous. Stamens hypogynous, distinct. Ovary with parietal placentas and orthotropous ovules; style single; stigma simple. Fruit capsular. Seeds with mealy albumen; embryo inverted, curved or spiral.

Distribution and Numbers.—These plants are most abundant in the south of Europe and the north of Africa. Some few are found in other parts of the globe. *Illustrative Genera:*—Cistus, *Tourn.*; Helianthemum, *Tourn.* There are about 200 species.

Properties and Uses.—These plants have generally resinous and balsamic properties. Some are regarded as stimulant, expectorant, and emmenagogue.

Cistus creticus.—The fragrant resinous substance called Ladanum or Labdanum is obtained from this plant in the Levant, and also from *C. ladaniferus*, *C. laurifolius*, and *C. salvifolius.* Ladanum was formerly used as a stimulant and expectorant; and is still employed by the Turks as a perfume, and for fumigation.

Order 8. VIOLACEÆ, the Violet Order.—Character.—*Herbs* or *shrubs. Leaves* simple, stipulate (*fig.* 379), with an involute vernation, alternate or sometimes opposite. *Sepals* 5 (*fig.* 797), persistent, imbricate, usually prolonged at the base. *Petals* 5 (*fig.* 797), hypogynous, equal or unequal, one usually spurred. *Stamens* equal in number to the petals (*fig.* 797), and usually alternate with them, or rarely opposite, inserted on a hypogynous disk, often unequal; *anthers* 2-celled, sometimes united

FIG. 900.

FIG. 901.

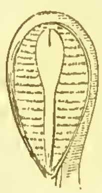


Fig. 900. Essential organs of the Pansy (*Viola tricolor*). *st.* Obliquely hooded stigma. *a.* United anthers, two having long spurred appendages at the base.——*Fig.* 901. Vertical section of the seed.

(*fig.* 900), introrse; *filaments* short and broad (*fig.* 900), and elongated, so as to project beyond the anthers (*fig.* 527); when the flowers are irregular, two of the anthers are spurred at the base (*figs.* 527 and 900). *Ovary* 1-celled (*fig.* 33), with 3 parietal placentas (*fig.* 797); *style* single, usually declinate (*fig.* 33); *stigma* capitate, oblique, hooded (*fig.* 900, *st*); *ovules* usually numerous (*fig.* 33, *o*, *o*). *Fruit* capsular, 3-valved, dehiscence loculicidal; *placentas* parietal, on the middle of the valves (*fig.* 681). *Seeds* usually numerous (*fig.* 681), sometimes definite; *embryo* straight, erect, in the axis of fleshy albumen (*fig.* 901).

Diagnosis.—Herbs or shrubs. Leaves simple, stipulate, and with involute vernation. Sepals, petals, and stamens 5 each, hypogynous. Stamens all perfect; anthers introrse with the filaments prolonged beyond them, and sometimes having spur-like appendages below. Ovary 1-celled, with 3 parietal placentas; style and stigma single. Fruit 1-celled, dehiscing by

3 valves, each valve bearing a placenta in its middle. Seeds having a straight erect embryo in the axis of fleshy albumen.

Division of the Order and Illustrative Genera.—The order has been divided as follows :—

Sub-order 1. *Violeæ.*—Having irregular flowers and appendaged anthers. *Illustrative Genera :*—Viola, *Linn.* ; Ionidium, *Vent.*

Sub-order 2. *Alsodeæ.*—With regular flowers, and anthers not furnished with spurred appendages. *Illustrative Genera :*—Alsodeia, *Thouars* ; Pentaloba, *Lour.*

Distribution and Numbers.—The herbaceous plants of the sub-order Violeæ are chiefly natives of Europe, Siberia, and North America ; the shrubby mostly of South America. The Alsodeæ are exclusively natives of South America, Africa, and Malacca. There are about 300 species belonging to the order.

Properties and Uses.—The plants of this order are chiefly remarkable for emetic and purgative properties. A few also are mucilaginous, and others have been reputed to be anodyne. The emetic property is due to a peculiar alkaloid named *violine*, which greatly resembles, if it be not identical with, *emetine*, the active principle of the true Ipecacuanha root. (See *Cephaëlis.*) This principle is more especially found in some of the shrubby South American species, but it also occurs, to some extent at least, in many of the herbaceous European species.

Ionidium.—The root of *I. Ipecacuanha*, Woody Ipecacuanha, is the False Ipecacuanha of Brazil ; it is employed as an emetic in that region. Other species of *Ionidium*, as *I. parviflorum*, *I. Itubu*, and others, possess similar properties. The roots of *I. parviflorum* (*I. microphyllum*, Humb.) constitute the Cuchunchully de Cuença, which is much used in Venezuela as a remedy for elephantiasis.

Viola.—The flowers of *V. odorata*, the March or Sweet Violet, have been always highly esteemed for their fragrance. An infusion or syrup of the petals is a useful chemical test, as its violet or purplish colour is turned red by acids, and green by alkalies. The syrup is employed partly on account of its colour and odour, but chiefly as a laxative for very young children. The flowers were formerly regarded as anodyne. The roots, stems, and seeds have been also regarded as emetic and purgative. They contain *violine*, a principle which, as just stated, is closely analogous to, if not identical with, *emetine*.—*V. pedata*, a native of North America, possesses similar properties to *V. odorata*.—*Viola canina*, the Dog Violet, is said to be efficacious in certain cutaneous diseases.—*Viola tricolor*, a common indigenous plant, is the species from which all our cultivated varieties of Pansies or Heartsease have been derived. The Violets generally have been used on the Continent as demulcent expectorants.

Order 9. SAUVAGESIACEÆ, the Sauvagesia Order.—Character.—This order is by some botanists considered as merely a sub-order of Violaceæ. It is distinguished by the flowers of its species having either 5 perfect stamens alternate with 5 sterile ones, or numerous stamens. If there are only 5 stamens, these are also opposite the petals ; the *anthers* are likewise extrorse, and have no appendages. The fruit also bursts septicidally, and hence each valve bears the placentas at its margins.

Distribution and Numbers.—They are natives chiefly of South America and the West Indies. *Illustrative Genera:*—Sauvagesia, *Linn.*; Lavradia, *Velloz.* There are about 15 species.

Properties and Uses.—But little is known of the properties of the plants in this order. *Sauvagesia erecta* contains a good deal of mucilaginous matter, and has been used internally as a diuretic, and in inflammation of the bowels, and also externally in diseases of the eye.

Order 10. CANELLACEÆ, the Canella Order.—*Diagnosis.*—By some authors this small order is placed in Clusiaceæ; it is, however, at once distinguished from the Clusiaceæ, by its general appearance; alternate leaves; longitudinal dehiscence of anthers; absence of disk; presence of a style; and albuminous seeds. It is placed here in accordance with the views of Bentham and Hooker.

Distribution and Numbers.—This order contains but 2 genera and 3 species. They are natives of the West Indies and continent of America.

Properties and Uses.—These plants have aromatic, stimulant, and tonic properties; being closely allied in these respects to the Magnoliaceæ.

Canella alba, the Laurel-leaved Canella or Wild Cinnamon.—The inner bark of this plant is the official Canella of the British Pharmacopœia. It has been confounded, as already noticed, with Winter's Bark, and hence has been called *Spurious Winter's Bark.* (See *Drimys.*) In its properties it is a warm aromatic stimulant and tonic. In America it has been employed as an antiscorbutic. In the West Indies, and in some parts of Europe, it is used as a spice. It has an odour intermediate between cloves and cinnamon. By distillation it yields a volatile oil, to the presence of which its properties are, in a great measure, due; it also contains a peculiar *bitter principle.*

Cinnamodendron.—*C. axillare*, a native of Brazil, and *C. corticosum*, a native of Jamaica, &c., have aromatic barks, which possess similar properties to the bark of *Canella alba.*—*C. corticosum* yields the so-called Winter's Bark, as now commonly found in commerce. (See *Drimys.*)

Order 11. BIXACEÆ, the Arnatto Order.—Character.—*Shrubs* or small *trees. Leaves* alternate, exstipulate, usually entire and leathery, and very often dotted. Flowers polypetalous or apetalous; usually hermaphrodite, but sometimes unisexual. *Sepals* 4—7, somewhat united at the base. *Petals* hypogynous, distinct, equal in number to the sepals and alternate with them, or sometimes absent; sometimes with scales at the base. *Stamens* hypogynous, of the same number as the petals, or some multiple of them. *Ovary* 1- or more celled, sessile or slightly stalked; *placentas* 2 or more, parietal, sometimes branched so as to form a network over the inner surface of the ovary and fruit. *Fruit* 1-celled, dehiscent or indehiscent, having a thin pulp in its centre. *Seeds* numerous, usually enveloped in a covering formed by the withered pulp ; *albumen* fleshy-oily ; *embryo* straight, axial ; *radicle* turned to the hilum. The Pangiaceæ of some authors are included in this order, in accordance with the views of Bentham and Hooker.

Diagnosis.—Shrubs or small trees, with alternate exstipulate leaves. Flowers polypetalous or apetalous, rarely unisexual ; petals hypogynous, sometimes with scales at the base. Stamens hypogynous, equal in number to the petals or some multiple of them. Fruit dehiscent or indehiscent ; placentas parietal. Seeds numerous, albuminous ; embryo axial, straight ; radicle towards the hilum.

Distribution and Numbers.—The plants of this order are almost confined to the hottest parts of the East and West Indies, and Africa. *Illustrative Genera:*—Bixa, *Linn.* ; Pangium, *Rumph.* There are over 100 species.

Properties and Uses.—Many plants of the order are feebly bitter and astringent, and have been used as stomachics ; others are alterative, tonic, and emetic. The fruits of *Oncoba* and of some of the *Flacourtias* are edible and wholesome ; but those of some other plants are poisonous. It is said, however, that by boiling, and maceration afterwards in cold water, the poisonous properties may, in some cases, be got rid of, as in the seeds of *Pangium edule*, the kernels of which are then used as a condiment, and for mixing in curries. But even these, according to Horsfield, act as a cathartic upon those unaccustomed to their use. The seeds of some species are employed as dyeing and colouring agents.

Bixa Orellana.—The seeds of this plant are covered by a reddish pulp, from which Arnatto or Annatto is made. This is used as a red dye, and for colouring cheese, chocolate, butter, &c. The seeds are said to be cordial, astringent, and febrifugal.

Cochlospermum Gossypium.—According to Royle, the trunk of this plant yields the gum Kuteera, which in the North-western Provinces of India is used as a substitute for Tragacanth.

Gynocardia odorata.—The seeds, which are official in the Pharmacopœia of India, are known under the names of *Chaulmugra*, *Chaulmogra*, or *Chaulmoogra.* They yield by expression a fixed oil in which their properties essentially reside. The oil and seeds have long been employed internally with success in India, in leprosy, scrofula, skin diseases, and in rheumatism ; and the oil has also been of late years used with some success in this country in similar diseases. The oil and seeds, in the form of an ointment, have also been much employed as a local stimulant in various skin diseases, etc.

Hydnocarpus.—The seeds of *H. Wightiana* and of *H. venenata*, both of which species were formerly confounded together under the name of *H. inebrians*, also yield fixed oils, which have similar properties, and are used both externally and internally in similar cases to the seeds and oil of Chaulmugra. The fruit of *H. venenatus* is poisonous, and is employed in Ceylon for poisoning fish.—*H. anthelmintica* is held in high esteem by the Chinese as a remedy in skin diseases.

Order 12. PITTOSPORACEÆ, the Pittosporum Order.—Character.—*Trees* or *shrubs*, with simple alternate exstipulate leaves.

Flowers regular. *Sepals* and *petals* 4 or 5, hypogynous, imbricate, deciduous. *Stamens* 5, hypogynous, alternate with the petals; *anthers* 2-celled. *Ovary* superior; *style* single; *stigmas* equal in number to the placentas, which are 2 or more, and either axile or parietal; *ovules* anatropous, horizontal or ascending. *Fruit* baccate, or a loculicidal capsule. *Seeds* numerous, with a minute embryo in copious fleshy albumen.

Distribution and Numbers.—They are chiefly Australian plants; but are occasionally found in Africa and some other parts of the globe. None, however, occur in Europe or America. *Illustrative Genera*:—Pittosporum, *Soland.*; Cheiranthera, *Cunningham.* The order includes about 80 species.

Properties and Uses.—These plants are chiefly remarkable for their resinous properties. Some have edible fruits, as certain species of *Billardiera*. A few are cultivated in this country on account of their flowers, as *Sollya*, *Billardiera*, &c.

Order 13. TREMANDRACEÆ, the Porewort Order.—Character.—Heath-like *shrubs*, with usually glandular hairs. *Leaves* exstipulate, alternate or whorled. *Flowers* axillary, solitary, pedicellate. *Sepals* 4 or 5, equal, slightly coherent, deciduous, and with a valvate æstivation. *Petals* corresponding in number to the sepals, deciduous, and with an involute æstivation. *Stamens* distinct, hypogynous, 8—10, 2 being placed before each petal; *anthers* 2- or 4-celled, with porous dehiscence (*fig.* 537). *Ovary* 2-celled; *ovules* 1—3 in each cell, pendulous; *style* 1 or 2; *stigmas* 1—2. *Fruit* 2-celled, a capsule with loculicidal dehiscence. *Seeds* pendulous, hooked at the chalazal end; *embryo* straight, in the axis of fleshy albumen; *radicle* next the hilum.

Distribution and Numbers.—All are natives of New Holland. *Illustrative Genera*:—Tetratheca, *Smith*; Tremandra, *R. Br.* The order includes about 16 species.

Properties and Uses.—Altogether unknown.

Cohort 3. *Polygalineæ.*—Gynœcium syncarpous; ovary usually 2-3-celled; placentation generally axile, or very rarely parietal.

Order 1. POLYGALACEÆ, the Milkwort Order.—Character.—*Shrubs* or *herbs*. *Leaves* alternate (*fig.* 902) or opposite, exstipulate, and usually simple. *Pedicels* bracteate. *Flowers* irregular, unsymmetrical (*figs.* 902 and 903), and arranged in a somewhat papilionaceous manner; but here the *wings* are derived from the calyx, whereas in the Leguminosæ they belong to the corolla. *Sepals* 5 (*fig.* 903, *s*), very irregular, usually distinct; of which 3 are placed exterior, and of these 1 is posterior and 2 anterior; the 2 interior are lateral, usually petaloid (*fig.* 902), *and form the wings to the flower.* *Petals* hypogynous, usually 3, more or less united, of which 1, forming the keel, is larger than the rest, and placed at the anterior part of the flower; the keel is either naked, crested, or 3-lobed; the other 2 petals are posterior, and alternate with the wings and posterior sepal of the calyx, and are often united to the keel; sometimes there are five petals (*fig.* 903), and then the 2 additional ones, *pr*, *pr*, are of small size, and alternate with the wings and anterior sepals. *Stamens* hypogynous, 8 (*figs.* 903, *e*, and 907), usually combined into a tube, unequal, the tube split on the side next to the posterior sepal (*fig.* 907); *anthers* clavate, innate, usually 1-celled (*fig.* 907), rarely 2-celled, opening by a

FIG. 902.

FIG. 903.

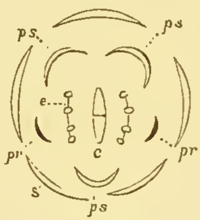


FIG. 904.

FIG. 905.

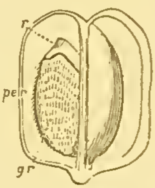


FIG. 907.

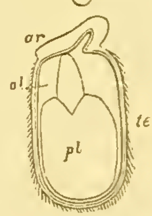


FIG. 906.

Fig. 902. A portion of the stem of the common Milkwort (*Polygala vulgaris*).with simple alternate exstipulate leaves, and irregular flowers. ——*Fig.* 903. Diagram of the flower of the same. *s.* Sepals. *ps, ps, ps.* Posterior and anterior large petals. *pr, pr.* Lateral petals. *e.* Stamens. *c.* Carpels.——*Fig.* 904. Gynœcium of the same. *ov.* Ovary. *styl.* Style. *stig.* Stigma.——*Fig.* 905. Fruit with one cell opened. *per.* Pericarp. *gr.* Seed. *r.* Caruncula.——*Fig.* 906. Section of seed. *te.* Testa. *ar.* Caruncula. *al.* Albumen. *pl.* Embryo.——*Fig.* 907. Andrœcium of the same, with one-celled anthers dehiscing at their apex.

pore at their apex, or rarely by valves. *Ovary* (*figs.* 903, *c*, and 904, *ov*) 2—3-celled, one cell being frequently abortive; *ovules* solitary or twin, suspended; *style* simple (*fig.* 904, *styl*), curved, sometimes hooded at the apex; *stigma* simple (*fig.* 904, *stig*). *Fruit* (*fig.* 905) varying in its nature and texture, indehiscent or opening in a loculicidal manner, occasionally winged. *Seeds* pendulous (*fig.* 905, *gr*), smooth or hairy, with a caruncule next the hilum (*figs.* 905, *r*, and 906, *ar*); *embryo* straight or nearly so, in copious fleshy albumen, and with the radicle towards the hilum (*fig*. 916, *pl*). (See *Krameria*).

Diagnosis (excluding *Krameria*).—Herbs or shrubs, with simple exstipulate leaves. Flowers irregular, unsymmetrical. Sepals and petals imbricate, not commonly corresponding in number, and usually arranged in a somewhat papilionaceous manner; odd petal anterior; odd sepal posterior. Stamens 8, hypogynous, usually combined; anthers generally 1-celled, with porous dehiscence. Fruit flattened, usually 2-celled and 2-seeded. Seeds with abundant fleshy albumen, and with a caruncule next the hilum.

Distribution and Numbers.—Some genera of the order are found in almost every part of the globe. The individual genera are, however, generally confined to particular regions, with the exception of the genus *Polygala*, which is very widely distributed, being found in almost every description of station, and in both warm and temperate regions. *Illustrative Genera*:—Polygala, *Linn.*; Monnina, *Ruiz et Pavon*; Soulamea, *Lam.* There are over 500 species.

Properties and Uses.—The greater part of the plants of this order are bitter and acrid, and their roots milky; hence they are frequently tonic, stimulant, and febrifugal. Some are emetic, purgative, diuretic, sudorific, or expectorant. The roots of the different species of *Krameria* are very astringent from the presence of tannic acid; they are commonly known under the name of *Rhatany roots*. A few species have edible fruits, and others abound in a saponaceous principle.

Krameria.—(The species of this genus are sometimes separated from the Polygalaceæ and placed in an order by themselves termed Krameriaceæ. They are distinguished by their flowers not presenting a papilionaceous arrangement; in their stamens being 1, 3, or 4, and distinct; in their ovary being 1-celled, or incompletely 2-celled; and in their exalbuminous seeds). The root of *Krameria triandra*, a native of Peru, which is known as Peruvian, Payta, or Red Rhatany; and the root of another species, *K. tomentosa*, St. Hil. (*K. Ixina*, var. *granatensis*, Triana), a native of New Granada and Brazil, which is termed Savanilla, New Granada, or Violet Rhatany, are official in the British Pharmacopœia. A third kind of Rhatany, which is said to be derived from *K. argentea*, is imported from Para; it is known as Brazilian or Para Rhatany, or from its colour Brown Rhatany. Other species of *Krameria* also yield roots similar to Rhatany, but they are not usually found in commerce; and Holmes has recently described a very astringent root which has appeared in the London market as Rhatany, and imported from Guayaquil, which he believes is obtained from a genus nearly allied to *Krameria*. Rhatany root is used in medicine as an astringent, and is well adapted for all those diseases which require the employment of such medicines. It is also employed, mixed with equal parts of orris rhizome and charcoal, as a tooth-powder. A saturated tincture of Rhatany root in brandy is called wine colouring, and is used in Portugal to give roughness to Port wines.

Monnina polystachya and *M. salicifolia*.—The bark of the root of these plants is especially remarkable for the presence of a saponaceous principle; it is used in Peru as a substitute for soap, and for cleaning and polishing silver. It is moreover reputed to be a valuable medicine in diarrhœa and similar diseases. The leaves are also reputed to be expectorant.

Polygala.—Many species of this genus have bitter properties, as *P. amara*, *P. rubella*, *P. vulgaris*, and *P. major*; they have been used as tonics, stimulants, diaphoretics, &c.—*Polygala Senega*, Senega root.—The root of this species was first introduced into medicine as an antidote to the bites of snakes. Various other species of *Polygala* have been reputed to possess similar properties, but they are generally regarded as altogether useless in such cases. Senega root is official in the British Pharmacopœia; it is used in large doses as an emetic and cathartic; and in moderate doses as a sialagogue, expectorant, diaphoretic, diuretic, and emmenagogue. Its principal virtues are due to the presence of a very acrid substance, which has been called Senegin or Polygalic Acid: it is said to be a glucoside, and is in the form of a white amorphous powder.—*P. sanguinea* and *P. purpurea*, in North America; *P. Serpentaria* at the Cape; *P. Chamæbuxus*, in Europe; *P. crotalarioides* and *P. telephioides*, in the Himalayas, and other species, are said to possess somewhat similar properties; and one species, *P. venenosa*, a native of Java, has the acrid principle in so concentrated a state as to render it poisonous.—*P. tinctoria*, an Arabian species, is used for dyeing.

Soulamea amara, a native of Malacca, is intensely bitter, and is regarded as a valuable febrifuge; it is also a medicine which has been employed with very great success in cholera and pleurisy.

Order 2. VOCHYSIACEÆ, the Vochysia Order.—Character.—*Trees* or *shrubs*, with entire usually opposite leaves, which are furnished at the base with glands or stipules. *Flowers* very irregular and unsymmetrical. *Sepals* 4—5, united at the base, very unequal, the upper one spurred; *æstivation* imbricate. *Petals*, 1, 2, 3, or 5, unequal, inserted upon the calyx; *æstivation* imbricate. *Stamens* 1 to 5, usually opposite the petals, or rarely alternate, arising from the bottom of the calyx, most of them sterile. *Ovary* superior or partially inferior, 3-celled, or rarely 1-celled; *placentas* axile; *style* and *stigma* 1. *Fruit* usually capsular, 3-cornered, 3-celled, with loculicidal dehiscence; or rarely indehiscent and 1-celled. *Seeds* usually winged, without albumen, erect.

This order is, on account of its calycifloral character, frequently placed near *Combretaceæ*, but it is readily distinguished from it by its superior or nearly superior ovary. Lindley considers it most nearly allied to the *Violaceæ* and the *Polygalaceæ*—hence we place it here.

Distribution and Numbers.—Natives of equinoctial America. *Illustrative Genera*:—Vochysia, *Juss.*; Salvertia, *St. Hil.* There are about 50 species.

Properties and Uses.—Generally unimportant, although some are said to form useful timber.

Order 3. FRANKENIACEÆ, the Frankenia Order.—Character.—*Herbs* or *undershrubs*, much branched, with small opposite exstipulate leaves, and sessile flowers. *Calyx* tubular, furrowed, persistent. *Petals* unguiculate, 4–6, hypogynous. *Stamens* 4 or more, hypogynous, distinct, or connate at the base. *Ovary* superior, 1-celled, with parietal placentas. *Fruit* capsular, 1-

celled, enclosed in the calyx, and dehiscing in a septicidal manner. *Seeds* numerous, minute ; *embryo* straight, erect, in the middle of mealy albumen.

Distribution and Numbers.—The plants of this order are scattered over the globe, except in tropical India and North America, but they chiefly occur in the south of Europe and north of Africa. *Illustrative Genera:*—Frankenia, *Linn.* ; Beatsonia, *Roxb.* There are about 24 species.

Properties and Uses.—Unimportant. They have been reputed mucilaginous and slightly aromatic. The leaves of a species of *Beatsonia* are used at St. Helena as a substitute for tea.

Cohort 4. *Caryophyllineæ.* — Gynœcium syncarpous ; ovary ultimately 1-celled, with free central placentation, or very rarely parietal.

Order 1. CARYOPHYLLACEÆ, the Pink Order.—Character.—*Herbs.* *Stems* swollen at the nodes. *Leaves* opposite, entire, exstipulate, or with small membranous stipules, often connate at their base. *Inflorescence* cymose (*fig.* 434). *Flowers* generally hermaphrodite, or rarely unisexual. *Sepals* 4 or 5 (*fig.* 908), distinct or united into a tube (*fig.* 460), persistent. *Petals* equal in number to the sepals (*fig.* 908), hypogynous, unguiculate (*fig.* 475, *o*), often deeply divided (*fig.* 474, *p*), sometimes absent, frequently raised above the calyx on a stalk (*fig.* 909). *Stamens* equal in number to the sepals, and then either alternate or opposite to them, or usually twice as numerous (*figs.* 908 and 910), or rarely fewer, frequently attached with the petals on a stalk above the calyx (*fig.* 909) ; *filaments* generally distinct (*fig.* 910), or sometimes united at the base, subulate ; *anthers* innate. *Ovary* sessile (*fig.* 910), or supported with the petals and stamens on a short gynophore (*figs.* 602, *g*, and 909), generally 1-celled, and with a free central placenta (*figs.* 633 and 634), or rarely 2—5-celled (*figs.* 632 and 908) ; *styles* 2 (*fig.* 602) to 5 (*figs.* 633, *s*, and 634, *s*), papillose on their inner surface (*fig.* 602), and hence should be properly regarded as stigmas ; *ovules* few or numerous (*figs.* 633 and 634, *g*), amphitropous. *Fruit* a 1-celled capsule, opening by 2—5 valves, or by 4—10 teeth at the apex (*figs.* 663 and 911), and having a free central placenta (*figs.* 633 and 634, *p*), or rarely 2—5-celled with a loculicidal dehiscence, and with the placentas slightly attached to the dissepiments. *Seeds* usually numerous, rarely few ; *embryo* curved round the albumen (*figs.* 782 and 912), which is of a mealy character, or rarely straight.

Diagnosis.—Herbaceous plants with the stems swollen at the nodes, and opposite entire exstipulate leaves : or rarely with small membranous stipules. Inflorescence cymose. Flowers usually hermaphrodite. Sepals, petals, and stamens with a quaternary or quinary arrangement, the petals sometimes absent. Calyx persistent. Stamens hypogynous; anthers innate. Ovary commonly 1-celled, styles 2—5. Capsule 1-celled, or rarely 2—5-celled; placenta usually free central, or in the 2—5-celled fruit slightly attached to the dissepiments. Seeds with the embryo curved round mealy albumen; or rarely straight.

Division of the Order and Illustrative Genera.—The order has been divided into four tribes or sub-orders as follow :—

Tribe 1. *Alsineæ.*—Sepals distinct, and opposite the stamens when the latter are equal to them in number. Styles free (*fig.*

Fig. 908.

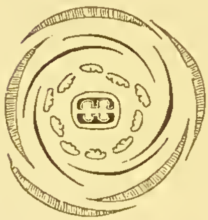


Fig. 909.

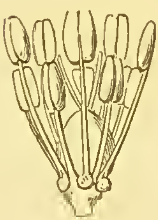


Fig. 910.

Fig. 911.

Fig. 912.

Fig. 908. Diagram of the flower of a species of *Dianthus.*——*Fig.* 909. Vertical section of the flower of the same.——*Fig.* 910. Essential organs of a species of *Stellaria.*——*Fig.* 911. Capsule of a species of *Dianthus*, dehiscing partially in a valvular manner so as to form four teeth at the apex.——*Fig.* 912. Vertical section of the seed of Chickweed (*Stellaria media*).

910). Stipules none, or small and membranous. *Illustrative Genera* :—Alsine, *Wahlenb.*; Stellaria, *Linn.*; Spergula, *Linn.*

Tribe 2. *Sileneæ.*—Sepals cohering into a tube (*fig.* 460), and opposite the stamens when the latter are equal to them in number. No stipules. *Illustrative Genera* :— Dianthus, *Linn.*; Lychnis, *Linn.*

Tribe 3. *Mollugineæ.*—Sepals distinct or nearly so, and alternate with the stamens when the latter are equal to them in number. If the stamens are fewer than the sepals, they are then alternate with the carpels. No stipules. *Illustrative Genera* :—Mollugo, *Linn.*; Cœlanthum, *E. Mey.*

Tribe 4. *Polycarpeæ.*—Sepals distinct. Ovary sessile. Styles connate at the base. Stipules membranous. *Illustrative Genus:*—Polycarpon, *Linn.*

Distribution and Numbers.—They are natives chiefly of temperate and cold climates. When found in tropical regions they are generally on the sides and summits of mountains, commonly reaching the limits of eternal snow. The order contains nearly 1,100 species.

Properties and Uses.—The plants of this order possess no important properties. They are almost always insipid. Some of the wild species are eaten as food by small animals, and some have been said to increase the lacteal secretions of cows fed upon them. This is supposed to be the case more particularly with *Vaccaria vulgaris*. *Saponaria officinalis* has been used in syphilis; it contains a peculiar principle called *saponin*. This principle has also been found in species of *Lychnis*, *Silene*, *Cucubalus*; and more especially in *Gypsophila Struthium*, to which latter plant it communicates well-marked saponaceous properties: hence it is commonly termed Egyptian Soap-root. The other species in which saponin is found also possess, to some extent, similar properties. Saponin is reputed to be poisonous in its nature.

Some of the plants have showy flowers, as the species of *Dianthus*, *Silene*, and *Lychnis*: but they are generally insignificant weeds. *Dianthus barbatus* is the Sweet-William of our gardens; *D. plumarius* is the parent of all the cultivated varieties of the common Pink; and *D. Caryophyllus*, the Clove Pink, is the origin of the Carnation and its cultivated varieties, which are commonly known as Picotees, Bizarres, and Flakes.

The three following Orders have been variously placed by botanists, but they are closely allied to Caryophyllaceæ, and we put them here following Bentham and Hooker, except that the Scleranthaceæ are included by them in Paronychiaceæ.

Order 2. PARONYCHIACEÆ, the Knotwort Order.—Character.—*Herbs* or *shrubs*, with entire, simple, alternate or opposite leaves, and membranous stipules. *Flowers* minute. *Sepals* 5, or rarely 3 or 4, distinct or more or less united. *Petals* small or absent, perigynous. *Stamens* somewhat hypogynous, either equal in number to the sepals and opposite to them, or more numerous, or rarely fewer. *Ovary* superior, 1- or 3-celled; *styles* 2—5. *Fruit* dry, 1- or 3-celled, dehiscent or indehiscent. *Seeds* either numerous upon a free central placenta, or solitary on a long funiculus arising from the base of the fruit; *albumen* farinaceous; *embryo* curved.

Distribution and Numbers.—Natives chiefly of barren places in the south of Europe and the north of Africa. *Illustrative*

Genera:—Illecebrum, *Linn.*; Corrigiola, *Linn.* There are about 100 species.

Properties and Uses.—Slightly astringent.

Paronychia.—The flowers and leaves of *Paronychia argentea* and *P. nivea* are used in the preparation of a kind of tea in France, which is employed as a remedy for persons suffering from oppression of the chest, or from any difficulty of digestion. It is known as *Thé Arabe* or *Sanguinaire.*

Order 3. SCLERANTHACEÆ, the Scleranthus Order.—*Diagnosis* &c.—This is a small order of inconspicuous herbs, generally considered as a sub-order of Paronychiaceæ, but from which its plants are distinguished by the want of stipules; by being apetalous; by the tube of their calyx becoming hardened and covering the fruit, which is solitary and 1-celled; and by their stamens being evidently perigynous. They are valueless weeds found in barren places in the temperate regions of the globe. There are about 14 species, of which two species belonging to the genus *Scleranthus* are natives of Britain. Their uses are unknown.

Order 4. PORTULACACEÆ, the Purslane Order.—Character.—*Succulent herbs* or *shrubs*, with entire exstipulate leaves. *Flowers* unsymmetrical. *Sepals* 2, or rarely more, united at the base. *Petals* usually 5, distinct or united. *Stamens* perigynous or hypogynous, varying in number, sometimes opposite to the petals; *filaments* distinct; *anthers* 2-celled, versatile. *Ovary* superior, or rarely partially adherent. *Fruit* capsular, usually dehiscing transversely, or by valves; sometimes indehiscent; *placenta* free central. *Seeds* numerous or solitary; *embryo* curved round farinaceous albumen.

Distribution and Numbers.—Natives of waste dry places in various parts of the world, but chiefly at the Cape of Good Hope and in South America. *Illustrative Genera*:—Portulaca, *Tourn.*; Claytonia, *Linn.* There are about 190 species.

Properties and Uses.—The fleshy root of *Claytonia tuberosa* is edible. *Portulaca oleracea* has been used from the earliest times as a pot-herb, and in salads. It possesses cooling and antiscorbutic properties. Many of the plants have large showy flowers.

Order 5. TAMARICACEÆ, the Tamarisk Order.—Character.—*Shrubs* or *herbs*, with alternate entire scale-like leaves, and spiked or racemose *flowers*. *Calyx* 4—5-partite, imbricate, persistent. *Petals* distinct, and attached to the calyx, withering, imbricate. *Stamens* hypogynous; *anthers* introrse. *Ovary* superior, 1-celled, with 3 distinct styles. *Fruit* 1-celled, with 3 parietal or basal placentas, and dehiscing loculicidally by 3 valves. *Seeds* numerous, comose, without albumen, and having a straight embryo, with the radicle towards the hilum.

Distribution and Numbers.—The plants of this order usually grow by the sea-side, or sometimes on the margins of rivers or lakes. They are most abundant in the basin of the Mediterranean, and are altogether confined to the northern hemisphere of the Old World. *Illustrative Genera:*—Tamarix, *Linn.*; Myricaria, *Desv.* There are about 40 species.

Properties and Uses.—The bark of these plants is astringent, slightly bitter, and tonic. The ashes of some species of *Tamarix* contain much sulphate of soda.

Tamarix.—*T. mannifera* produces a saccharine substance, which is known under the name of Mount Sinai Manna. This is considered by Ehrenberg as an exudation produced by a species of Coccus, which inhabits this plant.—*T. gallica, T. orientalis*, and some other species of *Tamarix*, are liable to the attack of insects, which produce galls on their surface. These galls are astringent, and are sometimes used in medicine, and as dyeing agents where astringent substances are required.

Cohort 5. *Guttiferales.*—Calyx with imbricate æstivation. Stamens generally numerous. Gynœcium syncarpous. Seeds usually exalbuminous.

Order 1. ELATINACEÆ, the Water-pepper Order.—Character.—Little annual marsh plants, with hollow creeping stems, and opposite leaves with interpetiolar membranous

FIG. 913.

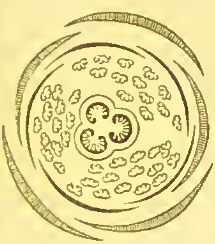


FIG. 914.

FIG. 915.

Fig. 913. Diagram of the flower of a species of St. John's Wort (*Hypericum*).——*Fig.* 914. Vertical section of the flower of the same.——*Fig.* 915. Vertical section of the seed.

stipules. *Flowers* small and axillary. *Sepals* and *petals* 3—5, the latter, as well as the stamens, being distinct and hypogynous. *Ovary* superior; *styles* 3—5; *stigmas* capitate. *Fruit* capsular, 3—5-celled, placentation axile; dehiscence loculicidal. *Seeds* numerous, exalbuminous; *embryo* straight. This order has been variously placed, but it appears to be most nearly related to Hypericaceæ, although in some respects resembling the Alsineæ in Caryophyllaceæ.

Distribution and Numbers.—The plants of this small order are scattered all over the world. *Illustrative Genera:*—Elatine, *Linn.*; Merimea, *Camb.* Lindley enumerates 22 species.

Properties and Uses.—They are generally considered acrid, hence the English name of the order.

Order 2. HYPERICACEÆ, the St. John's Wort Order.—Character.—*Herbs, shrubs,* or *trees. Leaves* opposite or very rarely alternate, exstipulate, simple, entire, often dotted and bordered with black glands. *Flowers* regular. *Sepals* 4 or 5 (*fig.* 913), persistent, unequal, distinct or united at the base, imbricate. *Petals* (*fig.* 913) equal in number to the sepals, hypogynous, unequal-sided (*fig.* 914), frequently bordered with black glands ; *æstivation* twisted. *Stamens* usually numerous, rarely few, hypogynous (*fig.* 914), mostly polyadelphous (*fig.* 554), or rarely distinct, or monadelphous, sometimes having glands alternating with the bundles of stamens ; *filaments* filiform ; *anthers* 2-celled, with longitudinal dehiscence. *Ovary* 1-celled, formed of from 3—5 carpels, which are partially inflected so as to project into the cavity ; or 3—5-celled by the union of the dissepiments in the centre (*fig.* 913) ; *styles* equal in number to the carpels ; *stigmas* usually capitate or truncate, rarely 2-lobed. *Fruit* capsular, usually 3—5-celled, sometimes 1-celled ; *placentas* axile or parietal, dehiscence septicidal. *Seeds* minute, numerous ; *embryo* straight or curved, exalbuminous (*fig.* 915).

Diagnosis.—Leaves entire, often dotted, exstipulate. Flowers regular. Sepals and petals hypogynous, with a quaternary or quinary distribution ; the former with an imbricate æstivation ; the latter unequal-sided, commonly marked with black glands, and having a twisted æstivation. Stamens hypogynous, usually numerous and polyadelphous, rarely few, and then distinct or monadelphous ; anthers 2-celled, opening longitudinally. Styles several. Fruit 1-celled, or 3—5-celled. Seeds numerous, exalbuminous.

Distribution and Numbers.—The plants are generally distributed over the globe, inhabiting both temperate and hot regions, and almost all varieties of soil. *Illustrative Genera* :—Hypericum, *Linn.*; Vismia, *Vell.* There are about 280 species.

Properties and Uses.—They abound usually in a resinous yellow juice, which is frequently purgative, as in *Vismia guianensis* and *V. micrantha*. Other plants of the order, as *Hypericum perforatum* and *H. Androsæmum*, have tonic and astringent properties, and *Cratoxylon Hornschuchii* is slightly astringent and diuretic.

Order 3. REAUMURIACEÆ, the Reaumuria Order.—This small order was first instituted by Ehrenberg. The plants belonging to it do not differ in any essential characters from Hypericaceæ, except that they have a pair of appendages at the base of the petals, and shaggy seeds with a small quantity of mealy albumen. *Bentham and Hooker refer them to Tamaricaceæ.*

Distribution and Numbers.—Natives of the coast of the Mediterranean and the salt plains of Northern Asia. *Illustrative Genus* :—Reaumuria, *Hasselq.* There are 4 species.

Properties and Uses.—They contain much saline matter. A decoction of the leaves of *Reaumuria vermiculata* is used internally; and the bruised leaves as an external application for the cure of scabies.

Order 4. GUTTIFERÆ or CLUSIACEÆ, the Gamboge or Mangosteen Order.—Character.—*Trees* or *shrubs*, sometimes parasitical, with a resinous juice. *Leaves* (*fig.* 916) coriaceous, entire, simple, opposite, exstipulate. *Flowers* usually perfect, sometimes unisexual by abortion. *Sepals* 2, 4, 5, 6, or 8, imbricate, usually persistent, frequently unequal and petaloid. *Petals* hypogynous, equal in number to (*fig.* 916), or a multiple of, the sepals, sometimes passing by imperceptible gradations into them. *Stamens* usually numerous, rarely few, hypogynous, distinct, monadelphous, or polyadelphous; *anthers* adnate, not beaked, introrse or extrorse, opening by a pore or transverse slit, 2-celled, or sometimes 1-celled. *Disk* fleshy, or rarely with five lobes. *Ovary* superior, 1- or many-celled; *style* absent; *stigmas* peltate or radiate (*fig.* 916); *placentas* axile. *Fruit* dehiscent or indehiscent, 1- or many-celled. *Seeds* solitary or numerous, frequently arillate, without albumen; *embryo* large, straight, with minute cotyledons.

Diagnosis.—Trees or shrubs with a resinous juice, and with opposite, simple, coriaceous, exstipulate leaves. Sepals and petals usually having a binary arrangement of their parts; the former imbricate and frequently unequal; the latter equal and hypogynous. Stamens almost always numerous; anthers adnate, without a beak, opening by a pore or transversely. Disk fleshy or lobed. Ovary superior, with sessile radiate stigmas, and axile placentas. Seeds exalbuminous; cotyledons minute.

FIG. 916.

Fig. 916. Flowering stem and fruit of the Mangosteen plant (*Garcinia Mangostana*).

Distribution and Numbers.—Exclusively tropical, and especially occurring in moist situations. The larger proportion are natives of South America, but a few occur in Madagascar and the African continent. *Illustrative Genera*: — Clusia, *Linn.*; Garcinia, *Linn.* There are about 250 species.

Properties and Uses.—The plants of this order are chiefly remarkable for yielding a yellow gum-resin of an acrid and purgative nature. In many cases, however, the fruits are edible, and are held in high estimation for their delicious flavour. The seeds of some are oily, and other plants of the order are good timber-trees.

Calophyllum.—*C. Calaba* is reputed to yield the resinous substance known as East Indian Tacamahaca. This is useful as an application to indolent ulcers.—*C. Inophyllum* and *C. brasiliense* also yield similar resins. From the seeds of *C. Inophyllum* an oil is likewise obtained by expression; this is the *Bitter Oil* or *Weandee* of Indian commerce. It is in great repute throughout the East Indies and Polynesia as a liniment in rheumatism, pains in the joints, and bruises. The timber of the same plant is also applied to several useful purposes.—*C. angustifolium*, the Piney tree, furnishes valuable timber.

Calysaccion longifolium.—The dried flower-buds of this tree constitute, with those of *Mesua ferrea*, the *Nag-kesar* or *Nag-kassar* of the Indian bazaars. (See *Mesua.*)

Clusia.—*Clusia flava*, *C. alba*, and *C. rosea*, yield a glutinous resinous matter, which is used in some parts of the West Indies in place of pitch, *C. flava* is called in Jamaica the Balsam-tree. In Nevis and St. Kitt's the three species are known indifferently under the names of Fat Pork, Monkey Apple, and Mountain or Wild Mango. The flowers of *C. insignis* also yield a resinous substance in Brazil.

Garcinia.—The official and well-known gum-resin *Gamboge* has been shown by Hanbury to be the produce of *Garcinia Morella*, var. *pedicellata*, now termed *G. Hanburii*; it is official in the British Pharmacopœia. Commercial Gamboge is obtained principally from Siam; it is the only kind used in Europe. Siam Gamboge occurs in two forms:—1st, in the form of cylinders, which are either solid or more or less hollow, and commonly known as *pipe* or *roll Gamboge*; and, 2nd, in large cakes or amorphous masses, called *lump* or *cake Gamboge*. The pipe Gamboge is the finest kind. Gamboge is used in medicine as an active hydragogue and drastic purgative. It is also an anthelmintic. It was the basis of the once celebrated nostrum, termed Morrison's pills. In over-doses it acts as an acrid poison. Gamboge likewise forms a valuable water-colour, and hence is much used in painting; it is also employed to give a colour to the lacquer-varnish for brass-work, &c. In India, a gum-resin resembling Siam Gamboge, and identical with it in its properties, is obtained from *G. pictoria*. It is only found in irregular masses. Good Gamboge is also obtained in Travancore from *G. travancorica*.

The Mangosteen, which is reputed to be the most delicious of all fruits, is obtained from *G. Mangostana*, a native of Malacca. This plant has produced fruit in stoves in this country. The rind is astringent, and has been substituted, as first noticed by the author, in this country, for Indian Bael (see *Ægle Marmelos*). It has been employed with great advantage in India in chronic diarrhœa, and in advanced stages of dysentery.—*G. cornea*, *G. Kydiana*, and *G. pedunculata*, also yield fruits of a similar character to the Mangosteen, although very inferior to it. The seeds of *G. indica* (*purpurea*), upon being boiled in water, yield a concrete oil, called *Kokum Butter* or *Concrete Oil of Mangosteen*. It is useful in chapped hands, &c., and might be employed in the preparation of suppositories, and for other pharmaceutical purposes. The fruit has an agreeable acid flavour, and is used in India for various purposes.

Mammea americana.—The fruit is highly esteemed in the West Indies and South America. It is known under the names of the Mammee Apple and the Wild Apricot of South America. The seeds are anthelmintic. A spirit and a kind of wine may be also obtained from this plant—thus, from the flowers a kind of spirit, and from the sap a wine.

Mesua.—The species of this genus are remarkable for their very hard timber. Lindley remarks, 'that the root and bark of these plants are bitter, aromatic, and powerfully sudorific; their leaves mucilaginous; their unripe fruit aromatic, acrid, and purgative.' The flower-buds of *Mesua ferrea* occur in the bazaars of India, with those of *Calysaccion longifolium* (see *Calysaccion*), under the name of *Nag-kassar*; they are highly esteemed for their fragrance, and are also used in Bengal, as well as the leaves of the same plant, as antidotes to snake-poisons. Nag-kassar is also much employed for dyeing silks. Nag-kassar was imported into England a few years since. The flower-buds are about the size of peppercorns, of a cinnamon-brown colour, and have a very fragrant odour somewhat resembling that of violets.

Pentadesma butyracea.—The fruit of this plant yields a fatty matter, hence it is called the Butter or Tallow Tree of Sierra Leone.

Order 5. TERNSTRŒMIACEÆ or CAMELLIACEÆ, the Tea Order.—Character.—*Trees* or *shrubs*. *Leaves* leathery, alternate, usually exstipulate, and sometimes dotted. *Flowers* regular, and generally very showy, rarely polygamous. *Sepals* 5 or 7, coriaceous, imbricate, deciduous. *Petals* 5, 6, or 9, often united at the base, imbricate. *Stamens* hypogynous, numerous, distinct or united by their filaments into one or several bundles; *anthers* 2-celled, versatile or adnate. *Ovary* superior, many-celled; *styles* filiform, 3—7. *Fruit* capsular, 2—7-celled; *placentas* axile; dehiscence various. *Seeds* few, sometimes arillate; *albumen* wanting or in very small quantity; *embryo* straight or folded; *cotyledons* large and oily; *radicle* towards the hilum.

Diagnosis.—Trees or shrubs, with alternate usually exstipulate leathery leaves. Sepals and petals imbricate in æstivation, and having no tendency to a quaternary arrangement. Stamens numerous, hypogynous; anthers versatile or adnate. Ovary superior; styles filiform. Seeds solitary or very few, attached to axile placentas; albumen wanting or in very small quantity.

Distribution and Numbers.—These plants, which are mostly ornamental trees or shrubs, are chiefly natives of South America, but a few are found in the East Indies, China, and North America. One species only occurs in Africa. There are no European species, although a few are cultivated in Europe. *Illustrative Genera*:—Ternstrœmia, *Mut.*; Camellia, *Linn.* The order, as defined above, following Lindley, contains about 130 species.

Properties and Uses.—Generally speaking, we know but little of the properties of the plants of this order; but some, as those from which China Tea is prepared, are moderately stimulant, astringent, and slightly soothing and sedative.

Camellia or *Thea* (see *Thea*).—Numerous varieties of *Camellia japonica*, which is a large tree in its native country, are cultivated in our greenhouses, and are celebrated for the beauty of their flowers and foliage. The seeds of *C. oleifera* yield by expression a good salad oil.—*C. Sasanqua* has fragrant flowers, which are said to be used in some districts to give flavour and odour to Chinese Tea.

Freziera theoides.—The leaves of this shrub are used as a kind of tea in Panama.

Gordonia.—The bark is astringent, and is therefore useful in tanning, for which purpose it is sometimes employed in the United States.

Kielmeyera speciosa.—The leaves of this plant, which is a native of Brazil, contain much mucilage, and are used on that account for fomentations.

Thea or *Camellia.*—The genus *Thea* is now more generally regarded as not really distinct from that of *Camellia*, and hence the species of the two genera are frequently included under one genus, which is named by botanists either *Camellia* or *Thea*. Formerly it was supposed that China Tea, which is so extensively used as a beverage in this and many other countries, was prepared from the leaves of three species, two being natives of China, namely, *Thea Bohea* and *T. viridis*; and another, a native of Assam, *Thea assamica*. Nearly all botanists are, however, now agreed that these three supposed species are only varieties of one, which is termed *Thea chinensis* or *Camellia Thea*. It was also formerly supposed that Black and Green Teas were the produce of distinct plants; but Fortune, Ball, and others have proved that both Black and Green Teas may be made indifferently from the same plant, the differences between such teas depending essentially upon their mode of preparation. Thus, Green Teas are prepared by drying the leaves as quickly as possible after they are gathered; and then slightly heating them; after which they are rolled separately or in small heaps, and then dried as quickly as possible; while Black Teas are made from the leaves, which, after being gathered, are exposed to the air for some time, and then, after having been tossed about, are placed in heaps, where they undergo a kind of fermentation; after which they are exposed to a fire for a short time; then rolled in masses to get rid of the moisture and to give them a twisted character; then they are again exposed to the air, and subsequently exposed for a second time in a shallow pan to the heat of a charcoal fire, rolled again, and exposed to the air, and finally dried slowly over a fire. Thus, Green Tea consists of the leaves quickly dried after gathering, so that their colour and other properties are in a great measure preserved; while Black Tea is composed of the leaves dried some time after being gathered, and after they have undergone a kind of fermentation, by which their original green colour is changed to black, and other important changes produced. A great part of the Green Tea which is exported from China, and consumed in this country, and in other parts of Europe and America, is coloured artificially with a mixture of prussian blue, turmeric, and gypsum. Several varieties of Black and Green Teas are known in commerce. Thus of the former we have Bohea, Congou, Souchong, Pekoe, Caper, &c.; of the latter, Hyson, Hyson-Skin, Twankay, Gunpowder, &c. Some teas have a particular odour somewhat resembling the flowers of the common Cowslip; this is produced by mixing with them the dried flowers of the sweet-scented Olive (*Olea fragrans*). Other teas are scented with the dried flowers of *Chloranthus inconspicuus*, *Aglaia odorata*, &c.

The cultivation of the Tea-plant is now being carried on with great success in India. Thus, in 1882 no less than 60,000,000 lbs. of Tea were exported, and its cultivation is largely increasing. A large quantity of Tea is also at the present time produced in Japan and Java. China, however, is the great tea-producing country: in that part of the world, nearly 4,000,000 acres of ground are devoted to it alone, and the total annual produce, at the present time, is probably not less than 600 millions of pounds. In the United Kingdom, the consumption of Tea has very much increased of late years. Thus, in 1840, it was only 50,000,000 lbs., while at the present time it amounts to about 140,000,000 lbs. Tea owes its chief properties to the presence of a volatile oil, tannic acid, and more especially the alkaloid, called *theine*. *Theine* is identical with *caffeine*, the alkaloid contained in Coffee, and is official under that name in the British Pharmacopœia, and *guaranine* the alkaloid of Guarana, and is closely allied to *theobromine* the alkaloid of cocoa-seeds. (See *Coffea*, *Paullinia*, and *Theobroma*.) Tea-leaves also contain about

6 per cent. of gluten. but this is scarcely extracted in any amount by the ordinary mode of making Tea. It has been stated that Tea, besides its well-known stimulating and soothing effects, is indirectly nutritive—that is to say, the theine it contains has the effect of preventing the waste and decay of the body, and any substance that does this necessarily saves food, and is thus indirectly nutritive; but Dr. Edward Smith has shown that, on the contrary, Tea increases the bodily waste. As a nervine stimulant, tea—or, still better, its alkaloid theine or caffeine and its salts—may be taken with much advantage in headache and neuralgia, and in other affections caused by exhaustion of the system from depression of nerve power.

Order 6. Marcgraaviaceæ, the Marcgraavia Order.—*Diagnosis.*—This is a small order which is generally regarded as allied to Clusiaceæ and Hypericaceæ. The species belonging to it are chiefly distinguished from Clusiaceæ, by their unsymmetrical flowers, versatile anthers, and very numerous minute seeds. Some genera of the order are remarkable for their peculiar bracts, which become hooded, pouched, or spurred. They are distinguished from Hypericaceæ chiefly by their unsymmetrical flowers, equal-sided petals, distinct stamens, and sessile stigmas. They are sometimes placed as a tribe of Ternstrœmiaceæ.

Distribution and Numbers.—Generally natives of equinoctial America. *Illustrative Genera*:—Ruyschia, *Jacq.*; Marcgraavia, *Plum.* There are 26 species.

Properties and Uses.—Scarcely anything is known of their properties. *Marcgraavia umbellata* is reputed to be diuretic and antisyphilitic.

Order 7. Rhizobolaceæ, the Souari-nut Order.—Character.—Large *trees.* *Leaves* opposite, coriaceous, digitate, exstipulate, with an articulated stalk. *Sepals* 5 or 6, more or less united. imbricate. *Petals* 5 to 8, unequal. *Stamens* very numerous, slightly monadelphous, in two whorls, the inner shorter and often abortive, inserted with the petals on an hypogynous disk; *anthers* 2-celled, with longitudinal dehiscence. *Ovary* 4-, 5-, or many-celled; *styles* short, as many as the cells of the ovary; *stigmas* small; *ovules* solitary, attached to the axis. *Fruit* consisting of several combined indehiscent 1-seeded nuts. *Seed* reniform, exalbuminous, with the funiculus expanded so as to form a spongy excrescence; *radicle* very large, forming nearly the whole of the nucleus; *cotyledons* very small (*fig.* 771, *c*). This order is frequently incorporated with the Ternstrœmiaceæ.

Diagnosis.—Large trees, with opposite digitate exstipulate leaves, with an articulated stalk. Flowers regular, hypogynous. Petals equal-sided, and inserted with the numerous stamens on an hypogynous disk. Styles very short. Seed solitary, exalbuminous, with a very large radicle, and two very small cotyledons.

Distribution and Numbers.—The order contains but 2 genera, including 8 species, all of which are large trees, natives of the forests in the hottest parts of South America. *Illustrative Genus*:—Caryocar, *Linn.*

Properties and Uses.—Some of the trees are valuable for their timber, others yield edible nuts, and some an excellent oil.

Caryocar.—*C. butyrosum* (*Pekea tuberculosa* or *butyrosa*).—This tree is much esteemed for its timber, which is used in shipbuilding and for other purposes. The separated portions of the fruit constitute the Souari, Surahwa, or Suwarrow-nuts of commerce, the kernels of which are probably the most agreeable of all the nut kind. They are occasionally imported into this country. An excellent edible oil may be also extracted from them.—*C. nucifera* also yields *Souari-nuts.* A concrete oil is obtained in Brazil, from *C. brasiliense.*

Order 8. DIPTERACEÆ, the Sumatra Camphor Order.—Character.—Large *trees* with a resinous juice. *Leaves* alternate, involute, feather-veined, with large convolute deciduous stipules. *Calyx* 5-lobed, tubular, unequal, persistent, imbricate, ultimately enlarged into winglike expansions. *Petals* 5, hypogynous, often coherent at the base ; *æstivation* twisted. *Stamens* numerous, hypogynous, distinct or united in an irregular manner by their filaments so as to become somewhat polyadelphous ; *anthers* innate, 2-celled, subulate, prolonged above or beaked. *Ovary* superior, 3-celled ; *ovules* pendulous ; *style* and *stigma* simple. *Fruit* 1-celled, dehiscent or indehiscent, surrounded by the enlarged permanent calyx. *Seed* solitary, exalbuminous ; *radicle* superior.

Distribution and Numbers. — Natives exclusively of the forests of the tropical East Indies, with the exception of the genus *Lophira*, which belongs to tropical Africa. (The latter genus, by Endlicher and others, has been separated from the Dipteraceæ, and placed in an order by itself under the name of Lophiraceæ. The chief characters of distinction are, its 1-celled ovary with numerous ovules on a free central placenta, and its inferior radicle.) *Illustrative Genera* :—Dipterocarpus, *Gärtn.* ; Dryobalanops, *Gärtn.* There are about 50 species belonging to this order.

Properties and Uses.—These plants form very large and handsome trees, which abound in an oleo-resinous juice. To the presence of this they owe their peculiar properties.

Dipterocarpus.—The trunks of *D. lævis*, and other species, natives of the East Indies, yield by incision an oleo-resinous substance, called Wood Oil or Gurjun Balsam. In its properties Wood Oil resembles Copaiba, and is largely employed for similar purposes in India, where it is official ; it is also in use in England as a substitute for, or as an adulterant of, that drug. Wood Oil is also used in India for painting houses, &c.

Dryobalanops aromatica or *Camphora.*—This is a large tree, a native of Sumatra and Borneo. From its stem, a liquid called Liquid Camphor or Camphor Oil, and a crystalline solid substance named Sumatra or Borneo Camphor, are derived. The *Liquid Camphor* is obtained by making deep incisions into the tree. It is a hydrocarbon, and has an odour resembling a mixture of Cajuput oil, camphor, and cardamoms. It has been used in the preparation of scented soap. The *Solid Sumatra Camphor* is found in fissures and cavities in the interior of the trunks of the full-grown trees, and can only be extracted from the tree by cutting it down and dividing it into pieces. It generally occurs only in small pieces, but occasionally masses weighing 10 or 12 lbs. have been removed. This camphor resembles in its properties the ordinary official or Laurel Camphor (see *Cinnamomum Camphora*). It is not, however, a commercial article in this country, or in Europe, because it is so highly esteemed by the Chinese, that they will give from eighty to a hundred times more money for it than that which they obtain for their own camphor, which is the kind we employ, and which is more valued by us. Thus the first quality is valued at about 10*l.* a pound. It is sometimes termed *Barus Camphor.* It is regarded as especially valuable for embalming the dead.

Hopea odorata.—This plant yields a fragrant resin, which, when powdered, is a popular styptic amongst the Burmese.

Shorea robusta is a valuable timber-tree; it is a native of India, and its wood is there extensively used under the name of *Sál.* A colourless, yellowish or brownish resin, called Dammar in Bengal, is also obtained from this plant. It forms a substitute for the ordinary resins of the Coniferæ in the making of plasters.

Vateria indica.—This plant yields an oleo-resinous substance which is known in India under the name of White Dammar or Piney Resin. It is used as a varnish, and for making candles. The substance called Piney Tallow, or Vegetable Butter of Canara, is a concrete oil obtained from the fruits of this plant. It has been employed in India as a local application in rheumatism, &c., and some has been lately imported into this country.

Vatica Tumbugaia is said to yield a portion of the Black Dammar of India. (See *Canarium.*)

Order 9. Chlænaceæ, the Sarcolæna Order.—Character.—*Trees* or *shrubs. Leaves* entire, alternate, with large deciduous convolute stipules. *Flowers* regular, unsymmetrical, furnished with an involucre: the *involucre* surrounding 1—2 flowers, and persistent. *Sepals* 3, imbricate. *Petals* 5, convolute, sometimes united at the base. *Stamens* generally very numerous, rarely but 10, monadelphous; *anthers* roundish, 2-celled. *Ovary* 3-celled; *style* 1; *stigma* trifid. *Fruit* capsular, 3-celled or rarely 1-celled; *placentas* axile. *Seeds* solitary or numerous, suspended; *embryo* in the axis of fleshy albumen; *cotyledons* leafy; *radicle* superior.

Diagnosis.—Readily distinguished among the Thalamifloræ by their alternate simple stipulate leaves; and involucrate flowers, which are regular and unsymmetrical. The calyx is also imbricate, the stamens monadelphous, and the seed has abundant albumen.

Distribution and Numbers.—There are but 8 species included in this order, all of which are natives of Madagascar. *Illustrative Genus:*—Sarcolæna, *Thouars.*

Properties and Uses.—Altogether unknown.

Cohort 6. Malvales.—Calyx with valvate æstivation. Stamens usually numerous. Placentation axile or sutural.

Order 1. Malvaceæ, the Mallow Order.—Character.—*Herbs, shrubs,* or *trees. Leaves* alternate, often downy, more or less divided in a palmate manner (*fig.* 324), stipulate. *Flowers* regular, usually axillary, and often surrounded by an involucre or epicalyx (*figs.* 470 and 917). *Sepals* usually 5 (*figs.* 470 and 917), rarely 3 or 4, more or less united (*fig.* 470); with valvate or some form of circular æstivation (*fig.* 917). *Petals* hypogynous, equal in number to the divisions of the calyx (*fig.* 917), with a twisted æstivation, either attached to the column formed by the united stamens (*fig.* 918) or free. *Stamens* hypogynous, numerous, monadelphous (*figs.* 549 and 918); *anthers* 1-celled,

FIG. 917.

FIG 918.

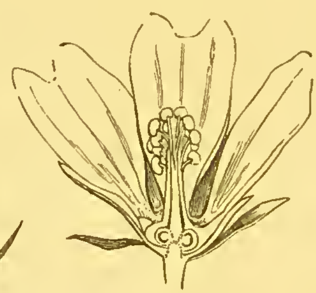


FIG. 919.

FIG. 920.

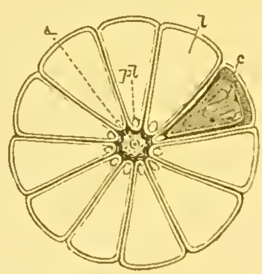


Fig. 917. Diagram of the flower of a species of *Malva*. The three external lines represent bracts, which together form an epicalyx or involucre.——*Fig.* 918. Vertical section of the flower of a Mallow.——*Fig.* 919. Pistil of the same surrounded by the inferior calyx and involucre.——*Fig.* 920. Horizontal section of the fruit of *Malva sylvestris*. *a*. Axis. *pl*. Placenta. *l*. An empty cell. *c*. Embryo with twisted cotyledons.

reniform, with transverse dehiscence (*fig.* 535). *Ovary* superior, consisting of several carpels (*figs.* 917 and 919), which are either apocarpous (*fig.* 919), or united so as to form a compound ovary with as many cells as there are carpels; *placentas* attached to the ventral sutures when the carpels are apocarpous (*fig.* 920, *pl*), or axile when the ovary is compound; *styles* equalling the carpels in number (*fig.* 919), united or distinct. *Fruit* either a carcerule, that is, consisting of a number of 1-celled, indehiscent (*figs.* 707 and 920), 1- or many-seeded carpels; or a capsule with loculicidal (*fig.* 672) or septicidal dehiscence, and numerous seeds. *Seeds* sometimes hairy; *albumen* none or in small quantity; *embryo* curved; *cotyledons* much twisted (*fig.* 920, *c*).

Diagnosis. — Leaves alternate, palmately-veined, simple, stipulate. Flowers regular. Calyx with valvate or some form of circular æstivation. Petals twisted in æstivation. Stamens hypogynous, numerous; anthers 1-celled, reniform, dehiscing transversely; filaments united so as to form a column. Carpels distinct or united. Seeds with very little or no albumen; embryo curved; cotyledons twisted.

Division of the Order and Illustrative Genera.—This order may be divided into three tribes as follows :—

Tribe 1. *Malveæ.*—Flowers furnished with an involucre or epicalyx (*fig.* 917). Fruit consisting of separate carpels (apocarpous) (*figs.* 707 and 920). *Illustrative Genera* :—Malva, *Linn.*; Althæa, *Linn.*

Tribe 2. *Hibisceæ.*—Flowers furnished with an involucre (*fig.* 470). Fruit formed of united carpels (syncarpous) (*fig.* 672). *Illustrative Genera* :—Hibiscus, *Linn.*; Gossypium, *Linn.*

Tribe 3. *Sideæ.*—Flowers without an involucre. Fruit apocarpous or syncarpous. *Illustrative Genus* :—Sida, *Linn.*

Distribution and Numbers.—These plants are chiefly natives of the tropics and the warmer parts of temperate regions. They diminish gradually as we approach the north, and are altogether absent in the frigid zone. There are more than 1,000 species.

Properties and Uses.—No plant of this order possesses any deleterious properties. The order is generally characterised by mucilaginous and demulcent qualities. From the liber of many species strong and tough fibres are obtained, and the hairs covering the seeds of certain species constitute cotton.

Abutilon esculentum. Bençao de Deos, furnishes an article of diet, the boiled flowers being used in Brazil as a vegetable.

Althæa.—The root and leaves of *A. officinalis*, the Marsh-mallow plant, abound in mucilage, particularly the root, and hence all preparations from these parts are demulcent, and useful in diseases of the mucous membranes, &c. An emollient cataplasm is also occasionally prepared from the boiled root. In France Marsh-mallow is in much greater request than in this country. A favourite preparation there is the Pâte de Guimauve, which is a kind of lozenge made with the mucilage of Althæa root, gum-arabic, sugar and white of egg.—*Althæa rosea*, the Hollyhock of our gardens, has similar properties. From the leaves a blue colouring matter resembling indigo is obtained. Strong fibres have been also procured from the bark, and used in the manufacture of good cordage.

Gossypium.—Several species and varieties of this genus furnish cotton, which is the hairy covering of their seeds. (See page 67.) There appear, however, to be three species more especially from which our commercial cotton is obtained, namely, *G. herbaceum*, *G. barbadense*, and *G. peruvianum*. 1. *Gossypium herbaceum*, which is supposed by Masters to be a cultivated variety of *G. Stocksii*, a native of Sindh, yields the common Indian cottons, as Dacca, Behar, Nankin, &c. Nankin Cotton is remarkable for its yellowish-brown colour, which colour was formerly thought to be artificial, and produced by dyeing, but it is now known to be natural to it. 2. *G. barbadense* is the species which yields all the best long-staple cotton of commerce. Thus from it the much-esteemed Sea-Island Cotton is obtained, as also the New Orleans, Georgian, and other cottons derived from the United States. It also yields the Bourbon cotton of India. 3. *G. peruvianum* or *acuminatum*, probably a variety of the latter, furnishes the South American varieties of cotton, as Pernambuco, Peruvian, Brazilian Cotton, &c. Another species, *Gossypium arboreum*, is the Tree-Cotton of India, which yields a variety of a very fine, soft, and silky nature. This is used by the natives of India for making turbans. The amount of cotton employed for manufacturing purposes in this and other countries is enormous, although the supply was much interfered with by the late American civil war: hence, since that period, the cultivation in the East Indies, Africa, &c., of the plants yielding it has been much extended, and large supplies are now obtained from the East Indies, Egypt, &c. The amount of cotton, however, produced in the United States during the year 1881 exceeded 7,000,000 bales. The increase in the consumption of cotton in this country may be at once judged of by the following statement. In 1800, the amount of cotton imported was 50,010,732 lbs.; in 1810, it had increased to 132,488,935 lbs.; in 1820, to 151,672,655 lbs.; in 1830, to 263,961,452 lbs.; in 1840, to 592,488,000 lbs.; and in 1850, to about 772,000,000 lbs. This latter amount is equivalent to about 2,600,000 bales, each of which averages 336 lbs. in weight, making altogether about 340,000 tons. It has been computed that the value of this in a raw state is about 30,000,000*l.*, and when manufactured into cotton fabrics, about three times that amount, or 90,000,000*l.* Of these about 30,000,000*l.* worth were exported from the United Kingdom, and 60,000,000*l.* worth consumed in this country. In the United Kingdom there were at the same period about 2,000 cotton factories, using a motive power equivalent to that of 90,000 horses, and employing 350,000 human beings. The above interesting statistical record will exhibit in a prominent manner the immense importance of cotton to the inhabitants of this country. From 1850 up to the time of the American war the consumption of cotton enormously increased; it then materially decreased, but at the present time the quantity consumed in this country alone is probably not less than 1,500,000,000 lbs.; and by the whole manufacturing world about double this quantity.

Cotton is official in the British Pharmacopœia for the purpose of preparing gun-cotton (*Pyroxylin*), from which *collodion* and *flexible collodion* are directed to be made. Collodion is a valuable local application to wounds, &c., and in burns, skin diseases, erysipelas, &c. Cotton in itself is also a useful application to burns and inflamed surfaces. It acts by excluding the air, and by keeping the affected parts at a uniform temperature. The seeds of the Cotton-plants, after the cotton has been obtained from them, upon being submitted to pressure, yield a fixed oil, which may be employed for burning in lamps, and for other purposes. From 80,000 to 100,000 tons are imported annually. The oil has been largely used in place of olive oil for edible purposes, and for making soap. The cake left after the expression of the oil is employed for feeding cattle. A decoction of cotton seeds has been employed in the United States as a remedy in intermittent fevers. *Cotton-root bark* is also regarded in the United States of America as an excellent emmenagogue.

Hibiscus.—The unripe fruit of *Hibiscus* (*Abelmoschus*) *esculentus*, known in the East and West Indies under the name of Okra, Gombo, Bendikai, &c., is used, on account of the abundance of the mucilage it contains, to thicken soups, &c., and in Western Africa in various ways in the preparation of native dishes. It also possesses valuable emollient and demulcent properties, and may be employed in all cases where such remedies are required. It is officinal in the Pharmacopœia of India. The roasted seeds have been used as a substitute for coffee. The seeds also yield by expression an oil which may be employed for edible and other purposes like olive oil. The fibre of the stems is also valuable for paper-making, and a patent has been taken out in France for this purpose, and the plant has been introduced into Algeria. The paper prepared from it is called *banda paper.* —*Abelmoschus moschatus* derives its specific name from the musky odour of its seeds, which are regarded as cordial and stomachic, and are sometimes mixed with coffee by the Arabs. They are also employed as a perfume. The powdered seeds steeped in rum are used in the West Indies as a remedy against the bites of serpents.—*H. cannabinus* yields the valuable fibre known under the name of Sunnee or Brown Indian Hemp, which is commonly used in India as a substitute for true Hemp. It is sometimes termed Sunn Hemp, but improperly so, as the true Sunn Hemp is derived from *Crotalaria juncea*, a plant of the order Leguminosæ. (See *Crotalaria.*) From the seeds a fixed oil is obtained by expression.—*Hibiscus arboreus*, a native of the West Indies, is also remarkable for the tenacity of its inner bark, and it is said by some authors that the whips formerly used by the slave-drivers were manufactured from its fibres. (See *Lagetta.*)—*Hibiscus Rosa-sinensis* has astringent petals, which are used by the Chinese to blacken their eyebrows and the leather of their shoes. The expressed fresh juice of these petals is said to form a good substitute for litmus: and an infusion of the petals has also been reputed useful as a demulcent refrigerant drink in fevers. Various other species of *Hibiscus*, as *H. striatus*, *H. tiliaceus*, &c., also yield valuable fibres, useful for textile fabrics, or for paper-making.

Malachra capitata.—The leaves are reputed to be anthelmintic, and are employed for such a purpose in Panama.

Malva.—*Malva sylvestris*, the common Mallow, has similar, although very inferior, properties to the Marsh-mallow. (See *Althæa.*) Its bark also yields strong fibres.—*Malva Alcea.*—The petals of this plant have astringent properties, and yield a black dye.

Paritium elatum.—The material known as Cuba Bast, now largely used by gardeners for tying up plants, &c., is prepared from the liber of this tree. Cuba Bast is also employed for tying up the bundles of Havannah cigars.

Pavonia diuretica derives its specific name from its supposed diuretic property, for which purpose it is used in Brazil.

Sida.—*Sida micrantha* and other species supply fibres useful in the manufacture of cordage, &c. Rocket-sticks are also obtained from the stems of *S. micrantha.*—*Sida cordifolia* and *S. mauritiana* have demulcent and emollient properties.—*S. lanceolata* has a very bitter root, which is reputed to be a valuable stomachic. The roots of *S. retusa* and other species are held in esteem by the natives of India for the treatment of rheumatism.

Many plants of the order have showy flowers, and are cultivated in our gardens and stoves; for example, the *Althæa rosea* (Hollyhock), *Abutilon*, *Hibiscus*, *Sida*, &c.—*Hibiscus mutabilis* is remarkable for the changing colour of its flowers, which vary in a single day from a cream-coloured rose to a rich rose or pink colour.

Order 2. STERCULIACEÆ, the Silk-cotton Order.—Character.—*Trees* or *shrubs*, sometimes climbing. *Leaves* alternate, simple or compound, with deciduous stipules. *Flowers* usually perfect, sometimes by abortion unisexual, regular or irregular, often surrounded by an involucre. *Calyx* and *corolla* resembling the Malvaceæ, always, however, having five parts; but the petals are sometimes absent. *Stamens* usually united by their filaments into a column, and indefinite, or rarely few and distinct; *anthers* usually 2-celled, or rarely 1-celled. *Carpels* 3 or 5, either distinct or united so as to form a compound ovary, sessile or stalked, or rarely more numerous or solitary; *styles* equal in number to the carpels, distinct or united; *ovules* usually definite, sometimes indefinite. *Fruit* either composed of a number of follicles, or capsular (*fig.* 708), or rarely baccate. *Seeds* with fleshy-oily albumen or none; *embryo* straight or curved; *cotyledons* either plicate or rolled round the plumule.

The order Byttneriaceæ of some botanists is here included in Sterculiaceæ.

Diagnosis.—The plants of this order are at once known among the Thalamifloræ by their valvate 5-partite calyx; twisted corolla consisting of 5 distinct petals; numerous perfect stamens united by their filaments into a column; and usually by their 2-celled anthers. The character presented by the anthers should be particularly noticed, as that alone, in most cases, at once distinguishes them from the Malvaceæ, which in many other respects they closely resemble; indeed the Sterculiaceæ have been combined with the Malvaceæ. It should, however, also be observed, that the flowers of some of the Sterculiaceæ are unisexual by abortion.

Distribution and Numbers.—Natives chiefly of the tropics or of very warm regions; but some of the species are found scattered in almost every quarter of the globe, except Europe. *Illustrative Genera:*—Sterculia, *Linn.*; Helicteres, *Linn.*; Theobroma, *Linn.* There are more than 500 species belonging to this order.

Properties and Uses.—In their properties the plants of this order resemble the Malvaceæ: thus, they are generally mucilaginous, demulcent, and emollient; some have a hairy covering to their seeds; and others yield useful liber-fibres. The cottony covering of their seeds, and the fibres yielded by certain plants of this order, are not, however, to be compared in importance to the similar products of the Malvaceæ. Some plants are reputed to be diuretic, emetic, or purgative.

Adansonia.—*A. digitata*, the Baobab-tree.—The fruit, commonly known as Monkey-bread or Ethiopian Sour-gourd, has its seeds surrounded by a large quantity of a starchy pulp with an acid flavour much resembling cream of tartar. Its acid nature is said to be due to *malate of potassium.* This forms a wholesome and agreeable article of food. When mixed with water it is used as an acid drink, which is regarded as a specific in putrid and pestilential fevers. It is also employed in Egypt in dysentery. All parts of the tree possess emollient and demulcent properties. Its powdered leaves are used by the Africans under the name of Lalo, mixed with their daily food, to check excessive perspiration. This property is owing to the presence of an astringent matter; hence they have been found serviceable in diarrhœa, &c. The bark is said to be febrifugal, and its liber-fibres are employed by certain African tribes, living where the tree is common, in the manufacture of various articles of dress, cordage, &c. The Baobab-tree is also remarkable for its enormous size, and the great age to which it attains, in some cases reputed to be several thousand years. One tree of this species has been found to have a trunk from 90 to 100 feet in circumference. Their hollowed trunks are used by the natives in some districts of Africa as burial-places for such of their dead as are believed to have communion with evil spirits.—*A. Gregorii.*—The fruit of this tree, which is a native of North Australia, where it is known as Sour-gourd and Cream-of-tartar tree, has similar properties to that of *A. digitata. This genus is sometimes placed in Malvaceæ.*

Bombax.—B. Ceiba, the Silk-Cotton tree of South America, and *B. pentandrum*, the Silk-Cotton tree of India, are both remarkable for their size and height. The seeds of these plants are covered by long silky hairs; hence their common name. But these hairs cannot be spun like those of ordinary cotton, chiefly on account of the smoothness and consequent want of adhesion between their sides, and are therefore useless for manufacturing purposes. They are employed, however, in many parts of the world, for stuffing cushions, &c. The bark of *B. pentandrum* is reputed to be emetic. *This genus is sometimes referred to Malvaceæ.*

Chorisia.—C. speciosa has its seeds covered with silky hairs, which are used for stuffing cushions, &c. This material is termed Vegetable Silk. The bark of *C. crispiflora* is employed for making cordage in Brazil.

Durio zibethinus.—This tree, which is about the size of the ordinary pear-tree, yields the fruit called Durian, which is highly esteemed in the south-eastern parts of Asia, being accounted next in value to the Mangosteen. It has, however, a strong smell, which renders it disagreeable at first, but this quality is soon forgotten after the palate has become familiar with it. *This genus is sometimes referred to Malvaceæ.*

Eriodendron Samauma, a native of South America, is remarkable for its great height. Its trunk frequently overtops all the surrounding trees before it gives off a single branch. The hairy covering of the seeds of various species of *Eriodendron* is employed for stuffing cushions and similar purposes.

Guazuma.—The fruit of *G. ulmifolia* contains a sweetish mucilaginous agreeable pulp, which is eaten in Brazil, and the young bark possesses mucilaginous properties.

Ochroma Lagopus, a West Indian tree, has an antisyphilitic bark, and a spongy wood, which is sometimes used as a substitute for cork.

Salmalia.—The bark of some species of this genus is said to be emetic, and honey obtained from the flowers of *S. malabarica* is commonly regarded as both emetic and purgative.

Sterculia.—The seeds of *Sterculia* (*Cola*) *acuminata*, and probably of other species, constitute the Kola-nuts of tropical West Africa, and the Guru-nuts of Soudan. They are largely used in various parts of Africa as food and medicine, and are also commonly stated to be employed to sweeten water which has become more or less putrid. Their use, however, as a purifier of water is denied by Dr. Daniell. They have been used of recent years in this country and elsewhere, as a stimulant tonic, and as a remedy in chronic diarrhœa, cardiac affections, and cachexia. These properties are especially due to the presence of *theine*; they also contain *tannic acid.* It is said that these nuts have the power of staying, for even a prolonged period, the cravings of hunger, and of enabling those who eat them to endure continued labour without fatigue, resembling in these respects coca-leaves. The seeds of other species of *Sterculia* are also eaten in different parts of the globe. This is the case with *S. Chica*, and *S. lasiantha* in Brazil; and *S. nobilis* in Asia.—*Sterculia Tragacantha*, a native of Sierra Leone, receives its specific name from yielding a gum resembling Tragacanth. It is termed African Tragacanth, and has been stated by Dr.

Flückiger to be a good substitute for the official Tragacanth. (See *Astragalus*.)—*S. urens*, a native of Coromandel, yields a gum of a similar nature, which is called Gum Kutteera. (See also *Cochlospermum*.) The fruit, seeds, leaves or bark of other species of *Sterculia* are also used for various purposes as medicinal agents in different parts of the globe. The seeds of all the species contain a fixed oil, which may be used for burning in lamps, &c. According to Hooker, *S. villosa* and *S. guttata* yield fibres from which ropes of excellent quality and cloth are made.

Theobroma Cacao, the Cacao or Cocoa-tree. This tree, by far the most important plant of the order, is a native of Demerara and Mexico, and it is extensively cultivated in the West Indies, Central America, Mauritius, &c. From its seeds Cacao or Cocoa, and Chocolate are prepared. In the manufacture of *Chocolate*, the seeds are first roasted, then divested of their husks and ground, and afterwards triturated in a mortar with an equal quantity of sugar, to which some vanilla or cinnamon is added for flavouring, and a small quantity of Arnatto as a colouring agent. All the finer qualities are thus prepared, but the flavouring of the inferior kinds is sometimes produced by adding Sassafras nuts, cloves, or some other aromatic. Chocolate derives its name from the Indian term *chocolat*. *Cocoa* is either prepared by grinding up the roasted seeds with their outer shells or husks between hot cylinders into a paste, which is then mixed with starch, sugar, &c.,—this forms *common cocoa, rock cocoa, soluble cocoa*, &c.,—or the roasted seeds divested of their husks are broken into small fragments, in which state they form *cocoa nibs*, the purest state of Cocoa. The husks of the Cocoa seeds are also sometimes used by the poorer classes of Italy and Ireland in the preparation of a wholesome and agreeable beverage; they are imported from Italy under the name of 'miserable.' Both Cocoa and Chocolate are used for the preparation of agreeable and nutritious beverages; these are not so stimulating as Tea and Coffee, but they disagree with many persons on account of their fatty nature. The generic name, *Theobroma*, was given to this tree by Linnæus, signifying 'food of the gods,' to mark his opinion of the nutritious and agreeable nature of the beverages prepared from its seeds; but Belzoni, a traveller of the sixteenth century, regarded them in a very different light, for he declared that Cocoa was a drink 'fitter for a pig than for a man.' Cocoa seeds owe their properties chiefly to a peculiar alkaloid, named *theobromine*, which resembles *theine*, the alkaloid contained in China Tea (*see* Thea), &c., and to a concrete oil or fat called *Butter of Cocoa*, which constitutes about half their weight. It has been computed that Cocoa and Chocolate form the common unfermented beverages of about fifty million persons in Spain, Italy, France, and Central America, and that the consumption of Cocoa in these countries annually is over 100,000,000 lbs. Cocoa is also now largely used in Britain; and its use has much increased of late years. Thus the consumption in 1820 was only about 276,000 lbs.; in 1866 it was 4,583,124 lbs.; in 1873 over 8,000,000 lbs.; and it is now estimated to exceed 10,000,000 lbs. annually. From the pulp which surrounds the seeds a peculiar kind of spirit is distilled.

The concrete oil is official in the British Pharmacopœia. It enters into the composition of the suppositories ordered in that volume. In itself it possesses emollient properties. It is especially valuable from not readily becoming rancid by exposure to the air.

Order 3. TILIACEÆ, the Lime-tree or Linden Order.—Character.—*Trees, shrubs*, or rarely *herbs*. *Leaves* simple, alternate (*fig.* 290), with deciduous stipules. *Sepals* 4 or 5 (*fig.* 921), distinct or united, valvate in æstivation (*fig.* 921), deciduous. *Petals* equal in number to the sepals (*fig.* 921), entire or divided, or rarely wanting, imbricate. *Stamens* hypogynous (*figs.* 923 and 924), usually numerous (*figs.* 921-923), distinct (*fig.* 923) or polyadelphous (*fig.* 557); *anthers* 2-celled (*figs.* 525 and 922), opening longitudinally, or by pores at the apex. *Disk* glandular, hypogynous. *Carpels* 2—10, which are generally united so as to form a compound many-celled ovary (*fig.* 921), sometimes distinct; *placentas* axile (*fig.* 921); *style* 1 (*figs.* 922 and 923); *stigmas* equal in number to the carpels. *Fruit* dry or pulpy, sometimes samaroid, usually many-celled, or rarely 1-celled by abortion. *Seeds* solitary or numerous; *embryo* erect, straight, in the axis of fleshy albumen; *cotyledons* flat and leafy (*fig.* 764, *c*, *c*); *radicle* next the hilum.

Diagnosis.—This order resembles, in many respects, the

FIG. 921.

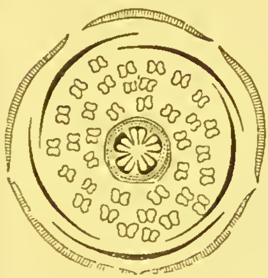


FIG. 923.

FIG. 922.

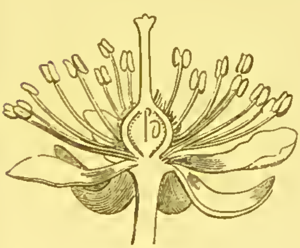


Fig. 921. Diagram of the flower of the Lime.——*Fig.* 922. Vertical section of the flower of the same (*Tilia europæa*).——*Fig.* 923. Peduncle of the Lime, bearing two flower-buds and a fully expanded flower.

Malvaceæ and Sterculiaceæ. It may be at once distinguished from them by having a glandular disk, and by the stamens not being monadelphous; and from the Malvaceæ also, by the anthers being 2-celled. From all other Thalamifloræ the plants of this order may be known by their alternate simple stipulate leaves; valvate æstivation of calyx, which is also deciduous; floral envelopes in 4 or 5 divisions; stamens either distinct or polyadelphous; anthers 2-celled; hypogynous glandular disk; many-celled fruit with axile placentas; and embryo erect, straight, in the axis of fleshy albumen.

Division of the Order and Illustrative Genera.—The order has been divided into two tribes, as follows:—

Tribe 1. *Tilieæ.*—Corolla with entire petals, or wanting; anthers dehiscing longitudinally. *Illustrative Genera:*—Corchorus, *Linn.*; Tilia, *Linn.*

Tribe 2. *Elæocarpeæ.*—Petals divided, anthers opening by pores at the apex. *Illustrative Genera:*—Elæocarpus, *Linn.*; Vallea, *Mut.*

Distribution and Numbers.—A few are found in the northern parts of the world, where they form large trees; but the plants of this order are chiefly tropical, and are there found as herbs, shrubs, or trees. There are about 350 species.

Properties and Uses.—In their properties the Tiliaceæ resemble the Malvaceæ. They are altogether innocuous, and are generally mucilaginous, emollient, and demulcent. Many of them also yield fibres, which are much used for manufacturing purposes. Some are valuable timber-trees, and some have edible fruits.

Aristotelia.—*A. Maqui* has an edible fruit, and from it a kind of wine is also made in Chili, which is given in fevers of a malignant type. The fibres of the bark and the wood have been used in the manufacture of musical instruments. In New Zealand the fruits of *A. racemosa*, the Mako Mako, are also eaten.

Corchorus.—The fibres obtained from the bark of *Corchorus capsularis*, the Jute Plant, are commonly known under the name of Jute or Jute-hemp. This fibre is very valuable and is now imported in enormous quantities into this country, where it is used chiefly in the manufacture of coarse bags, and as a foundation for inferior carpets, &c. It is also frequently mixed with silk in the manufacture of cheap satin fabrics, and is likewise employed as a substitute for hair, and in the manufacture of chignons, &c. It does not appear to be well adapted for sailcloth or cordage, because it will not bear exposure to wet. The imports in 1875 were over 500,000,000 lbs., the value of which was 2,362,226*l.*, of which only about 80,000,000 lbs. were exported. In India it is used chiefly for the purpose of making the coarse canvas called *Gunny*, which is the material employed there for the bags, &c., in use for packing raw produce.—*Corchorus olitorius*, commonly called Jew's Mallow, is used in some parts of the world as a pot-herb; it is also one of the sources of Jute. In Panama, the leaves of *C. mompoxensis* are infused in boiling water, and the infusion is then taken as a substitute for tea.

Elæocarpus.—*E.* (*Ganitrus*) *serratus.*—The fruits are commonly known under the name of Molucca Berries. When the fruit is divested of its pulp, the endocarp, which is hard and bony, and beautifully furrowed, is used for making necklaces. These are frequently brought as presents from India, and are also to be purchased in this country. The fruits of some species of *Elæocarpus* are eaten, while others are used in the preparation of Indian curries. The bark of *E. Hinau* (*dentatus*) affords an excellent dye, varying in colour from brown to puce or nearly black. It is employed in New Zealand for dyeing the garments of the natives. It is also useful as a tanning agent.

Grewia.—*G. sapida*, *G. asiatica*, and other species, have pleasant acid fruits, and are used in the East for making Sherbet.—*G. elastica* affords valuable timber.—*G. polygama* is regarded in Queensland as a very valuable remedy in dysentery. The seeds are also employed in the preparation of a sub-acid drink.

Luhea grandiflora.—The bark is astringent, and is employed in Brazil for tanning leather. The wood of other species is used for various purposes in Brazil, as for making soles to boots, musket-stocks, &c.

Tilia europæa, Common Lime or Linden Tree.—The inner bark is employed in the northern parts of Europe, more particularly in Russia, in the manufacture of mats, which are commonly known as Russian, Bast, or Bass mats. This Bast is one of the substances employed by gardeners for tying up plants. The flowers are very fragrant when fresh, and an infusion of them is much used on the Continent for its expectorant and antispasmodic properties. The wood of this and other species of *Tilia* is very white and smooth, and is employed for various purposes, as for carving, wainscoting, &c.

Triumfetta.—Several species of this genus have astringent and mucilaginous leaves and fruits, and are employed in Brazil for making injections, which are reputed to be useful in gonorrhœa.

Vallea cordifolia.—The leaves are used for the purpose of dyeing yellow.

Artificial Analysis of the Orders in the Sub-class Polypetalæ.

Series 1. THALAMIFLORÆ.

1. FLOWERS with more than 20 stamens.

A. *Leaves without stipules.*

a. *Carpels more or less distinct (at least as to the styles), or solitary.*

1. Stamens distinct.
   - Carpels immersed in a fleshy tabular thalamus . . . . *Nelumbiaceæ.*
   - Carpels not immersed in a thalamus.
     - Embryo in a vitellus . . . . . *Cabombaceæ.*
     - Embryo naked, very minute.
       - Seeds arillate . . . . . . *Dilleniaceæ.*
       - Seeds exarillate. Albumen fleshy and homogeneous.
         - Flowers hermaphrodite . . *Ranunculaceæ.*
         - Flowers unisexual . . . . *Schizandraceæ.*
       - Seeds usually exarillate. Albumen ruminate . . . . . . *Anonaceæ.*
2. Stamens united in one or more parcels.
   - Calyx much imbricate.
     - Seeds smooth . . . . . . *Hypericaceæ.*
     - Seeds shaggy . . . . . . *Reaumuriaceæ.*

b. *Carpels wholly combined (at least as to the ovaries), with more than one placenta; or with a free central placenta.*

- Placentas parietal, in distinct lines.
  - Anthers versatile. Juice watery . . *Capparidaceæ.*
  - Anthers innate. Juice milky . . *Papaveraceæ.*
- Placentas parietal, spread over the lining of the fruit . . . . *Bixaceæ.*
- Placentas covering the dissepiments . *Nymphæaceæ.*
- Placentas in the axis.
  - Stigma large, broad, and petaloid . *Sarraceniaceæ.*
  - Stigma simple. Calyx much imbricate.
    - Leaves compound . . . . . *Rhizobolaceæ.*

Leaves simple.	
Petals equal in number to the sepals.	
Seeds few	*Guttiferæ.*
Seeds numerous. Petals flat .	*Marcgraaviaceæ.*
Seeds numerous. Petals crumpled	*Cistaceæ.*
Petals not equal in number to the sepals. Styles not perfectly combined	*Ternstrœmiaceæ.*
Placenta free central	*Portulacaceæ.*
B. *Leaves with stipules.*	
a. *Carpels more or less distinct (at least as to the styles).*	
Carpels numerous	*Magnoliaceæ.*
b. *Carpels wholly combined (at least as to the ovaries), with more than one placenta.*	
Placentas parietal	*Bixaceæ.*
Placentas in the axis.	
Calyx with an imbricate æstivation.	
Flowers involucrate	*Chlænaceæ.*
Flowers not involucrate . . .	*Cistaceæ.*
Calyx with a valvate æstivation.	
Stamens monadelphous. Anthers 2-celled.	*Sterculiaceæ.*
Stamens monadelphous. Anthers 1-celled	*Malvaceæ.*
Stamens monadelphous. Calyx irregular, and enlarged in the fruit .	*Dipteraceæ.*
Stamens quite distinct . . .	*Tiliaceæ.*

2. FLOWERS with less than 20 stamens.

A. *Leaves without stipules.*	
a. *Carpels more or less distinct, or solitary.*	
Anthers with recurved valves . . .	*Berberidaceæ.*
Anthers with longitudinal dehiscence.	
Albumen abundant, embryo minute.	
Flowers unisexual. Seeds usually numerous	*Lardizabalaceæ.*
Flowers perfect.	
Embryo in a vitellus . . .	*Cabombaceæ.*
Embryo not in a vitellus.	
Albumen homogeneous.	
Sepals 2	*Fumariaceæ.*
Sepals more than 2 . . .	*Ranunculaceæ.*
Albumen ruminate. Shrubs .	*Anonaceæ.*
Albumen in small quantity, or altogether wanting.	
Flowers unisexual	*Menispermaceæ.*
Flowers perfect	*Calycanthaceæ.*
b. *Carpels wholly combined (at least as to the ovaries).*	
Placenta parietal.	
Stamens tetradynamous . . .	*Cruciferæ.*
Stamens not tetradynamous.	
Large hypogynous disk.	
Flowers tetramerous. Fruit closed at the apex	*Capparidaceæ.*

Flowers not tetramerous. Unripe fruit usually open at the apex . *Resedaceæ.*
Small hypogynous disk, or none.
Albumen abundant.
Flowers irregular . . . *Fumariaceæ.*
Flowers regular. Sap milky. Fruit without central pulp . . *Papaveraceæ.*
Fruit with central pulp, or fleshy. Sap watery . . . . *Bixaceæ.*
Albumen in small quantity, or wanting.
Calyx tubular, furrowed . . *Frankeniaceæ.*
Placentas covering the dissepiments . *Nymphæaceæ.*
Placentas axile or free central.
Styles distinct to the base.
Calyx much imbricate.
Seeds smooth. Petals unequal-sided, without appendages . . . *Hypericaceæ.*
Seeds shaggy. Petals unequal-sided, usually with appendages at the base . . . . *Reaumuriaceæ.*
Calyx slightly imbricate.
Petals not twisted in æstivation. Ovary with a free central placenta *Caryophyllaceæ.*
Styles more or less combined.
Calyx much imbricate, in an irregular broken whorl.
Flowers symmetrical . . . *Guttiferæ.*
Flowers unsymmetrical, papilionaceous . . . . . *Polygalaceæ.*
Calyx but little imbricate, in a complete whorl.
Carpels 4 or more.
Ovary 1-celled, with a free central placenta . . . . . *Portulacaceæ.*
Carpels less than 4.
Seeds comose . . . . *Tamaricaceæ.*
Seeds not comose.
Ovules pendulous. Petals twisted in æstivation. . . . *Canellaceæ.*
Ovules ascending or horizontal. Petals imbricate in æstivation *Pittosporaceæ.*
Calyx valvate, or but very slightly imbricate.
Anthers opening by pores . . *Tremandraceæ.*

B. *Leaves with stipules.*

a. *Carpels distinct, or solitary.*
Anthers with recurved valves. Carpel solitary . . . . *Berberidaceæ.*

b. *Carpels wholly combined (at least as to the ovaries), with more placentas than one.*
Placentas parietal.
Leaves with involute vernation. Anthers crested, and turned inwards . . . *Violaceæ.*
Stamens opposite to the petals. Anthers naked, and turned outwards . . . *Sauvagesiaceæ.*

Placentas in the axis.
Styles distinct to the base.
Calyx much imbricate, in an irregular broken whorl.
Petals small, sessile . . . . *Elatinaceæ.*
Calyx but little imbricate, in a complete whorl.
Petals minute . . . . . . *Paronychiaceæ.*
Calyx valvate . . . . . . *Tiliaceæ.*
Styles more or less combined.
Calyx much imbricate, in an irregular broken whorl.
Flowers surrounded by an involucre . *Chlænaceæ.*
Calyx but little imbricate, in a complete whorl.
Sepal spurred . . . . . . *Vochysiaceæ.*
Calyx valvate.
Stamens united by their filaments into a column. . . . . . *Sterculiaceæ.*
Stamens not united into a column . *Tiliaceæ.*

In order to prevent the student being misled, and thus to refer plants to their wrong positions in the Vegetable Kingdom, it should be particularly noticed, that although the general character of the Thalamifloræ is to have dichlamydeous flowers and polypetalous corollas, yet exceptions do occur occasionally to both these characters. Thus, we find apetalous genera and species in *Ranunculaceæ, Magnoliaceæ, Berberidaceæ, Sarraceniaceæ, Menispermaceæ, Papaveraceæ, Cruciferæ, Canellaceæ, Bixaceæ, Violaceæ, Caryophyllaceæ, Paronychiaceæ, Scleranthaceæ, Malvaceæ, Sterculiaceæ,* and *Tiliaceæ.*

Again, in the orders *Anonaceæ. Pittosporaceæ, Polygalaceæ, Portulacaceæ, Tamaricaceæ, Ternstrœmiaceæ, Rutaceæ,* and *Dipteraceæ,* we find some monopetalous species and genera.

In *Dilleniaceæ, Papaveraceæ, Capparidaceæ, Resedaceæ, Violaceæ, Caryophyllaceæ, Portulacaceæ, Malvaceæ,* and *Sterculiaceæ,* some of the species have stamens more or less perigynous instead of hypogynous. Again, in some orders, as in certain *Ranunculaceæ, Calycanthaceæ. Anonaceæ, Nymphæaceæ. Portulacaceæ, Capparidaceæ, Polygalaceæ, Bixaceæ, Ternstrœmiaceæ, Vochysiaceæ, Tiliaceæ,* and *Dipteraceæ,* the calyx is more or less superior.

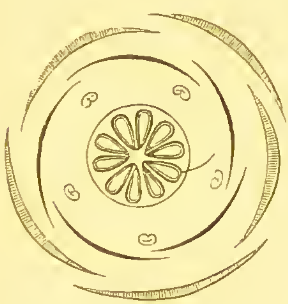
Series 2. Discifloræ.

Cohort 1. *Geraniales.*—Calyx generally imbricate, or rarely valvate. Gynœcium usually syncarpous, or sometimes apocarpous ; ovules suspended ; raphe ventral. Seeds albuminous or exalbuminous.

Order 1. LINACEÆ, the Flax Order.—Character.—*Herbs* or rarely *shrubs. Leaves* alternate, opposite, or rarely verticillate, simple, entire, exstipulate, or rarely stipulate. *Inflorescence* cymose. *Flowers* regular (*fig.* 924), symmetrical, generally very showy. *Calyx* imbricate, with 3, 4, or 5 sepals (*fig.* 924), persistent. *Petals* 4—5 (*fig.* 924), unguiculate, very deciduous, twisted in æstivation. *Stamens* 4—5, united at the base so as to form an hypogynous ring (*fig.* 925), from which proceed 5 tooth-like processes (*staminodes*) which alternate with the fertile stamens, and are opposite to the petals (*fig.* 925). *Disk* none or glandular. *Ovary* compound (*figs.* 618 and 924), its cells usually corresponding in number to the sepals ; *styles* 3—5 ; *stigmas* capitate (*figs.* 925 and 926). *Fruit* a septicidal capsule, each cell more or less perfectly divided into two by a spurious dissepiment proceeding from the dorsal suture (*fig.* 618, *b*), and having a single seed in each division. *Seed* compressed, with or without albumen ; *embryo* straight, with the radicle towards the hilum.

Diagnosis.—Herbs or very rarely shrubs, with simple entire leaves, which are usually exstipulate. Flowers regular, symmetrical. Sepals, petals, and stamens 3—5 each ; the sepals

FIG. 924. FIG. 925. FIG. 926.



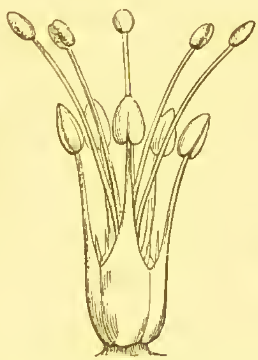


Fig. 924. Diagram of the flower of the Flax Plant (*Linum usitatissimum*). ——*Fig.* 925. Essential organs of the same, showing the monadelphous stamens surrounding the pistil.——*Fig.* 926. Pistil of the same, with distinct styles and capitate stigmas.

persistent and imbricate ; the petals fugacious and twisted in æstivation ; and the fertile stamens united at their base, and having little tooth-like staminodes alternating with them. Ovary 3—5-celled, styles distinct, stigmas capitate. Fruit a septicidal capsule, each cell more or less divided by a spurious dissepiment, and each division containing one seed. Seeds compressed, with or without albumen, and having a straight embryo.

The plants of the order *Erythroxylaceæ* of some botanists, which, following Bentham and Hooker, we include in this order, are exceptional in the petals having at their base two scales, in their drupaceous fruit, and woody stem.

Distribution and Numbers.—Chiefly natives of the south of Europe, Brazil, and some other parts of South America, West Indies, and the north of Africa, but more or less distributed over most regions of the globe. *Illustrative Genera* :—Linum, *Linn.* ; Radiola, *Gmelin.* There are about 160 species.

Properties and Uses.—The plants of this order are generally remarkable for the tenacity of their liber fibres, and also for the mucilage and oil contained in their seeds ; hence the latter are emollient and demulcent. A few of the plants are bitter and purgative ; and some are stimulant and sedative. Others are tonic, and some are used for dyeing red.

Erythroxylon.—Some species of *Erythroxylon* are tonic, others purgative, and a few stimulant and sedative. The wood of *E. hypericifolium* and the bark of *E. suberosum* are red, and are used in the preparation of dyes of that colour. The wood of others has a similar reddish appearance, and from this common colour of the wood the name of the genus is derived. But by far the more important plant of this genus is the following :—*E. Coca.* The dried leaves of this plant, under the name of Coca or Cuca, are commonly used mixed with a little lime, or wood ashes formed of the burnt stems of *Chenopodium Quinoa*, *Cecropia peltata*, or other plants, by the natives of Peru and some other parts of South America, as a masticatory. The Peruvian Indians have always ascribed to coca the most extraordinary virtues. Thus, they believe that it lessens the desire and the necessity for ordinary food, and, in fact, that it may be considered as almost a substitute for food. Spruce says, that an Indian with a chew of Ipadú (the native name for coca of the Indians of the Rio Negro) in his cheek, will go two or three days without food, and without feeling any desire to sleep. Von Tschudi, Markham, Stevenson, Dr. Scherzer, and others have also given somewhat similar testimony as to the effects of coca. But Weddell speaks far less highly of its virtues. He states that it does not satisfy the appetite, but merely enables those who chew it to support abstinence for a length of time without a feeling of hunger or weakness. The use of coca is also said to prevent the difficulty of respiration which is generally experienced in ascending long and steep mountains. Its excessive use has been stated to be very injurious by producing analogous effects to those occasioned by the immoderate consumption of opium and fermented liquors ; but Tschudi says that its moderate use is rather beneficial than otherwise. Christison has also testified to its value, from experiments made on himself and others, in removing and preventing fatigue. He states that by its use 'hunger and thirst are suspended ; but eventually appetite and digestion are unaffected.' It was computed by Johnston some time since, that the annual consumption of coca was 30,000,000 lbs., and that its chewing was indulged in by about 10,000,000 of the human race. In Bolivia alone 15,000,000 lbs. of coca are produced annually. The constituent thus said to give rise to the peculiar stimulating, hunger-allaying, and narcotic effects of coca seems essentially to be the alkaloid *cocaine*. It also contains a peculiar form of tannic acid, termed *coca-tannic acid*. *Coca leaves* and *hydrochlorate of cocaine* have now been made official in the British Pharmacopœia ; the former have been used as a nervine stimulant like tea and coffee, and also as a remedy in insomnia and otherwise. Cocaine itself in the form of the official hydrochlorate and other salts has been used most extensively and with very beneficial effects as a local anæsthetic in operations on the eye and in other cases. & teeth &c

Linum.—The liber-fibres of *Linum usitatissimum*, when prepared in a particular way, constitute *flax*, of which linen fabrics are made. In 1873, 2,194,000 cwt. of flax were imported into this country. Linen, when scraped, forms *lint*, which is so much used for surgical dressings ; and the short fibres of flax which are separated in the course of its preparation, constitute *tow*, which is much employed in pharmacy, surgery, and for other purposes. The seeds of this plant, which is commonly known as the Flax Plant, are termed Flaxseed, Linseed, or Lintseed ; they contain much mucilage, and a fixed oil. The oil may be readily obtained from the seeds by expression ; the amount depending upon the quality of the seed, and the mode adopted for its expression, and varying from about 20 to 30 per cent. Linseed oil is especially remarkable for drying readily when applied to the surface of any body exposed to the air, and thus forming a hard transparent varnish. This peculiarity is much accelerated if the oil be previously boiled, either alone, or with some preparations of lead. The cake left after the expression of the oil is known as *Oil-cake,* and is employed as food for cattle; and when powdered, it is frequently sold as Linseed Meal, but the official Linseed Meal is simply Linseed powdered; hence it contains the oil, which is not present in the former. Linseed Meal which thus contains the oil is to be preferred when in a fresh state. An infusion of Linseed is employed medicinally for its demulcent and emollient properties. The oil is extensively used in the arts, &c.; and is a valuable application to burnt or scalded parts, either alone, or combined with an equal quantity of Lime-water; this mixture is commonly known under the name of *Carron-oil,* a name derived from its having been extensively employed in the Carron Iron-foundry.—The *seeds, linseed meal,* and *linseed oil* are all official in the British Pharmacopœia.—*Linum catharticum,* popularly termed Purging Flax, is a common indigenous plant. It possesses active purgative properties, and might be much more employed as a medicine than is the case at present.—*Linum selaginoides,* a Peruvian species, is reputed to be bitter and aperient.

Sethia.—S. indica is in great repute in Ceylon as a vermifuge for children. The leaves are dried, powdered, and given mixed with boiled rice.—*S. acuminata* is also used in a similar way for the same purpose. It is known in Ceylon as Matura Worm Medicine.

Order 2. MALPIGHIACEÆ, the Malpighia Order.—Character.—*Trees* or *shrubs,* often climbing. *Leaves* usually opposite or whorled, rarely alternate; *stipules* generally short and deciduous, sometimes large and interpetiolar; the leaves are occasionally furnished with hairs, which are fixed by their middle, that is, peltate (*fig.* 168). *Flowers* perfect or polygamous. *Calyx* 5-partite, persistent, frequently with glands at the base of one or all of the divisions; *æstivation* imbricate or rarely valvate. *Petals* 5, hypogynous, unguiculate; *æstivation* convolute. *Stamens* usually 10, monadelphous or distinct; *connective* fleshy and elongated beyond the anther-lobes. *Ovary* generally consisting of 3 carpels, rarely 2 or 4, partially or wholly combined; *ovules* 1 in each cell, pendulous from a long stalk; *styles* 3, distinct or united; *stigmas* 3, simple. *Fruit* either drupaceous, samaroid, or a woody nut. *Seed* solitary, exalbuminous; *embryo* straight or variously curved.

Diagnosis.—Trees or shrubs, with simple stipulate leaves. Flowers perfect or polygamous. Calyx and corolla with 5 parts; the sepals having usually large glands at the base, and imbricate or very rarely valvate in æstivation; the petals unguiculate, without appendages, hypogynous, convolute. Stamens usually 10, sometimes 15, with a fleshy prolonged connective. Ovary generally composed of 3 carpels, or in any case not corresponding in number, or being any power of the three outer whorls; ovules solitary, pendulous from long stalks. Seeds exalbuminous, usually with a convolute embryo.

Distribution and Numbers.—They are almost exclusively natives of tropical regions. *Illustrative Genera*:—Malpighia, *Plum.*; Byrsonima, *Rich.*; Nitraria. There are about 580 species.

Properties and Uses.—An astringent property appears to be most general in the plants of this order. Some have edible fruits; and the seeds of others are reputed to be poisonous.

Bunchosia armeniaca, a native of Peru, is stated to have poisonous seeds.

Byrsonima.—Some species have edible fruits. The *Byrsonimas* are, however, principally remarkable for their astringency. Thus the fruit of *B. spicata* (*Bois-tan*) is used in dysentery; the bark of *B. crassifolia* is employed internally as an antidote to the bite of the rattlesnake, and for other purposes where astringent medicines are desirable. The bark of other species is also in use for tanning in Brazil. American Alcornoque bark, which is imported into this country for the use of the tanner, is said to be the produce of *B. laurifolia*, *B. rhopalæfolia*, and *B. coccolobæfolia.*

Malpighia glabra and *M. punicifolia* have edible fruits, which are used in the West Indies, as a dessert, under the name of Barbados Cherries.

Nitraria.—This genus is by some put into an order by itself called Nitrariaceæ. According to Munby, *N. tridentata* is the true Lotus-tree of the ancients. (See also *Zizyphus.*) It is a native of the desert of Soussa, near Tunis, and its fruit is of a somewhat intoxicating nature.—*N. Billardieri*, a native of Australia, has an edible fruit.

Order 3. HUMIRIACEÆ, the Humirium Order.—Character.—*Trees* or *shrubs* with a balsamic juice. *Leaves* alternate, simple, coriaceous, exstipulate. *Calyx* 5-partite, imbricate. *Petals* 5, imbricate. *Stamens* hypogynous, 20 or more, monadelphous; *anthers* 2-celled; *connective* elongated beyond the anther lobes. *Ovary* superior, usually surrounded by a *disk*. 5-celled; *ovules* 1 or 2 in each cell, suspended; *style* simple; *stigma* 5-lobed. *Fruit* drupaceous, 5-celled, or fewer-celled by abortion. *Seed* with a narrow embryo lying in fleshy albumen, orthotropous.

Distribution and Numbers.—Natives of tropical America. *Illustrative Genera*:— Humirium, *Mart.*; Vantanea, *Aubl.* There are 18 species.

Properties and Uses.—A balsamic yellow oily liquid, called Balsam of Umiri, is obtained from the incised stem of *Humirium floribundum*; this is reputed to resemble Copaiba in its properties. The bark is used by the Brazilians as a perfume. Other species are also said to yield useful balsamic liquids. The so-called balsamic liquid found in plants of this order is probably not a true balsam, but an oleo-resin resembling Wood Oil and Copaiba.

Order 4. ZYGOPHYLLACEÆ, the Bean-caper or Guaiacum Order.—Character.—*Herbs*, *shrubs*, or *trees*. *Leaves* opposite, stipulate, without dots, usually imparipinnate, or rarely simple. *Flowers* perfect, regular, and symmetrical. *Calyx* 4- or 5-partite, convolute. *Petals* unguiculate, 4 or 5, imbricate, hypogynous. *Stamens* 8—10, hypogynous, usually arising from the back of small scales; *filaments* dilated at the base. *Ovary* 4—5-celled, surrounded by glands or a *toothed disk*; *style* simple; *ovules* 2 or more in each cell (*figs.* 659 and 660); *placentas* axile. *Fruit* capsular, dehiscing in a loculicidal manner, or separating into cocci, 4- or 5-celled, and presenting externally as many angles or winged expansions as cells; rarely indehiscent. *Seeds* few; *albumen* in small quantity, or rarely absent; *radicle* superior; *cotyledons* foliaceous.

Diagnosis.—Herbs, shrubs, or trees, with opposite stipulate dotless leaves. Calyx and corolla with a quaternary or quinary arrangement; the former convolute in æstivation, the latter with unguiculate petals and imbricate. Stamens 8—10, hypogynous, usually arising from the back of scales. Ovary 4—5-celled; style simple. Fruit 4- or 5-celled. Seeds few, with little or no albumen; radicle superior; cotyledons foliaceous.

Distribution and Numbers.—They are generally distributed throughout the warm regions of the globe, but chiefly beyond the tropics. *Illustrative Genera*:—Zygophyllum, *Linn.*; Guaiacum, *Plum.* There are about 100 species. *Melianthus* is by some botanists separated from the Zygophyllaceæ, and taken as the type of a new order, to which the name Melianthεæ has been applied.

Properties and Uses.—Some of the plants are resinous, and possess stimulant, alterative, and diaphoretic properties; others are anthelmintic. The wood of the arborescent species is remarkable for its hardness and durability.

Guaiacum.—The heart-wood, and the resin obtained from the stem of *G. officinale* and *G. sanctum* are official in the British Pharmacopœia; they are commonly known as Guaiacum Wood, and Guaiacum Resin. The resin is generally procured by burning logs of the wood much incised in the middle, and catching the resin as it flows from the central incised portion in a calabash or some other suitable vessel placed below it. It also exudes to some extent spontaneously, and especially so when the tree is cut or wounded in any way. Both the wood and resin are used as stimulants, diaphoretics, and alteratives, chiefly in gout and rheumatism, but also in syphilitic and various cutaneous affections. The wood is known in commerce as Lignum Vitæ. It is remarkable for its hardness, toughness, and durability, which qualities render it very valuable for many purposes. The leaves are also used in the West Indies, on account of their detersive qualities, for scouring and whitening floors.—*G. sanctum* has similar medicinal properties to the above, and yields an analogous resin. A portion of the resin of commerce and also of the wood is obtained from this species; hence, as already noticed, this plant is likewise official in the British Pharmacopœia.

Larrea mexicana.—This plant is remarkable for having an odour resembling creasote: hence it is commonly known as the Creasote Plant. The Mexicans are said to use an infusion of the leaves for bathing in with good effect in rheumatic affections.

Melianthus major.—The flowers of this species contain a large amount of saccharine matter, which is used for food by the natives of the Cape of Good Hope, where the plant abounds.

Peganum Harmala—In India the seeds are reputed to be stimulant, emmenagogue, and anthelmintic. In Turkey they are used as a spice, and also in the preparation of red dyes; these dyes are, however, not of a very permanent nature.

Tribulus.—*T. terrestris* is a prickly plant, which is abundant in dry barren places in the East. It is considered to be the Thistle mentioned in Matt. vii. 16, and Heb. vi. 8. The fruit of *T. lanuginosus* is much esteemed in Southern India as a diuretic.

Zygophyllum Fabago, Bean-caper.—It derives its common name from the circumstance of its flower-buds being used in some parts of the world as a substitute for Capers. It is also reputed to possess anthelmintic properties.

Order 5. GERANIACEÆ, the Crane's-bill Order.—Character.—*Herbs* or *shrubs*, with swollen usually articulated joints (*nodes*). *Leaves* simple, opposite or alternate, with membranous stipules. *Flowers* regular or irregular. *Sepals* 5 (*fig.* 927), inferior, persistent, more or less unequal; *æstivation* imbricate. *Petals* 5 (*fig.* 927), or rarely 4 from abortion, unguiculate, hypogynous or perigynous; *æstivation* twisted (*fig.* 927). *Stamens* usually twice (*fig.* 928) as many as the petals, (some are, however, frequently abortive), hypogynous, and generally united at the base (*fig.* 928), the alternate ones shorter and occasionally barren. *Disk* inconspicuous or glandular. *Carpels* 5, arranged

FIG. 927. FIG. 928. FIG. 929.

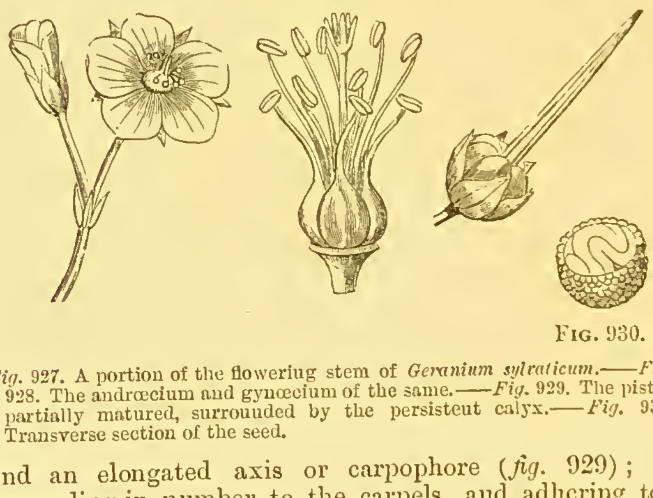


FIG. 930.

Fig. 927. A portion of the flowering stem of *Geranium sylvaticum.*——*Fig.* 928. The andrœcium and gynœcium of the same.——*Fig.* 929. The pistil, partially matured, surrounded by the persistent calyx.——*Fig.* 930. Transverse section of the seed.

around an elongated axis or carpophore (*fig.* 929); *styles* corresponding in number to the carpels, and adhering to the carpophore. *Fruit* consisting of five 1-seeded carpels, which ultimately separate from the carpophore from below upwards by the curling up of the styles, which remain adherent at the summit (*fig.* 640). *Seeds* without albumen; *cotyledons* foliaceous, convolute (*fig.* 930).

Diagnosis.—Herbs or shrubs, with simple leaves, membranous stipules, and swollen joints. Sepals 5, imbricate. Petals twisted in æstivation. Stamens hypogynous, generally united at the base. Fruit consisting of 5 carpels attached by means of their styles to an elongated axis or carpophore, from which they separate when ripe from below upwards by the curling up of the styles, and ultimately dehisce. Seeds 1 in each carpel, exalbuminous; embryo with foliaceous convolute cotyledons.

Distribution and Numbers.—Some are distributed over various parts of the world, but they abound at the Cape of Good Hope. *Examples of the Genera:*—Erodium, *L'Héritier*; Geranium, *Linn.*; Pelargonium, *L'Héritier.* There are nearly 550 species.

Properties and Uses. — Astringent, resinous, and aromatic qualities are the more important properties of the plants of this order. Many are remarkable for the beauty of their flowers; and others for the agreeable odours of their leaves and flowers, which render them useful in perfumery.

Erodium.—The species are reputed to be astringent.—*E. moschatum* is remarkable for its musky odour.

Geranium.—The root of *G. maculatum* is a powerful astringent, for which reason it is much used in North America, where it is called Alum-root. It contains much tannic acid, and forms a good substitute for kino and catechu.—*G. parviflorum* produces edible tubercular roots, which are known in Van Diemen's Land under the name of Native Carrots.

Pelargonium.—The species of this genus are favourite objects of culture on account of the beauty of their flowers. They are chiefly natives of the Cape of Good Hope, but the species have been much improved by cultivation. They are commonly, but improperly, called Geraniums. In their properties they are generally astringent, but the fresh tubercular roots of *P. triste* are eaten at the Cape of Good Hope. From the leaves and flowers of *Pelargonium roseum*, *P. odoratissimum*, and *P. Radula*, and some other species or varieties of *Pelargonium*, essential oils may be obtained by distillation with water. The latter species yields the true German Geranium Oil or Oil of Rose-leaved Geranium, as well as the French Geranium or 'Palma-rosæ' Oil; and the two first-named species yield the so-called Algerian Rose Oil. Both these oils, but especially the former, are used in perfumery. These true essential oils of Geranium must not be confounded with the so-called Geranium Oil of India, which is the produce of an Indian Grass, *Andropogon pachnodes*, Trin. (*A. schœnanthus*, Linn.). (See *Andropogon.*) This latter oil is that used in Turkey for mixing with Otto of Roses. (See *Rosa.*)—*P. capitatum*, or Rose-leaved Geranium, has been cultivated to some extent in this country, and the oil obtained from it is said to be equal to those imported under the name of Geranium oils.

Order 6. BALSAMINACEÆ, the Balsam Order.—Character.—*Herbaceous plants* with succulent *stems* and a watery juice. *Leaves* alternate or opposite, simple, exstipulate. *Flowers* hypogynous, very irregular. *Sepals* 3 (*fig.* 799)—5, very irregular, deciduous, with an imbricate æstivation, the odd one spurred (*fig.* 799). *Petals* 5 (*fig.* 799), or more usually 4, 1 being abortive, distinct or irregularly united, deciduous, alternate with the sepals; *æstivation* convolute. *Stamens* 5 (*fig.* 799), alternate with the petals, and somewhat united. *Disk* none. *Ovary* composed of 5 carpels, united so as to form a 5-celled compound body (*fig.* 799); *style* simple; *stigma* more or less divided into 5 lobes. *Fruit* usually capsular, 5-celled, and dehiscing in a septifragal manner by 5 elastic valves, which become coiled up (*fig.* 931); *placentas* axile; sometimes sucenlent and indehiseent. *Seeds* solitary or numerous, suspended, exalbuminous; *embryo* straight.

Fig. 931.

Fig. 931. Capsule of Touch-me-not (*Impatiens noli-me-tangere*), with recurved coiled-up valves.

Diagnosis.—Succulent herbaceous plants, with simple exstipulate leaves. Stems continuous and not separable at the nodes. Flowers hypogynous, very irregular. Sepals 3—5; petals usually 4; both irregular and deciduous; æstivation of sepals imbricate, that of the petals convolute. Stamens 5. Ovary 5-celled; style simple. Fruit 5-celled, usually bursting with elasticity, without a beak. Seeds suspended, exalbuminous. *This order is by some botanists, as Bentham and Hooker, included in Geraniaceæ.*

Distribution and Numbers.—A few are scattered over the globe; but they are chiefly natives of the Indies, growing generally in damp shady places and where the temperature is moderate. *Illustrative Genus:*—Impatiens, *Linn.* There are about 110 species.

Properties and Uses.—They are said by De Candolle to be diuretic, but their properties are generally unimportant.

Order 7. VIVIANIACEÆ, the Viviania Order.—*Diagnosis.*—These plants are readily known among the Disciforæ by their exstipulate leaves, regular flowers, valvate 10-ribbed calyx, permanent withering twisted petals, 10 hypogynous stamens with distinct filaments, 2-celled anthers with longitudinal dehiscence, superior 3-celled ovary, 3-celled capsule with loculicidal dehiscence and albuminous seeds with a curved embryo and radicle next the hilum. *This order is included by Bentham and Hooker in Geraniaceæ.*

Distribution and Numbers.—They inhabit Chili and South Brazil. *Illustrative Genera:*—Cæsarea, *Cambess.*; Viviania, *Willd.* There are 15 species.

Properties and Uses.—Unimportant.

Order 8. TROPÆOLACEÆ, the Indian Cress Order.—Character.—Smooth twining or trailing herbaceous plants, with an acrid juice. *Leaves* alternate, exstipulate. *Flowers* irregular. *Sepals* 3—5 (*fig.* 800), the upper one spurred; valvate or very slightly imbricate in æstivation. *Petals* (*fig.* 800) 3—5, hypogynous, more or less unequal; *æstivation* convolute. *Stamens* (*fig.* 800) 6—10, somewhat perigynous, distinct; *anthers* 2-celled. *Disk* none. *Ovary* of 3 (*fig.* 800) or 5 carpels, each of which contains one pendulous ovule; *style* 1; *stigmas* 3 or 5. *Fruit* indehiseent, usually consisting of 3 carpels arranged round a common axis, from which they ultimately separate, each carpel containing one seed. *Seed* large, exalbuminous; *embryo* large; *radicle* next the hilum. *This order is included in Geraniaceæ by Bentham and Hooker.*

Distribution and Numbers.—Chiefly natives of South America. *Illustrative Genera:*—Tropæolum, *Linn.*; Chymocarpus, *Don.* There are about 40 species.

Properties and Uses.—Generally acrid, pungent, and antiscorbutic, resembling the Cruciferæ. The unripe fruit of *Tropæolum majus*, which is commonly known as Indian Cress or Garden Nasturtium, is frequently pickled, and employed by housekeepers as a substitute for Capers. Most of the *Tropæolums* have tubercular roots, some of which are edible, as *T. tuberosum.*

Order 9. Limnanthaceæ, the Limnanthes Order.—*Diagnosis.*—This is a small order of plants included by Lindley in the Tropæolaceæ, with which it agrees in its general characters; but it is distinguished from that order by having regular flowers; more evidently perigynous stamens; and erect ovules. *It is placed in Geraniaceæ by Bentham and Hooker.*

Fig. 932.

Fig. 933.

Fig. 934.

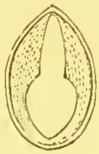


Fig. 932. Diagram of the flower of *Oxalis.*——*Fig.* 933. Vertical section of the flower of the same.——*Fig.* 934. Vertical section of the seed.

Distribution and Numbers.—Natives of North America. *Illustrative Genus:*—Limnanthes, *R. Br.* There are 3 species.

Properties and Uses.—In these they resemble the Cruciferæ and Tropæolaceæ.

Order 10. Oxalidaceæ, the Wood-sorrel Order.—Character.—*Herbs*, or rarely *shrubs* or *trees*, generally with an acid juice. *Leaves* alternate or rarely opposite, usually compound or occasionally simple; generally with stipules, or rarely exstipulate. *Flowers* regular and symmetrical. *Sepals* 5 (*fig.* 932), persistent, imbricate, occasionally somewhat united at their base. *Petals* 5 (*fig.* 932), hypogynous (*fig.* 933), unguiculate, rarely wanting; *æstivation* twisted. *Stamens* double the number of the petals and sepals (*fig.* 932), arranged in two rows alternating with each other, the inner row longer than the outer (*figs.* 550

and 933) and opposite to the petals, commonly somewhat monadelphous (*fig.* 550); *anthers* 2-celled, innate. *Disk* none. *Ovary* superior (*fig.* 933), 3—5-celled, with as many distinct styles as there are cells; *stigmas* capitate or somewhat bifid. *Fruit* usually capsular and 3—5-celled and 5—10-valved, occasionally drupaceous and indehiscent; *placentas* axile (*fig.* 933). *Seeds* few; sometimes provided with a fleshy integument, which bursts with elasticity when the fruit is ripe, and expels the seeds; *embryo* (*fig.* 934) straight, in cartilaginous fleshy albumen; *radicle* long, and turned towards the hilum; *cotyledons* flat.

Diagnosis.—Herbs, or rarely shrubs or trees, usually with compound exstipulate leaves. Stems continuous and not separable at the nodes. Flowers hypogynous, regular, symmetrical. Sepals, petals, and stamens with a quinary distribution; the sepals persistent and imbricate; the petals twisted in æstivation; the stamens commonly somewhat monadelphous, with 2-celled innate anthers. Disk absent. Styles filiform, distinct. Fruit 3—5-celled, without a beak. Seeds few, with abundant albumen, a straight embryo, long radicle turned towards the hilum, and flat cotyledons. *This order is closely allied to the Geraniaceæ, to which it is referred by Bentham and Hooker.*

Distribution and Numbers.—These plants are generally distributed throughout both the hot and temperate regions of the globe; the shrubby species are, however, confined to the former. They are most abundant at the Cape of Good Hope and in tropical America. *Illustrative Genera*:—Oxalis, *Linn.*; Averrhoa, *Linn.* There are about 330 species.

Properties and Uses.—Chiefly remarkable for their acid juice, which is due to the presence of binoxalate of potassium. They usually possess refrigerant properties. The fruits of some are eaten by the natives in the East Indies, but they are too acid to be generally acceptable to Europeans.

Averrhoa Bilimbi and *A. Carambola* yield acid fruits, known respectively under the names of Blimbing and Carambole. They are eaten by the natives in the East Indies, but are too acidulous for Europeans, who nevertheless use them for pickles.

Oxalis.—*O. Acetosella*, Common Wood-Sorrel, is a common indigenous plant abounding in woods. It has ternate leaves, and is considered by many to be the true Shamrock, as its leaves open about St. Patrick's Day. When infused in milk or water, it forms a pleasant refrigerant drink in fevers. The leaves, taken as a salad, are antiscorbutic.—*O. crenata*, a plant which is called Arracacha, together with others, as *O. Deppei*, *O. esculenta*, &c., have edible tubers, which are used as substitutes for potatoes in some districts.—*O. anthelmintica*, the Mitchamitcho of Abyssinia, has very acrid tubers. These are much employed for their anthelmintic properties in that country, being frequently preferred to Kousso (*Hagenia abyssinica*), a plant belonging to the Rosaceæ, and which is also largely used in Abyssinia for a similar purpose. (See *Hagenia abyssinica*.)

Order 11. RUTACEÆ, the Rue Order.—Character.—*Trees, shrubs*, or rarely *herbs*. *Leaves* exstipulate, simple or compound, dotted. *Flowers* perfect (*figs.* 579 and 935) or polygamous, regular. *Calyx* having 3—5 segments (*fig.* 935), imbricate. *Petals* equal in number to the divisions of the calyx (*figs.* 611 and 935) or wanting, rarely combined so as to form a monopetalous corolla; *æstivation* usually twisted, rarely valvate. *Stamens* distinct (*figs.* 579 and 611), or more or less united into one or several bundles (*fig.* 935), equal in number to or twice (*figs.* 579 and 611) as many as the petals, or some multiple of them, or rarely fewer by abortion. *Disk* annular or cup-shaped, glandular, hypogynous (*figs.* 597 and 937). *Ovary* sessile (*fig.* 611), or raised on a gynophore (*figs.* 608, *g*, and 624, *g*); it is composed of from 2 to 5 carpels, which are either distinct, or united so as to form a compound ovary having as many cells as there are component carpels; *style* simple (*fig.* 936) or divided

FIG. 935. FIG. 936. FIG. 937. FIG. 938.

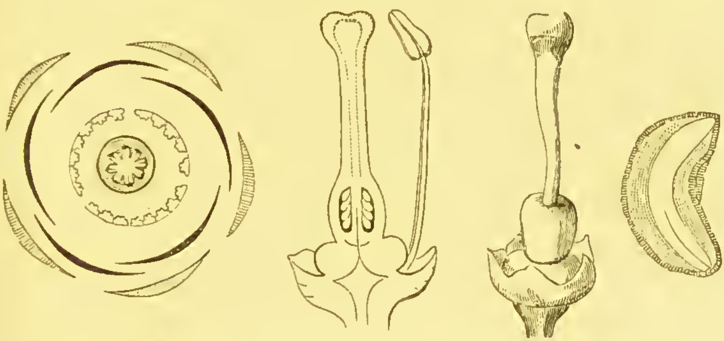


Fig. 935. Diagram of the flower of the Orange (*Citrus Aurantium*).——*Fig.* 936. Vertical section of the pistil, showing a portion of the disk at its base, and a solitary hypogynous stamen.——*Fig.* 937. Pistil of the Orange, with disk at its base, and the calyx: the petals and stamens have been removed.——*Fig.* 938. Vertical section of the seed of the Common Rue (*Ruta graveolens*).

towards the base (*fig.* 608); *ovules* 2, 4, or rarely more, in each cell. *Fruit* capsular, its carpels either united or more or less distinct, or succulent and indehiscent, and in *Aurantieæ* forming an hesperidium (*fig.* 715). *Seeds* solitary or in pairs; *albumen* present or absent; *radicle* superior (*fig.* 938).

Diagnosis.—Leaves exstipulate, dotted. Flowers perfect or polygamous. Calyx and corolla with a ternary, quaternary, or quinary distribution of their parts; the former with an imbricate æstivation, the latter twisted or valvate, and sometimes wanting. Stamens equal in number, or twice as many as the petals, or some multiple of them, or fewer. Ovary of from 2—5 carpels, separate or combined, either sessile and surrounded at the base by a fleshy and glandular disk, or elevated upon a gynophore; ovules sessile. Fruit capsular or succulent. Embryo with a superior radicle. Albumen present or absent.

Division of the Order and Illustrative Genera.—The Rutaceæ have been variously divided, and Bentham and Hooker have largely extended the order by including the orders Aurantiaceæ and Xanthoxylaceæ of former botanists, which arrangement is here adopted. As thus extended, they have divided it into the following tribes :— Cuspariceæ, Ruteæ, Diosmeæ, Boronieæ, Xanthoxyleæ, Toddalieæ, and Aurantieæ. *Illustrative Genera :* —Ruta, *Tourn.* ; Barosma, *Willd.* ; Xanthoxylon, *Kunth.* ; Toddalia, *Juss.* ; Citrus, *Linn.*

The Xanthoxyleæ are especially distinguished by their *polygamous flowers* ; and the Aurantieæ by the blade of their leaves being articulated to the petiole (*fig.* 320), their deciduous imbricate petals (*fig.* 935), and their peculiar fruit (*hesperidium*) (*fig.* 715).

Distribution and Numbers.—The Ruteæ are found chiefly in the southern part of the temperate zone and in Northern Asia ; the genera *Diosma*, *Barosma*, &c., abound at the Cape of Good Hope ; other genera are found in Australia ; and some in equinoctial America. Xanthoxyleæ are mostly American ; Aurantieæ usually East Indian. There are about 620 species.

Properties and Uses.—The Ruteæ are generally characterised by a powerful penetrating odour, and bitter taste. In medicine they are employed as antispasmodics, tonics, febrifuges, diuretics, &c. The Xanthoyleæ are almost universally characterised by pungent and aromatic properties, and sometimes by bitterness. In medicine, they have been employed as stimulants, sudorifics, febrifuges, tonics, sialogogues, and emmenagogues. The Aurantieæ abound in glands containing essential oils, which render them fragrant ; hence such oils are useful in perfumery, and for flavouring, and other purposes. These volatile oils are especially abundant in the leaves, the petals, and the rind of the fruit. The latter also contains a bitter tonic principle. The pulp of the fruit has an acid or somewhat saccharine taste ; and the wood is always hard, and of a compact nature.

Adenandra fragrans.—The leaves are sometimes used to adulterate Buchu.

Ægle Marmelos, Indian Bael.—The half-ripe fruit is a favourite remedy in India as a demulcent and astringent in diarrhœa and dysentery. In a dried state it is official in the British Pharmacopœia, but it appears in this condition to be far less active than when fresh. Mangosteen rind has been substituted for it in this country, as first noticed by the author of this volume. (See *Garcinia.*) The bark of the root likewise possesses astringent properties. Its leaves are also reputed to be useful in asthmatic complaints. The rind of the ripe fruit yields a pleasant perfume, and its pulp is described as being very nutritious and most pleasant to the taste ; it possesses, moreover, laxative properties.

Amyris.—(See Burseraceæ.)

Barosma.—The leaves of several species, which are commonly known as *Buchu leaves*, are used in medicine for their aromatic, stimulant, antispasmodic, and diuretic properties ; they seem also to have a specific influence over the urinary organs. The plants yielding them are natives of the Cape of Good Hope. They owe their properties essentially to a powerfully scented volatile oil. They also contain abundance of *mucilage*, and, according to Landerer, a peculiar bitter principle called *barosmin* or *diosmin*, but of this nothing definite is known. The official species of the British Pharmacopœia are *B. betulina*, *B. crenulata*, and *B. serratifolia.*

Casimiroa edulis.—The fruit is said by Seemann to be delicious, and also to produce a soporific effect.

Citrus.—This is by far the most important genus of the order; the fruits yielded by the different species and varieties being highly valued for dessert and other purposes. The Orange, Lemon, Lime, Shaddock, Pompelmoose, Forbidden Fruit, Kumquat, and Citron, are all well-known, although the species from which they are derived are not in all cases well-defined.—*Citrus Aurantium*, Risso.—The fruit is the Common or Sweet Orange. Of this there are a great many varieties; the most important of which are the Common or China Orange, the Blood Red or Malta Orange, and the St. Michael's Orange. Other varieties are sometimes imported, as the Noble or Mandarin Orange and the Tangerine Orange. The Orange-tree is remarkable for the enormous number of fruits it is capable of yielding; thus, one tree will sometimes produce as many as 20,000 oranges. The small unripe fruits of this species, as well as those of the Bitter Orange, form what are called *Orange-berries*; these are used for flavouring Curaçoa, and when polished by a lathe, they constitute the ordinary *issue peas* of the pharmacies. The leaves and young shoots of the Sweet Orange, as well as those of the Bitter Orange, by distillation with water, yield a volatile oil, which is called *Oil of Orange-leaf* or *Essence de petit grain*; that obtained from the Bitter Orange is considered to be of the finest quality. A similar oil may be also distilled from orange-berries. From the rind of the ripe fruit a fragrant oil is procured, which is known as *Essence de Portugal* or *Essential Oil of Sweet Orange.* The flowers of this species, as well as those of the Bitter Orange, yield *Oil of Neroli*; that from the latter is preferred. The distilled water of the flowers of these two species, after the oil is removed, constitutes the *Aqua Naphæ* or *Orange-flower Water* of commerce, which is official in the British Pharmacopœia. It is to the presence of Oil of Neroli that the odour of Eau de Cologne is more particularly due. The rind of the Sweet Orange is an aromatic stimulant and tonic; its juice is also very extensively used as a refreshing and agreeable beverage at table, and also medicinally as a refrigerant.—*Citrus Bigaradia* of Duhamel or *Citrus vulgaris* of Risso, is the official Bitter or Seville Orange. The leaves, flowers, and unripe fruits of this species yield, by distillation or otherwise, similar essential oils to those obtained from analogous parts of the Sweet Orange. (See above.) *Orange-flower Water* is generally prepared from the flowers of the Bitter Orange, as it is considered more fragrant than that obtained from the Sweet Orange. The unripe fruits (as already noticed), like those of the Sweet Orange, are called *Orange-berries*, and are used like them for making *issue peas*, and for flavouring Curaçoa. The rind of the ripe fruit yields a volatile oil, called *Essential Oil of Bitter Orange* or *Essence de Bigarade.* The chief use of the Bitter Orange is in the making of marmalade. The rind is also employed in medicine as a tonic and stomachic, and is more valuable in these respects than that of the Sweet Orange. It is likewise used for flavouring Curaçoa and other substances; and in the preparation of *candied orange-peel.*—*Citrus Limonum* of Risso is the Lemon tree. Of the fruit we have several varieties; the more important of which are,—the Wax Lemon, the Imperial Lemon, and the Gaeta Lemon; they are chiefly imported from Sicily and Spain, the latter being the most esteemed. Both the rind and the juice are employed in medicine, and for other purposes; the former as a stomachic and carminative, and for flavouring; the latter as an agreeable and refreshing beverage, and also for its refrigerant and antiscorbutic effects.

The juice contains a large quantity of citric acid. *Candied Lemon-peel* is employed in confectionery, and as a dessert. The concentrated juice of Lemons, as well as that of the Lime, is imported in enormous quantities, and used in the preparation of the official citric acid. The rind contains a large quantity of essential oil, which is generally obtained from it by expression by what is termed the *sponge* or *ècuelle* process, or sometimes by distillation; it is commonly known as *Essential Oil* or *Essence of Lemon.* The best is obtained by the first process, and it is distinguished as *Essence de Citron au zeste*, the latter being termed *Essence de Citron distillée.* This oil is principally used as a flavouring agent in confectionery, and in medicine, and also in perfumery.—*Citrus Limetta*, DC., or *C. Bergamia*, Risso et Poit., is the source of the Lime fruit. This is sometimes imported into this country in a preserved state, and in that condition it forms a most agreeable dessert. Its juice is also imported and largely employed with that of Lemons in the preparation of citric acid, as already noticed. Both the fruit of *C. Limonum* and *C. Bergamia* are official in the British Pharmacopœia as the source of citric acid, and the fruit of the Lemon-tree is also official for its rind and juice. The *Bergamot Orange* is obtained from *C. Bergamia* var. *vulgaris* of Risso. From the full-grown, but still unripe and greenish fruits of this variety, either by expression or distillation, the essential oil, called *Oil* or *Essence of Bergamot*, which is largely used in perfumery, is obtained.—*Citrus Medica.*—The fruit of this is the Citron, or the *Cédrat* of the French. This is supposed to be the Hebrew Tappuach, which is translated in our version of the Old Testament as Apple-tree and Apples. The rind of this fruit is commonly imported into this country in a preserved state, and is used in confectionery. Its pulp is less acid and juicy than the Lemon, but it may be employed, as well as that of the Lime, for similar purposes. *Essence* or *Essential Oil of Cédrat* is obtained from the nearly ripe fruit by the sponge or *ècuelle* process. It is chiefly used in perfumery. The Citron, Lime, and Lemon are distinguished from Oranges by having a more closely adherent rind, by their more lengthened form, and by the possession of a more or less prominent protuberance at their apex. Besides the above fruits obtained from the genus *Citrus*, we have also the Shaddock, from *C. decumana*; and the Kumquat of China, from *C japonica.* The Forbidden Fruit and the Pompelmoose also, both of which, as sold in the London markets, are varieties of the Shaddock,—the former being the smallest fruits, and the latter those of the largest size.

Cookia punctata.—This plant produces the Wampee-fruit, which is much esteemed in the islands of the Indian Archipelago, and in China.

Correa alba, and other species.—The leaves are sometimes employed as a substitute for tea in Australia.

Dictamnus Fraxinella, False Dittany.—The root was formerly much used in medicine, and reputed to possess aromatic tonic, diuretic, antispasmodic, and emmenagogue properties, but it is now rarely if ever employed. The plant contains such a large amount of volatile oil as to render, it is said, the atmosphere around it inflammable in hot weather; we have, however, never found this to be the case.

Esenbeckia febrifuga, a native of South America, has a febrifugal bark, which is used in Brazil as a substitute for Peruvian Bark. As stated by Maisch, it is sometimes substituted for the official Angustura Bark in the United States, and has also been met with in France.

Evodia glauca.—The bark is extensively used by the Japanese, both medicinally and for dyeing purposes.

Feronia elephantum.—This is a large tree, a native of India. A kind of gum exudes from its stem which closely resembles Gum Arabic. The young leaves have an Anise like odour, and are used by the native practitioners of India for their stomachic and carminative effects. The unripe fruit is said to resemble that of Indian Bael in its properties, and has been substituted for it in this country; the ripe fruit is stated to be antiscorbutic. This fruit is commonly known under the name of the Elephant or Wood-apple.

Galipea Cusparia.—This species is the source of Cusparia or Angustura Bark, which is official in the British Pharmacopœia. This bark is imported directly or indirectly from South America. It is used in medicine as a stimulant tonic and febrifuge, in small doses; while in large doses it is somewhat emetic and purgative. It has fallen into disrepute on the Continent, in consequence of the substitution for it formerly of the poisonous bark of *Strychnos Nux-vomica.* At one time, indeed, the substitution was so common that the importation of Angustura Bark into Austria was prohibited, and the whole of it then found in that empire was ordered to be destroyed. At the present time such a substitution is never met with although it occurred in Dublin about thirty years ago.

Murraya (*Bergera*) *Konigii.*—The bark, root, and leaves of this plant are employed by the native practitioners in India for their tonic and stomachic properties.

Pilocarpus pennatifolius.—The leaves of this plant, which is a native of Brazil, are the source of the drug known under the name of Jaborandi. Jaborandi is now official in the British Pharmacopœia. It is an energetic diaphoretic and sialogogue. It owes its properties to a peculiar alkaloid named *pilocarpine*, the *nitrate* of which is official in the British Pharmacopœia.—*P. Selloanus*, an allied species or variety of the above, is also stated to afford Jaborandi. This name Jaborandi is likewise applied in South America to several other plants of very different affinities. A species of pepper, *Piper Jaborandi*, is especially so designated.

Ptelea.—The root-bark is much employed by the eclectic practitioners in the United States of America as a tonic in remittent and intermittent fevers. The fruit is very bitter and aromatic, and has been used as a substitute for Hops, while the young green shoots are reputed to possess anthelmintic properties.

Ruta.—*R. graveolens*, Common Rue.—This plant, which is a native of Europe, has a very powerful disagreeable peculiar odour, which it owes to the presence of a volatile oil, which is official in the British Pharmacopœia. Its taste is bitter and nauseous. It is used in medicine as an antispasmodic, anthelmintic, emmenagogue, stimulant, and carminative. It has been regarded for ages as most beneficial in warding off contagion, and in keeping off noxious insects. This plant is said to be the Peganon of the New Testament (Luke xi. 42).—*Ruta montana* possesses very acrid properties; so much so, indeed, as to blister the hands of those who gather it.

Ticorea febrifuga, a native of South America, has a febrifugal bark which is used in some districts as a substitute for Peruvian Bark.

Toddalia aculeata.—The bark of the root is official in the Pharmacopœia of India. It possesses aromatic tonic, stimulant, and antiperiodic properties, and was formerly known in Europe under the name of Lopez root, and used as a remedy in diarrhœa.

Xanthoxylon (*Zanthoxylum*).—The species of this genus possess in a remarkable degree pungent and aromatic properties; hence they are popularly termed Peppers in their native countries. In America they are commonly known, from their prickly bark, under the name of Prickly Ash. The fruit of *X. piperitum* is employed by the Chinese and Japanese as a condiment, and as an antidote against all poisons. It is generally termed in commerce Japanese Pepper. The aromatic pungent properties appear to be confined to the pericarp.—*X. alatum* yields an analogous pepper to the above, and Stenhouse has described two peculiar principles which he obtained from it, viz. an *oil* and a *stearoptene*: the former is a pure hydrocarbon, to which the aromatic odour of the pepper is due, and to which he has given the name of *Xanthoxylene*; the latter is a crystalline solid body consisting of carbon, oxygen, and hydrogen, but devoid of nitrogen when pure, and which he has called *Xanthoxyline*. It is probable that it also contains a resinous substance, to which its pungency is due. The fruits of *X. hastile* and *X. Budrunga* have similar properties. The seeds and fruits of the former are sometimes employed in India for the purpose of stupefying fish. The seeds of *X. Budrunga* are aromatic and fragrant, like Lemon-peel; and the unripe fruits and seeds of *X. Rhetsa* have a taste like that of orange-peel. The root of *X. nitidum* is used as a sudorific, stimulant, febrifuge, and emmenagogue by the Chinese. The bark of *X. fraxineum* is official in the United States Pharmacopœia under the name of Prickly Ash Bark. It is chiefly used as a remedy in chronic rheumatism. It is also a popular remedy as a masticatory in toothache; hence the plant is also known under the name of the Toothache Shrub. The bark contains *berberine*. The barks of other species, as those of *X. Clava-Herculis*, Linn., and of *X. carolinianum* of Lamarck, possess somewhat similar properties to the bark of *X. fraxineum*.

Order 12. SIMARUBACEÆ, the Quassia Order.—Character.—*Shrubs* or *trees*. *Leaves* without dots, alternate, compound or sometimes simple, exstipulate. *Flowers* regular and symmetrical, axillary, or terminal, perfect or unisexual by abortion. *Calyx* imbricate, in 4 or 5 divisions. *Petals* equal in number to the divisions of the calyx, with an imbricate æstivation, sometimes united into a tube. *Stamens* twice as many as the petals, the *filaments* usually with a scale at their back; *anthers* with longitudinal dehiscence. *Disk* conspicuous, hypogynous. *Ovary* stalked, 4- or 5-lobed, 4- or 5-celled, each cell with 1 suspended ovule; *style* simple; *stigma* with as many lobes as there are cells to the ovary. *Fruit* usually consisting of 4 or 5 indehiscent, 1-seeded, drupaceous carpels, arranged around a common axis, or capsular or samaroid. *Seed* with a membranous integument, exalbuminous; *radicle* superior, retracted within thick cotyledons.

Distribution and Numbers.—With the exception of one plant, which is a native of Nepaul, they are all found in the tropical parts of India, America, and Africa. *Illustrative Genera*:—Quassia, *Linn.*; Simaruba, *Aubl.* There are about 50 species.

Properties and Uses.—A bitter principle is the most remarkable characteristic of the order; hence many of them are tonic and febrifugal.

Ailanthus.—The bark of *A. excelsa* is regarded in India as a tonic and febrifuge. It may be used as a substitute for Quassia. The bark of *A. malabarica*, when incised, yields an aromatic gum-resinous substance, which is employed in dysentery, and as incense in the East Indies. The leaves of *A. glandulosa* are the favourite food of the silk moth (*Bombyx Cynthia*). The root is largely used in China as a remedy in dysentery.

Brucea quassioides, a native of the Himalayas, has a very bitter root, which forms a good substitute for Quassia.

Irvingia.—*I. Barteri*, a native of the Western Coast of Africa, has edible seeds, from which a kind of food, called Dika or Udika bread, is prepared. The fruits of species of *Irvingia* are edible, and are termed Wild Mangoes in tropical Africa.

Picræna excelsa yields our official Quassia Wood. (See *Quassia.*) It is much used as a tonic, febrifuge, and stomachic, and also possesses anthelmintic properties. An infusion of Quassia sweetened with sugar acts as a powerful narcotic poison on flies and other insects; hence it is used as a fly-poison. Like other pure bitters, its infusion may be also employed to preserve animal matters from decay. It is largely used by brewers as a substitute for hops. It owes its active properties chiefly to the presence of an intensely bitter crystalline substance called *Quassine.* In Jamaica this plant is known under the name of Bitter Ash or Bitter Wood. The wood was much used a few years since in the manufacture of small goblets, which were sold under the name of *bitter cups.*

Quassia amara.—The wood is intensely bitter. It is a native of Surinam, and was formerly much used as a febrifuge and tonic; the flowers are also stomachic. It is the original Quassia of the shops, but it is no longer imported into this country; that now sold under the name of Quassia being derived from *Picræna excelsa,* a native of Jamaica: hence the latter may be called Jamaica Quassia, and the former Surinam Quassia. It is, however, still official in some of the Continental pharmacopœias. (See *Picræna.*)

Samadera indica.—The bark is used in parts of India as a febrifuge; the oil from the seeds is largely employed in rheumatism; and the leaves externally in erysipelas. Both bark and seeds contain a principle, which has been termed *samaderine.*

Simaba Cedron.—The seeds are highly esteemed throughout Central America, where they are employed for their febrifugal properties, and are thought to be a specific against the bites of venomous snakes and other noxious animals. They have been used in this country for the latter purpose but without any sensible effect. The active principle has been named *cedrine.*

Simaruba (*Simarouba*) *amara* is a native of Northern Brazil and Guiana, and some of the West Indian islands. In Jamaica and the West Indies generally its place is taken by the closely allied species *S. glauca,* which is known under the name of Mountain Damson. This latter plant has often been confounded with *S. amara.* The bark of the root of *S. amara* is official in the United States Pharmacopœia. It possesses tonic properties, and has been used in diarrhœa, dysentery, &c. It contains *Quassine,* the same principle which has been found in Quassia wood

Order 13. OCHNACEÆ, the Ochna Order.—Character.—*Under-shrubs* or *smooth trees,* with a watery juice. *Leaves* simple, stipulate, alternate. *Pedicels* jointed in the middle. *Sepals* 5, persistent, imbricate. *Petals* hypogynous, definite, sometimes twice as many as the sepals, deciduous, imbricate. *Stamens* equal in number to the sepals and opposite to them, or twice as many, or more numerous; *filaments* persistent, inserted on an *hypogynous fleshy disk*; *anthers* 2-celled, with longitudinal or porous dehiscence. *Carpels* sessile, corresponding in number to the petals, inserted on a large fleshy disk, which becomes larger as the carpels grow; *ovules* 1 in each carpel. *Fruit* consisting of several indehiscent, somewhat drupaceous, 1-seeded carpels. *Seed* exalbuminous or nearly so; *embryo* straight; *radicle* towards the hilum.

Distribution and Numbers.—Natives chiefly of the tropical parts of India, Africa, and America. *Illustrative Genera*:—Gomphia, *Schreb.*; Ochna, *Schreb.* There are about 80 species.

Properties and Uses.—The plants are generally remarkable for their bitterness. Some have been employed as tonics and astringents; others, as *Gomphia parviflora*, yield oil, which is used in Brazil for salads. In their properties generally, the Ochnaceæ much resemble the Simarubaceæ.

Order 14. BURSERACEÆ or AMYRIDACEÆ, the Myrrh Order. —Character.—*Trees* or *shrubs*, abounding in a fragrant gum-resinous or resinous juice. *Leaves* compound, alternate or opposite, frequently dotted and stipulate. *Flowers* perfect, or rarely unisexual. *Calyx* persistent, with 2—5 divisions. *Petals* 3—5, arising from the calyx below the disk; *æstivation* valvate, or occasionally imbricate. *Stamens* twice as many as the petals, perigynous. *Disk* perigynous. *Ovary* 1—5-celled, superior, sessile, placed in or upon the disk; *ovules* in pairs, attached to a placenta at the apex of the cell, anatropous. *Fruit* dry, 1—5-celled; *epicarp* often splitting in a valvular manner. *Seeds* exalbuminous; *radicle* superior, turned towards the hilum.

Distribution and Numbers.—They have been only found in the tropical regions of America, Africa, and India. *Illustrative Genera*:—Boswellia, *Roxb.*; Balsamodendron, *Kunth.* There are about 60 species.

Properties and Uses.—The plants of the order appear to be almost universally characterised by an abundance of fragrant resinous or gum-resinous juice. Some are considered poisonous; others bitter, purgative, or anthelmintic; and a few furnish useful timber.

Amyris.—*A. hexandra* and *A. Plumieri* have been stated to yield a portion of the Elemi of commerce, but there is no proof whatever of such being the case.—*A. elemifera*, of Royle, yields Mexican or Vera Cruz Elemi.—*A. balsamifera* is said to furnish one kind of *Lignum Rhodium*, but on no sufficient authority.—*A. toxifera*, as its name implies, is regarded as poisonous. *This genus is now sometimes placed in Rutaceæ.*

Balanites ægyptiaca has slightly acid leaves, which are reputed to be anthelmintic, while the unripe fruits are acrid, bitter, and purgative; they are eaten, however, when ripe. The seeds of this plant also yield by expression a fixed oil of a fatty nature, called *zachun* in Egypt, where the plant is cultivated.

Balsamodendron or *Balsamodendrum.*—*B. Myrrha* is generally regarded as supplying the gum-resin known in commerce under the name of Myrrh. It is called in Hebrew *mor* or *mur*, and is mentioned in the Old Testament for the first time in Gen. xxxvii. 25; hence it must have been in use for more than 3,500 years. The plants yielding the different kinds of Myrrh, although it is not yet positively known from whence they are derived, are natives of Somali-land and the adjoining parts of Arabia. But from recent investigations it would appear certain that the official or African Myrrh is the produce of *B. Myrrha*; that kind known as Arabian Myrrh being also derived from the same or a nearly allied species; and that of East Indian Myrrh or Bissa Bôl from probably *B. Kataf*, Kunth. Other species yield similar products. The botanical source of the Stacte or Liquid Myrrh of the ancients, and which entered into the composition of the holy incense in use by the Jews, is entirely unknown, for no drug of modern times has been identified with it. Medicinally, myrrh is regarded as tonic, stimulant, expectorant, and antispasmodic, when taken internally; and as an external application it is astringent and stimulant. The substance called *Balm of Gilead* or *Balm of Mecca*, and which is supposed to be the *Balm* of the Old Testament, is procured from *B. Opobalsamum.* The gum-resin known as *Indian Bdellium* or *False Myrrh* (the *Bdellium* of Scripture), is derived from *B. Mukul* and *B. pubescens.* This Bdellium is the *Googul* of the Indian Materia Medica, and the *Mokul* of the Persians. It is very similar to Myrrh. The resinous substance known as *opaque Bdellium* is derived from *B. Playfairii*, a native of Somali-land. *African Bdellium* is derived from *B. africanum.* The inner bark of *B. pubescens* peels off in thin white layers like that of *Boswellia papyrifera.* (See below.)

Boswellia.—The gum-resin known under the name of Olibanum is obtained from species of this genus. The name Olibanum appears to be derived from the Greek λίβανος. It is the *Lebonah* of the Hebrews, the *Incense* or *Frankincense* of the Bible, and the *Lubân* of the Arabs. Olibanum or Frankincense is now principally obtained from Arabia and the Somali country in Africa. Three species of *Boswellia*, natives of the Somali country, have been described by Birdwood, who has named them, *B. Carterii*, *B. Bhau-Dajiana*, and *B. Frereana.* The former is the true Frankincense or Luban-tree; but a similar product is obtained from *B. Bhau-Dajiana*, which is probably only a variety of *B. Carterii.*—*B. Frereana* is the Yegaar-tree of the Somalis, and affords *Luban Maitee*, a very fragrant resin, which is chiefly employed in the East as a masticatory. The two first species are the principal botanical sources of the Arabian or African Olibanum of commerce. The kind known as East Indian Olibanum is derived from *B. thurifera* (*serrata*). It is the Salai-tree of India, where its resin is much used for incense. Olibanum is chiefly used for fumigation, and in the preparation of incense. It is also regarded as a remedial agent in bronchitis and in chronic pulmonary affections.—*B. papyrifera*, a native of Abyssinia, also yields a fragrant gum-resin. This tree is likewise remarkable on account of its inner bark, which peels off in thin white layers, which may be used as paper.

Bursera gummifera and *B. acuminata* yield fragrant resinous substances —that from the former is termed Chibou or Cachibou resin; that from the latter, Resin of Carana.

Canarium.—*C. commune* is the plant referred to in the British Pharmacopœia as the reputed source of Manila Elemi, which is the only kind now found in commerce. Other authorities, however, refer it to *C. album* and *Icica Abilo* (see *Icica*). But at present we have no trustworthy data as to its botanical source. Elemi is used as an external stimulant application to indolent ulcers, &c. The kernels of *C. commune*, known as Java Almonds, also yield by expression a bland oil, which resembles almond oil in its properties.—*C. balsamiferum* of Ceylon, and *C. album*, a native of the Philippine Islands, also yield fragrant resinous substances resembling Elemi.—*C. edule* yields African Elemi.—*C. strictum* is the principal, if not the only, source of the Black Dammar of Southern India. It is said to be a good substitute for Burgundy Pitch. This resin is also sometimes stated to be obtained from *Vatica Tumbugaia*, a tree of the order Dipteraceæ. (See *Vatica.*)

Elaphrium.—*E. tomentosum* produces one of the resinous substances called Tacamahac.—*E. graveolens*, a native of Mexico, is reputed to be the source of a wood sometimes imported under the name of Mexican Lign-aloe Wood, and also of a volatile oil obtained from it. This must not be confounded with the true Lign-aloes of the Bible. (See *Aloexylon.*)

Icica.—*I. Icicariba* and other species of Icica, yield Brazilian Elemi.—*I. Abilo*, Blanco.—Flückiger and Hanbury regard this plant as the source of Manila Elemi (see *Canarium*). Other species produce somewhat analogous fragrant resins, as *I. Carana*, the source of American Balm of Gilead;

I. heterophylla, the plant yielding Balsam of Acouchi; *I. heptaphylla*, &c.—*I. altissima* furnishes the Cedar-wood of Guiana, of which there are several varieties. It is chiefly used for making canoes.

Order 15. Meliaceæ, the Melia Order.—Character.—*Trees* or *shrubs*. *Leaves* alternate or rarely somewhat opposite, simple or pinnate, exstipulate. *Flowers* occasionally unisexual by abortion. *Calyx* 3- 4- or 5-partite. *Petals* equal in number to the divisions of the calyx, hypogynous, sometimes united at the base; imbricate or valvate. *Stamens* twice as many as the petals, monadelphous; *anthers* sessile, placed within the orifice of the tube formed by the united filaments. *Disk* hypogynous, sometimes large and cup-like. *Ovary* compound, usually 2- 3- 4- or 5-celled, rarely 10- or 12-celled; *style* 1; *stigmas* separate or combined; *ovules* 1, 2, or rarely 4, in each cell. *Fruit* baccate, drupaceous, or capsular, in the latter case opening loculicidally; many-celled, or by abortion 1-celled. *Seeds* few, not winged, arillate or exarillate; *albumen* fleshy or usually absent; *embryo* generally with leafy cotyledons.

Diagnosis.—This order is very nearly allied to Cedrelaceæ, and by some botanists the latter order is included in it. It is chiefly distinguished from Cedrelaceæ by having more completely monadelphous stamens; by the possession of fewer seeds; and in those seeds being without wings.

Distribution and Numbers.—They are found more or less in all the tropical parts of the globe; but are said to be more common in America and Asia than in Africa. A few are extra-tropical. *Illustrative Genera*:—Melia, *Linn.*; Aglaia, *Lour.*; There are about 150 species.

Properties and Uses.—These plants are generally remarkable for bitter, tonic, and astringent properties. Others are powerful purgatives and emetics, as *Guarea Aubletii*, *G. trichilioides*, *G. purgans*, *G. spiciflora*, and some species of *Trichilia*; these all require much caution in their administration, and in some cases are reputed poisonous. A few species have edible fruits. The seeds of some yield fixed oils by expression.

Aglaia odorata.—The flowers are used to give a perfume to certain varieties of Tea.

Carapa.—The seeds of *C. guineensis*, an African species, yield by expression a fatty oil, called Kundah or Tallicoonah, which is purgative and anthelmintic: it is also adapted for burning in lamps, and for other purposes. An oil of a similar nature is also obtained from *C. Touloucouna*; it has been imported under the name of *mote-grease*. The seeds of *C. guianensis*, an American species, also yield a somewhat similar oil, called Crab oil, which possesses analogous properties. The bark of these species possesses febrifugal properties.

Lansium.—This is a genus of plants inhabiting the East Indian Archipelago. They yield fruits which are much esteemed, and known under the names of Langsat, Lanséh, Ayer-Ayer, and Bejetlan.

Melia Azadirachta, the Nim, Neem, or Margosa tree of India.—The bark possesses astringent, tonic, and antiperiodic properties; and the fresh leaves are stimulant, and are used as an external application in the form of a poultice to indolent ulcers, &c. The leaves have been also recommended as a valuable remedy in the premonitory and progressive stages of small-pox. The seeds yield a bitter oil, which is a favourite native remedy in India as an anthelmintic, and as an external application in rheumatism, &c. Both the bark and leaves are official in the Pharmacopœia of India. —*M. Azedarach.*—The root-bark of this tree is official in the United States Pharmacopœia ; it is regarded as an anthelmintic. The fresh bark is the most active.

Milnea edulis produces an agreeable fruit.

Xylocarpus Granatum.—The bark possesses astringent and tonic properties, and is employed as a remedy by the Malays in diarrhœa, cholera, &c.

Order 16. CEDRELACEÆ, the Mahogany Order.—Character. —*Trees. Leaves* alternate, pinnate, exstipulate. *Calyx* 4—5-cleft, imbricate. *Petals* hypogynous, of the same number as the divisions of the calyx, imbricate. *Stamens* twice as many as the petals and divisions of the calyx, either united below into a tube, or distinct and inserted into an *annular hypogynous disk* ; *anthers* 2-celled, with longitudinal dehiscence. *Ovary* usually with as many cells as there are divisions to the calyx and corolla, or rarely only 3 ; *ovules* 4 or more, in two rows, anatropous ; *style* and *stigma* simple. *Fruit* capsular (*fig.* 677), dehiscence usually septifragal (*fig.* 678). *Seeds* (*fig.* 677, *g*) flat, winged, attached to axile placentas ; *albumen* thin or none ; *embryo* straight, erect, with the radicle next the hilum. *This order is now frequently incorporated with Meliaceæ.* (See Meliaceæ.)

Distribution and Numbers.—Chiefly natives of the tropical parts of America and India ; they are very rare in Africa. *Illustrative Genera* :—Swietenia, *Linn.* ; Soymida, *Adr. Juss.* There are about 25 species.

Properties and Uses.—The plants of this order have fragrant, aromatic, tonic, astringent, and febrifugal properties, and many of them are valuable timber-trees.

Cedrela.—The bark of the plants of this genus is generally fragrant.—*C. febrifuga, C. Toona*, and other species have febrifugal and astringent barks ; they have been used as substitutes for Cinchona.—*C. odorata* is the source of Jamaica or Honduras Cedar.—*C. Toona* furnishes a wood resembling mahogany, which is much used in the East Indies, and is occasionally imported into this country. It is termed Toon, Tunga, Poma, or Jeea wood ; and is said to be one of the woods known as Chittagong wood.—*C. australis* produces the Red Cedar of Australia.

Chloroxylon.—The leaves of this genus are dotted, and yield by distillation an essential oil.—*C. Swietenia* is the source of East Indian Satin-wood, which is sometimes imported into this country for the use of cabinet-makers. It is also employed for making the backs of hair and clothes-brushes, and by the turner.

Oxleya xanthoxyla furnishes the Yellow-wood of Queensland.

Soymida febrifuga, the Rohuna or Red-wood Tree.—The bark, which is official in the Pharmacopœia of India, is commonly known under the name of Rohun Bark, and is regarded as tonic, febrifugal, and astringent. In the Bengal bazaars, the bark of *Strychnos Nux-vomica* is also known under the native name of *Rohun*, and this has led to its occasional substitution for Soymida bark (see *Strychnos*). It is much employed in the East Indies in intermittent fevers, diarrhœa, and dysentery.

Swietenia Mahagoni supplies the well-known valuable wood called Mahogany. This is chiefly imported from Honduras and Cuba, and also to some extent from other West Indian islands. Its bark possesses febrifugal properties.

Order 17. CHAILLETIACEÆ, the Chailletia Order.—Character.—*Trees* or *shrubs*. *Leaves* alternate, entire, stipulate. *Calyx* inferior, with 5 sepals; *æstivation* induplicate. *Stamens* 10, perigynous, in two alternate whorls, the outer petaloid and sterile; but the latter whorl more resembles a *corolla*. *Ovary* superior, 2—3-celled, with twin suspended ovules. *Fruit* dry, 1—3 celled. *Seeds* exalbuminous. This order has been variously placed, but is more commonly referred here.

Distribution and Numbers.—Natives of tropical regions. *Illustrative Genera*:—Chailletia, *DC.*; Stephanopodium, *Pöpp.* There are about 10 species.

Properties and Uses. — Unimportant. The fruit of *Chailletia toxicaria*, a native of Sierra Leone, is commonly called Ratsbane on account of its poisonous nature.

Cohort 2. *Olacales.*—Calyx imbricate. Gynœcium syncarpous; ovules suspended; raphe dorsal. Seeds albuminous.

Order 1. OLACACEÆ, the Olax Order.—Character.—*Trees* or *shrubs*, with alternate simple entire exstipulate leaves. *Flowers* small, regular, axillary. *Calyx* minute, monosepalous, generally enlarging so as to cover the fruit; *æstivation* imbricate. *Petals* hypogynous, valvate in æstivation. *Stamens* definite, partly sterile and partly fertile; the latter opposite to the petals, inserted upon or outside of a *conspicuous disk*; *anthers* 2-celled, bursting longitudinally. *Ovary* free, often imbedded in the disk; *ovules* suspended from a free central placenta. *Fruit* drupaceous. *Seed* without integuments, solitary; *embryo* minute; *albumen* fleshy.

Distribution and Numbers.—Natives of tropical or sub-tropical regions. *Illustrative Genera*:—Olax, *Linn.*; Liriosma, *Pöpp.* The number of species is doubtful.

Properties and Uses.—Some have fragrant flowers. The fruit of *Ximenia americana* is eaten in Senegal. The leaves of *Olax zeylanica* are used by the Cingalese in their curries, &c., and the wood in putrid fevers. The wood of *Heisteria coccinea* is considered by some to furnish the Partridge-wood of cabinet-makers. (See *Guettarda*.)

Order 2. ICACINACEÆ, the Icacina Order.—*Diagnosis.*—This is an order of plants consisting of evergreen trees and shrubs, and formerly included in the order Olacaceæ; but, as shown by Miers, they are clearly distinguished from that order, as follows:—'They differ most essentially in the *calyx* being always small, persistent, and unchanged, and never increasing with the growth of the fruit; the *stamens* being always alternate with the petals, not opposite; the *petals* and *stamens* are never fixed on the margin of the *conspicuous cup-shaped disk*; the *ovary* is normally plurilocular with axile placentation, and when unilocular, this happens only from the abortion of the other cells, the traces of which are always discernible, never completely unilocular at the summit, and plurilocular at base, with free central placentation. In Icacinaceæ the *ovules* are suspended below the summit of the cell in pairs superimposed by cup-shaped podosperms; only one of these becomes perfected, and the *seed* is furnished with the usual integuments.'

Distribution and Numbers.—'They are natives of tropical or sub-tropical countries; chiefly the East Indies, Africa, and South America, a single species being found each in New Holland, Norfolk Island, and New Zealand.' *Illustrative Genera*:—Icacina, *Adr. Juss.*; Sarcostigma, *W. et A.* There are about 70 species.

Properties and Uses.—Unknown.

Order 3. CYRILLACEÆ, the Cyrilla Order.—*Diagnosis.*—Evergreen shrubs, with alternate exstipulate leaves, nearly related to *Olacaceæ*, but chiefly distinguished by their imbricate petals, which are altogether free from any hairiness on their inside; and by the stamens being all fertile, and, if equal in number to the petals, alternate with them.

Distribution and Numbers.—They are all natives of North or Tropical America. *Illustrative Genera*:—Cyrilla, Mylocaryum. There are 6 species.

Properties and Uses.—Unknown.

Order 4. PHYTOCRENACEÆ, the Phytocrene Order.—*Diagnosis.*—This order has been variously placed by botanists, *but is referred here by Bentham and Hooker.* Formerly it was incorporated with the Artocarpaceæ, but their seeds have a large quantity of albumen, which at once distinguishes them from that order. The plants belonging to it, all of which belong to the genus Phytocrene, *Wall.*, are climbing shrubs, natives of the East Indies, with dichlamydeous unisexual flowers, and seeds with a large quantity of albumen. Their wood has also a very peculiar structure. They yield a large quantity of watery juice when wounded, hence they are termed Water-vines, or 'Plant-fountains.' In Martaban this juice is drunk by the natives.

Order 5. AQUIFOLIACEÆ or ILICACEÆ, the Holly Order.—Character.—Evergreen *trees* or *shrubs*. *Leaves* (*fig.* 323) coriaceous, simple, exstipulate or with minute stipules. *Flowers* small, axillary, sometimes unisexual. *Sepals* distinct, 4—6, imbricate. *Corolla* 4—6-partite, imbricate. *Stamens* equal in number to the divisions of the corolla and alternate with its segments; *anthers* 2-celled, adnate, opening longitudinally. *Disk* none. *Ovary* superior, 2—6- or more celled, with one suspended ovule in each cell; *placentas* axile. *Fruit* fleshy, indehiscent. *Seed* suspended; *embryo* small, at the base of a large quantity of fleshy albumen; *radicle* superior.

Distribution and Numbers.—They are widely although sparingly scattered over the globe. Only one species, the common Holly, is found in Europe. *Illustrative Genera*:—Ilex, *Linn.*; Prinos, *Linn.* There are about 115 species.

Properties and Uses.—Bitter, tonic, and astringent properties are those chiefly found in the plants of this order. Some are emetic and purgative, while others are largely used as a kind of Tea.

Ilex.—The leaves and bark of *I. Aquifolium*, the Common Holly, have been employed in intermittent fevers. The berries are purgative and emetic. Bird-lime is prepared from the bark, and its white wood is used by cabinet makers for inlaying. A decoction of the leaves of *I. vomitoria* constitutes the Black drink of the Cree Indians. The dried leaves and young twigs of *I. paraguayensis*, the Brazilian or Paraguay Holly, and other species or varieties, are extensively employed in South America as Tea, under the name of Maté or Paraguay Tea. It is remarkable that Maté contains *Theine*, the alkaloid already noticed as existing in China Tea, &c. (See *Thea*, page 472.) Like China Tea it also contains a volatile oil, tannic acid, and gluten; its properties are therefore somewhat similar, but it is more exciting, and when taken to excess produces a kind of intoxication. In Brazil a kind of Maté, called Gongonha, is also prepared from *I. Gongonha* and *I. theezans*. Maté tea is generally used in Brazil, Paraguay, Peru, Uruguay, Chili, and other parts of South America. The consumption of Maté in the various South American Republics is from 20 to 40 millions of pounds annually. From the great astringency of the fresh leaves of *I. paraguayensis*, *I. Gongonha*, and other species, they are used by the dyers in Brazil. The unripe fruits of *I. Macoucoua* contain much tannic acid, and are employed in dyeing cotton.

Prinos glaber.—The leaves of this plant, which is a native of North America, are used as a substitute for China Tea. This is known under the name of Appalachian Tea. (See *Viburnum*.) The bark of *P. verticillatus*, called *Black Alder Bark* or *Winter Berry*, is employed in the United States in the form of a decoction, as a tonic and astringent.

Cohort 3. *Celastrales.*—Calyx imbricate or valvate. Gynœcium syncarpous; ovules erect; raphe ventral. Seeds usually albuminous; radicle inferior. Nearly always trees or shrubs.

Order 1. CELASTRACEÆ, the Spindle-tree Order.—Character.—*Shrubs* or *small trees*. *Leaves* simple, generally alternate, or rarely opposite, with small deciduous stipules. *Sepals* 4—5, imbricate. *Petals* with imbricate æstivation, equal in number to the sepals, inserted on a large disk; sometimes wanting. *Stamens* as many as the petals and alternate with them, inserted on the disk; *anthers* innate. *Disk* large, flat, expanded. *Ovary* sessile, superior, surrounded by the disk, 2—5-celled, each cell with 2 ovules; *ovules* erect, with a short stalk. *Fruit* superior, 2—5-celled, either drupaceous and indehiscent, or capsular with loculicidal dehiscence. *Seeds* with (*fig.* 758) or without an aril;

albumen fleshy; *embryo* straight; *radicle* short, inferior; *cotyledons* flat.

Diagnosis.—Shrubby plants, with simple leaves and small deciduous stipules. Flowers small, regular, and perfect; or rarely unisexual by abortion. Sepals and petals 4—5, imbricate in æstivation. Stamens equal in number to, and alternate with, the petals, and inserted with them on a large flat expanded disk. Ovary superior, sessile, surrounded by the disk. Fruit superior, 2—5-celled. Seeds albuminous; embryo straight; radicle inferior.

Distribution and Numbers.—Chiefly natives of the warmer parts of Asia, North America, and Europe; they are also plentiful at the Cape of Good Hope. Generally speaking, the plants of the order are far more abundant out of the tropics than in them. *Illustrative Genera:*—Euonymus, *Linn.*; Celastrus, *Kunth.* There are about 280 species.

Properties and Uses.—Chiefly remarkable for the presence of an acrid principle. The seeds of some contain oil.

Catha edulis.—The young slender shoots, with the attached leaves, constitute the Arabian drug called Kât, Khat, or Cafta. This is largely chewed by the Arabs, and is said to produce great hilarity of spirits and an agreeable state of wakefulness. A decoction is also made from it, and used as a beverage like our tea: its effects are described as being somewhat similar to those produced by strong green tea, but the excitement of a more pleasing nature. By some writers the term Kât is applied to the drug in its unprepared state, and Cafta to a preparation made from it. The leaves and young shoots of *C. spinosa* are also said to be used in the preparation of Kât.

Celastrus.—The seeds of *C. paniculatus* yield an oil of a powerfully stimulating nature, which is sometimes used as a medicine in India under the name of 'Oleum nigrum.'—*C. scandens* and *C. senegalensis* have purgative and emetic barks.

Elæodendron Kubu.—The drupaceous fruits of this species are eaten at the Cape of Good Hope.

Euonymus.—*E. europæus* is the common Spindle-tree of our hedges. The wood is used to make skewers, spindles, &c. In France, charcoal is said to be prepared from the wood, and used in the manufacture of gunpowder; while the young shoots in a charred condition form a kind of drawing-pencil. The seeds are reputed to be purgative and emetic, and are also said to be poisonous to sheep; those of some other species have similar properties. The bark of *E. tingens* has a beautiful yellow colour on its inside, which may be used as a dye.—*E. atropurpureus.* Wakoo.—The bark, chiefly of the root, of this plant, and also, to some extent, of that of *E. americanus* are used in the United States of America in the preparation of what has been termed *euonymin.* This is reputed to possess tonic, hydragogue, cathartic, diuretic, alterative, and anti-periodic properties. It has been used with some success in this country as an hepatic stimulant.

Order 2. Hippocrateaceæ, the Hippocratea Order.—Character.—*Shrubs*, with opposite simple leaves, and small deciduous stipules. *Flowers* small, regular, and unsymmetrical. *Sepals* and *petals* 5, hypogynous, imbricate, the former persistent. *Stamens* 3, hypogynous, monadelphous; *anthers* with transverse dehiscence. *Disk* conspicuous, *Ovary* 3-celled; *placentas* axile; *style* 1. *Fruit* baccate, or consisting of

3 samaroid carpels. *Seeds* definite, exalbuminous; *embryo* straight; *radicle* inferior. *This order is referred to Celastraceæ by Bentham and Hooker.*

Distribution and Numbers.—They abound principally in South America; some are also found in Africa and the East Indies. *Illustrative Genera:*—Hippocratea, *Linn.*; Tontelea, *Aubl.* There are about 86 species.

Properties and Uses.—Very little is known generally of the plants of this order. The fruit of several Brazilian species of *Tontelea* is edible, and in Sierra Leone that of *T. pyriformis* is described as very pleasant. *Hippocratea comosa* yields nuts of an oily and sweet nature. The inner yellow bark of *Kokoona zeylanica* is employed in Ceylon as a febrifuge and sternutatory, and as a dye.

Order 3. Stackhousiaceæ, the Stackhousia Order.—Character.—*Herbs* or rarely *shrubs*, with simple, entire, alternate, minutely stipulate leaves. *Calyx* 5-cleft, with its tube inflated. *Petals* 5, united below into a tube, arising from the top of the tube of the calyx, and having a narrow stellate limb. *Stamens* 5, distinct, of unequal length, perigynous. *Ovary* superior, 3- or 5-celled, each cell containing one erect ovule; *styles* 3 or 5, distinct or united at the base. *Fruit* consisting of from 3—5 indehiscent carpels, attached to a central persistent column. *Seeds* with fleshy albumen; *embryo* erect; *radicle* inferior.

Distribution and Numbers.—Natives of Australia. *Illustrative Genera:*—Stackhousia, *Smith*; Tripterococcus, *Endl.* There are about 20 species.

Properties and Uses.—Unknown.

Order 4. Rhamnaceæ, the Buckthorn Order.—Character. *Shrubs* or *small trees*, which are often spiny. *Leaves* simple, alternate or rarely opposite; *stipules* small or wanting. *Flowers* small, usually perfect (*fig.* 793) or sometimes unisexual. *Calyx* 4—5-cleft, with a valvate æstivation (*fig.* 793). *Disk* fleshy, lining the tube of the calyx. *Petals* equal in number to the divisions of the calyx (*fig.* 793), and inserted into its throat, hooded or convolute, sometimes wanting. *Stamens* perigynous, equal in number to the petals (*fig.* 793) and opposite to them when present, and alternate to the divisions of the calyx. *Ovary* (*fig.* 793) superior or half superior, immersed in the disk, 2- 3- or 4-celled; *ovules* one in each cell, erect. *Fruit* dry and capsular, or fleshy and indehiscent. *Seeds* one in each cell, erect, usually with fleshy albumen, but this is sometimes wanting, exarillate; *embryo* long, with a short inferior radicle, and large flat cotyledons.

Diagnosis.—Small trees or shrubs, with simple leaves and small regular usually perfect flowers; rarely unisexual. Calyx 4—5-parted, valvate, with the tube coated with a disk. Petals and stamens distinct, perigynous, and equal in number to the divisions of the calyx; the petals sometimes wanting, but, when present, opposite to the stamens. Ovary more or less superior, surrounded by a fleshy disk. Fruit 2- 3- or 4-celled, with one erect seed in each cell. Seed usually albuminous, without an aril.

Distribution and Numbers.—Generally distributed over the globe except in the very coldest regions. *Illustrative Genera:*—Zizyphus, *Tourn.*; Rhamnus, *Juss.* There are about 400 species.

Properties and Uses.—Some of the plants have acrid and purgative properties; others are bitter, febrifugal, and tonic. A few are used in the preparation of dyeing materials, and some few others have edible fruits.

Ceanothus americanus.—The young shoots are astringent; and in New Jersey the leaves are dried and used as a substitute for China tea; forming what is commonly known as New Jersey Tea.

Discaria febrifuga.—The root is used in Brazil as a febrifuge and tonic.

Gouania domingensis is reputed to possess stomachic properties.

Hovenia dulcis.—The peduncles of this plant become ultimately enlarged and succulent, and are much esteemed in China, where they are eaten as a fruit.

Rhamnus.—This genus is by far the most important in the order. Thus, *R. catharticus*, commonly called Buckthorn, produces a fruit the fresh juice of which has been used for ages as a hydragogue cathartic; but it is rarely employed at the present day, on account of its violent and unpleasant operation, except in veterinary practice. The pigment known as *sap-green*, the *vert de vessie* of the French, is prepared by evaporating to dryness the fresh juice of Buckthorn berries previously mixed with lime. The bark of *R. Frangula*, the Black Alder, has long been employed in Germany, Holland, and some other parts of Europe, as a laxative, and is now official in the British Pharmacopœia. The bark of the young trunks and larger branches is regarded as the most active, and more especially so after having been kept for a year or more. A greenish or yellowish-green dye is made from the leaves. The wood under the name of 'Dogwood' is largely used in the manufacture of the finer kinds of gunpowder. The bark of *R. Purshianus* has also been much employed of late years in the United States of America, and in this country more recently, as a purgative in large doses, and as a tonic and stomachic in small doses. It is known under the name of *Cascara Sagrada*, and is obtained from California; it is now official in the British Pharmacopœia. The unripe fruits of *R. infectorius* are known in commerce under the name of *French berries* (Graines d'Avignon of the French); while those of *R. amygdalinus* constitute the berries called *yellow berries* or *Persian berries*. Some authors say that both the French and Persian berries are the produce of one species, the *R. infectorius*, and that the only difference between them is in size—those called French or Avignon berries being smaller, and not of such good quality as the Persian berries, which are obtained from Asiatic Turkey and Persia. These berries produce a beautiful yellow colour, which is used for dyeing morocco leather, and by calico printers.—*R. saxatilis* produces a fruit, which may be also employed for dyeing yellow. In Abyssinia, the leaves of *R. pauciflorus*, and the fruit of *R. Staddo*, both of which possess bitter properties, are employed as a substitute for hops in the preparation of beer. From *R. alaternus* a blue dye may be prepared. The Chinese green dye (*Lo-kao*), known here as Chinese Green Indigo, and now much used in Europe, is prepared from *R. chlorophorus* (*globosus*) and *R. utilis*.

Sageretia theezans is a native of China, where its leaves are used as a substitute for tea by the poorer inhabitants.

Ventilago Maderaspatana, Pupli.—The bark of the root is used in India in the production of orange and other dyes.

Zizyphus.—Many species of this genus have edible fruits. Thus, the

Z. vulgaris, *Z. Jujuba*, and others, yield the fruits known under the name of Jujubes. Jujube is a favourite dessert fruit in Japan; and another Japanese species, *Z. sinensis*, yields the fruits known as Japonicas, which are occasionally to be met with in Covent Garden Market.—*Z. Lotus* has also an edible fruit, which is esteemed by the Arabs, &c. This is generally believed to be the Lotus of the ancients, and from which the Lotophagi received their name. By some, however, the Lotus of the ancients is supposed to be the *Nitraria tridentata*. (See *Nitraria*.) The berries or seeds of some species of *Zizyphus* are regarded as sedative, while those of *Z. Baclei* are reputed to be poisonous. Some believe that the crown of thorns which was placed on our Saviour's head was made from *Z. Spina-Christi*.

Order 5. VITACEÆ, the Vine Order.—Character.—Usually *shrubs* climbing by tendrils (*fig.* 214), with a watery juice, the joints swollen and separable from each other. *Leaves* simple (*fig.* 214) or compound, opposite below, alternate above, stipulate or exstipulate. *Flowers* regular, small, green, stalked (*fig.* 426); *peduncles* sometimes cirrhose. *Calyx* minute, with the limb generally obsolete. *Petals* 4 or 5, sometimes united at the base; *æstivation* induplicate; inserted *on a disk* which surrounds the ovary, caducous. *Stamens* corresponding in number to the petals and opposite to them, also inserted on the disk (*fig.* 518); *filaments* distinct or somewhat united at the base; *anthers* versatile, bursting longitudinally (*fig.* 518). *Ovary* superior, surrounded by a disk, 2—6-celled, usually 2; *style* very short, simple; *stigma* simple (*fig.* 518). *Fruit* succulent (*fig.* 720), sometimes termed a nuculanium, usually 2-celled. *Seeds* erect, few, usually 2 in each cell; *testa* bony; *albumen* hard; *embryo* erect, with an inferior radicle.

Diagnosis.—Shrubby plants, climbing by tendrils, with simple or compound leaves, which are opposite below and alternate above. Flowers small, green, regular. Petals and stamens corresponding in number, 4 or 5, the latter opposite to the petals, both inserted on an hypogynous disk; æstivation of petals induplicate; anthers versatile, opening longitudinally. Ovary superior, surrounded by a disk, with a very short simple style and stigma. Fruit a nuculanium. Seeds few; testa bony; embryo erect in horny albumen; radicle inferior.

Distribution and Numbers.—The plants of this order are found in warm and tropical regions of the globe. None are natives of Europe. The common Grape Vine, which is now completely naturalised in the South of Europe, and is cultivated nearly all over the globe where the temperature does not rise too high or fall too low, is supposed to be a native of the shores of the Caspian. *Illustrative Genera*:—Vitis, *Linn.*; Ampelopsis, *L. C. Rich.* There are about 260 species.

Properties and Uses.—The leaves, stems, and unripe fruits, especially the latter, of the plants of this order, abound more or less in an acid juice, the acidity being chiefly due to the presence of tartaric and malic acids, and acid tartrate of potash. As the fruit ripens, it generally loses its acidity, and becomes sweet, owing to the formation of Glucose or Grape Sugar.

Ampelopsis hederacea, Virginian Creeper.—The juice of the leaves and other parts is said to possess poisonous properties.

Cissus.—The leaves and fruits of some species, as *C. setosa*, *C. cordata*, &c., are acrid. A blue dye is obtained in Brazil from the leaves and fruit of *C. tinctoria*.

Vitis vinifera.—This very valuable plant, which is commonly known as the Grape Vine, has followed the steps of man into almost every region of the globe where the climate is at all adapted to its growth. The varieties of the Vine are exceedingly numerous, being more than 300. The fruits, under the name of *Grapes*, are too well known to need any particular description. They have been in use for more than 4,000 years for the making of wine, vinegar, brandy, and other fermented liquors. Grapes possess refrigerant properties, and are hence useful in febrile and inflammatory affections. Grapes when dried are called *raisins*, which are largely used at dessert and for culinary purposes. They are also official in the British Pharmacopœia under the name of *Uvæ*. Of raisins we have several commercial varieties, the more important of which are Valentias, Muscatels, and Sultanas. The Muscatels, or Raisins of the Sun, are considered the finest. The Sultanas are remarkable for the absence of seeds. Raisins possess demulcent and slightly refrigerant properties, but they are principally employed in medicine for flavouring purposes. Besides the above kinds, there is also a small seedless variety of raisin, commonly known under the name of Currants. This name is a corruption of Corinth, where they were originally grown, but they are now chiefly obtained from Zante and the other Ionian Islands. The leaves and tendrils of the Vine are astringent, and have been used in diarrhœa; and the sap has been employed in France in chronic ophthalmia.—*Vitis vulpina*, *V. Labrusca*, and other species or varieties, which grow wild in North America, yield fruits which are known as the Muscadine and Fox-grapes. These are similar, although very inferior in their properties, to those of the common Grape.

Cohort 4. *Sapindales.*—Calyx imbricate. Gynœcium usually syncarpous, or rarely apocarpous; ovules generally ascending, with the raphe ventral. Seeds nearly always exalbuminous. Trees or shrubs, rarely herbs.

Order 1. SAPINDACEÆ, the Soapwort Order.—Character.—Usually large *trees* or twining *shrubs*, or rarely climbing *herbs*. *Leaves* generally compound (*fig.* 368), or rarely simple, alternate or sometimes opposite, often dotted, stipulate or exstipulate. *Flowers* (*figs.* 939 and 940) mostly perfect and unsymmetrical, sometimes polygamous. *Sepals* 4—5 (*fig.* 939), either distinct or united at the base, imbricate. *Petals* 4—5 (*fig.* 939), rarely 0, hypogynous, alternate with the sepals, imbricate, naked or furnished with an appendage on the inside. *Stamens* 8—10, rarely 5—6—7 (*fig.* 939), or very rarely 20, inserted into the disk or into the thalamus; *filaments* distinct or slightly monadelphous; *anthers* introrse, bursting longitudinally. *Disk* fleshy or glandular, hypogynous or perigynous. *Ovary* usually 3-celled (*fig.* 939), rarely 2- or 4-celled, each cell containing 1, 2 (*fig.* 735), 3, or rarely more ovules; *style* undivided or 2—3-cleft. *Fruit* either fleshy and indehiscent; or capsular, with 2—3 valves. *Seeds* usually arillate, exalbuminous; *embryo* rarely straight, usually curved (*fig.* 941) or twisted in a spiral direction; *cotyledons* sometimes very large; *radicle* next the hilum.

Diagnosis.—Flowers unsymmetrical, hypogynous. Sepals and petals 4—5, imbricate, the latter commonly with an appendage. Stamens never agreeing in number with the sepals and petals, inserted on a fleshy or glandular disk, or upon the thalamus; anthers bursting longitudinally. Fruit usually consisting of 3 carpels. Seeds commonly 2, sometimes 1 or 3, or very rarely more, exalbuminous, usually arillate and without wings; embryo almost always curved or spirally twisted.

FIG. 939.

FIG. 940.

FIG. 941.

Fig. 939. Diagram of the flower of the Horsechestnut (*Æsculus Hippocastanum*).——*Fig.* 940. Vertical section of the flower.——*Fig.* 941. Vertical section of the seed.

Division of the Order and Illustrative Genera:—This order has been divided by Lindley into 4 sub-orders, as follows:—

Sub-order 1. *Sapindeæ.*—Leaves alternate. Ovules usually solitary. Embryo generally curved or sometimes straight. *Illustrative Genera:*—Sapindus, *Linn.*; Nephelium, *Linn.*

Sub-order 2. *Hippocastaneæ.*—Leaves opposite. Ovules 2 in a cell, of which one is ascending, and the other suspended (*fig.* 735). Embryo curved (*fig.* 941), with a small radicle and large fleshy consolidated cotyledons. *Illustrative Genus:*—Æsculus, *Linn.*

Sub-order 3. *Dodoneæ.*—Leaves alternate. Ovules 2 or 3 in a cell. Embryo spiral. *Illustrative Genera:*—Dodonæa, *Linn.*; Ophiocaryon, *Schomb.*

Sub-order 4. *Meliosmeæ.*—Leaves alternate. Flowers very irregular. Stamens 5, 3 of which are abortive, and only 2, therefore, fertile. Ovules 2 in each cell, suspended. Fruit drupaceous. Embryo folded up. *Illustrative Genus:*—Meliosma, *Blume. Bentham and Hooker include the Meliosmeæ in the order Sabiaceæ.*

Distribution and Numbers.—Chiefly found in tropical regions, especially those of South America and India; some occur in temperate climates, but none inhabit the cold northern parts of the globe. There are no native plants of this order in Europe. The Horsechestnut, now so well known in this country, is only naturalised among us. There are nearly 400 species.

Properties and Uses.—One of the most prominent characteristics of the plants of this order is the presence of a saponaceous principle, from which its common name is derived. Many are poisonous in all their parts ; but it is more frequently the case that, while the root, leaves, and branches are dangerous, the poisonous juice becomes so diffused throughout their succulent fruits as to render them innocuous, or, in several instances, even valuable articles of dessert. It sometimes happens, as in the Litchi and Longan fruits, that while the pericarp is wholesome, the seeds are dangerous. Some plants of the order are astringent and aromatic ; others are diaphoretic, diuretic, and aperient ; and some are valuable timber trees.

Æsculus.—The bark of *Æsculus Hippocastanum*, the Horsechestnut, is febrifugal. Its young leaves are somewhat aromatic, and Endlicher says that they have been used as a substitute for Hops. The seeds have been long employed as an excellent food for sheep in Switzerland, and have been also recommended as a substitute for Coffee. They contain a saponaceous principle like the fruits of certain species of *Sapindus*. They also contain a large quantity of starch, and are much used in France, instead of potatoes and cereals, as a source of that substance. In some parts of Holstein also, this starch, which is there very carefully prepared, has been used for many years for household purposes, being much preferred to that obtained from wheat, rice, or potatoes. The seeds are said to yield by expression a fixed oil, which has been introduced under the name of Oil of Horsechestnut, as an external application in rheumatism, &c. Nothing, however, is known of the extraction of the oil from these seeds, and its source from them is scarcely probable. The roots, leaves, and fruits of the *Æsculus ohiotensis*, the Buckeye or American Horsechestnut, are generally regarded as poisonous, both to man and animals.

Cardiospermum Halicacabum.—The root is described as diuretic, diaphoretic, and aperient. Its leaves, when boiled, are eaten as a vegetable in the Moluccas.

Cupania (*Blighia*) *sapida.*—The distilled water of the flowers is used by negro women as a cosmetic. The succulent slightly acid aril of the seeds is eaten, and much esteemed in the West Indies and elsewhere. The fruit in which the seeds are contained is commonly known under the name of the Akee-fruit. A decoction of these has been used in diarrhœa.

Dodonæa.—Some of the species of this genus are aromatic. The wood of *D. dioica* is carminative. Others are reputed to be slightly purgative and febrifugal.

Nephelium.—This genus yields the delicious fruits of China and the Indian Archipelago, known under the names of Litchi, Longan, and Rambutan. *Nephelium Litchi* produces the Litchi ; *N. Longan*, the Longan ; and *N. Rambutan* or *N. lappaceum*, the Rambutan fruit. The Litchi fruits are frequently imported into this country; and rarely also, the Longan. It should be noticed that the seeds of all these fruits are very bitter, and are probably poisonous.

Paullinia.—The seeds of *Paullinia sorbilis*, Guarana, are used in Brazil in the preparation of a kind of food which is known as Guarana bread, Brazilian Cocoa, or simply as Guarana. Guarana is also there used as a remedy in many diseases. Guarana bread is prepared by taking the dried seeds deprived of their aril, and pounding and kneading them into a mass, which is afterwards made into oblong or rounded cakes. These cakes are used in the same manner as we use cocoa and chocolate—that is, they are mixed with water, and the mixture sweetened and drunk. This beverage is largely consumed in Brazil, both on account of its nutritive qualities, and for its stomachic, febrifugal, and reputed aphrodisiac effects. It contains a bitter crystalline principle called *Guaranine*, which appears to be identical with *theine* (see *Thea*, p. 472), the active principle of tea and coffee, and hence Guarana has a somewhat similar effect upon the system to that produced by these two beverages. Guarana has been lately highly recommended for use in this country and elsewhere as a remedy in nervous headache. Its action is probably similar to tea, over which it seems to possess no advantages. It has also been recommended as a remedy in neuralgia, diarrhœa, and other diseases. In many species of *Paullinia*, the narcotic property, which is but slightly marked in *P. sorbilis*, is very evident. Thus, the leaves, bark, and fruit of *P. pinnata* are very dangerous, and are used in the preparation of a poison by the Brazilians, which slowly but surely destroys life. Martius suggests that this poison might be efficacious in hydrophobia and insanity. *P. cururu* and *P. australis* have similar poisonous properties.

Sapindus.—The fruits of *Sapindus Saponaria*, as well as those of *S. inæqualis* and others, contain a saponaceous principle, so that when mixed with water they produce an abundant lather; hence they are used in the West Indies instead of soap. It is said that 'a few of them will cleanse more linen than sixty times their weight of soap.' These plants also contain a narcotico-acrid principle, as the pounded fruits, when thrown into water in which fish are contained, will produce upon them a kind of intoxication. The pericarp of *S. senegalensis* is eaten, but the seeds act as a narcotico-acrid poison. The fruits of *Sapindus esculentus* and others are also edible.

Schmidelia serrata has an astringent root, which has been used in India for diarrhœa.

The fruits of many plants belonging to this order, besides those already named, are edible, as those of *Pierardia sativa* and *P. dulcis*, producing the Rambeh and Choopa of Malacca; and *Hedycarpus malayanus* producing the Tampui. *Schmidelia edulis*, in Brazil; *Melicocca bijuga*, in the West Indies and Brazil; *Pappea capensis*, at the Cape of Good Hope, &c., also yield edible fruits.

Order 2. ACERACEÆ, the Maple Order.—Character.—*Trees. Leaves* opposite, simple, without stipules; *venation* usually radiate, rarely pinnate. *Flowers* often polygamous, racemose or corymbose, regular. *Calyx* with an imbricate æstivation, usually 5-partite, occasionally 4- or 9-partite. *Petals* imbricate, without appendages at their base, corresponding in number to the divisions of the calyx, or altogether absent. *Stamens* usually 8, inserted on a *fleshy hypogynous disk*, or rarely the disk is absent. *Ovary* superior, 2-lobed, 2-celled; *stigmas* 2; *ovules* in pairs. *Fruit* a samara, 2-celled (*fig.* 706). *Seeds* 1 or 2 in each cell, ascending, without an aril, exalbuminous; *embryo* curved, with leafy wrinkled *cotyledons*, and an inferior *radicle*. *This order is placed by Bentham and Hooker in Sapindaceæ, tribe Acerineæ.*

Diagnosis.—Trees with opposite simple exstipulate leaves. Flowers often polygamous, and usually regular. Sepals and petals imbricate, the latter without any appendages on their inside. Stamens hypogynous, usually on a fleshy disk; anthers bursting longitudinally; ovary superior, 2-celled. Fruit a samara, 2-celled, each cell containing 1 or 2 seeds. Seeds ascending, without an aril, exalbuminous; embryo curved, with an inferior radicle.

Distribution and Numbers.—The plants of this order are natives of the temperate parts of Europe, Asia, and North America. None have been found in Africa and the southern hemisphere. *Illustrative Genera:*—Acer, *Linn.*; Negundo, *Mönch.* There are about 50 species.

Properties and Uses.—These plants are chiefly remarkable for their saccharine sap. Their light and handsome timber is also much used in turnery, for certain parts of musical instruments, and for other purposes; and their bark is astringent, and is employed in different districts by the dyer in the production of yellow, reddish-brown, and blue colours.

Acer.—*A. saccharinum* is the Sugar Maple. The Maple Sugar of America is obtained from this tree by making perforations into its trunk at the commencement of spring, and boiling down the saccharine sap which then exudes to the crystallising point. A few years since nearly 50 millions of pounds of Maple Sugar were annually produced in North America, but the quantity is diminishing yearly in consequence of the destruction of the native forests.—*A. dasycarpum* and other species also yield sugar. The bark of *A. saccharinum* has been also used in America in the production of a blue dye, and as an ingredient in the manufacture of ink.—*A. campestre* and *A. Pseudo-platanus* are common trees in Britain, and afford useful timber; the latter is generally known under the names of the Sycamore, Greater Maple, and Mock-plane. It derives the latter name from the resemblance of its leaves to those of the true Plane-tree (see *Platanus*), but their venation is different. Its wood is also used for making charcoal.

Order 3. STAPHYLEACEÆ, the Bladder-nut Order.—Character.—*Shrubs*, with opposite or rarely alternate pinnate leaves, which are furnished with deciduous stipules and stipels. *Flowers* symmetrical. *Calyx* 5-partite (*fig.* 788), coloured, imbricate. *Petals* 5 (*fig.* 788), alternate with the divisions of the calyx, imbricate. *Stamens* 5 (*fig.* 788), alternate with the petals, and inserted with them on a *large disk.* *Ovary* superior, composed of 2 (*fig.* 788) or 3 carpels, which are more or less distinct; *ovules* numerous; *styles* 2 or 3, united at the base. *Fruit* fleshy or membranous. *Seeds* ascending, with a bony testa; *embryo* straight; *albumen* little or none. *This order is now frequently placed in Sapindaceæ.*

Distribution and Numbers.—They are scattered irregularly over the globe. *Illustrative Genus:*—Staphylea, *Linn.* There are about 14 species.

Properties and Uses.—The bark of some species is bitter and astringent, as that of *Euscaphis staphyleoides.* Others have oily and somewhat purgative seeds, as *Staphylea pinnata*, &c.

Order 4. SABIACEÆ, the Sabia Order.—*Diagnosis.*—This is a small order of plants, containing but 2 genera, and 9 species, which were formerly placed as doubtful genera of the Anacardiaceæ; but the Sabiaceæ differ essentially from the Anacardiaceæ, in their stamens being opposite to the petals; in their distinct carpels; and in their solitary ovules being directly attached to the ventral suture. Miers and Blume regard the Sabiaceæ as related to Menispermaceæ and Lardizabalaceæ. *Bentham and Hooker include the Meliosmeæ of the Sapindaceæ in this order.*

Distribution, Properties, and Uses.—Natives of the East Indies. Their properties are altogether unknown.

Order 5. ANACARDIACEÆ, the Cashew-nut Order.—Character.—*Trees* or *shrubs*, with alternate, simple or compound, dotless, exstipulate leaves, and a milky acrid or resinous juice. *Flowers* regular, small, and frequently unisexual. *Calyx* persistent (*fig.* 942), with usually 5, or sometimes 3, 4, or 7 lobes. *Petals* equal in number to the divisions of the calyx, perigynous, imbricate; sometimes absent. *Stamens* alternate with the petals, and of the same number, or twice as many, or even more numerous; perigynous, and united at the base if there is no disk, but if this is present then distinct and inserted upon it. *Disk* annular and hypogynous, or wanting. *Ovary* usually single, 1-celled, generally superior, or very rarely inferior; *styles* 1, 3, 4, or none; *stigmas* the same number as the styles; *ovules* solitary, attached to a long funiculus which arises from the base of the cell. *Fruit* (*fig.* 942) indehiscent, drupaceous, or nut-like. *Seed* without albumen.

FIG. 942.

Fig 942. Flowering branch of the *Rhus Cotinus*, or Wig-tree, with one branch bearing fruit, and the others covered with hair-like appendages and sterile.

Distribution and Numbers.—The plants of this order are chiefly found in the tropical regions of the globe, although a few are found in the South of Europe and in other extra-tropical warm districts. *Illustrative Genera:*—Pistacia, *Linn.*; Anacardium, *Rottb.* There are about 110 species.

Properties and Uses. — They abound in a resinous, somewhat gummy, acrid, or milky juice, which is occasionally very poisonous, and sometimes becomes black in drying. The fruits and seeds of some species are, however, held in high estimation, and are largely eaten in different parts of the world. Many plants of this order furnish varnishes.

Anacardium occidentale, the Cashew-nut, is remarkable for its enlarged fleshy peduncle, which is eaten as a fruit; and its juice, when fermented, produces a kind of wine in the West Indies; and in Bombay and other places a spirit is also distilled from it. Each peduncle bears a small kidney-shaped nut-like fruit, the pericarp of which is very acrid, but the seed is edible. By roasting the fruit the acridity is destroyed, and the seed then possesses a fine flavour. The acrid principle, which is of an oily nature, possesses powerful rubefacient and vesicant properties. The Cashew-tree also yields a large supply of a kind of gum, which is however but little used.

Holigarna longifolia.—The fruits of this species and those of *Semecarpus Anacardium.* furnish the black varnish of Sylhet, which is much used in India. (See *Semecarpus.*)

Mangifera indica.—The fruit of this plant is the Mango, which is so highly esteemed in tropical countries. Several varieties are cultivated: these differ very much in the size and flavour of their fruits. The kernel of the seed is employed in Brazil and in India as an anthelmintic.

Melanorrhœa usitatissima furnishes the *Black Varnish* of the Burmese. It is employed in the arts, and also as an anthelmintic.

Odina Wodier has an astringent bark, which has been used in India. It also yields an astringent gum.

Pistacia.—*P. Lentiscus* is the source of the concrete resin, which is official in the British Pharmacopœia, called *mastic* or *mastich*. It is obtained from the stem by incision. Mastich, when dissolved in spirit of wine or oil of turpentine, forms a good varnish, which was formerly much employed in this country, but of late years the place of mastich for this purpose has been supplied in a great degree by Dammar and other less expensive resins. It is used in the East as a masticatory; and also to some extent for fumigation, and in the manufacture of confections and cordials. It is also employed in this country by dentists as a temporary stopping for teeth, when dissolved in alcohol or ether, for the relief of toothache and other purposes. It possesses stimulant and diuretic properties, but is rarely employed in medicine. It is exclusively collected, and from male plants only, in the island of Scio, where this plant is much cultivated.—*P. Terebinthus* is the source of the liquid oleo-resin called *Chian Turpentine*. It is obtained from the stem by incision, in the same way as mastich. Chian Turpentine becomes solid by keeping, from the loss of its volatile oil. It has the general properties of the ordinary Turpentines derived from some of the Coniferæ, and was formerly employed for similar purposes; but its use in medicine had become nearly obsolete until it was recommended recently as being almost a specific in the treatment of uterine cancer, for which purpose it has been extensively employed, but without any evident success. It is used in Greece and the Levant in the manufacture of cordials. Chian Turpentine, as its name indicates, is obtained from the island of Scio.—*Pistacia vera* produces the fruit known as Pistachio or Pistacia nut, the kernels of which are of a green colour, and have an agreeable flavour. They are highly esteemed by the Turks and Greeks, and are occasionally imported into this country. They are either eaten raw, or after having been fried, with pepper and salt. —*P. Khinjuk* and *P. cabulica* yield concrete resins resembling mastich. This kind of mastich is imported into India from Cabul; and rarely into Europe under the name of *Bombay* or *East Indian Mastich*. Curiously shaped galls of a slightly astringent terebinthinate taste are also obtained from *P. Khinjuk*, which enter into the native Materia Medica of India under the name of *Gúl-i-pista.*—*P. atlantica* also yields a concrete resin, which is used in place of mastich by the Arab tribes of Northern Africa.

Rhus, the Sumach.—Several species of this genus have more or less poisonous properties. They have generally a milky juice, which becomes black on exposure to the air; and the emanations from some of them excite violent erysipelatous inflammation upon certain individuals when brought within their influence.—*R. Toxicodendron* is the Poison-oak of North America. The leaves contain a peculiar acrid principle, to which their medicinal properties appear to be due. They have been thought to be useful in old paralytic cases and in chronic rheumatism.—*R. venenata* is the Poison-ash or Poison-elder, and, like the two former, has very poisonous properties. The above plants, in a fresh state, ought to be very carefully handled, as their juices frequently cause violent erysipelatous inflammation. The bark of *R. Coriaria* is a powerful astringent, and is used in tanning; other species have similar properties. The fruit is acidulous, and is eaten by the Turks. The leaves, when dried and powdered, constitute the material called *Shumac* or *Sumach*, which has been employed in tanning and dyeing for ages. The wood of *R. Cotinus* is known in commerce as *Young Fustic* or *Zante Fustic*. It is used for dyeing, and produces a rich yellow colour. This must not be confounded with *Old Fustic*, which is derived from an entirely different plant (see *Maclura tinctoria*).—*R. Metopium*, a native of Jamaica, furnishes the Hog-gum of that island: this is said to have astringent, diuretic, and purgative properties when given internally, and to act as a vulnerary when applied to wounds, &c. From the fruits of *R. succedanea*, and probably other species, Japanese Wax is obtained, which is now largely used in this country for candles, &c. On the branches of this plant in India, peculiar horn-like galls are found, which possess astringent properties.

Semecarpus Anacardium is the source of the Marking-nut. These fruits are used extensively in the preparation of a black varnish. The seeds are edible, like those of the Cashew. These nuts and the fruit of *Holigarna longifolia* (as before noticed) furnish the black varnish of Sylhet, which is used in the East Indies for varnishing lacquer work and for marking linen, hence their common name. The black thick juice of this plant has powerfully caustic properties, and is in use by the natives of the East Indies as a vesicant. Its employment, however, has frequently led to serious consequences, and should be condemned as dangerous.

Spondias.—*S. purpurea*, *S. Mombin*, and other species, have edible fruits, called Hog-plums in Brazil and the West Indies. The fruit of *S. cytherea* or *S. dulcis*, a native of the Society Islands, is said to rival the Pineapple in flavour and fragrance.

Stagmaria verniciflua (*Rhus vernicifera*) is the source of a valuable hard black varnish, known in the Indian Archipelago under the name of *Japan Lacquer*.

Order 6. Coriariaceæ, the Coriaria Order.—*Diagnosis.*—This name is given to an order which includes but 1 genus, and 8 species. Its affinities are by no means understood; but it appears to be most nearly related to Ochnaceæ, with which it agrees in having its carpels distinct, and placed on an enlarged disk; but it is distinguished from that order by its opposite leaves; sometimes polygamous flowers; persistent fleshy petals; absence of style; and long linear distinct stigmas.

Distribution.—Natives of the South of Europe, Chili, Peru, New Zealand, and Nepaul.

Properties and Uses.—The plants of this order are generally to be regarded with suspicion, as they have sometimes produced poisonous effects. The fruits of some, however, are edible, as *Coriaria nepalensis*, a native of the north of India, and those of *C. sarmentosa*, a native of New Zealand; in the latter case the pericarp is alone eaten, the seeds being poisonous. The fruits of *C. myrtifolia* and *C. ruscifolia* are very poisonous; these plants have been employed by dyers in the production of a black dye. The leaves of the former species have been also used on the Continent to adulterate Senna; this is a most serious adulteration, as these leaves are poisonous. They owe their poisonous properties to a glucoside called *coria-myrtin*. They may be at once distinguished from Senna leaflets by their two sides being equal and symmetrical at the base, those of Senna being unequal. Chemically they are also known from Senna by their infusion producing a very abundant blue precipitate on the addition of persulphate of iron.

Order 7. MORINGACEÆ, the Ben-nut Order.—Character. *Trees* with bi- or tri-pinnate leaves, and thin deciduous stipules. *Flowers* white, irregular. *Sepals* and *petals* 5 each; the former deciduous, petaloid, and furnished with a *fleshy disk*; *æstivation* imbricate. *Stamens* 8 or 10, placed on the disk lining the tube of the calyx in two whorls, the outer of which is sometimes sterile; *anthers* 1-celled. *Ovary* stalked, superior, 1-celled, with 3 parietal placentas. *Fruit* long, pod-shaped, capsular, 1-celled, 3-valved, with loculicidal dehiscence. *Seeds* numerous, without albumen.

Distribution and Numbers.—Natives of the East Indies and Arabia. There is only one genus (*Moringa*, Burm.), and 4 species.

Properties and Uses.—Pungent and slightly aromatic properties more or less prevail in plants of the order, hence they have been employed as stimulants.

Moringa pterygosperma.—The root resembles that of Horseradish in its taste and odour, and has been used internally as a stimulant and diuretic, and locally, when fresh, as a rubefacient and vesicant. A kind of gum somewhat resembling Tragacanth exudes from the bark when wounded. Its seeds are called in France *Pois Quéniques* and *Chicot*, and in England Ben-nuts. They yield a fixed oil called Oil of Ben, which is occasionally used by painters, and also by perfumers and watchmakers. The wood has been supposed, but on no trustworthy authority, to be the *lignum nephriticum* of the old Materia Medica writers.

Artificial Analysis of the Orders in the Sub-class Polypetalæ.

Series 2. DISCIFLORÆ.

1. FLOWERS with more than 20 stamens.

A. *Leaves with stipules.*

Carpels more or less distinct, (at least as to the styles), or solitary, superior or partially inferior	*Anacardiaceæ.*
Carpels wholly combined, (at least as to the ovaries), superior	*Humiriaceæ.*

2. FLOWERS with less than 20 stamens.

A. *Leaves without stipules.*

a. *Carpels more or less distinct, or solitary.*

Leaves without dots.	
Albumen abundant	*Zygophyllaceæ.*
Albumen absent	*Anacardiaceæ.*
Leaves dotted	*Burseraceæ.*

b. *Carpels wholly combined, (at least as to their ovaries).*

Styles distinct to the base.
- Calyx valvate . . . . . *Vivianiaceæ.*
- Calyx imbricate . . . . *Linaceæ.*

Styles more or less combined.
- Calyx valvate or united, or but very slightly imbricate.
  - Stamens hypogynous.
    - Calyx generally enlarging with the fruit . . . . . *Olacaceæ.*
    - Calyx not enlarging with the fruit.
      - Stamens opposite to the petals, isomerous . . . . *Rhamnaceæ.*
      - Stamens alternate with the petals, isomerous.
        - Leaves compound . . . *Burseraceæ.*
        - Leaves simple . . . *Icacinaceæ.*
  - Stamens more or less perigynous.
    - Flowers irregular, ovules suspended . . . . . *Tropæolaceæ.*
    - Flowers regular, ovules erect . *Limnanthaceæ.*
- Calyx imbricate.
  - Fruit gynobasic.
    - Stamens arising from scales . *Simarubaceæ.*
    - Stamens not arising from scales.
      - Styles wholly combined.
        - Flowers perfect . . . *Rutaceæ.*
        - Flowers polygamous . . *Xanthoxyleæ of Rutaceæ.*
      - Styles divided at the apex.
        - Flowers irregular, fruit usually with elastic valves . *Balsaminaceæ.*
  - Fruit not gynobasic.
    - Calyx much imbricate, in an irregular broken whorl.
      - Petals with appendages at their base. Leaves alternate *Sapindaceæ.*
      - Petals without appendages at their base. Leaves opposite *Aceraceæ.*
    - Calyx but little imbricate, in a complete whorl.
      - Carpels 4 or more.
        - Seeds winged . . . *Cedrelaceæ.*
        - Seeds wingless.
          - Stamens united into a long tube . . . *Meliaceæ.*
          - Stamens distinct, or nearly so.
            - Leaves dotted.
              - Seeds amygdaloid . *Aurantieæ of Rutaceæ.*
            - Leaves without dots.
              - Seeds erect . . *Celastraceæ.*
      - Carpels less than 4.
        - Petals imbricate.
          - Ovules suspended . . *Cyrillaceæ.*
          - Ovules erect . . . *Celastraceæ.*

B. *Leaves with stipules.*

a. *Carpels distinct, or solitary.*
- Carpels several . . . . *Coriariaceæ.*

b. *Carpels wholly combined, (at least as to their ovaries), with more placentas than one.*
- Placentas parietal . . . . . . *Moringaceæ.*
- Placentas in the axis.
  - Styles distinct to the base.
    - Petals conspicuous, stalked . . *Malpighiaceæ.*
  - Styles more or less combined, fruit gynobasic.
    - Gynobase fleshy . . . . . *Ochnaceæ.*
    - Gynobase dry.
      - Leaves regularly opposite . . *Zygophyllaceæ.*
      - Leaves more or less alternate.
        - Fruit beaked . . . . . *Geraniaceæ.*
        - Fruit not beaked . . . *Oxalidaceæ.*
  - Styles more or less combined, fruit not gynobasic.
    - Calyx much imbricate, in an irregular broken whorl.
      - Flowers not surrounded by an involucre . . . . . . *Sapindaceæ.*
    - Calyx but little imbricate, in a complete whorl.
      - Stamens 3, sepals and petals pentamerous . . . . . . *Hippocrateaceæ.*
      - Stamens more than 3.
        - Calyx glandular.
          - Petals without appendages . *Malpighiaceæ.*
        - Calyx not glandular.
          - Leaves simple.
            - Petals united by their claws into a tube . . . *Stackhousiaceæ.*
          - Leaves compound.
            - Petals distinct . . . *Staphyleaceæ.*
    - Calyx valvate.
      - Stamens opposite to the petals, isomerous.
        - Seeds one in each cell . . . *Rhamnaceæ.*
      - Stamens opposite to the petals if isomerous, anthers versatile, seeds two in each cell . . *Vitaceæ.*
      - Stamens twice as many as the petals . . . . . . *Burseraceæ.*

The following exceptions may be noted to the characters usually distinctive of the Disciflora. Thus we have apetalous species in *Zygophyllaceæ*, *Geraniaceæ*, *Balsaminaceæ*, *Rutaceæ*, *Simarubaceæ*, *Burseraceæ*, *Olacaceæ*, *Celastraceæ*, *Rhamnaceæ*, *Sapindaceæ*, *Anacardiaceæ*, and some others.

Gamopetalous corollas are found in *Humiriaceæ*, *Rutaceæ*, *Balsaminaceæ*, *Meliaceæ*, and *Stackhousiaceæ*.

Again, in *Geraniaceæ*, *Balsaminaceæ*, *Tropæolaceæ*, *Oxalidaceæ*, *Aceraceæ*, *Anacardiaceæ*, *Malpighiaceæ*, *Linaceæ*, &c., the disk is small, or entirely, or partially absent. The ovary is more or less inferior in some *Olacaceæ* and *Rhamnaceæ*; and the placentation is parietal instead of axile in some *Ochnaceæ* and in *Moringaceæ*.

Series 3. Calycifloræ.

Cohort 1. *Rosales.*—Stamens perigynous or epigynous. Gynœcium generally simple or apocarpous, or rarely syncarpous; ovary superior or inferior; placentation usually marginal or axile; styles generally solitary or distinct, or rarely united; seeds albuminous or exalbuminous.

Order 1. CONNARACEÆ, the Connarus Order.—Character. *Trees* or *shrubs.* *Leaves* alternate, without dots, compound, and generally exstipulate. *Flowers* usually perfect, or rarely unisexual. *Calyx* 5-partite, inferior, imbricate or valvate in æstivation. *Petals* 5, inserted on the calyx, imbricate or valvate. *Stamens* 10, usually monadelphous, nearly or quite hypogynous. *Carpels* 1 or more; *ovules* 2, sessile, collateral, ascending, orthotropous. *Fruit* follicular. *Seeds* with or without albumen, arillate or exarillate; *radicle* superior, at the extremity most remote from the hilum.

Distribution and Numbers.—Natives of the tropics and most common in tropical America. *Illustrative Genera:*—Connarus, Omphalobium. There are about 42 species.

Properties and Uses.—Some have oily seeds; others, as certain species of *Omphalobium*, have edible arils. The zebra-wood of the cabinet makers is said by Schomburgk to be furnished by *Omphalobium Lamberti,* a very large Guiana tree. (See *Guettarda.*)

Order 2. LEGUMINOSÆ, the Leguminous Order.—Character. *Herbs, shrubs,* or *trees.* *Leaves* alternate, stipulate, usually compound (*figs.* 275, 377, and 380). *Calyx* (*figs.* 943, *s*, and 944, *c*) monosepalous, inferior, more or less deeply divided into five parts, the odd division being anterior (*fig.* 943, *s*). *Petals* usually 5 (*fig.* 943), or sometimes by abortion 4, 3, 2, 1, or rarely none, inserted into the base of the calyx, equal or unequal, often papilionaceous (*fig.* 944), the odd petal, if any, posterior (*fig.* 943, *ps*). *Stamens* definite (*figs.* 943 and 945), or indefinite, usually perigynous, or rarely hypogynous, distinct or united into 1, 2 (*figs.* 552 and 945), or rarely 3 bundles. *Ovary* superior, usually formed of 1 carpel (*figs.* 603 and 943), although rarely of 2 or 5; 1-celled with 1, 2, or many ovules; *style* and *stigma* simple (*figs.* 603 and 945). *Fruit* usually a legume (*figs.* 668 and 689-691), or sometimes a lomentum (*figs.* 686 and 692), or rarely a drupe. *Seeds* 1 or more, sometimes arillate, attached to the upper or ventral suture (*fig.* 946); *albumen* usually absent; *embryo* (*fig.* 16) straight, or with the radicle folded upon the cotyledons; *cotyledons* leafy or fleshy, and either hypogeal or epigeal.

Diagnosis.—Herbs, shrubs, or trees. Leaves nearly always alternate and stipulate, and usually compound. Flowers regular or irregular. Calyx inferior, 5-partite; odd division anterior. Petals 5, and then unequal or equal; or fewer by abortion, or none, perigynous ; odd one, when present, posterior. Stamens distinct, or united into one or more bundles. Ovary superior, simple, 1-celled ; style simple, proceeding from the ventral suture. Fruit usually a legume, or sometimes a lomentum, and rarely a drupe. Seeds 1 or more, rarely with, or usually without

FIG. 943.

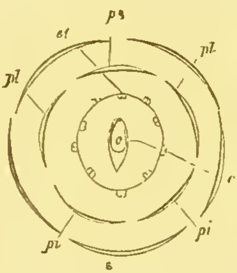


FIG. 944.

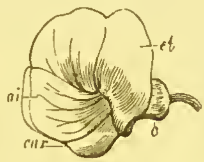
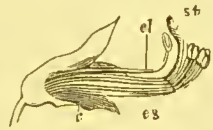


FIG. 945.



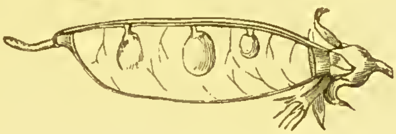


FIG. 946.

Fig. 943. Diagram of the flower of the Garden Pea (*Pisum sativum*). *s.* Anterior sepal. *ps.* Superior petal. *pi, pi.* Inferior petals. *pl, pl.* Lateral petals. *et.* Stamens. *c.* Carpel——*Fig.* 944. The flower of the same. *et.* Standard or vexillum. *ai.* Wings or alæ. *car.* Carina or keel enclosing the essential organs. *c.* Calyx.——*Fig.* 945. The essential organs of the same surrounded by the calyx *c. es.* Bundle of nine stamens. *el.* Solitary stamen. *st.* Style and stigma.——*Fig.* 946. Legume of the same, with one valve removed.

albumen. *This order may be generally distinguished by having papilionaceous corollas or leguminous fruit.*

Division of the Order and Illustrative Genera.—The order has been divided into three sub-orders as follows :—

Sub-order 1. PAPILIONACEÆ.—Petals arranged so as to form a papilionaceous corolla (*fig.* 944), imbricate in æstivation, and the upper or odd petal exterior to the lateral petals. *Illustrative Genera:*—Ulex, *Linn.* ; Trifolium, *Linn.* ; Vicia, *Linn.*; Ornithopus, *Linn.*

Sub-order 2. CÆSALPINIEÆ.—Petals not arranged in a papilionaceous manner, imbricate in æstivation, and the upper or odd petal with its margins inside the lateral petals. *Illustrative Genera :*—Cæsalpinia, *Linn.* ; Cassia, *Linn.* There are no British plants in this sub-order.

Sub-order 3. MIMOSEÆ.—Petals equal, valvate in æstivation. Pollen compound. *Illustrative Genera :* — Mimosa, *Linn.* ; Acacia, *Willd.* There are no British plants in this sub-order.

Distribution and Numbers.—This is a very extensive order, and has some representatives in almost every part of the world. A considerable number of the genera are, however, confined within certain geographical limits, while others have a very wide range. As a general rule the *Papilionaceæ* are universally distributed, although most abundant in warm regions ; while the

Cæsalpinieæ and *Mimoseæ* are most common in the tropics; but many of the latter are also to be found in Australia. There are about 7,000 species in this order.

Properties and Uses.—The properties and uses of the plants of this order are exceedingly variable. Lindley remarks, that 'the Leguminous Order is not only among the most extensive that are known, but also one of the most important to man, whether we consider the beauty of the numerous species, which are amongst the gayest-coloured and most graceful plants of every region; or their applicability to a thousand useful purposes. The Cercis, which renders the gardens of Turkey resplendent with its myriads of purple flowers; the Acacia, not less valued for its airy foliage and elegant blossoms, than for its hard and durable wood; the Braziletto, Logwood, and Rosewoods of commerce; the Laburnum, the classical Cytisus; the Furze and the Broom, both the pride of the otherwise dreary heaths of Europe; the Bean, the Pea, the Vetch, the Clover, the Trefoil, the Lucerne, all staple articles of culture by the farmer, are so many Leguminous species. The gums Arabic and Senegal, Kino, Senna, Tragacanth, and various other drugs, not to mention Indigo, the most useful of all dyes, are products of other species; and these may be taken as a general indication of the purposes to which Leguminous plants may be applied. There is this, however, to be borne in mind, in regarding the qualities of the order from a general point of view; viz., that upon the whole it must be considered poisonous, and that those species which are used for food by man or animals are exceptions to the general rule; the deleterious juices of the order not being in such instances sufficiently concentrated to prove injurious, and being, in fact, replaced to a considerable extent by either sugar or starch.' In alluding to the properties and uses of the more important plants of this order, we shall arrange them alphabetically under their respective sub-orders.

Sub-order 1. PAPILIONACEÆ.—In this sub-order we have included a number of plants which yield nutritious food for man or other animals, such as Peas (*Pisum*), Broad-beans (*Faba*), Kidney-beans, Scarlet-runners and Haricots (*Phaseolus*), Lentils (*Lens*), Pigeon-peas (*Cajanus*, &c.). The seeds of the above plants, and many others, are commonly known under the name of pulse, and do not need any detailed description. The tubercular roots of *Dolichos tuberosus* and *D. bulbosus*, *Lathyrus tuberosus*, and other plants, are eaten in the same way as potatoes. Lucerne and Medick (*Medicago*), Melilot (*Melilotus*), Clover (*Trifolium*), Tares and Vetches (*Ervum*, *Vicia*), Saintfoin (*Onobrychis*), and many others which are common fodder plants in different parts of the globe, also belong to this sub-order, and do not require any notice in detail. Some plants, or parts of plants, which it contains, are, however, poisonous, as the roots of the Scarlet-runner (*Phaseolus multiflorus*), the roots of *Phaseolus radiatus*, the seeds of *Lathyrus Aphaca*, the seeds, root, and bark of Laburnums (*Cytisus alpinus* and *C. Laburnum*), the seeds of *Anagyris fœtida*, the seeds of the Calabar Bean (*Physostigma venenosum*), and also the seeds of the Bitter Vetch (*Ervum Ervilia*), the juice of *Coronilla varia*, the leaves of some *Gompholobiums*, the leaves and young branches of *Tephrosia toxicaria*, the bark of the root of *Piscidia Erythrina*, and the parts or products of some other plants.

Abrus precatorius.—The seeds are used as beads for making rosaries, necklaces, &c.—hence their common name of *prayer-beads.* They are also employed in India as a standard of weight by Hindoo jewellers and druggists under the name of *Retti* or *Rati.* Each seed is estimated as equal to $2\frac{3}{16}$ grains. They are of a scarlet colour, with a black mark on one side, and are poisonous when introduced in wounds or under the skin of animals, but innocuous when eaten. Under the name of *Jequirity seeds,* they have been used by the ophthalmic surgeon for the cure of granular lids. The roots resemble those of the Liquorice plant, and are used as a substitute for them; hence the names of *Wild Liquorice* and *Indian Liquorice,* by which this plant is known. This root is official in the Pharmacopœia of India.

Æschynomene.—The stems of *Æschynomene aspera* furnish the *Sola* or *Shola* of India. These stems are remarkably light and spongy, and are therefore used for making floats and buoys for fishermen, for the manufacture of very light hats, and for other purposes where elasticity and lightness are necessary. A fibre called Duchai Hemp is obtained from *Æschynomene cannabina.*

Alhagi Maurorum, Camel's Thorn.—This plant and other species related to it, natives of Persia and Afghanistan, secrete a kind of manna. This substance is obtained by simply shaking the branches. It is highly esteemed by the Afghans as a food for cattle. In some parts of the East it is also used as food for man, and as a laxative. It has been supposed to be the manna upon which the Israelites were fed in the wilderness, but such an idea is undoubtedly incorrect. (See *Lecanora*).

Andira.—The bark of *Andira inermis,* known as Cabbage Bark or Worm Bark, was formerly much used as an anthelmintic. It possesses cathartic, emetic, and narcotic properties. In large doses it is poisonous.—*Andira anthelmintica* also possesses vermifuge properties. The powder known as *Araroba,* and which has been largely used of late years in many skin diseases under the name of *Goa Powder,* is also derived from a species of *Andira,* which has been named *A. Araroba.* It is official in the British Pharmacopœia under the name of 'Chrysarobin.'—*A. retusa* also yields a bark with similar properties to that of *A. inermis*; it is known under the name of Surinam Bark.

Arachis hypogæa.—This plant is remarkable for ripening its legumes under the surface of the ground, hence it is commonly known as the *Ground Nut.* The seeds are used as food in various parts of the world, and are occasionally roasted and served up, in the same manner as Chestnuts, as an article of dessert in this country. In the United States the roasted seeds are employed as a substitute for coffee, in the preparation of a kind of chocolate, and for other purposes. Tuson has recommended ground-nut cake for the feeding of cattle. It is sometimes used for adulterating the more expensive feeding cakes in this country and elsewhere. The seeds yield by expression a fixed oil which is official in the Pharmacopœia of India; it is employed very extensively in India for cooking, &c., where it is called *Katchung oil.* The oil is also occasionally imported, or it is obtained here by expression from the seeds. It is known commonly as *ground-nut* or *earth-nut oil.* It is a very liquid oil, and is accordingly employed for watches and other delicate machinery; also for burning and other purposes. It forms a good and cheap substitute for olive oil.

Astragalus.—*A. gummifer* and some other species of *Astragalus* furnish the official Tragacanth of the British Pharmacopœia, or, as it is commonly termed—*gum dragon.* It is used by manufacturers for stiffening crape, &c.; and in medicine for its demulcent and emollient properties, and as a vehicle for the exhibition of more active substances. Tragacanth exudes naturally, or more especially from wounds made in the stems of the above plants. The gum known as *Sarcocolla,* which is imported into Bombay from the Persian port of Bushire, is also considered by Dymock to be derived from a species of *Astragalus*, or from one nearly allied to that genus. The seeds of *A. bæticus* are used as a substitute for coffee in some parts of Germany.

Baptisia tinctoria.—This plant is the Wild Indigo of the United States. Its receives its common name from yielding a blue dye resembling indigo, although it is of far inferior quality to that substance. The roots and other parts are reputed to be emetic and purgative. The eclectic remedy known as *baptisin* is obtained from this plant.

Bowdichia virgilioides.—The bark of this plant, with that of one or more species of *Byrsonima* (Malpighiaceæ), is said to form the American Alcornoco or Alcornoque Bark of commerce. (See *Byrsonima.*) It is used by the tanners.—*B. major*, Mart.—The root bark of this plant, which is a native of Brazil, is in great repute in rheumatism, syphilis, &c., but more especially in psoriasis and other skin diseases. A kind of gum resembling Senegal gum in appearance also exudes from the stem, and is useful in diarrhœa.

Butea.—*B. frondosa*, a native of India, yields an astringent substance called *Butea gum* or *Bengal Kino*, which resembles the official Kino in its properties. (See *Pterocarpus.*) It is official in the Pharmacopœia of India; it is used in diarrhœa and similar diseases, and also for tanning, &c.—*B. superba* and *B. parviflora* also yield a similar astringent substance. The dried flowers of *B. frondosa*, and those of *B. superba*, are known under the names of Tisso and Kessaree flowers. They are extensively used in India in the production of beautiful yellow and orange dyes, and have been imported into this country. The fibres of the inner bark of *B. frondosa* are known under the name of *Pulas cordage.* The seeds of the same plant are also highly esteemed as a vermifuge in India; and from these seeds the oil known in India as *moodooga oil*, which is also regarded as an anthelmintic, is obtained. The substance known as *stick-lac* is also derived from this tree. It is produced on the young twigs by the puncture of a species of *Coccus.* Stick-lac is used in the preparation of sealing-wax, and in dyeing, &c.

Castanospermum australe.—The seeds when roasted are said to resemble in flavour the chestnut, but they are very inferior to it. The plant is a native of Moreton Bay, in Queensland, hence the seeds are called Moreton Bay Chestnuts.

Cicer arietinum, Chick Pea; Bengal Gram.—The seeds are very largely used in India as food for cattle, &c. An acid liquid exudes from the hairs of the stem, and other parts; it is employed as a refrigerant by the natives of India.

Clitoria ternatea.—The seeds of this Indian climber have been used with success as a purgative.

Colutea arborescens, Bladder-senna.—The leaflets have been employed on the Continent to adulterate Alexandrian Senna. They are at once distinguished from Senna leaflets by their regularity at the base.

Coronilla Emerus has cathartic leaves. They have been used to adulterate Senna on the Continent. They form the *Séné Sauvage*, or Wild Senna, of France.

Crotolaria juncea is an Indian plant which furnishes a coarse fibre called *Sunn, Sun, Shunum, Taag, Bengal Hemp*, &c. In Bombay and Madras this fibre is used as well as jute for making gunny bags. (See *Corchorus capsularis.*) Sunn is sometimes confounded with *Sunnee*, a fibre obtained from *Hibiscus cannabinus.* (See *Hibiscus cannabinus.*)—*Crotalaria tenuifolia*, another Indian plant, now sometimes regarded as only a variety of *C. juncea*, is the source from whence *Jubbulpore Hemp* is derived.

Cyclopia.—The leaves of some species of this genus are used as substitutes for China Tea at the Cape of Good Hope under the names of *Honig-thee*, *Cape Tea*, and *Bush Tea.* According to Henry C. Greenish and others, these species are probably *C. longifolia, C. galeoides, C. genistoides*, and *C. brachypoda.*

Cytisus scoparius (*Sarothamnus scoparius*) is the Common Broom. The seeds and tops in small doses are diuretic and laxative, and in large doses purgative and emetic; the fresh and dried tops are official in the British Pharmacopœia.—*Cytisus junceus*, the Spanish Broom, has similar properties. The fibre has also been used from an early period in many parts of Southern Europe for the manufacture of a coarse kind of cloth for home use; it has been lately much employed in Italy, and a patent has been taken out for preparing the fibre.

Dalbergia.—Several species of this genus are good timber trees. The most valuable of them all is *D. Sissoo.* In India its wood is called Sissoo and Sissum. East Indian Rosewood, or Black Wood, is obtained from *D. latifolia.* According to Dr. Allemão, of Brazil, the best Rosewood of commerce is derived from *D. nigra*, a native of Brazil; and other qualities from species of *Machærium.* (See *Triptolomæa.*)

Dipteryx.—The seeds of *D. odorata*, a native of Guiana, have a very powerful and agreeable odour, which is due to the presence of *coumarin.* They are used for scenting snuff and in perfumery, and are commonly known under the name of Tonquin or Tonka Beans. Coumarin is also present in other plants of this sub-order, as in the seeds and flowers of *Melilotus officinalis* and *M. cærulea.* Fragrant seeds are also obtained from *D. eboënsis.* They are the Eboe nuts of the Mosquito Coast; they yield a fatty oil.

Flemingia.—The glands of the young legumes of *F. rhodocarpa*, Baker, a native of Arabia and East Tropical Africa, form the dye known at Aden under the names of *Warus* or *Wurrus.* This, which is in the form of a powder, has long been known and used as a dye for silk, for which purpose it is commonly mixed with alum, carbonate of soda, &c., when it produces a deep, durable, beautiful orange or flame colour. In its medicinal activity it is said to resemble Kamala (see *Mallotus*), with which it was formerly confounded.

Genista tinctoria, the Dyer's Broom, yields a good yellow dye, or when mixed with Woad (*Isatis tinctoria*), a green. (See *Isatis.*)

Geoffroya vermifuga, *G. spinulosa*, and other species, possess barks which have similar properties to those from the species of *Andira.* (See *Andira.*)

Glycyrrhiza.—The fresh and dried roots and underground stems of *G. glabra*, the common Liquorice plant, are official in the British Pharmacopœia; these, as well as those of other species or varieties, particularly *G. glabra* var. *glandulifera* and *G. echinata*, possess a remarkably sweet taste, which is especially due to the presence of a peculiar glucoside to which the name of *glycyrrhizin* or *glycion* has been given. Extract of liquorice root is imported in very large quantities into this country under the name of *liquorice juice*, or *Spanish*, or *Italian juice*, from the countries whence it is obtained. The Spanish juice is prepared from *G. glabra*; the Italian from *G. echinata.* The root and extract of liquorice are employed in medicine as flavouring substances, and for their demulcent and emollient properties. Various preparations of liquorice are commonly kept in the shops, and sold under the names of *Pipe liquorice, Pontefract lozenges, Spanish juice, Solazzi juice*, &c.

Indigofera tinctoria, *I. cærulea*, and some other species, when subjected to a peculiar process, yield commercial indigo, one of the most important of dyeing materials. Sulphate of Indigo has been introduced into the Appendix of the British Pharmacopœia as a test agent. Indigo is very poisonous, although in proper doses it has been employed in epilepsy and amenorrhœa, but its value in such diseases rests on no very trustworthy evidence.

Lens esculenta.—The seeds are commonly known under the name of *Lentils*, which have been esteemed from the earliest periods on account of their value as an article of food.

Machærium.—*M. firmum*, *M. legale*, and probably other species, are said to be the source of the inferior kinds of Rosewood. (See *Dalbergia* and *Triptolomæa.*)

Melilotus officinalis.—The flowers and seeds of this and other species possess a peculiar fragrance, which is due to the presence of *coumarin.* They are used to give flavour to the 'Schabzieger,' a hard cheese used for grating.

Mucuna.—The hairs covering the legumes of *M. pruriens*, a native of the East and West Indies, are sometimes used as a mechanical anthelmintic, under the name of *Cowhage* or *Cow-itch.* An infusion of the root of *M. pruriens* has also been employed in India as a remedy for cholera. The young legumes are also cooked and eaten.—*M. urens* and *M. altissima* furnish a black dye.

Myroxylon or *Myrospermum.*—Two balsams which are obtained from plants of this genus are official in the British Pharmacopœia, namely, Balsam of Tolu and Balsam of Peru. Balsam of Tolu is obtained from the stem of *Myroxylon Toluifera* (*Toluifera Balsamum*), by incision. It possesses mild stimulant and expectorant properties, and is used in chronic bronchial affections. It is also employed in perfumery, and as an ingredient in fumigating pastilles. Balsam of Peru is obtained from *M. Pereiræ* (*Toluifera Balsamum*, var.), a native of the Balsam Coast of the State of San Salvador, in Central America. It is a viscid liquid balsam, which exudes from the tree after the bark has been first beaten and charred by the application of lighted torches or bundles of burning wood, and subsequently removed. Balsam of Peru has similar properties to Balsam of Tolu, but it is far less frequently employed. Balsam of Peru is sometimes known in commerce under the names of Sonsonate or St. Salvador Black Balsam. Two other medicinal products are also derived from *M. Pereiræ*, namely, White Balsam, which is obtained by pressing without heat the interior of the fruit and seeds; and Balsamito, or Essence or Tincture of Virgin Balsam, which is made by digesting the fruit (deprived of its winged appendages) in rum. A peculiar crystalline substance has been obtained by Stenhouse from White Balsam, to which he has given the name of *Myroxocarpin.*—*M. peruiferum*, a native of Ecuador, Peru, and Brazil, and which was long erroneously regarded as the botanical source of Balsam of Peru, yields a fragrant balsam not unlike Balsam of Tolu, called at Rio 'Olea vermelho.'

Orobus tuberosus.—The roots are occasionally eaten in the Highlands of Scotland, and in Holland.

Physostigma venenosum, Calabar Bean.—The seeds of this plant have been known for some years under the name of the Ordeal Beans of Old Calabar, from their use in that country for trial by ordeal. They are very poisonous, acting as a powerful sedative of the spinal nervous system. Calabar Beans and their active alkaloid, *Physostigmine* or *Eserine*, are official in the British Pharmacopœia, and in the form of an extract, or some other suitable preparation, have been extensively employed as a local application to the eye to cause contraction of the pupil. The seeds, &c., have also been administered internally in tetanus, chorea, and some other nervous affections; and also in the treatment of strychnia poisoning. The seeds, described by Holmes as the produce of another species named *P. cylindrosum*, do not probably differ in any very important characters from those of *P. venenosum*, and the two plants do not appear to be specifically distinct; but they require further examination.

Pongamia glabra.—The seeds yield an oil by expression which is a favourite application in India in rheumatism and in several skin affections.

Psoralea glandulosa.—The leaves are used in Chili as a substitute for Paraguay tea.

Pterocarpus.—*P. Marsupium* is the source of the kind of Kino which is official in the British Pharmacopœia. This is known under the names of East Indian, Amboyna, or Malabar Kino, or commonly as Gum Kino. It is a valuable and powerful astringent.—*P. erinaceus*, a native of West Africa, yields a similar astringent substance called African Kino. East Indian Kino is that commonly met with in this country. Some other species appear to yield similar products.—*Red Sandal* or *Red Sanders Wood*, which is official in the British Pharmacopœia, is obtained from *P. santalinus.* It is used in medicine as a colouring agent, and also by the dyer for the production of red and scarlet dyes. It contains a peculiar colouring matter called *Santalin* or *Santalic acid.*—*P. dalbergioides* is said to yield the Andaman Red Wood. It is a valuable timber tree, and is also useful as a dyeing material. The bark of *P. flavus* is used in China for dyeing yellow.—*P. Draco* is one of the plants from which the Dragon's Blood of commerce is obtained. This is sometimes, but improperly, called Gum Dragon. The true Gum Dragon of the shops is yielded by species of *Astragalus.* (See *Astragalus.*)—*P. angolensis* is said to supply the wood exported from Gaboon which is the 'Santal rouge d'Afrique' of the French, or Barwood of English commerce. (See *Baphia.*)

Robinia Pseud-acacia is the North American Locust-tree. It is frequently cultivated in Britain on account of its flowers and its hard and durable wood.

Soja hispida.—The seeds are largely used in China, Japan, India, &c., in the preparation of the sauce called by the Japanese *Sooja*, and by us known as *Soy.* The seeds are also consumed in immense quantities by the Japanese as a vegetable.

Sophora japonica.—The dried flower-buds are extensively used in China for dyeing yellow. They are known under the name of *Wai-fa.*

Tephrosia apollinea and *T. toxicaria* are used in Africa for the preparation of a blue dye resembling indigo. Several species of *Tephrosia*, particularly *T. toxicaria*, are employed as fish poisons. They stupefy the fish, which are then readily taken by the hand. It has been thought by some that *T. toxicaria* would act on the human system like Digitalis, and hence might be used as a substitute for it in those parts of the world where that plant is not a native. The leaflets of *T. apollinea* have been employed in Egypt to adulterate Alexandrian Senna. They may be readily distinguished from Senna leaflets by their silky or silvery appearance, and by being equal-sided at the base.

Trigonella Fœnum-græcum.—The powdered seeds of this plant are used in veterinary medicine under the name of *Fenugreek.* They are also employed as an ingredient of curry powder; and for flavouring, &c. the so-called concentrated cattle foods. In India they are largely used by the natives both as food and medicine; whilst the fresh plant is consumed as a vegetable.

Triptolomæa.—The true Rosewood of cabinet-makers, which is imported from Brazil, has been generally regarded as the produce of one or more species of this genus, but this is now said to be derived from a species of *Dalbergia*, &c. (See *Dalbergia.*)

Voandzea.—The seeds of this plant resemble those of the *Arachis hypogæa* in being edible. They are boiled and eaten as peas. Their native name in Surinam is *Gobbe.*

Sub-order 2. Cæsalpinieæ.—The plants of this sub-order are principally remarkable for their purgative properties. Many important dye-woods and several tanning substances are also obtained from plants belonging to it. The fruits of some again are edible, and none possess any evident poisonous properties.

Baphia nitida, a native of Sierra Leone and other parts of Africa, is said by some to furnish the dye-wood known under the name of Barwood or Camwood. This wood produces a brilliant red colour. (See *Pterocarpus angolensis.*)

Bauhinia.—*B. Vahlii*, *B. racemosa*, and *B. parviflora* furnish fibres which are used in making ropes.—*B. retusa* produces a kind of gum.—*B. variegata* has an astringent bark, which is used in medicine, and for tanning and dyeing leather. The buds and dried flowers of *B. tomentosa* are also astringent, and are employed in dysentery, &c. Other species of *Bauhinia* are used in Brazil for their mucilaginous properties.

Cæsalpinia.—The twisted legumes of *C. coriaria* are powerfully astringent; they are extensively used in tanning under the name of *Divi-divi* or *Libi-dibi*. The legumes of *C. Papai* are employed for a similar purpose, but they are very inferior to them; they are called *Pi-pi*. The powdered legumes of *C. coriaria* have been used with some success in India as an astringent and antiperiodic.—*C. Sappan* furnishes the Sappan, Bookum, or Bukkum-wood of India. It is used for dyeing red. The roots of the same tree, under the names of Yellow-wood and Sappan-root, are sometimes imported from Singapore, and employed for dyeing yellow. Sappan wood is also a useful astringent, somewhat resembling Logwood in its effects.—*C. echinata* furnishes Nicaragua, Lima, or Peach-wood, which is very extensively used in dyeing red and peach-colours.—*C. crista* is the plant from which Brazil-wood is obtained. It is employed for dyeing yellow, rose-colour, and red.—*C. brasiliensis* furnishes another dyewood, called Braziletto-wood, which produces fine red and orange colours. The exact species furnishing the above three dyewoods cannot, however, be said to have been altogether ascertained.

Cassia.—The species of this genus are frequently characterised by purgative properties. The leaflets of several species furnish the different varieties of Senna. The kind, known commonly as *Alexandrian Senna*, is obtained from *C. acutifolia* of Delile. This variety is that which is generally most esteemed in this country; but it was formerly much adulterated with the leaves, fruits, &c., of other plants. The *Common East Indian*, *Arabian*, *Mocha*, or *Bombay Senna* is derived from *C. angustifolia*, Vahl. *Tinnivelly Senna* is furnished by the same plant cultivated in Southern India. The above three varieties are those generally used in England; but the Alexandrian and Tinnivelly kinds are alone official in the British Pharmacopœia. The Italian and Jamaica kinds of Senna are both derived from *C. obovata*. *American Senna*, which was formerly official in the United States Pharmacopœia, is obtained from *C. marilandica*.—*Cassia Fistula*.—The fruit, which is divided into a number of cells by spurious dissepiments, contains a blackish-brown viscid pulp with a sweetish taste, which possesses laxative and purgative properties. This pulp is official in the British Pharmacopœia. The root is also said to be purgative.—*C. brasiliana* (*C. grandis*) has a larger, longer, and rougher fruit, which also possesses purgative properties. It is commonly used in veterinary medicine, and is known as Horse Cassia. The fruit of *C. moschata* is the *Small American Cassia* of the French pharmaciens. It is occasionally imported. The pulp has similar properties to the two former, but is more astringent. The bark of *C. auriculata* is said by Roxburgh to be employed for tanning and dyeing leather. It has also been used instead of oak bark in the preparation of astringent gargles, &c. The seeds are also regarded as a valuable local application in certain forms of ophthalmia. The flowers are also used for dyeing yellow. The powdered seeds of *C. absus*, under the name of *Chichm*, are used in Egypt as a remedy in ophthalmia. They are also employed for a similar purpose in India. The leaves of *C. alata* are held in great esteem in the East Indies and elsewhere as a local application in skin diseases; and the leaves of *C. Sophora*, *C. occidentalis*, and *C. Tora* are said to possess similar properties.

Ceratonia Siliqua.—The ripe fruit is known under the names of Carob, Locust, and St. John's Bread. Its pulp has a very sweet taste, and is supposed to have been the food of St. John in the wilderness. The Carob Bean contains about 63 per cent. of sugar when in a dried state, and upwards of 20 per cent. of other respiratory and fat-producing principles, and about 1 per cent. of oil. Hence it is especially adapted for fattening purposes, and is now largely imported into this country as a food for cattle. It is said that the small seeds of this plant formed the original carat weight of jewellers.

Codarium (*Dialium*) *acutifolium* and *C. obtusifolium* yield fruits which are known under the names of Brown and Velvet Tamarinds. They are both natives of Sierra Leone. The pulp of both species is eaten, and has an agreeable taste.

Copaifera.—Several species of this genus, as *C. Langsdorfii*, *C. officinalis*, *C. guianensis*, *C. coriacea*, &c., yield the oleo-resin commonly known under the name of Balsam of Copaiba; but it is improperly so called, as it contains neither benzoic nor cinnamic acids, the presence of at least one of which substances is necessary to constitute a true balsam. Copaiba is obtained by boring or cutting deeply into the trunks of these trees. Copaiba is said in the British Pharmacopœia to be derived from *C. Langsdorfii* and other species of *Copaifera.*—*C. pubiflora*, and probably *C. bracteata* also, furnish the Purple Heart or Purple Wood of Guiana, which is largely employed for making musket-ramrods, &c.—*C. Guibourtiana* or *Guibourtia copallifera*, is the principal, if not the sole, source of the copal resin of Sierra Leone. Dr. Welwitsch has, however, expressed his belief that all West African copal, and probably all gum resin exported under this name from Tropical Africa, may be looked upon as a fossil resin, produced in times past by trees which at present are either entirely extinct, or exist only in a dwarfed posterity. (See *Hymenæa* and *Trachylobium.*)

Dialium indicum yields a fruit called the Tamarind Plum, the pulp of which has an agreeable, slightly acidulous taste, somewhat resembling that of the common Tamarind. (See *Codarium.*)

Guilandina Bonducella, the Nicker Tree.—The seeds are very bitter, and possess tonic and antiperiodic properties. They are official in the Pharmacopœia of India, and have been employed with success in intermittent fevers, &c. The seeds are also used for necklaces, rosaries, &c. The bark of the root likewise possesses bitter and tonic properties.

Hæmatoxylon campechianum.—The heart-wood is employed in dyeing, and as an astringent and tonic in medicine. It is commonly known under the name of Logwood; and is official in the British Pharmacopœia. It contains a crystalline colouring principle called *hæmatoxylin*, to which its properties are essentially due.

Hymenæa.—*H. Courbaril*, the West Indian Locust-tree, is supposed to furnish Gum Animé or East Indian Copal, but upon no reliable authority. Some of the East Indian Copal is, however, probably obtained from *H. verrucosa.* Mexican Copal is also supposed to be derived from a species of *Hymenæa.* (See *Copaifera* and *Trachylobium.*) The inner bark of *H. Courbaril* is reputed to possess anthelmintic properties. The seeds of the same plant are imbedded in a mealy substance, which is sweet and pleasant to the taste; and from the liquor obtained by boiling them and the pulp in water, and subsequently allowed to undergo fermentation, an intoxicating beverage is procured. This tree grows to a large size, and its timber, under the name of Locust-wood, is used by ship-carpenters.

Mora excelsa.—This plant, which is a large tree, a native of Guiana, furnishes the Mora Wood employed largely for ship-building. The bark is astringent, and useful for tanning.

Parkinsonia aculeata.—Useful fibres are obtained from the stems of this plant. (For Jamaica Dogwood see Corrections & Additions, p. xii)

Poinciana pulcherrima.—The roots are said to be tonic, and the leaves to have purgative properties.

Swartzia tomentosa, the Bully-tree, a native of Guiana, yields a hard and durable wood, called Beefwood.

Tamarindus indica.—The fruit is the well-known Tamarind. It contains an agreeable, acidulous, sweet, reddish-brown pulp, which, when preserved in sugar, or in its pure state, is employed medicinally in the preparation of cooling laxative drinks, and in other ways. The preserved pulp is official in the British Pharmacopœia.

Trachylobium.—Sir John Kirk has shown that *T. mossambicense* is the botanical source of the kind of Zanzibar Copal known as 'Sandarusi-m'ti,' Tree Copal. He also believes that the Copal known in the English market as 'Animé,' the most valuable of all, and which 'is now dug' from the soil, is the produce of extinct forests, but probably derived originally from the same species of *Trachylobium.* Sir Joseph Hooker exhibited specimens of Fossil Copal at a meeting some years since of the Linnean Society, from *T. Hornemannianum.* This and other kinds of Copal are used in the preparation of varnishes. Brazilian Copal is said by some to be derived from *T. Martianum* and several species of *Hymenæa*, but on no reliable authority. The origin of the kind of Copal known as Angola Copal is at present undetermined. It has been referred to *T. Martianum*, but this tree has never been found in Africa. (See *Hymenæa* and *Copaifera.*)

Sub-order 3. MIMOSEÆ.—The plants of this sub-order are chiefly remarkable for yielding gum and astringent substances. Some few are reputed to be poisonous, as *Acacia varians*, the root of a Brazilian species of *Mimosa*, the leaves and branches of *Prosopis utiliflora*, the bark of *Erythrophlœum guineense*, &c.

Acacia.—Various species of this genus yield gum, to which the common name of Gum Arabic is applied; but this is a misnomer, as very little gum is collected in, and none is exported from, Arabia. It is official in the British Pharmacopœia under the name of Gum Acacia, and is said to be obtained from *Acacia Senegal* (*A. Verek*), and other species of *Acacia.* The more important varieties now known in the London market are as follows: Kordofan, Picked Turkey, or White Sennaar Gum, which is derived from *A. Senegal* (*Verek*); Senegal Gum, also from *A. Senegal*; Suakin Gum, Talca, or Talha Gum, from *A. stenocarpa* and *A. Seyal*, Delile, var. *Fistula*; Morocco, Mogadore, or Brown Barbary Gum, from *A. arabica*, Willd.; Cape Gum, principally from *A. horrida* (*A. capensis*); East India Gum, from *A. arabica*, and other species; and Australian or Wattle Gum, from various species, as *A. pycnantha*, *A. decurrens*, *A. dealbata*, and *A. homalophylla*; but the botanical sources of some of these commercial varieties cannot as yet be said to have been definitely determined. The extract prepared from the duramen or inner wood of *Acacia Catechu* furnishes a kind of Catechu or Cutch, which is commonly known as Black Catechu; it is a powerfully astringent substance, containing much tannic acid, and largely employed in the processes of tanning and dyeing, and also to some extent in medicine. (See *Uncaria Gambier.*) The dried legumes of *A. nilotica* are imported under the names of *Neb-neb*, *Nib-nib*, or *Bablah*, and are also used by tanners on account of their astringent properties. The bark of *A. arabica* possesses similar properties, and is used extensively in India under the name of *Babul Bark* as a substitute for oak bark. The barks of several other species which are natives of the East Indies possess similar astringent properties. The extract of the bark of *A. melanoxylon*, an Australian species, is also a valuable tanning substance, and is frequently imported on that account into this country. The bark is also sometimes imported under the name of Acacia Bark.—*A. formosa*, a native of Cuba, furnishes a very hard, tough, and durable wood, of a dull red colour, called *Sabicu.* This is the wood that was used in constructing the stairs of the Crystal Palace in Hyde Park, at the Great Exhibition in 1851, and which upon removal was found to be but little worn. The flowers of *A. Farnesiana* are very fragrant, and when distilled with water or spirit yield a delicious perfume. This plant also yields a valuable gum.—*A. Seyal* is supposed to be the Shittah-tree or Shittim-wood of the Bible. By others, however, the plant yielding this wood has been thought to be *A. vera*, and by some *A. horrida* The first is probably correct.

Adenanthera pavonina, a native of India, &c., produces a dye-wood, called Red Sandal-wood. This must not be confounded with the official Red Sandal-wood already alluded to as being derived from *Pterocarpus santalinus*. The seeds, under the name of Barricarri seeds, are used in the northern parts of South America for making necklaces, &c. They are perfectly smooth, and have a bright red colour.

Erythrophlœum guineense, the Sassy Tree of Western Africa.—The bark, under the name of 'ordeal bark' or 'doom bark,' is used in certain parts of Africa as an ordeal, to which persons suspected of witchcraft, secret murder, &c., are subjected as a test of their innocence or guilt. It is also used for poisoning arrows. It is also known under the names of *Sassy*, *Casca*, *Cassa*, and *Mancona Bark*. It has been lately recommended as a remedial agent, but the experiments of Dr. Lauder Brunton have been unattended with marked results. In its action it has been said to resemble that of digitalin and picrotoxin combined.

Prosopis.—The legumes of *P. pallida* and some other species are very astringent, and have been employed in tanning under the name of Algarobilla. The legumes of *P. dulcis* and other species or varieties found in South America, &c., have a sweetish taste resembling the Carob Beans (*Ceratonia Siliqua*), and like them are used as food for cattle, under the name of Algorobo; and a drink called Chica is also prepared from them. The name of Chica was at first given to a fermented liquor of the Maize, but is now commonly applied in South America to several fermented drinks. The legumes of *P. pubescens*, under the name of *Mosquit* or *Screw Bean*, are largely used for feeding cattle in Arizona. A gum also exudes from the stems resembling Gum Arabic; it is employed in Texas and Arizona medicinally, and for technical purposes.

Order 3. ROSACEÆ, the Rose Order.—Character.—*Trees, shrubs*, or *herbs*. *Leaves* simple (*fig.* 308) or compound (*fig.* 378), alternate (*fig.* 289), usually stipulate (*figs.* 308 and 378).

FIG. 947.

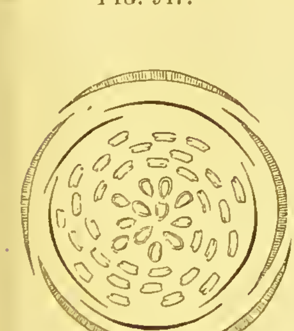


FIG. 948.

Fig. 947. Diagram of the flower of a species of Rose, with five sepals, five petals, numerous stamens, and many distinct carpels.——*Fig.* 948. Vertical section of the flower.

Flowers regular, generally hermaphrodite (*figs.* 947—950), or rarely unisexual. *Thalamus* more or less convex (*fig.* 605), elongated (*fig.* 606, *l*), or concave (*fig.* 948). *Calyx* monosepalous (*figs.* 476, *ct*, and 948), with a disk either lining the tube or surrounding the orifice, 4- or 5-lobed, when 5 the odd lobe posterior (*fig.* 947), sometimes surrounded by a whorl of bracts forming an *involucre* or *epicalyx* (*fig.* 456). *Petals* 5, distinct, (*fig.* 476, *p*, and 947), perigynous; or rarely none (*fig.* 952). *Stamens* definite (*fig.* 952) or numerous, perigynous (*figs.* 948—950); *anthers* (*fig.* 951) 2-celled, dehiscing longitudinally.

Fig. 949.

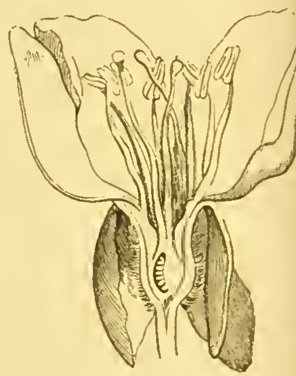


Fig. 950.

Fig. 951.

Fig. 952.

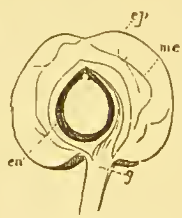


Fig. 953.

Fig. 954.

Fig. 955.

Fig. 949. Vertical section of the flower of the Peach (*Prunus* (*Amygdalus*) *persica*).——*Fig.* 950. Vertical section of the flower of the Quince (*Pyrus Cydonia*).——*Fig.* 951. Two-celled anther with part of the filament of a species of *Rubus*.——*Fig.* 952. Vertical section of the flower of a species of *Alchemilla*.——*Fig.* 953. Vertical section of the fruit (*drupe*) of the Cherry (*Prunus Cerasus*). *ep*. Epicarp. *me*. Mesocarp. *en*. Endocarp, within which is the seed with embryo.——*Fig.* 954. Vertical section of an achænium of a species of Rose.——*Fig.* 955. Vertical section of the ovary, *o*, of a species of *Rubus*, with the ovule, *ov*.

Carpels 1 (*fig.* 952), 2, 5, or numerous (*figs.* 947 and 948), with 1-celled ovaries (*figs.* 952 and 955), usually apocarpous and superior (*figs.* 947 and 948), or sometimes more or less combined together, and even with the tube of the calyx, and thus becoming inferior (*fig.* 950); *styles* basilar (*figs.* 639 and 952), lateral (*fig.*

638), or terminal (*fig.* 949); *ovules* 1 (*fig.* 955) or few (*fig.* 950). *Fruit* various: either a drupe (*figs.* 693—695), an achænium, a follicle, a dry or succulent etærio (*figs.* 661 and 703), a cynarrhodum, or a pome (*figs.* 473 and 722). *Seeds* 1 (*figs.* 953 and 954) or few (*fig.* 473), exalbuminous; *embryo* straight.

Diagnosis.—Trees, shrubs, or herbs, with alternate leaves. Flowers regular. Calyx 4—5-lobed; when 5, the odd lobe posterior. Petals 5, perigynous, or rarely none. Stamens perigynous, distinct; anthers 2-celled. Carpels one or more, usually distinct or sometimes united; generally superior or occasionally more or less inferior. Seeds 1 or few, exalbuminous; embryo straight.

Division of the Order and Illustrative Genera.—The order Rosaceæ, as above defined, may be divided into five sub-orders, which are by some botanists considered as distinct orders. They are characterised as follows:—

Sub-order 1. CHRYSOBALANEÆ.—Trees or shrubs, with simple leaves and free stipules. Carpel solitary, cohering more or less on one side with the tube of the calyx; ovules 2; style basilar. Fruit a drupe. Seed erect; radicle inferior. *Illustrative Genus:*—Chrysobalanus, *Linn.* There are no British plants in this sub-order.

Sub-order 2. DRUPACEÆ.—Trees or shrubs, with simple leaves and free stipules. Calyx deciduous. Carpel solitary, not adherent to the calyx; style terminal. Fruit a drupe. Seed suspended (*fig.* 953). *Illustrative Genus:*—Prunus, *Linn.*

Sub-order 3. ROSEÆ.—Shrubs or herbs, with simple or compound leaves and adherent stipules. Carpels 1 or more, superior, not united to the flower-tube, distinct or sometimes more or less coherent; styles lateral or nearly terminal. Fruit either an etærio, cynarrhodum, or consisting of several follicles. Seed usually suspended (*fig.* 955), or rarely ascending; radicle superior. *Illustrative Genera:*—Rosa, *Linn.*; Rubus, *Linn.*

Sub-order 4. SANGUISORBEÆ or POTERIEÆ.—Herbs or undershrubs. Flowers often unisexual. Petals frequently absent. Carpels 1—3; style terminal or basilar (*fig.* 952). Fruit an achænium enclosed in the flower-tube, which is often indurated. Seed solitary, suspended, erect, or ascending. *Illustrative Genera:*—Alchemilla, *Linn.*; Poterium, *Linn.*

Sub-order 5. POMEÆ.—Trees or shrubs, with simple or compound leaves and free stipules. Carpels 1 to 5, adhering more or less to each other and to the sides of the flower-tube, and thus becoming inferior; styles terminal (*fig.* 950). Fruit a pome, 1—5-celled or rarely spuriously 10-celled (*figs.* 473 and 722). Seeds erect or ascending. *Illustrative Genera:*—Pyrus, *Linn.*; Cratægus, *Linn.*

Distribution and Numbers.—The *Chrysobalaneæ* are principally natives of the tropical parts of America and Africa. The *Drupaceæ* are almost exclusively found in the cold and temperate regions of the northern hemisphere. The *Roseæ* and *Sanguisorbeæ* are also chiefly natives of cold and temperate climates, although a few are found within the tropics. The *Pomeæ* occur only in the cold and temperate regions of the northern hemisphere. The order Rosaceæ comprises about 1,000 species, of which about one-half belong to the sub-order Roseæ.

Properties and Uses.—The plants of the order are principally remarkable for their astringency, and for their succulent edible fruits. The seeds, flowers, leaves, and young shoots of many of the *Drupaceæ* and *Pomeæ*, when moistened with water, yield hydrocyanic acid; hence the parts of such plants are sometimes poisonous. All other Rosaceæ are entirely devoid of poisonous properties.

Sub-order 1. CHRYSOBALANEÆ.—Many plants of this sub-order produce edible drupaceous fruits.

Chrysobalanus.—The fruit of *C. Icaco* is edible. It is known in the West Indies under the name of the Cocoa-plum. The fruit of *C. luteus* is also eaten in Sierra Leone. The root, bark, and leaves of *C. Icaco* are employed in Brazil as a remedy in diarrhœa and similar diseases.

Parinarium.—*P. excelsum* yields an edible fruit which is known in Sierra Leone under the name of the Rough-skinned or Gray Plum. The kernels of *P. campestre* and *P. montanum* are likewise reputed to resemble the Almond in flavour.

Sub-order 2. DRUPACEÆ.—This sub-order is remarkable from the parts of many of its plants yielding, when moistened with water, hydrocyanic acid. Their barks also frequently possess astringent and febrifugal properties, and yield a kind of gum; while many, again, have edible fruits and seeds.

Prunus.—*P. domestica* and its varieties produce the well-known fruits called Plums, Greengages, and Damsons. When dried, plums are termed Prunes or French Plums; the variety *Juliana* being official in the British Pharmacopœia.—*P. spinosa* is the common Sloe or Blackthorn, and *P. insititia* the Bullace.—*P. armeniaca* is the Apricot. The barks of *P. spinosa* and *P. Cocomilia* have febrifugal properties. The leaves of *P. spinosa* are sometimes used for adulterating the black varieties of China tea. A mixture consisting of the leaves of *P. spinosa* and those of *Fragaria collina* or *F. vesca*, in the proportion of one third of the former to two-thirds of the latter, have been used as a substitute for China Tea.—*Prunus Amygdalus* (*Amygdalus communis*) is the Almond-tree, of which two varieties are commonly distinguished, from the varying nature of their seeds, under the names of *P. amygdalus*, var. *dulcis*, and *P. amygdalus*, var. *amara*, both of which are official in the British Pharmacopœia. There are however no definite botanical characters distinguishing the Sweet and Bitter Almond trees; they cannot therefore, in spite of the different qualities of their seeds, be properly separated even as varieties. The seeds of the former, on account of their taste, are known as Sweet Almonds; and those of the latter as Bitter Almonds. The Almond-tree is a native of Morocco, Syria, Persia, and Turkestan; it is also extensively cultivated in the southern parts of Europe for the sake of its seeds. *Sweet Almonds* yield by expression a fixed oil commonly known as Oil of Almonds. They also contain sugar, and two albuminous substances called *amandin* and *synaptase* or *emulsin*. The cake left after the expression of the oil, when dried and powdered, is known under the name of Almond-powder. *Bitter Almonds* yield a similar oil by expression. They also contain *emulsin*, and, in addition to the other ordinary constituents of Sweet Almonds, a crystalline substance called *amygdalin*. When bitter almonds are moistened with water, the emulsin acts as a kind of ferment upon the amygdalin, and the result is the formation of a volatile oil containing hydrocyanic acid, which is known as the *Essential Oil of Bitter Almonds*. The presence of hydrocyanic acid renders this oil very poisonous, but this is not the case when the acid is separated from it. Bitter Almonds and their essential oil are extensively employed for flavouring by the cook and confectioner, and also for scenting soap and for other purposes by the perfumer. The cake left after expressing the oil is frequently used for fattening pigs and for other purposes.—*Prunus* (*Amygdalus*) *persica* is the Peach-tree of our gardens, and a variety of the same species produces the Nectarine. The flowers have been employed as a vermifuge, and the leaves for flavouring, and also as a vermifuge. The kernels may be used for the same purposes as the Bitter Almond. All these parts, as well as the bark, possess poisonous properties owing to the formation of hydrocyanic acid.

The following plants are considered by some botanists to constitute a distinct genus, which is termed *Cerasus*, but the species comprised in it are now far more commonly included under *Prunus*. Several species or varieties produce the fruits called Cherries: thus, *P. virginiana* of Miller is the Wild Black Cherry of the United States; *P. avium*, the Wild Cherry; *P. Padus*, the Bird Cherry; and *P. Virginiana* of Linnæus, the Choke Cherry or Choke-berry. The latter is one of the fruits used commonly for mixing with Pemmican. (See *Amelanchier*.) The leaves, bark, and fruit of the *Prunus Lauro-cerasus*, the Common Laurel or Cherry-laurel, are poisonous. Their poisonous properties are due to the production of a volatile oil containing hydrocyanic acid when they are moistened with water. Cherry-laurel water is anodyne and sedative in its action, and may be employed in all cases where the use of hydrocyanic acid is indicated. It is, however, very liable to vary in strength. It is official in the British Pharmacopœia, and is prepared by the distillation of the fresh leaves with water. The bark of *P. virginiana* of Miller (*Prunus serotina*, Ehrh.) is official in the United States Pharmacopœia, and is much valued as a remedial agent. It is regarded as tonic, calmative of nervous irritability, and as an arterial sedative. The kernels of *P. occidentalis* and other species are used for flavouring liqueurs, as Noyau, Cherry-brandy, Maraschino, &c. A gummy exudation somewhat resembling tragacanth takes place more or less from the stems of the different species of *Prunus*.

Sub-order 3. ROSEÆ.—The Roseæ are chiefly remarkable for their astringent properties. Many yield edible fruits, and some very agreeable perfumes.

Agrimonia Eupatoria has been used as a vermifuge and astringent.

Fragaria elatior, *F. vesca*, and other species or varieties of *Fragaria*, furnish the different kinds of Strawberries.

Geum urbanum and *G. rivale* are reputed to possess aromatic, tonic, and astringent properties.

Gillenia trifoliata and *G. stipulacea*.—The roots of both these species are used in the United States as medicinal agents. In small doses they are tonic, and in larger doses emetic. They are commonly known under the names of Indian Physic and American Ipecacuanha.

Hagenia abyssinica (*Brayera anthelmintica*) is a native of Abyssinia. The flowers and tops, under the name of Cusso or Kousso, have been long employed by the Abyssinians for their anthelmintic properties. They have been also used of late years in this and other countries for a similar purpose, and are said to be effectual in destroying tape-worms. Cusso is official in the British Pharmacopœia.

Potentilla Tormentilla.—The rhizome and rootlets possess astringent and tonic properties. They are used in the Orkney and Feroe Islands to tan leather; and in Lapland in the preparation of a red dye. Some other species possess analogous properties.

Quillaia saponaria.—The bark of this and other species contains a large amount of *saponine.* It is employed in some parts of America as a substitute for soap. It has been much used in this country as a detergent in cases of scurfiness and baldness.

Rosa.—The various species and varieties of this genus are well known for the beauty of their flowers and for their delicious odours. The fruits (which are commonly known under the name of *hips*) of *R. canina*, the Dog-rose, and of other allied species or varieties, are employed in medicine for their refrigerant and astringent properties; they are official in the British Pharmacopœia. The fresh and dried petals of the unexpanded flowers of *R. gallica* constitute the official *Red-rose* petals of the British Pharmacopœia. They are used in medicine as a mild astringent and tonic, and on account of their colour. The petals of *R. centifolia*, the Hundred-leaved or Cabbage-rose, and of some of its varieties and allied species, are remarkable for their fragrance. Rose-water is prepared by distilling the fresh petals with water to which a little spirit of wine has been added. The petals of *R. centifolia* are also employed in medicine as a mild laxative; the fresh, fully-expanded petals are official in the British Pharmacopœia. The volatile oil known in commerce as *Attar* or *Otto of Rose* is now almost exclusively obtained from Roumelia on the southern slopes of the Balkan mountains. It is also largely produced in India, and to some extent in other parts, but the otto of these districts is almost, if not entirely, consumed in the countries whence it is obtained. The species cultivated for this purpose in Roumelia and India is *Rosa damascena.* All commercial Otto of Rose is obtained by distillation, and, according to Heber, it requires 20.000 roses to yield Otto of Rose equal in weight to that of a rupee. In Turkey, 5,000 pounds (German weight) of roses are said to yield by careful distillation one pound of oil. It is exported from Smyrna and Constantinople. Otto of Rose is rarely or ever pure when imported into this country. It is commonly adulterated with spermaceti, and a volatile oil which is derived from *Andropogon pachnodes*, Trin. (*A. schœnanthus*, Linn.). This oil is known under the names of *Oil of Geranium*, *Rusa Oil*, or *Rusa-ka-tel*, and is imported into Turkey from India for the express purpose of adulterating Otto of Rose. (See *Pelargonium.*)

Rubus.—Several species of this genus yield edible fruits: thus, the fruit of *Rubus Idæus* is the Raspberry; that of *R. fruticosus*, the Blackberry; that of *R. cæsius*, the Dewberry; and that of *R. Chamæmorus*, the Cloudberry. The bark of the root of *R. villosus* and *R. canadensis* is much employed as an astringent in some parts of North America, and is official in the United States Pharmacopœia.

Spiræa.—*S. filipendula* and *S. Ulmaria.*—The roots of these plants have tonic properties. *S. Ulmaria* is called Meadow-sweet from the fragrance of its flowers, which is due to the presence of *coumarin.* Seemann says that in Kamtschatka a strong liquor is prepared from the root of *S. Kamtschatka.*

Sub-order 4. SANGUISORBEÆ.—The plants of this sub-order have generally astringent properties like the *Roseæ.*

Acæna Sanguisorba.—The leaves are used in Australia as a substitute for tea.

Alchemilla arvensis, Field Ladies' Mantle or Parsley Piert, is astringent and tonic. It is also reputed to be diuretic, and was formerly thought to be useful in gravel and stone; hence it was called *break-stone.*

Sub-order 5. POMEÆ.—Many plants of this sub-order yield edible fruits, and from their seeds hydrocyanic acid may be frequently obtained.

Amelanchier canadensis.—The fruit is known in Rupert's Land, &c., under the name of Shad-berry or Service-berry. It is used for mixing with Pemmican, an article of Arctic diet. (See *Prunus.*)

Eriobotrya japonica produces a fruit called the Loquat. Some of these fruits in good condition have occasionally been imported into this country from Japan and South America.

Mespilus germanica yields the fruit called the Medlar, of which there are several varieties.

Pyrus.—Some species of this genus produce edible fruits.—*Pyrus Malus* and its varieties produce the different kinds of Apples.—*P. communis* is the Pear-tree, so well known for its fruit. The wood is also sometimes used by wood-engravers instead of Box.—*P. Cydonia* (*Cydonia vulgaris*) is the common Quince.—The fruit is frequently mixed with apples in making pies or tarts, and is much esteemed for the preparation of a kind of marmalade and for other purposes by the confectioner. The seeds contain much mucilage, which is nutritive, emollient, and demulcent.—*P. Aucuparia* is the Mountain Ash or Rowan-tree. Its flowers, root, and bark yield hydrocyanic acid, and therefore possess, in a slight degree, sedative properties.—*P. Aria* is the Beam-tree, the timber of which is used for axle-trees and other purposes.—*P. domestica* is the common Service-tree, and *P. torminalis* the Wild Service-tree.

Order 4. SAXIFRAGACEÆ, the Saxifrage Order.—Character.—*Herbs* with alternate *leaves*, which are entire or lobed (*fig.*

FIG. 956.

FIG. 957.

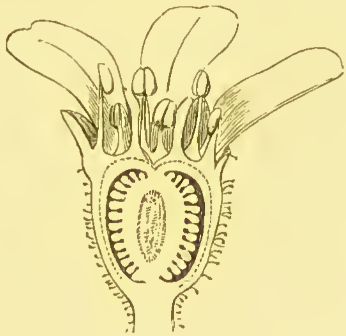


FIG. 958.

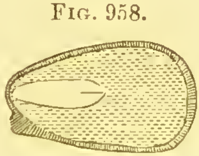


Fig. 956. *Saxifraga tridactylites.* The leaves are trifid and wedge-shaped, and the flowers arranged in a racemose cyme.——*Fig.* 957. Vertical section of the flower.——*Fig.* 958. Vertical section of the seed.

956), stipulate or exstipulate. *Calyx* of 4 or 5 sepals, which are more or less united at the base (*fig.* 625), inferior or more or less superior (*figs.* 625 and 957). *Petals* 4 or 5, perigynous, imbricate, alternate with the lobes of the calyx (*fig.* 957), sometimes wanting. *Stamens* 5—10, perigynous (*fig.* 957) or hypogynous; *anthers* 2-celled, with longitudinal dehiscence. *Disk* usually evident, either existing in the form of 5 scaly processes, or annular and notched, hypogynous or perigynous. *Ovary* superior or more or less inferior (*figs.* 625 and 957), usually composed of two carpels, united below, but more or less distinct towards the apex; 1- or 2-celled; *styles* equal in number to the carpels, distinct, diverging. *Fruit* capsular, 1—2-celled, usually membranous. *Seeds* small, numerous; *embryo* (*fig.* 958) in the axis of fleshy albumen, and with the radicle towards the hilum.

Diagnosis.—Herbs with alternate leaves. Flowers unsymmetrical. Calyx inferior or generally more or less superior, 4—5-partite. Stamens perigynous or hypogynous. Ovary superior or more or less inferior, composed of 2 carpels united at the base, and diverging at the apex; styles distinct, equal in number to the carpels. Fruit capsular, 1—2-celled. Seeds numerous, small, with fleshy albumen.

*Bentham and Hooker include the succeeding orders, Francoaceæ, Escalloniaceæ, Philadelphaceæ, Hydrangeaceæ, Hensloviaceæ, Cunoniaceæ, and Ribesiaceæ, in the order Saxifragaceæ, and arrange the whole in the following sub-orders:—*1. *Saxifrageæ.* 2. *Francoeæ.* 3. *Escallonieæ.* 4. *Philadelpheæ* or *Hydrangeæ.* 5. *Cunonieæ.* 6. *Ribesieæ.*

Distribution and Numbers.—They are exclusively natives of the northern parts of the world, where they chiefly inhabit mountainous districts, and sometimes grow as high as 16,000 feet above the level of the sea. *Illustrative Genera:*—Saxifraga, *Linn.*; Heuchera, *Linn.* There are about 320 species.

Properties and Uses.—The plants of the order are all more or less astringent. This is remarkably the case with the root of *Heuchera americana*, which is much employed for its astringent properties in the United States under the name of *Alum-root.*

Saxifraga.—*S. sibirica* is said to contain a crystalline bitter principle, which has been termed *bergenin*, and is reputed to be a powerful tonic, ranking in its action between salicin and quinine.

Order 5. FRANCOACEÆ, the Francoa Order.—Character.—Stemless *herbs.* *Leaves* exstipulate. *Calyx* 4-partite. *Petals* 4, persistent. *Stamens* hypogynous or nearly so, four times as many as the petals, the alternate ones sterile, and commonly termed scales. *Ovary* superior, 4-celled; *ovules* numerous; *stigma* sessile, 4-lobed. *Fruit* a membranous 4-celled, 4-valved capsule, with loculicidal or septicidal dehiscence. *Seeds* small, indefinite; *embryo* very minute, at the base of a large quantity of fleshy albumen.

Distribution and Numbers.—Natives of Chili. *Illustrative Genera:*—Francoa, *Cavan.*; Tetilla, *DC.* These are the only genera; they include about 6 species.

Properties and Uses.—The *Francoas* are reputed to be cooling and sedative. *Tetilla* is astringent, and is employed as a remedy in dysentery.

Order 6. ESCALLONIACEÆ, the Escallonia Order.—Character.—Evergreen *shrubs*, with alternate exstipulate glandular leaves and axillary showy flowers. *Calyx* superior, 5-toothed, imbricate in æstivation. *Petals* 5, alternate with the divisions of the calyx, perigynous, or rarely hypogynous. *Stamens* 5, alternate with the petals, perigynous, or rarely hypogynous. *Ovary* inferior, 2—5-celled, crowned by a cone-shaped disk ; *placentas* axile ; *style* simple ; *stigmas* 2—5-lobed. *Fruit* capsular or baccate, crowned by the persistent style and calyx. *Seeds* very numerous, minute ; *embryo* small, in a mass of oily albumen.

Distribution and Numbers.—They are chiefly natives of the mountains of South America. *Illustrative Genera* :—Escallonia, *Mutis* ; Itea, *Linn.* ; Brexia, *Thouars.* There are above 66 species.

Properties and Uses.—Unknown.

Brexia.—This genus has been made the type of a distinct order, named Brexiaceæ ; but Bentham and Hooker place it near the genus *Escallonia.*

Order 7. PHILADELPHACEÆ, the Syringa Order.—Character.—*Shrubs. Leaves* opposite, simple, deciduous, exstipulate. *Calyx* superior, persistent, 4—10-lobed, with a valvate æstivation. *Petals* equal in number to the divisions of the calyx, and alternate with them. *Stamens* numerous, epigynous. *Ovary* inferior ; *styles* united or distinct ; *stigmas* several. *Capsule* half-inferior, 4—10-celled, *placentas* axile. *Seeds* numerous, with fleshy albumen.

Distribution and Numbers.—Natives of the South of Europe, North America, Japan, and India. *Illustrative Genera* :—Philadelphus, *Linn.* ; Deutzia, *Thunb.* There are about 25 species.

Properties and Uses.—Of little importance.

Deutzia.—The leaves of some species of *Deutzia*, especially those of *D. scabra*, are covered with beautiful scales ; hence, from their roughness, they are used in Japan for polishing purposes. *D. gracilis*, a greenhouse plant, is extensively grown for our flower markets.

Philadelphus coronarius is commonly cultivated in our shrubberies. It is a native of the South of Europe. It is generally known as the Syringa, or Mock Orange, from its flowers somewhat resembling those of the Orange in appearance and odour. This odour is due to the presence of a volatile oil, which may be readily obtained from them by distillation with water. The leaves have a flavour and odour resembling the Cucumber.

Order 8. HYDRANGEACEÆ, the Hydrangea Order.—*Diagnosis.*—This order is frequently regarded as a sub-order of Saxifragaceæ, with which it agrees in many important particulars ; but it differs in its plants being of a shrubby nature ; in their having opposite leaves, which are always exstipulate ; in their valvate calyx ; in their tendency to a polygamous structure, as exhibited in the possession of radiant staminal flowers ; and in having frequently more than 2 carpels, with a corresponding increase in the number of styles and cells to the ovary.

Distribution and Numbers.—Natives chiefly of the temperate regions of Asia and America. About one-half of the species are natives of China and Japan. *Illustrative Genera:*—Hydrangea, *DC.*; Bauera, *Sm.* There are about 45 species.

Properties and Uses.—Unimportant:

Hydrangea.—The leaves of *Hydrangea Thunbergii* are used in Japan as tea, and this tea is so highly valued by the Japanese that they call it *Ama-tsjâ*, or the Tea of Heaven. The root of *H. arborescens*, under the name of *Leven Bark* or *Wild Hydrangea*, is largely employed in the United States in calculous complaints.

Order 9. HENSLOVIACEÆ, the Henslovia Order.—*Diagnosis.*—This is a small order of tropical plants containing but 1 genus, and 3 or 4 species, which is considered by Lindley to be nearly allied to Hydrangeaceæ; but distinguished by their tree-like habit, their styles being united into a cylinder, and in the total absence of albumen. *Illustrative Genus:*—Henslovia, *Wall.*

Properties and Uses.—Unknown.

Order 10. CUNONIACEÆ, the Cunonia Order.—*Diagnosis.*—Nearly allied to Saxifragaceæ, but differing from them in being trees or shrubs, with opposite or whorled leaves, and large interpetiolar stipules. The latter character will also distinguish them readily from Hydrangeaceæ, which are exstipulate. They are also known from the latter order by their calyx not being valvate.

Distribution and Numbers.—Natives of South America, the Cape, the East Indies, and Australia. *Illustrative Genera:*—Weinmannia, *Linn.*; Cunonia, *Linn.* There are about 100 species.

Properties and Uses.—Astringent. Some have been used for tanning; others exude a gummy secretion.

Order 11. RIBESIACEÆ, the Currant Order.—Character.—*Shrubs* with (*fig.* 384) or without spines or prickles. *Leaves* alternate, simple, lobed, radiate-veined. *Flowers* axillary, racemose, perfect or rarely unisexual. *Calyx* superior, 4—5-lobed. *Petals* 4—5, minute, inserted on the calyx. *Stamens* 4—5, perigynous, alternate with the petals. *Ovary* inferior, 1-celled, with 2 parietal placentas (*fig.* 718, *pl*). *Fruit* a berry (*figs.* 718 and 719). *Seeds* numerous; *embryo* minute, in horny albumen.

Distribution and Numbers.—Natives of the temperate regions of Europe, Asia, and North America. *Illustrative Genera:*—Ribes, *Linn.*; Polyosma, *Br.* These are the only genera; which include about 100 species.

Properties and Uses.—Some are showy garden plants, as *Ribes fuchsioides*, *R. sanguineum*, *R. aureum*, *R. coccineum*; but they are chiefly remarkable for their agreeable acid fruits. Thus, the fruit of *Ribes Grossularia* is the Gooseberry; *R. rubrum* and its varieties yield both Red and White Currants; and *R. nigrum* is the Black Currant.

Order 12. CRASSULACEÆ, the Houseleek Order.—Character.—*Succulent herbs* or *shrubs*. *Leaves* entire or pinnatifid, exstipulate. *Flowers* usually cymose (*fig.* 436), symmetrical (*figs.* 785 and 786). *Calyx* generally composed of 5 sepals, but varying in number from 3—20, more or less united at the base, inferior (*fig.* 785, *c*), persistent. *Petals* equal in number to the divisions of the calyx (*fig.* 785, *p*), with which they are alternate, either distinct or united, and inserted into the bottom of the calyx; *æstivation* imbricate. *Stamens* inserted with the petals (*fig.* 785, *e*), either equal to them in number and alternate with them (*fig.* 785); or twice as many (*fig.* 786), and then forming 2 whorls, one of which is composed of longer stamens than the other, the longer stamens being placed alternate to the petals, and the shorter stamens opposite to them; *anthers* adnate, 2-celled, with longitudinal dehiscence. *Carpels* equal in number to the petals and opposite to them (*fig.* 785, *o*), each having frequently a scale on the outside at the base (*fig.* 785, *a*), distinct or more or less united; *styles* distinct. *Fruit* either consisting of a whorl of follicles, or a capsule with loculicidal dehiscence. *Seeds* very small, variable in number; *embryo* in the axis of fleshy albumen, with the radicle towards the hilum.

Diagnosis.—Succulent herbs or low shrubs. Leaves exstipulate. Flowers perfectly symmetrical, the sepals, petals, and carpels being equal in number, and the stamens being also equal to them, or twice as many. Petals and stamens almost or quite hypogynous. Corolla monopetalous or polypetalous. Carpels opposite the petals. Fruit either apocarpous and follicular, or a many-celled capsule with loculicidal dehiscence. Seeds small; embryo in the axis of fleshy albumen.

Division of the Order and Illustrative Genera:—The order may be divided as follows:—

Sub-order 1. CRASSULEÆ.—Fruit consisting of a whorl of follicles. Crassula, *Haw.*; Sedum, *Linn.*

Sub-order 2. DIAMORPHEÆ.—Fruit a many-celled capsule with loculicidal dehiscence. Diamorpha, *Nutt.*; Penthorum, *Linn.*

Distribution and Numbers.—They are found in very dry situations in all parts of the world; a large number occur at the Cape of Good Hope. There are about 450 species.

Properties and Uses.—Astringent, refrigerant, and acrid properties are found in the plants of this order, but none are of much importance.

Cotyledon.—*C. Umbilicus.*—This plant, which is a common native, more especially in the West of England, has long been in use as a popular remedy in hysteria, and as an external application to destroy corns and warts. It has also been frequently used of late years as a remedy for epilepsy.—*C. orbiculata*, a native of the Cape of Good Hope, is employed in similar cases. *Rhodiola esculenta* is eaten by the Greenlanders.

Sedum.—*S. acre* is the common yellow Biting Stonecrop of our walls, and, as its name implies, is of an acrid nature. It is also reputed to possess emetic and purgative properties.—*Sedum Telephium* is astringent. Lindley says that, in Ireland, the leaves of *Sedum dasyphyllum*, rubbed among oats, are regarded as a certain cure for worms in horses.

Order 13. DROSERACEÆ, the Sundew Order.—Character. Herbaceous plants growing in boggy or marshy places, frequently glandular. *Leaves* alternate, fringed at their margins (*fig.* 375), and with a circinate vernation. *Inflorescence* scorpioid. *Sepals* and *petals* 5, hypogynous, equal, imbricate, persistent. *Stamens* as many as the petals and alternate with them, or twice, thrice, or four times as many, distinct, withering, hypogynous; *anthers* innate or versatile, extrorse. *Ovary* superior, 1-celled, with parietal placentation, superior; *styles* 3—5, distinct or connected at the base; *ovules* numerous, anatropous. *Fruit* capsular, 1-celled, bursting by 3 or 5 valves, which bear the placentas in their middle or at their base; hence the dehiscence is loculicidal. *Seeds* numerous, with or without an aril; *embryo* minute, at the base of abundant fleshy albumen.

Diagnosis.—Bog or marsh herbs, with alternate exstipulate leaves and a circinate vernation. Inflorescence scorpioid. Flowers regular and symmetrical, hypogynous, with a quinary arrangement of their parts, which are also persistent and imbricate. Anthers extrorse. Placentas parietal. Fruit capsular, 1-celled, with loculicidal dehiscence. Seeds numerous; embryo small, at the base of copious fleshy albumen.

Distribution and Numbers.—These plants are found in almost all parts of the world with the exception of the Arctic regions. *Examples of the Genera:*—Drosera, *Linn.*; Dionæa, *Ellis.* There are about 110 species in this order.

Properties and Uses.—They possess slightly acid and acrid properties. *Drosera rotundifolia* and *D. longifolia* appear to have been very early employed as a remedy for consumption, but have now fallen into disuse. Some of the *Droseras* are said to be poisonous to cattle, but there is no satisfactory proof of such being the case. It has been supposed that certain species of *Drosera* would yield valuable dyes, because they communicate a brilliant purple stain to the paper upon which they are dried, and also from the circumstance of their yielding a yellow colour when treated with ammonia. The plants of the order are, however, chiefly interesting from the peculiar irritability of the glands on their leaves. Thus, the Sundews (*Droseras*) are fringed with beautiful stalked glands, which close more or less in different species when insects alight upon them; while the plant known as Venus's Flytrap (*Dionæa muscipula*) (*fig.* 375), a native of North America, has two-lobed leaves, each of which is furnished on its upper surface with three stiff glands, which, when touched, cause the two halves of the leaf to collapse and enclose the object touching them. The glands in these plants secrete a viscid acid digestive fluid, so that insects which alight on them are unable to escape, and become ultimately dissolved and absorbed for their nourishment. The acid present in this fluid is said to be citric.

Order 14. HAMAMELIDACEÆ, the Witch-hazel Order.—Character.—Small *trees* or *shrubs*, with alternate simple *leaves* and deciduous stipules. *Flowers* in globular heads or spicate, perfect or unisexual, polygamous or monœcious. *Calyx* superior, 4- or 5-lobed. *Petals* 4 or 5, with an involute, valvate, or circinate æstivation, or altogether wanting. *Stamens* 8, half of which are scale-like, sterile, and placed opposite to the petals, and half fertile and alternate with them ; or numerous. *Ovary* inferior, 2-celled ; *ovules* solitary or numerous ; *styles* 2. *Fruit* capsular, 2-celled, with 1 seed in each cell ; *seed* albuminous.

Distribution and Numbers.—Natives of North America, Asia, and Africa. *Illustrative Genera*:—Hamamelis, *Linn.*; Liquidambar, *Linn.* There are about 25 species.

Properties and Uses.—Chiefly remarkable for their fragrant balsamic properties. Some have acrid bitter barks ; and the leaves and bark of others are astringent.

Hamamelis virginica, Witch Hazel, yields oily edible seeds. Its bark possesses powerful astringent properties, and has been much used in the United States and in this country for checking excessive mucous discharges and hæmorrhages.

Liquidambar (*Altingia*).—This genus was formerly placed in an order, of which it was the only representative, termed Liquidambaraceæ or Altingiaceæ.—*L. orientalis* is the source of the balsam named *Liquid Storax*, which, when purified, forms the official Prepared Storax of the British Pharmacopœia. (See *Styrax*.) This plant is a native of Asia Minor. The storax is obtained from the inner bark, which is afterwards used by the Turks for the purpose of fumigation. This bark is the *Cortex Thymiamatis* or *Storax Bark* of pharmacologists.—*L. styraciflua*, a native of the United States and Central America, yields by incision, or from natural fissures, a balsamic resin called *Sweet Gum*, *Liquidambar*, or *Copalm Balsam*.—*L. Altingiana*, a native of the Indian Archipelago and Assam, yields a similar fragrant balsam. In their effects and uses, both Liquid Storax and Liquidambar resemble other balsamic substances, as the Balsams of Peru and Tolu, Benzoin, &c.—*L. formosana* of Hance also yields a resin, which is fragrant when heated.

Order 15. BRUNIACEÆ, the Brunia Order.—Character.—Heath-like *shrubs*, with small imbricate, rigid, entire, exstipulate *leaves*. *Calyx* usually superior, or sometimes nearly inferior, imbricate. *Petals* and *stamens* 5, inserted on the calyx, the petals alternate with the divisions of the calyx and valvate ; *anthers* 2-celled, extrorse, bursting longitudinally. *Ovary* superior or half-inferior, 1—3-celled, with 1 or 2 suspended anatropous ovules in each cell ; *style* simple or bifid. *Fruit* crowned by the remains of the calyx and a disk, 1—2-celled, in the first case indehiscent, in the latter dehiscent. *Seeds* with a minute embryo, in fleshy albumen.

Distribution and Numbers.—Natives of the Cape of Good

Hope, except one Madagascar species. *Illustrative Genera*:—Brunia, *Linn.*; Ophiria, *Linn.* There are about 60 species.

Properties and Uses.—Unknown.

Order 16. HALORAGACEÆ, the Mare's-tail Order.—*Diagnosis.*—*Herbs* or *shrubs*, generally aquatic. *Flowers* small (*fig.* 412), frequently incomplete and unisexual. They are nearly allied to Onagraceæ, and, in fact, are merely a degeneration or imperfect form of that order. They are known from it by their minute calyx, the limb of which is frequently obsolete; and by having solitary pendulous seeds, which have fleshy albumen.

Distribution and Numbers.—They are found in all parts of the world. *Illustrative Genera*:—Hippuris, *Linn.*; Trapa, *Linn.* There are about 70 species.

Properties and Uses.—Of little importance except for their edible seeds.

Trapa.—This is a genus of floating aquatic plants, remarkable for their horned fruit and large amygdaloid seeds with unequal cotyledons. The seeds are edible; those of *Trapa natans* are called *Chataigne d'Eau* by the French, and Jesuit's Nuts at Venice. In some parts of Southern Europe they are ground, and made into a kind of bread.—*T. bicornis* is called *ling* by the Chinese, and its seeds are highly esteemed by them.—*T. bispinosa* is the Singhara Nut; its seeds are largely consumed in Cashmere and some other parts of India.

Order 17. CALLITRICHACEÆ, the Starwort Order.—Character.—Small aquatic *herbs*. *Leaves* opposite, entire, simple. *Flowers* minute, axillary, solitary, unisexual, achlamydeous. *Male flower* of 1—2 *stamens*; *anthers* reniform. *Female flower* with a 4-cornered, 4-celled *ovary*, with 1 pendulous ovule in each cell. *Fruit* indehiscent, 4-celled. *Seeds* 4, pendulous, with fleshy albumen; *embryo* inverted, with a very long superior radicle.

Distribution.—Natives of freshwater pools in Europe and North America. *Callitriche* is the only genus; this includes several varieties or species.

Properties and Uses.—Unknown.

Cohort 2. *Myrtales.*—Gynœcium syncarpous, usually with an undivided style; ovary inferior, or included within the calyx-tube; placentation generally axile. Seeds exalbuminous. Leaves nearly always simple.

Order 1. RHIZOPHORACEÆ, the Mangrove Order.—Character.—*Trees* (*fig.* 255) or *shrubs*. *Leaves* simple, opposite, dotless or rarely dotted, with deciduous interpetiolar stipules. *Calyx* superior, 4—12-lobed, with a valvate æstivation, the lobes sometimes united so as to form a calyptra. *Petals* arising from the calyx, alternate with its lobes and equal to them in number. *Stamens* on the calyx, twice or thrice as many as its lobes, or still more numerous. *Ovary* inferior, 2- 3- or 4-celled, each cell with 2 or more ovules. *Fruit* indehiscent, 1-celled, 1-seeded, crowned by the calyx. *Seed* pendulous, exalbuminous, usually germinating while the fruit is still attached to the tree.

Distribution and Numbers.—Natives of muddy sea-shores in tropical regions. *Illustrative Genera*:—Rhizophora, *Lam.*; Bruguiera, *Lam.* There are about 20 species.

Properties and Uses.—Generally remarkable for their astringent properties, whence they are used for dyeing and tanning; they are also used medicinally for their febrifugal and tonic properties.

Rhizophora Mangle.—The Mangrove-tree.—The bark is sometimes imported into this country as a tanning material, but it is not much used. The fruit is sweet and edible, and its juice when fermented forms a kind of wine.

Order 2. COMBRETACEÆ, the Myrobalans Order.—Character.—*Trees* or *shrubs*. *Leaves* alternate or opposite, exstipulate, entire, without dots. *Flowers* perfect or unisexual. *Calyx* superior, with a 4—5-lobed deciduous limb. *Petals* equal in number to, and alternate with, the lobes of the calyx; often absent. *Stamens* inserted with the petals on the calyx, generally twice as numerous as its lobes, or thrice as many, or sometimes equal to them in number; *anthers* 2-celled, with longitudinal or valvular dehiscence. *Ovary* inferior, 1-celled, with 2—4 ovules; *style* and *stigma* simple. *Fruit* indehiscent, 1-seeded. *Seed* pendulous, exalbuminous; *cotyledons* leafy, convolute or plaited.

Distribution and Numbers.—Exclusively natives of the tropical parts of America, Africa, and Asia.—*Illustrative Genera*:—Terminalia, *Linn.*; Combretum, *Löffl.* There are about 200 species.

Properties and Uses.—The order is chiefly remarkable for the presence of an astringent principle; hence the bark of some species, and the fruits and flowers of others, are employed in tanning and dyeing. Some yield excellent timber.

Combretum butyrosum, a native of South-eastern Africa, produces a kind of vegetable butter, which is called *Chiquito* by the Caffres, by whom it is used to dress their victuals.

Quisqualis indica.—The seeds are in repute in the Moluccas for their anthelmintic properties.

Terminalia.—The fruits of several species are largely imported into this country under the name of *Myrobalans* or *Myrabolams*. The principal kinds of myrobalans are the *Chebulic* and the *Belleric*; the first is obtained from *T. Chebula*, and the latter from *T. bellerica*. Myrobalans are principally used by calico printers for the production of a black colour which is very permanent. They are also employed by the tanner. The belleric myrobalans have been also called *Bastard Myrobalans* and *Bedda Nuts*. The flowers of *T. Chebula* are used as a dye in Travancore, and the ripe fruit is said to be an efficient purgative. The pulp of the fruit of Emblic Myrobalans (*Terminalia Emblica*) is also said to be laxative, and useful in habitual constipation. The seeds of *T. bellerica* are eaten by the natives of some parts of the East Indies, but they possess intoxicating properties, and have produced symptoms of narcotic poisoning. The seeds of *T. Catappa* yield about fifty per cent. of an oil which is said to resemble almond oil in its properties. The seeds are edible, resembling almonds in shape, and are hence called *Country Almonds* in India. The seeds of *T. citrina* are purgative.—*T. Benzoin* has a milky juice, which upon drying forms a fragrant and resinous substance resembling benzoin in its properties. (See *Styrax Benzoin.*)

Order 3. MYRTACEÆ, the Myrtle Order.—Character.—*Trees* or *shrubs*. *Leaves* opposite or alternate, entire, exstipulate (*fig.* 959), usually dotted, and having a vein running just within their margins. *Calyx* superior (*fig.* 463), 4- or 5-cleft, valvate, sometimes separating in the form of a cap. *Petals* 4—5 (*fig.* 959), imbricate, rarely absent. *Stamens* usually 8—10, or numerous (*figs.* 463 and 959), or rarely 4—5; *filaments* distinct or polyadelphous. *Ovary* inferior (*fig.* 463), 1—6-celled; *style* and *stigma* simple (*figs.* 463 and 959); *placentas* axile (*fig.* 463), or very rarely parietal. *Fruit* dry or succulent, dehiscent or indehiscent. *Seeds* without albumen, usually numerous.

FIG. 959.

Fig. 959. Flowering branch of the common Myrtle (*Myrtus communis*).

Division of the Order and Illustrative Genera.—The order may be divided into two tribes as follows:—

Tribe 1. *Leptospermeæ.* —Fruit capsular. *Illustrative Genera:* —Melaleuca, Leptospermum.

Tribe 2. *Myrteæ.*—Fruit baccate. *Illustrative Genera:*— Punica, *Linn.*; Myrtus, *Tourn.*

Distribution and Numbers.—Natives of the tropics and of the warmer parts of the temperate zones. *Myrtus communis*, the common Myrtle, is the most northern species of the order. This plant, although now naturalised in the South of Europe, was originally a native of Persia. There are about 1,320 species belonging to this order.

Properties and Uses.—These plants are generally remarkable for aromatic and pungent properties, which are due to the presence of volatile oils. Many of these oils have been used in medicine as stimulants, aromatics, carminatives, diaphoretics, or antispasmodics; and also in perfumery. The dried flower-buds and unripe fruits of some species are in common use as spices.

Other plants of the order are astringent, and a few secrete a saccharine matter. The fruits of some having a sweetish acidulous taste are edible. Many are valuable timber trees.

Eucalyptus.—*E. resinifera*, the Iron Bark-tree, a native of Australia and Van Diemen's Land, yields an astringent, very resinous substance, called *Australian* or *Botany Bay Kino. E. rostrata, E. cormybosa*, and other species, also yield an astringent substance resembling in appearance and properties the official kino. It is known as Red Gum or Eucalyptus Gum. It is soluble in water, but the so-called Australian Kino is but little soluble in that liquid. The leaves of *E. mannifera, E. viminalis*, and probably other species natives of Australia, spontaneously exude a saccharine substance resembling manna, which is therefore commonly termed *Australian Manna.* As this exudes, it hardens, and drops from the leaves on to the ground in pieces, which are sometimes as large as an almond. The products of the *Eucalypti* being frequently of a gummy nature, they are called Gum-trees in Australia.—*E. Globulus.*—Various preparations of the leaves and bark of this tree have been lately introduced, and recommended as valuable remedies in intermittent fevers, and so many medical practitioners have borne testimony to their value in such cases, that, allowing for exaggeration, their use must be, to some extent at least, beneficial ; but their antiperiodic properties are very inferior to those of the cinchona barks, none of the alkaloids of which, as proved by Broughton, they contain. The leaves and bark have also been recommended as useful in many other ways. Thus the leaves of this species, as well as those of *E. amygdalinus*, and others, yield by distillation a volatile oil, those of *E. amygdalinus* yielding more oil than any other species. Oil of Eucalyptus is official in the British Pharmacopœia ; it is a powerful antiseptic, and likewise rubefacient. It is also used in perfumery, &c. The timber of *E. Globulus*, and many other species, is very valuable owing to its solidity, hardness, durability, &c., and also from the great length of the planks that may be obtained from it. The bark of it, and other species, is also useful for tanning and dyeing ; and the ashes of the wood are also remarkable for the large proportion of potash they contain. But important as are the products obtainable from *E. Globulus*, it has been brought more especially into notice on account of the influence that plantations of this very rapid-growing tree exert in improving miasmatic climates by destroying the paludal miasm which causes fever in malarious districts, and by draining the ground, from which circumstance it has been called the fever-destroying tree. The bark of certain species separates in fibrous layers, which has occasioned them to be called Stringy-bark trees or Stringy-bark Gum-trees. These trees are sometimes of a prodigious height—350 feet or sometimes even 450 feet, and 100 feet in circumference, the trunks being destitute of branches to a height of from 100 to 200 feet.—*E. coccifera* appears to be the most hardy species for growth in this country. It grows well in Earl Annesley's garden, County Down, Ireland. The bark of *E. obliqua* and several other species is said by Baron Mueller to be useful for making good packing and printing paper. Good writing paper may also be made from the bark of *E. obliqua.*

Eugenia.—*Eugenia caryophyllata* (*Caryophyllus aromaticus*) is the Clove-tree.—The dried flower-buds constitute the *cloves* of commerce, which are so well known as a spice, and in medicine, for their aromatic, stimulant, and carminative properties. These properties are essentially due to the presence of a volatile oil. Both Cloves and the Volatile Oil of Cloves are official in the British Pharmacopœia. The dried unripe fruits are called *mother cloves* ; they are used in China and other countries as a spice, and are occasionally imported into this country ; but they are very inferior to the official cloves. The dried flower-stalks are also sometimes used as a spice instead of Cloves. They are commonly known as *Clove Stalks*, and by the French as *Griffes* *de Girofle.*—The *Rose-apples* of the East, which are much esteemed as dessert fruits, are the produce of various species of *Eugenia*; the most important are *E. malaccensis* and *E. Jambos.* In Brazil, the fruit of *E. cauliflora*, the Jabuticaba, is also much esteemed. The leaves of *E. Ugni* are used in Chili as a substitute for Paraguay Tea. The plant has been introduced into this country on account of its fruit, but not with any great success.

Glaphyria nitida is called by the Malays the Tree of Long Life. It is also known as the Tea plant, from its leaves being used as tea at Bencoolen.

Leptospermum.—The leaves of *L. scoparium* and *L. Thea* are employed in Australia as a substitute for China tea.

Melaleuca minor (*M. Cajuputi*).—The leaves when allowed to stand so as to undergo a species of fermentation, and then distilled with water, yield a volatile oil of a very limpid nature and light green colour, called Cajuput Oil, which is official in the British Pharmacopœia. This was formerly much employed as a remedy in cholera, but without any evident success. It has been used internally as a diffusible stimulant, antispasmodic, and diaphoretic; and externally, when mixed with olive oil, or dissolved in rectified spirit, as a stimulant embrocation in rheumatism, neuralgia, &c. This oil has the property of dissolving caoutchouc. In Australia, the leaves of *M. scoparia* and *M. genistifolia* are used as substitutes for China tea.

Metrosideros.—*M. scandens*, the *Aka* of New Zealand, and other species, afford valuable timber. The clubs and weapons of the South Sea Islanders are made from species of this genus.

Myrtus communis, the Common Myrtle.—The dried flower-buds and the unripe fruits were used as spices by the ancients, and are still so employed in Tuscany. By distillation with water, the flowers form a very agreeable perfume, known in France as *Eau d'Ange.* The leaves of *M. Chekan*, under the name of Chekan, have long been used in Chili as an aromatic astringent, and have recently been found in commerce.

Pimenta.—*Pimenta officinalis* (*Eugenia Pimenta*) is the Common Allspice.—The dried unripe full-grown fruits are our official *Pimento.* It is also known as *Jamaica Pepper*, or more commonly as *Allspice* (from its flavour combining that of Cinnamon, Cloves, and Nutmegs). It is used as a spice, and in medicine in similar cases to cloves. Its properties are chiefly due to the presence of a volatile oil, which is also official in the British Pharmacopœia.—*Pimenta acris*, *Eugenia acris*, or *Myrcia acris*, is commonly known under the names of Wild Clove, and Bay-berry. It is the source of the official *Spirit of Myrcia* or *Bay Rum* of the United States Pharmacopœia. Bay-rum is employed as a perfume, in faintness and various nervous affections, &c., and also in the preparation of hair-washes.

Psidium.—Various species or varieties of this genus yield excellent dessert fruits, which are commonly known under the name of *Guavas.* Of this fruit the natives of the West Indies make several kinds of preserves, as *Guava jelly, stewed Guava, Quake-pear*, and *Marmalade.* The more important are *P. pyriferum* and *P. pomiferum.* The bark of these plants also possesses astringent properties. Both plants are found frequently in tropical countries.

Punica Granatum, the Pomegranate, is the *rimmon* of the Bible, and the *rooman* of the Arabs. This plant is by some botanists regarded as the type of a distinct order, which is named *Granateæ, while by Bentham and Hooker it is placed in Lythraceæ.* We, however, retain it as an anomalous genus of the Myrtaceæ, as its affinities are commonly regarded as most nearly allied to the plants of this order. The leaves, the flowers, and the fruit were all used by the ancients for their astringent properties, and the juice of the fruit in the preparation of cooling drinks, on account of its acidulous taste. The flowers and fruit are still employed in the East. The flowers are the *Balaustion* of the ancients, whence their common name *balaustina flowers.* The rind of the fruit, and the bark of the root, are the parts now commonly used as medicinal agents in this country; but the latter is alone official in the British Pharmacopœia. These are employed for their astringent properties, and the latter is also commonly regarded as a valuable anthelmintic; the fresh bark is preferred by some, but apparently without any good reason. The astringent properties are principally due to tannic acid, but also partly to gallic acid. The bark of the root has also been recently proved by Tanret to contain a volatile alkaloid, which is evidently its important anthelmintic principle; this he has named *pelletierine*. The *sulphate of pelletierine* and *tannate of pelletierine* have been found very efficient remedies for tapeworm.

Sizygium Jambolanum.—The bark is employed in the East Indies as a useful astringent in chronic diarrhœa and dysentery.

Order 4. LECYTHIDACEÆ, the Brazil-nut Order.—Character. Large *trees*, with alternate dotless *leaves*, and small deciduous *stipules*. *Flowers* large and showy. *Calyx* superior. *Petals* 6, imbricate, distinct, or sometimes united at the base. *Stamens* numerous, epigynous; some of them cohering so as to form a unilateral petaloid hooded body. *Ovary* inferior, 2—6-celled; *placentas* axile. *Fruit* woody, either indehiscent or opening in a circumscissile manner (*fig.* 685). *Seeds* several, large, and without albumen. *This order is referred to Myrtaceæ by Bentham and Hooker.*

Distribution and Numbers.—Principally natives of Guiana and Brazil, and also occasionally of other hot regions of South America. *Illustrative Genera:*—Lecythis, *Löffl.*; Bertholletia, *Humb. et Bonpl.* There are about 40 species.

Properties and Uses.—These plants are chiefly remarkable for their large woody fruits, the pericarps of which are used as drinking-vessels and for other purposes. Their seeds are frequently edible.

Bertholletia excelsa, Berg. (*B. nobilis*, Miers), the Brazil-nut Tree.—The seeds constitute the edible nuts known as the Brazil, Juvia, Castanha, or Para Nuts. As many as 100,000 bushels are annually imported into this country from Brazil. An oil is obtained by expression from these seeds which is used by artists and watchmakers. The laminated inner bark is valuable for caulking ships and barges.

Lecythis.—The seeds of *L. Ollaria* are large and edible, and are termed Sapucaya nuts. They are now commonly sold in our fruit shops, and are generally thought to be superior in flavour to the ordinary Brazil nuts. The bark of this plant may be separated into thin papery layers, which are used by the Indians as wrappers for their cigarettes. The fruits of this and other species have been called Monkey-pots on account of their peculiar form.

Order 5. BARRINGTONIACEÆ, the Barringtonia Order.—*Diagnosis.*—This is a small order of plants frequently placed among the Myrtaceæ, but Lindley considered them as quite distinct from that order in the following particulars: namely, the presence of a large quantity of albumen in their seeds, and in their having alternate dotless and often serrated leaves. Thomson has, however, proved that the seeds are exalbuminous, so that the characters separating them from Myrtaceæ are very slight indeed. But another character of distinction is to be found in the æstivation of the calyx in the two orders; thus in that of Myrtaceæ it is valvate, while in Barringtoniaceæ it is imbricate.

Distribution and Numbers.—Natives of tropical regions in all parts of the world. *Illustrative Genera:*—Barringtonia, *Forsk.*; Gustavia, *Linn.*

Properties and Uses.—The bark of *Stravadium racemosum* is reputed to be febrifugal, and the root bitter, aperient, and acrid. The fruit of *Careya arborea* is eaten, while that of *Gustavia brasiliana* is emetic, and produces an intoxicating effect upon fish. Generally the plants of the order should be regarded as somewhat dangerous.

Order 6. CHAMÆLAUCIACEÆ, the Fringe-myrtle Order.—*Diagnosis.*—This is a small order of shrubby plants with evergreen dotted leaves, and nearly allied to Myrtaceæ, but distinguished from them by their Heath-like aspect, their more or less fringed scaly or bristly calyx-tube, and by their 1-celled ovary. From Lecythidaceæ they are at once known by their habit, their dotted exstipulate leaves, and 1-celled ovary.

Distribution and Numbers.—Exclusively natives of Australia. *Illustrative Genera:*—Chamælaucium, *Desf.*; Darwinia, *Rudg.* There are above 50 species.

Properties and Uses.—Unknown.

Order 7. BELVISIACEÆ, the Belvisia Order.—Character.—*Shrubs. Leaves* alternate, exstipulate, with a leathery texture. *Calyx* superior, coriaceous, 5-partite, with a valvate æstivation. *Corolla* consisting of three distinct whorls of united petals. *Stamens* 20, somewhat polyadelphous. *Disk* fleshy, and forming a cup-shaped expansion over the ovary. *Ovary* 5-celled, with two ovules in each cell; *placentas* axile; *style* 5-angled or 5-winged; *stigma* flat, pentagonal. *Fruit* a soft rounded berry crowned by the calyx. *Seeds* large, kidney-shaped, exalbuminous.

Distribution and Numbers.—Natives of tropical Africa and Brazil. *Illustrative Genera:*—Asteranthos, *Desf.*; Napoleona, *Palis.* These are the only genera; they include 4 species.

Properties and Uses.—Nothing is known of the uses of these plants except that the pulp of their fruits is edible, and the pericarp contains much tannic acid. They might, therefore, probably be used as astringents.

Order 8. MELASTOMACEÆ, the Melastoma Order.—Character.—*Trees, shrubs,* or *herbs. Leaves* opposite, and almost always with several large curved ribs, and dotless. *Flowers* showy. *Calyx* 4- 5- or 6-lobed, more or less adherent to the ovary, imbricate. *Petals* equal in number to the divisions of the calyx, twisted in æstivation. *Stamens* equal in number to, or twice as many as, the petals; *filaments* curved downwards in æstivation: *anthers* long, 2-celled, curiously beaked, usually dehiscing by two pores at the apex, or sometimes longitudinally; in æstivation lying in spaces between the ovary and sides of the calyx. *Ovary* more or less adherent, many-celled ; *placentation* axile. *Fruit* either dry, distinct from the calyx, and dehiscent ; or succulent, united to the calyx, and indehiscent. *Seeds* very numerous, minute, exalbuminous.

Distribution and Numbers.—They are principally natives of tropical regions, but a few are also extra-tropical, being found in North America, China, Australia, and also in the northern provinces of India. *Illustrative Genera:*—Melastoma, *Juss.* ; Medinilla, *Gaud.* There are about 2,000 species.

Properties and Uses.—The prevailing character of these plants is a slight degree of astringency. Many produce edible fruits, and some are used for dyeing black and other colours. The name *Melastoma* is derived from the fruits of the species dyeing the mouth black. Generally speaking, the plants of this order possess but little interest in a medicinal or economic point of

FIG. 960.

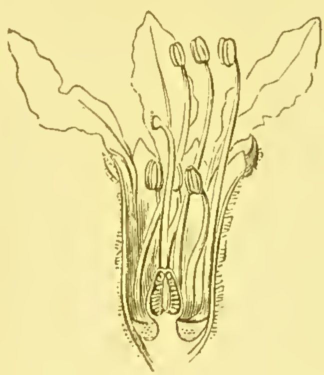


FIG. 961.

Fig. 960. Vertical section of the flower of the Purple Loosestrife (*Lythrum Salicaria*).——*Fig.* 961. Calyx of the same.

view, but none are unwholesome. A number of species are cultivated in this country on account of the beauty of their flowers.

Melastoma.—The leaves of *M. theezans* are used as a substitute for tea, which has been especially commended by Bonpland.

Memecylon.—The leaves of *Memecylon tinctorium* are used in some parts of India for dyeing yellow, &c.

Order 9. LYTHRACEÆ, the Loosestrife Order.—Character.—*Herbs* or rarely *shrubs*, frequently 4-sided. *Leaves* opposite or rarely alternate, entire, and exstipulate. *Flowers* regular or irregular. *Calyx* (*fig.* 961) persistent, ribbed, tubular below, the lobes with a valvate æstivation, sometimes with intermediate teeth (*fig.* 961). *Petals* inserted between the lobes of the calyx and alternate with them (*fig.* 960), occasionally wanting, deciduous *Stamens* perigynous, inserted below the petals (*fig.* 960), to which they are equal in number, or twice as many, or even more numerous; *anthers* adnate, 2-celled, opening longitudinally. *Ovary* superior (*fig.* 960), 1- 2- or 6-celled; *ovules* numerous or rarely few; *style* 1, filiform (*fig.* 960); *stigma* capitate or rarely 2-lobed. *Fruit* capsular, membranous, dehiscent, surrounded by the non-adherent calyx-tube. *Seeds* numerous, with or without wings, exalbuminous; *placentation* axile (*fig.* 960); *embryo* straight, with flat leafy cotyledons, and the radicle towards the hilum.

Diagnosis.—Herbs or shrubs, with entire exstipulate usually opposite leaves. Calyx tubular, ribbed, persistent, bearing the deciduous petals and stamens; the latter being inserted below the petals. Anthers 2-celled, adnate, bursting longitudinally. Ovary superior, with axile placentation; style 1. Fruit membranous, dehiscent, surrounded by the non-adherent calyx-tube. Seeds numerous, exalbuminous.

Distribution and Numbers.—The greater number are tropical plants, but some are also found in temperate regions, as, for instance, in Europe and North America. One species only, *Lythrum Salicaria*, has been hitherto found in Australia. *Illustrative Genera*:—Lythrum, *Linn.*; Lawsonia, *Linn.* There are about 250 species.

Properties and Uses.—These plants are chiefly remarkable for the possession of an astringent principle, and for their value in dyeing.

Ammannia vesicatoria.—The leaves are very acrid; they are much used in India by the natives as a vesicant, but their action is slow, and they cause great pain.

Grislea tomentosa.—In India the flowers are employed for dyeing, mixed with species of Morinda. (See *Morinda.*)

Lagerströmia Reginæ has narcotic seeds, and its leaves and bark are reputed to be purgative and hydragogue.

Lawsonia inermis (*L. alba*).—The leaves and young twigs of this shrub form the Henna, Henné, or Alkanna of Egypt and other countries. Henna is used by the women in the East to dye the tips of their fingers, their finger- and toe-nails, palms of the hand, and soles of the feet, of a reddish-orange colour. The men also use it for colouring their beards. It is likewise employed for dyeing skins and morocco leather reddish-yellow, and by the Arabs, Persians, &c., for dyeing their horses' tails and manes. The leaves are also used to some extent as an astringent.

Lythrum Salicaria, Purple Loosestrife, is a common British plant, and is said to be useful as an astringent in diarrhœa, &c. Other species probably possess similar properties.

Order 10. ONAGRACEÆ, the Evening Primrose Order.—Character.—*Herbs* or *shrubs*. *Leaves* alternate or opposite, simple, exstipulate, without dots. *Calyx* (*fig.* 962) superior, tubular, with the limb usually 4-lobed, or sometimes 2-lobed (*fig.* 787); in æstivation valvate; or rarely the limb is absent. *Petals* usually large and showy, generally regular and equal in number to the divisions of the calyx (*fig.* 787), twisted in æstivation, and inserted into the throat of the calyx (*fig.* 962); rarely absent. *Stamens* (*figs.* 787 and 962) definite, 2, 4, or 8, or rarely by abortion 1, inserted with the petals into the throat of the calyx; *filaments* distinct; *pollen* trigonal (*figs.* 573 and 576). *Ovary* inferior (*fig.* 962), 2—4-celled; *placentas* axile; *style* 1, filiform; *stigma* lobed or capitate. *Fruit* capsular, or succulent and indehiscent, 2—4-celled. *Seeds* numerous, without albumen; *embryo* straight.

FIG. 962.

Fig. 962. Vertical section of the flower of a species of Willow-herb (*Epilobium*).

Diagnosis.—Herbs or shrubs, with simple exstipulate dotless leaves. Calyx superior, 2—4-lobed, valvate in æstivation. Petals usually equal in number to the lobes of the calyx, with a twisted æstivation, or rarely absent. Stamens few, inserted into the throat of the calyx with the petals. Ovary inferior, 2—4-celled; style simple; stigma lobed or capitate. Fruit dehiscent or indehiscent. Seeds numerous, without albumen.

Distribution and Numbers.—Chiefly natives of the temperate parts of North America and Europe; many are also found in India, but they are rare in Africa, except at the Cape. *Illustrative Genera*:—Œnothera, *Linn.*; Circæa, *Tourn.* There are about 300 species.

Properties and Uses. — Generally the plants are harmless and possess mucilaginous properties. The roots of *Œnothera biennis* and other species of the same genus are edible. The fruits of many *Fuchsias* are somewhat acid and good to eat. Some species of *Jussiæa* are astringent.

Cohort 3. *Passiflorales.*—Gynœcium syncarpous; ovary usually 1-celled, or sometimes spuriously 3-celled; placentation parietal; ovules numerous. Seeds albuminous or exalbuminous. Leaves simple.

Order 1. SAMYDACEÆ, the Samyda Order.—Character.—*Trees* or *shrubs*. *Leaves* alternate, simple, evergreen, stipulate, usually with round or linear transparent glands. *Calyx* inferior, 4—5-partite. *Petals* absent. *Stamens* perigynous, 2, 3, or 4 times as many as the divisions of the calyx; *filaments* united, some of them frequently sterile; *anthers* 2-celled. *Ovary* superior, 1-celled; *style* 1, filiform; *placentas* parietal, bearing numerous ovules. *Fruit* capsular, leathery, 1-celled. *Seeds* numerous, arillate, with oily or fleshy albumen; *embryo* large.

Distribution and Numbers.—Exclusively tropical, and principally American. *Illustrative Genera*:—Samyda, *Linn.*; Casearia, *Jacq.* There are above 100 species.

Properties and Uses.—Of little importance. They are commonly bitter and astringent.

Casearia.—*C. ulmifolia*, a native of Brazil, is there highly esteemed as a remedy against snake-bites. Some species of *Casearia* have febrifugal properties, and others are said to be poisonous.—*C. esculenta* has purgative roots.

Order 2. HOMALIACEÆ, the Homalium Order.—Character. *Trees* or *shrubs*, with alternate leaves. *Calyx* superior, funnel-shaped, with from 5—15 divisions. *Petals* equal in number to, and alternate with, the divisions of the calyx. *Stamens* opposite to the petals and inserted on them, either distinct or in bundles of 3 or 6. *Ovary* inferior, 1-celled; *placentas* parietal; *ovules* numerous; *styles* 3—5. *Fruit* a capsule or berry. *Seeds* small; *embryo* in the axis of a little fleshy albumen. *This order is included in Samydaceæ by Bentham and Hooker.*

Distribution and Numbers.—They are natives of the tropical parts of India, Africa, and America. *Illustrative Genera*:—Homalium, *Jacq.*; Trimeria, *Harv.* There are about 36 species.

Properties and Uses.—Some species of *Homalium* are astringent, but nothing is known of the properties of the other genera.

Order 3. LOASACEÆ, the Chili Nettle Order.—Character.—*Herbaceous plants*, with stiff hairs or stinging glands. *Leaves* exstipulate. *Calyx* superior, 4- or 5-parted, persistent. *Petals* 5 or 10, in 2 whorls, often hooded. *Stamens* numerous, in several whorls, either distinct or united in bundles. *Ovary* inferior, 1-celled, with several parietal placentas, or 1 axile placenta; *style* 1; *ovules* anatropous. *Fruit* capsular or succulent. *Seeds* with a loose testa, and having an embryo lying in the axis of fleshy albumen.

Distribution and Numbers.—They are all natives of North and South America. *Illustrative Genera*:—Bartonia, *Muehl.*; Loasa, *Adans.* There are about 70 species.

Properties and Uses.—Some of the species are remarkable for their stinging glands; hence their common name of Chili Nettles. Several species are cultivated on account of the beauty of their flowers. A Mexican species, *Mentzelia hispida*, is reputed to possess a purgative root.

Order 4. TURNERACEÆ, the Turnera Order.—Character.—*Herbaceous* or somewhat *shrubby* plants. *Leaves* alternate, exstipulate, hairy. *Flowers* axillary. *Calyx* inferior, 5-lobed, imbricate in æstivation. *Petals* 5, equal, twisted in æstivation, without a corona, perigynous, deciduous. *Stamens* 5, alternate with the petals, perigynous; *filaments* distinct. *Ovary* 1-celled, superior, with 3 parietal placentas; *styles* 3, more or less united at the base, forked or branched above. *Fruit* capsular, 1-celled, 3-valved, partially dehiscing in a loculicidal manner. *Seeds* with a caruncule on one side, and a slightly curved *embryo* in the midst of fleshy albumen.

Distribution and Numbers.—Natives exclusively of South America and the West Indies. *Illustrative Genera*:—Turnera, *Plum.*; Piriqueta, *Aubl.* There are about 60 species.

Properties and Uses.—Some are said to be astringent, others tonic and expectorant, and a few aromatic.

Turnera.—The drug known in the United States under the name of 'Damiana' is principally derived, according to Holmes, from a species of *Turnera*, and probably *T. microphylla.* The source of another variety of Damiana, used in America, is, however, said to be *Aplopappus discoideus*, DC., a plant of the order Compositæ. (See *Aplopappus.*) Damiana is a nervine tonic, and is reputed to be a powerful aphrodisiac, but on no sufficient authority.

Order 5. PASSIFLORACEÆ, the Passion-flower Order.—Character.—*Herbs* or *shrubs*, usually climbing by tendrils (*fig.* 213), or rarely *trees*. *Leaves* alternate, with foliaceous or rarely minute stipules. *Flowers* perfect or very rarely unisexual. *Sepals* 5, united below into a tube, the throat of which bears a number of filamentous processes, and thus forming a kind of corona; *petals* 5, inserted into the throat of the calyx on the outside of the filamentous processes, with an imbricate æstivation; sometimes wanting. *Stamens* usually 5, monadelphous or rarely numerous, attached to, and raised above the calyx by, the stalk of the ovary. *Ovary* stalked, superior, 1-celled; *styles* 3, clavate; *placentas* parietal. *Fruit* 1-celled, stalked, generally succulent. *Seeds* numerous, arillate; *embryo* in thin fleshy albumen.

Distribution and Numbers.—They are chiefly found in tropical America, but a few also occur in North America and the East Indies, and several in Africa. *Illustrative Genera*:—Passiflora, *Juss.*; Tacsonia, *Juss.* There are about 214 species.

Properties and Uses.—Several have edible fruits, and others are said to be bitter and astringent, narcotic, emmenagogue, or diaphoretic.

Paropsis edulis has an edible fruit. It is a native of Madagascar.

Passiflora.—The fruits of several species of this genus are eaten under the name of Granadillas. The root of *P. quadrangularis* is said to be narcotic. The flowers of *P. rubra* are also narcotic. Other species are reputed to be anthelmintic, emmenagogue, expectorant, emetic, carminative, &c.

Tacsonia.—The pulpy fruits of *T. speciosa*, *T. mollissima*, *T. tripartita*, and others, are edible.

Order 6. MALESHERBIACEÆ, the Crownwort Order.—*Diagnosis.*—This is a small order of herbaceous or somewhat shrubby plants, resembling Passifloraceæ, *in which it is included by Bentham and Hooker*, but differing in never being climbers; in the want of stipules; in the filamentous processes of the flowers of that order being reduced to a short membranous ring or coronet in this; in the insertion of the styles at the back instead of the apex of the ovary; and in the seeds not being arillate.

Distribution and Numbers.—They are all natives of Chili and Peru. *Illustrative Genera:*—Malesherbia, *R. et P.*; Gynopleura, *Cav.* These are the only genera; they include 5 species.

Properties and Uses.—Altogether unknown.

Order 7. Papayaceæ, the Papaw Order.—Character.—*Trees* or *shrubs*, sometimes with an acrid milky juice. *Leaves* alternate, on long stalks, lobed. *Flowers* unisexual, or rarely perfect. *Calyx* inferior, minute, 5-toothed. *Corolla* monopetalous, and usually without scales or filamentous corona in the female flowers, 5-lobed. The *male flower* has a few stamens inserted on the corolla. The *female flower* has a 1-celled superior ovary, with 3—5 parietal placentas. *Fruit* succulent or dehiscent. *Seeds* numerous, albuminous, with the radicle towards the hilum. *It is included in Passifloraceæ by Bentham and Hooker.*

Distribution and Numbers.—Natives of South America and the warmer parts of the Old World. *Illustrative Genera:*—Carica, *Linn.*; Modecca, *Linn.* There are about 26 species.

Properties and Uses.—Generally unimportant; but the acrid milky juice is said to be poisonous in some species; and in others emmenagogue. The seeds of some species are also emmenagogue.

Carica.—The acrid milky juice of *Carica digitata* is said to be a deadly poison. The juice of the unripe fruits and the powdered seeds of *Carica Papaya*, the Papaw-tree, are powerful anthelmintics; the former being the more active and certain in its action. The fruit, however, when cooked, is eaten. The powdered seeds have also a great reputation in Southern India for their powerful emmenagogue properties, and it is well known that if the fruit be eaten in a certain stage by pregnant women it is exceedingly liable to produce abortion, hence doctors invariably warn such patients not to eat such fruit. The milky juice of the unripe fruit has the property of rapidly softening the toughest meat when boiled with it for a short time. Its use for this purpose is very general in Quito; and experiments have shown that it contains a substance called *papayotin* or *papain*, which has the property of digesting fibrin like pepsin. Papayotin has also been recommended in the form of a solution to remove warts, &c., and as a solvent of the false membrane in diphtheria. The leaves are also used in some districts as a substitute for soap.

Order 8. Cucurbitaceæ, the Gourd Order.—Character.—*Herbs*, generally of a succulent nature, and either prostrate or climbing by means of tendrils. *Leaves* succulent, alternate, with a radiate venation (*fig.* 310), more or less scabrous, exstipulate. *Flowers* unisexual (*figs.* 963 and 964), monœcious or diœcious. *Calyx* monosepalous, 5-toothed (*fig.* 963), the limb sometimes obsolete, superior in the female flowers (*fig.* 963, *co*). *Corolla* monopetalous (*figs.* 963, *p*, and 964, *p*), 4—5-parted, or of distinct valvate or induplicate petals, sometimes fringed, perigynous. *Male flower:*—*Stamens* usually 5, epipetalous (*fig.* 964, *st*), and alternate with the segments of the corolla, either distinct or monadelphous, or more frequently triadelphous (*fig.* 964, *st*) in such a way that two of the bundles contain each 2 stamens, and the other but 1 stamen; rarely there are but 2 or 3 stamens present; *anthers* 2-celled, usually long and sinuous

FIG. 963.

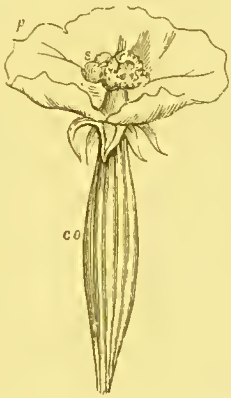


FIG. 965.

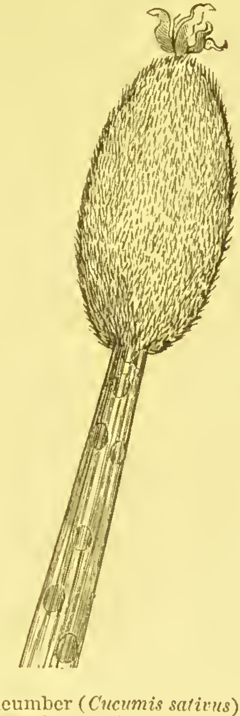


FIG. 964.

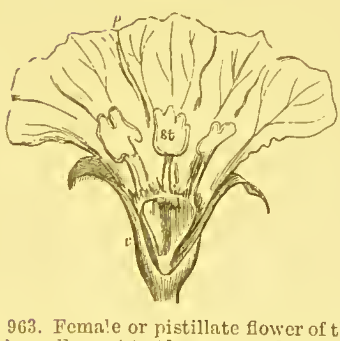


Fig. 963. Female or pistillate flower of the Cucumber (*Cucumis sativus*). *co.* Calyx adherent to the ovary; the limb is seen above, with five divisions. *p.* Corolla. *s.* Stigmas.——*Fig.* 964. Male or staminate flower of the same, the floral envelopes of which have been divided in a longitudinal manner. From Jussieu. *c.* Calyx. *p.* Corolla. *st.* Stamens.——*Fig.* 965. Pepo of the Squirting Cucumber (*Ecballium officinarum*), discharging its seeds and juice.

(*fig.* 531, *l*), or sometimes straight. *Female flower*:—*Ovary* inferior (*fig.* 963), 1-celled, or generally spuriously 3-celled from the projection inwards of the placentas; *placentas* parietal, usually 3, or rarely 2; *ovules* indefinite or sometimes solitary; *style* short (*fig.* 963); *stigmas* thickened (*figs.* 647 and 963, *s*), papillose, lobed (*fig.* 647) or fringed. *Fruit* a pepo (*figs.* 721 and 965), or rarely a succulent berry. *Seeds* more or less flattened, usually with a leathery or horny testa, which is enveloped in a succulent or membranous covering, generally numerous or rarely solitary; *embryo* flat, without albumen; *cotyledons* leafy ; *radicle* towards the hilum.

Diagnosis.—Herbs, usually of a succulent nature, prostrate or climbing. Leaves rough, alternate, radiate-veined, exstipulate. Flowers unisexual. Calyx 5-toothed or obsolete, superior in the female flowers. Corolla perigynous. Male flower with usually 5 stamens, which are distinct, monadelphous, or triadelphous, and epipetalous ; rarely there are but 2 or 3 stamens ; anthers long and usually sinuous or sometimes straight. Female flower :—Ovary inferior, with parietal placentas ; style short; stigmas more or less dilated. Fruit succulent. Seeds flat, generally numerous, exalbuminous, cotyledons leafy.

Division of the Order and Illustrative Genera.—This order has been divided into three sub-orders as follows :—

Sub-order 1. NHANDIROBEÆ.—Anthers not sinuous. Placentas projecting so as to meet in the centre of the fruit. Seeds numerous. *Illustrative Genera* :—Telfairia, *Hook.* ; Feuillæa, *Linn.*

Sub-order 2. CUCURBITEÆ.—Anthers sinuous (*fig.* 531, *l*). Placentas projecting so as to meet in the centre of the fruit (*fig.* 721, *pl*). Seeds numerous. *Illustrative Genera* :—Bryonia, *Linn.* ; Ecballium, *L. C. Rich.*

Sub-order 3. SICEÆ.—Placentas not projecting. Seed solitary, pendulous. *Illustrative Genera* :—Sicyos, *Linn.* ; Sechium, *P. Br.*

The Cucurbitaceæ have been divided by Bentham and Hooker as follows :—

Series 1. PLAGIOSPERMEÆ. — Ovules horizontal. *Illustrative Genus* :—Bryonia, *Linn.*

Series 2. ORTHOSPERMEÆ.—Ovules erect or ascending. *Illustrative Genus* :—Trianosperma, *Torr. et Gr.*

Series 3. CREMOSPERMEÆ. — Ovules pendulous. *Illustrative Genera* :—Sicyos, *Linn.* ; Sechium, *P. Br.*

Distribution and Numbers.—Natives principally of hot climates in almost every part of the world, but especially abundant in the East Indies. One species only occurs in the British Islands, *Bryonia dioica.* There are about 360 species.

Properties and Uses.—An acrid bitter purgative property is the chief characteristic of the plants of this order; this is possessed more or less by all parts of the plant, but it is especially evident in the pulp surrounding the seeds : the seeds themselves are, however, usually harmless. In some plants this acridity is so concentrated that they become poisonous : while in other cases, and especially from cultivation, it is so diffused that their fruit becomes edible. As a general rule, the plants of this order should be regarded with suspicion.

Bryonia dioica.—The fresh root is sold by herbalists under the names of White Bryony and Mandrake root; but the true Mandrake root is derived from *Mandragora officinalis*. (See *Mandragora.*) In the form of a tincture, in small doses it is said to be useful in pleurisy; but in large doses it acts as a hydragogue cathartic, and in excessive doses it is poisonous. The root is also employed as an external application to bruised parts. The young shoots when boiled are eaten as Asparagus.—*B. alba*, *B. americana*, and *B. africana* have similar properties. The root of *B. epigæa* is employed by the natives in India as an alterative in syphilis, and other affections. It is also reputed to be a powerful remedy in snake bites.

Citrullus Colocynthis, the Bitter Apple.—This plant is supposed to be the *wild vine* of the Old Testament, the fruit of which is translated in our version *wild gourd* (2 Kings iv. 39). The pulp of this fruit, which is commonly known as the *Bitter Apple* or *Colocynth*, is, in proper doses, a valuable hydragogue cathartic, but in excessive doses it is an irritant poison. It owes its properties to a bitter glucoside called *colocynthin*. Two kinds are known in commerce, viz.: *Peeled Colocynth*, which is chiefly imported from Spain and Syria; and *Mogador* or *Unpeeled Colocynth*, which is obtained from Mogador. The former is the best kind, and is official in the British Pharmacopœia. It is commonly known as Turkey Colocynth, but that imported from France and Spain is sometimes distinguished as French and Spanish Colocynth. Mogador Colocynth is principally used by pharmacists for their show-bottles. The seeds possess the purgative property to a slight extent, but the pulp is by far the more active part of the fruit. In parts of Africa, more especially in the Sahara, the seeds form an article of food.

Cucumis.—The fruit of *Cucumis sativus* is the Cucumber; that of *C. Melo* is the Melon.—*C. trigonus* and *C. Hardwickii*, both of which are natives of the East Indies, are reputed to be purgative, like the true official colocynth.

Cucurbita.—The fruits of several species or varieties are used as articles of food. Thus the fruit of *C. Citrullus* is the Water-melon; that of *C. Pepo* the White Gourd or Pumpkin; that of *C. Melopepo* the Squash; and that of *C. ovifera succada* is the Vegetable Marrow. The fruit of some other species or varieties of *Cucurbita* are also eaten. The seeds of the Pumpkin are said to possess valuable anthelmintic properties in cases of tape-worm; the expressed oil is also reputed to be equally effectual. By some the fresh seeds are preferred. The seeds of the so-called *C. maxima*, Duch., or Red Gourd, have similar properties; this plant is, however, only another form of *C. Pepo*, and in Bentley and Trimen's 'Medicinal Plants' both plants are treated of under *C. Pepo*. The seeds of the Water-melon and other species also possess diuretic properties. An oil called *Egusé* by the inhabitants of Yorruba in Africa, and which is largely used by them for dietetic purposes, and also as a medicine, is supposed to be derived from one or more species of *Cucurbita*. This oil is also well adapted for burning, and for the lubrication of machinery.

Ecballium officinarum (*Momordica Elaterium*) is commonly called the Squirting Cucumber, from the fruit separating when ripe from the stalk, and expelling its seeds and juice with much violence (*fig.* 965). The sediment from the juice of the nearly ripe fruit, when dried, constitutes the official Elaterium of the British Pharmacopœia. In doses of from $\frac{1}{16}$ to $\frac{1}{2}$ of a grain, when pure, it is a powerful hydragogue cathartic. It owes its properties to a white crystalline extremely bitter principle called *Elaterin*, which is also official in the British Pharmacopœia. In improper doses elaterium is an irritant poison.

Feuillæa cordifolia has intensely bitter seeds, which are violently purgative and emetic; thus forming a striking exception to the generally harmless properties of Cucurbitaceous seeds. The fruit is reputed to act as an antidote to poisoning by strychnine. (See *Strychnos.*)

Lagenaria vulgaris is commonly called the Bottle Gourd, from its hard pericarp being used as a receptacle for containing fluid. The seeds are purgative.

Luffa.—L. purgans and *L. drastica.*—The fruit of these plants is violently purgative. It is commonly called American Colocynth. The fruit of other species has similar properties. The fruit of *Luffa fœtida* is termed the Sponge Gourd, as its pericarp mainly consists of a mass of fibres entangled together; it is employed for cleaning guns and other analogous purposes. The dried fibrous part of the pericarp of *Luffa ægyptiaca* is used in bathrooms by Egyptian ladies to produce smoothness of the skin; it is commonly known as the Towel Gourd. These prepared pericarps may now be commonly met with in this country under the name of 'Loofahs.' An infusion of the fresh stalks and leaves of *Luffa amara*, an Indian species, is said to be useful in affections of the spleen. It possesses bitter tonic and diuretic properties.

Sechium edule.—The green fruit is commonly eaten in hot countries. It is called Chocho or Chacha.

Telfairia pedata (*Jolliffia africana*).—The seeds yield by expression a very good oil, resembling that obtained from Olives. They have a flavour like almonds, and are eaten in Africa. They have been imported into this country on account of their oil.

Trianosperma (*Bryonia*) *ficifolia* is the source of the celebrated remedy known by the natives of the Argentine Republic as *tayuru*, and in Brazil as *Leroy végétal.* It is said to possess powerful emetic and cathartic properties.

Trichosanthes anguinea is the Snake Gourd.—The fruits of this and some other species are eaten in India mixed with curries; but others are reputed to possess poisonous properties.

Order 9. BEGONIACEÆ, the Begonia Order.—Character.—*Herbs*, or low succulent *shrubs*. *Leaves* alternate, very unequal-sided at the base (*fig.* 338), with large membranous stipules. *Flowers* unisexual, monœcious. *Calyx* coloured. *Male flower* with 4 *sepals*, 2 of which are smaller than the others, and decussating with, and placed internal to them. *Stamens* numerous, distinct or united by their filaments into a column; *anthers* 2-celled, clavate, with longitudinal dehiscence, clustered. *Female flower* with 5 or 8 *sepals.* *Ovary* inferior, winged, 3-celled, from three large projecting placentas meeting in the axis; *stigmas* 3, sessile, 2-lobed. *Fruit* winged, capsular. *Seeds* numerous, with a thin reticulated testa, and without albumen.

Distribution and Numbers.—Natives chiefly of India, South America, and the West Indies. *Illustrative Genera*:—Begonia, *Linn.*; Diploclinium, *Lindl.* There are above 160 species.

Properties and Uses.—They are generally reputed to possess astringent and bitter properties, and occasionally to be purgative. Some species of *Begonia*, as *B. malabarica* and *B. tuberosa*, are used as pot-herbs. The species of *Begonia* are much cultivated for the beauty of their flowers and leaves, and from their unequal-sided leaves, very characteristic of this genus, they are commonly termed Elephant's Ears.

Order 10. DATISCACEÆ, the Datisca Order.—Character.—*Herbs*, or in the case of *Tetrameles* a large *tree*. *Leaves* alternate, exstipulate. *Flowers* diclinous, apetalous. *Male flower* with a 3—4-cleft *calyx*. *Stamens* 3—7; *anthers* 2-celled, linear, bursting longitudinally. *Female flower* with a superior 3—4-toothed *calyx*, and a 1-celled *ovary*, with 3—4 polyspermous parietal *placentas*. *Fruit* dry, opening at the apex. *Seeds* without albumen, minute, numerous. *This order is commonly placed among the Monochlamydeæ; but its affinities are clearly with Begoniaceæ and Cucurbitaceæ, and hence it is placed here.*

Distribution and Numbers.—They are widely distributed over the globe. *Illustrative Genera:*—Datisca, *Linn.*; Tetrameles, *R. Br.* The above are the only genera: there are 4 species.

Properties and Uses.—Of little importance. Useful fibres might probably be obtained from the plants of this order.

Datisca cannabina is bitter and purgative. The root is employed in Cashmere as a yellow dye.

Cohort 4. *Ficoidales.*—Stamens generally numerous, epigynous or perigynous. Gynœcium syncarpous; ovary 1- or many-celled. Seeds albuminous or exalbuminous. Leaves simple when present, and exstipulate. Stem usually fleshy.

Order 1. CACTACEÆ, the Cactus Order.—Character.—*Succulent plants*, which are usually spiny and leafless. *Stems* fleshy, globular, columnar, flattened, or 3- or more angled, and alto-

FIG. 966.

FIG. 967.

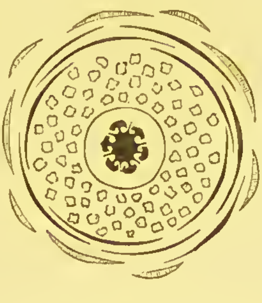


Fig. 966. Vertical section of the flower of the Prickly Pear (*Opuntia vulgaris*). ——*Fig.* 967. Diagram of the flower of the same.

gether presenting a peculiar and irregular appearance. *Flowers* solitary, sessile. *Sepals* and *petals* imbricate, usually numerous, in several whorls (*fig.* 967), and scarcely distinguishable from each other, or rarely 4-merous; adherent to the ovary (*fig.* 966). *Stamens* numerous (*figs.* 966 and 967), with long *filaments* and versatile *anthers*. *Ovary* inferior (*fig.* 966), fleshy, 1-celled, with parietal placentas (*fig.* 631); *style* 1; *stigmas* several. *Fruit* succulent. *Seeds* numerous, parietal or imbedded in the pulp, without albumen.

Distribution and Numbers.—Natives almost exclusively of the tropical regions of America. *Illustrative Genera:*—Melocactus, *C. Bauhin*; Mammillaria, *Haw.* There are about 800 supposed species.

Properties and Uses.—The fruit of many species is somewhat acid and agreeable, and is useful in febrile complaints. The fleshy stems of the Melon Cactus (*Melocactus*) are eaten by cattle on account of their juice in the dry districts of South America. Many species of *Cereus*, *Epiphyllum*, &c., are cultivated on account of their showy flowers. Some species of *Cereus*, as *C. grandiflorus* and *C. nycticallus*, open their flowers at night; they are remarkable for their size, some being as much as 1 foot in diameter.

Opuntia.—*O. vulgaris.*—The fruit of this plant is the Prickly Pear, which is much eaten in America and the South of Europe, and is now commonly imported into this country, and used as a dessert fruit. It is not, however, much esteemed. The fruit of *O. Tuna* is of a carmine colour, and has been employed as a water-colour.—*O. cochinillifera*, the Nopal Plant, is cultivated in Mexico, Teneriffe, &c., for the nourishment of the Cochineal Insect (*Coccus Cacti*); the dried female forming the Cochineal of commerce.

Pereskia aculeata.—The fruit of this plant is the Barbados Gooseberry.

Order 2. MESEMBRYANTHACEÆ or FICOIDEÆ, the Ice-plant Order.—Character.—*Succulent herbs* or *shrubs*, with opposite or alternate, simple, exstipulate leaves. *Calyx* 3—8-partite, either free or partially adherent to the ovary. *Petals* either numerous and showy, or altogether absent. *Stamens* perigynous or epigynous, distinct, numerous or definite. *Ovary* inferior or nearly superior, usually many-celled, rarely 1-celled; *placentas* axile, free central, or parietal; *styles* and *stigmas* as many as the cells of the ovary, distinct; *ovules* usually numerous or rarely solitary, amphitropous or anatropous. Fruit usually capsular and many-celled, or rarely 1-celled, dehiscing in a stellate or circumscissile manner at the apex, or splitting at the base; or woody and indehiscent. *Seeds* few or numerous, or rarely solitary; *embryo* curved or spiral, on the outside of mealy albumen.

Diagnosis.—Succulent herbs or shrubs, with simple exstipulate leaves. Sepals definite, generally more or less adherent to the ovary. Petals very numerous or absent. Stamens perigynous or nearly epigynous. Ovary inferior or nearly superior; styles distinct; placentas axile, free central, or parietal. Fruit capsular or indehiscent. Seeds with a curved or spiral embryo on the outside of mealy albumen.

Division of the Order and Illustrative Genera.—The Mesembryanthaceæ may be divided into three sub-orders as follows:—

Sub-order 1. MESEMBRYANTHEÆ.—Leaves opposite. Petals numerous, conspicuous. Stamens numerous. Fruit capsular, dehiscent. — *Illustrative Genera :* — Mesembryanthemum, *Linn.* ; Lewisia, *Pursh.*

Sub-order 2. Tetragonieæ.—Leaves alternate. *Petals* absent. Stamens definite. Fruit woody and indehiscent.—*Illustrative Genera :*—Tetragonia, *Linn.* ; Aizoon, *Linn.*

Sub-order 3. Sesuvieæ.—Leaves alternate. Petals absent. Stamens definite. Fruit capsular, with transverse dehiscence.—*Illustrative Genera :*—Sesuvium, *Linn.* ; Cypselea, *Turp.*

The two last sub-orders are sometimes placed in an order by themselves, called *Tetragoniaceæ*, which is distinguished from the Mesembryanthaceæ by having alternate leaves, no petals, and definite stamens. The plants comprehended in the above three sub-orders are, however, so nearly allied, that we have, *following Bentham and Hooker, placed them in one order as above. The tribe Mollugineæ of Caryophyllaceæ is also placed in this order by Bentham and Hooker.*

Distribution and Numbers.—Natives exclusively of warm and tropical regions. A large number are found at the Cape of Good Hope. There are about 450 species.

Properties and Uses.—Several are edible ; others yield an abundance of soda when burned ; but generally the plants of the order are of little importance.

Lewisia rediviva.—The root is eaten in Oregon. It is sometimes called Tobacco-root from the smell of tobacco which it is said to acquire by cooking. According to M. Geyer, it is the *racine amère* of the Canadian Voyageurs ; it forms a very agreeable and wholesome food when cooked.

Mesembryanthemum.—*M. crystallinum* is the Ice-plant. It is so called from its surface being studded with little papillæ (see page 69) of an ice-like appearance. Its juice is reputed to be diuretic. The ashes of this species, as well as those of *M. copticum*, *M. nodiflorum*, and others, contain much soda.—*M. geniculiflorum* is employed as a pot-herb in Africa, and its seeds are edible.—*M. edule* is called the Hottentot's Fig ; its leaves are eaten. The fruit of *M. æquilaterale* (Pig-faces or Canagong) is eaten in Australia.

Tetragonia expansa is used in New Zealand as a substitute for spinach. It has been cultivated in Europe, and employed for the same purpose under the name of New Zealand Spinach. It has been highly recommended for cultivation in this country. Its flavour is very similar to ordinary spinach.

Cohort 5. *Umbellales.*—Stamens few, epigynous. Gynœcium syncarpous ; ovary inferior ; ovules solitary, pendulous ; styles surrounded at the base by an epigynous disk, generally distinct, or sometimes united. Seeds albuminous. Leaves exstipulate.

Order 1. Umbelliferæ, the Umbelliferous Order.—Character.—*Herbs*, *shrubs*, or very rarely small *trees*, with usually hollow or rarely solid stems. *Leaves* alternate, generally amplexicaul (*fig.* 281), usually compound (*fig.* 363), or sometimes simple, and always exstipulate. *Flowers* generally in umbels, which are usually compound (*figs.* 398, 430, and 968), or sometimes simple, and rarely the flowers are capitate, with (*fig.* 398, *a*) or without (*fig.* 430) an involucre ; the partial umbels or umbellules also, with (*fig.* 968, *b*) or without (*fig.* 430, *b*) an involucel. *Calyx* superior, the limb entire, in the form of a ring, or 5-toothed, or obsolete. *Petals* 5 (*fig.* 578), usually inflexed at the point, often unequal in size, inserted on the

Fig. 968.

Fig. 969.

Fig. 970.

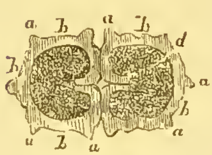


Fig. 971.

Fig. 968. *a.* General umbel of Fool's Parsley (*Æthusa Cynapium*) in fruit. *b.* One of the umbellules, showing the 3-leaved unilateral pendulous involucel.——*Fig.* 969. A side view of the ripe fruit of Hemlock (*Conium maculatum*).——*Fig.* 970. Transverse section of the fruit of the same.——*Fig.* 971. Vertical section of one of the halves (*mericarps*) of the same fruit. The letters refer to the same parts in the three last figures. *a.* Ridges. *b.* Channels. *d.* Albumen. *f.* Embryo. *g.* Remains of the styles. *h.* Axis. *i.* Prolonged axis or carpophore.

calyx outside the disk which crowns the ovary; *æstivation* imbricate, or rarely valvate or induplicate. *Stamens* 5, inserted with the petals and alternate with them (*fig.* 578), incurved in æstivation. *Ovary* inferior (*fig.* 578), crowned by a double fleshy disk (*stylopod*) (*fig.* 578, *d*), 2-celled, with a solitary pendulous ovule in each cell; *styles* 2; *stigmas* simple. *Fruit* called a *cremocarp* or *diachænium* (*figs.* 717 and 969), consisting of 2 carpels (*mericarps*) adhering by their face (*commissure*) to a common axis (*carpophore*), which is undivided (*fig.* 971, *h*) or forked (*fig.* 717), from which they ultimately separate and become pendulous (*fig.* 717); each mericarp (*figs.* 969 and 970) an indehiscent 1-seeded body, traversed on its dorsal surface by *ridges*, *a*, of which there are usually 5; but sometimes there are 4 others, alternating with them, in which case the former are termed *primary*, and the latter *secondary* ridges; the spaces between the ridges are called channels (*valleculæ*), *b*, in which are frequently oily receptacles called *vittæ* (*fig.* 175). *Seed* pendulous (*fig.* 971); *embryo* minute, *f*, at the base of abundant horny albumen, *d*; *radicle* pointing towards the hilum.

Diagnosis.—Herbs or shrubs. Stems generally hollow; leaves alternate, usually compound and amplexicaul, or sometimes simple, and always exstipulate. Flowers almost always arranged in a more or less umbellate manner, or rarely capitate. Calyx superior. Petals and stamens 5, inserted on the outside of a double fleshy epigynous disk. Ovary inferior, 2-celled, with a solitary pendulous ovule in each cell; styles 2. Fruit consisting of two indehiscent carpels, which separate when ripe from a common axis or carpophore. Seeds pendulous, one in each carpel, with a minute embryo at the base of abundant horny albumen.

Division of the Order and Illustrative Genera:—The order has been divided into three sub-orders from the appearance of the albumen, but these are by no means well defined. They are as follow:—

Sub-order 1. Orthospermeæ.—Albumen flat on its face. *Illustrative Genera:*—Hydrocotyle, *Linn.*; Œnanthe, *Linn.*; Heracleum, *Linn.*

Sub-order 2. Campylospermeæ.—Albumen rolled inwards at the margins, and presenting a vertical furrow on its face. *Illustrative Genera:*—Anthriscus, *Hoffm.*; Chærophyllum, *Linn.*; Conium, *Linn.*

Sub-order 3. Cœlospermeæ.—Albumen with the base and apex curved inwards on its face. *Illustrative Genera:*—Ormosciadium, *Boiss.*; Coriandrum, *Linn.*

By Bentham and Hooker this order has been divided as follows:—

Series 1. Heterosciadieæ.—Umbels generally simple or very irregularly compound, or the flowers are capitate. Vittæ none or obscure. *Illustrative Genera:*—Hydrocotyle, *Linn.*; Astrantia, *Linn.*; Eryngium, *Linn.*

Series 2. Haplozygieæ.—Umbels compound (*fig.* 430). Primary ridges of fruit alone conspicuous (*figs.* 969 and 970). Vittæ usually obvious. *Illustrative Genera:*—Conium, *Linn.*; Myrrhis, *Scop.*; Fœniculum, *Adanson.*

Series 3. DIPLOZYGIEÆ.—Umbels usually compound (*fig.* 398). Fruit with primary and secondary ridges generally well marked. *Illustrative Genera:* — Caucalis, *Linn.*; Daucus, *Linn.*

Distribution and Numbers.—Chiefly natives of the northern parts of Europe, Asia, and America. Many occur, however, in the southern hemisphere. They are rare in tropical regions except upon the mountains, where they are by no means uncommon. There are about 1,400 species.

Properties and Uses. — Extremely variable: thus, some are edible; others aromatic and carminative, and, in some cases, stimulant and tonic, from the presence of a volatile oil; some, again, contain a narcotico-acrid juice, which renders them more or less poisonous; while others are antispasmodic and stimulant from the presence of a more or less fœtid gum-resin, which is essentially composed of gum, resin, and volatile oil. This oil in the case of Asafœtida contains sulphur.

1. ESCULENT UMBELLIFERÆ.

Anthriscus.—Two species of this genus are cultivated.—*A. Cerefolium*, Chervil, the leaves of which are used for flavouring soups, salads, &c.; and *A. bulbosus*, Parsnip Chervil, for its edible roots.

Apium graveolens, Celery.—By cultivation with the absence of light, the stems and petioles become succulent and develop but little aromatic oil, and are then edible.

Anesorhiza capensis is eaten at the Cape of Good Hope.

Arracacha esculenta, Arracacha, a native of New Granada, has large esculent roots.

Bunium.—*B. flexuosum* and *B. Bulbocastanum* have roundish tubercular roots, which are edible; they are known under the name of Earth-nuts or Pig-nuts.—*B. ferulæfolium*, a native of Greece, has also edible tubercules, which are termed *Topana.*

Carum Gairdneri.—The roots of this plant are much eaten by the Indians of the Pacific coast of North America, either raw or boiled with other substances.

Crithmum maritimum, Samphire, is commonly used as an ingredient in pickles.

Daucus Carota var. *sativa*, the cultivated or Garden Carrot, is well known for its esculent roots.

Fœniculum.—*F. capillaceum* (*F. vulgare*) is the common Fennel, which, when cultivated, is so well known as a pot-herb and garnishing substance. —*F. capensis* is a Cape esculent.

Ferula.—The roots of several species of this genus are eaten in Oregon and some other parts of North America.

Haloscias scoticum is the Scottish Lovage.

Helosciadium californicum.—The roots are said by M. Geyer to be very delicious; they are eaten by the Saptoria Indians in Oregon.

Œnanthe pimpinelloides is said by Lindley to have wholesome roots, but the species of *Œnanthe* are generally very poisonous. (See *Poisonous Umbelliferæ.*)

Pastinaca sativa, the Parsnip.—The roots of the cultivated plant are the parts eaten.

Petroselinum sativum is the Common Parsley of our gardens. An oily liquid, which has been named *apiol*, may be obtained from the fruits; it has been reputed of value in intermittent fevers, and as an emmenagogue.

Prangos pabularia.—The herb is used as sheep food in Tartary and the adjoining countries, and has been introduced as a forage plant into this country. The prevalent idea that its use corrects the tendency to rot in sheep is erroneous.

Sium Sisarum is commonly known under the name of Skirret. It is sometimes cultivated for its edible roots.

Smyrnium Olusatrum, Alexanders.—This plant was formerly cultivated like Celery.

2. Aromatic, Carminative, Stimulant, and Tonic Umbelliferæ.

Peucedanum (*Anethum*) *graveolens*, the Dill; *Carum Carui*, the Caraway; *Coriandrum sativum*, the Coriander; *Cuminum Cyminum*, the Cummin; *Daucus Carota*, the Carrot; *Fœniculum capillaceum* (*vulgare*), the Fennel; *Fœniculum Panmorium*, an Indian species; *Pimpinella Anisum*, the Anise; and *Ptychotis* (*Carum*) *Ajowan*, the Ajwain or Omum, a native of Egypt, Persia, Afghanistan, &c., and much cultivated in India. The fruits of the above plants, commonly termed seeds, all possess aromatic, carminative, and more or less stimulant properties, which are due to the presence of volatile oils contained either in the vittæ, or their pericarps generally. Some are also employed as condiments, and for flavouring liqueurs. They are too well known to need any detailed description. The fruits of *Levisticum officinale*, Lovage, have somewhat similar properties. The fruits of *Peucedanum graveolens*, *Carum Carui*, *Coriandrum sativum*, *Pimpinella Anisum*, and *Fœniculum capillaceum*, as also their volatile oils, except that of Fennel, are official in the British Pharmacopœia.

Archangelica officinalis, Angelica.—The root and fruits are pungent aromatic stimulants and mild tonics. They are principally used in the preparation of gin, and the liqueur known under the name of *bitters*. The young shoots are also made with sugar into a sweetmeat or candy, which forms a very agreeable stomachic. The petioles were formerly blanched and eaten like Celery.

Daucus Carota var. *sativa.*—The roots are used in the form of a poultice, on account of their moderately stimulant properties.

Eryngium campestre and *E. maritimum*, Eryngo, have sweet aromatic roots, possessing tonic properties.

Ferula (*Euryangium*) *Sumbul.*—The root, which is official in the British Pharmacopœia, is imported into this country, by way of Russia, from Turkestan and Bucharia. It is also official in the Pharmacopœia of India. It is commonly known as *Sumbul-root*, and also, from its strong musky smell, as *Musk-root*. It is a nervine stimulant, and antispasmodic.

Hydrocotyle asiatica.—The leaves, particularly when in a fresh state, are employed in India both internally and externally, in leprosy, secondary syphilis, &c. They are official in the Pharmacopœia of India. As a remedial agent in leprosy they excited much attention some years since in the Island of Mauritius, under the name of *Bevilacqua*.

Meum.—*M. athamanticum*, Bald-money or Mew, and *M. Mutellina*, have aromatic tonic roots.

Selinum palustre.—The root has long been popularly used in some provinces of Russia as a remedy in epilepsy. It has also been employed in hooping-cough, and other nervous affections; but when tried in regular practice its use has not been attended with any marked success.

3. Poisonous Umbelliferæ.

The poisonous properties of these plants are due to the presence of a narcotico-acrid juice, and seem to vary according to the nature of the soil and climate, for Sir Robert Christison has noticed that certain species which are generally regarded as poisonous are quite harmless when obtained from certain localities near Edinburgh. This is a very important point, and one which requires further investigation. Should it prove to be true in all cases, it would probably account in a great degree for the varying strength of the official preparations of Hemlock, which is commonly believed to arise from their careless preparation; and also for the different opinions entertained as to the poisonous or non-poisonous properties of some other species of Umbelliferous plants.

Æthusa Cynapium, Fool's Parsley, is a very common indigenous plant, and is usually regarded as possessing poisonous properties; but this is altogether contrary to the experience of Dr. John Harley. Ficinius and Walz have, however, both isolated alkaloids: the first a crystallisable, very poisonous substance; the latter a liquid alkaloid, resembling, it is said, conine and nicotine. The leaves have been mistaken and eaten for those of Parsley.

Œnanthe.—Œnanthe crocata, Hemlock Dropwort or Dead-tongue, *Œnanthe Phellandrium*, Fine-leaved Water Dropwort, *Œnanthe fistulosa*, and some other species, are very poisonous. The roots of *Œnanthe pimpinelloides*, as already noticed, are said, however, to be wholesome. (See *Esculent Umbelliferæ.*) All the above species are indigenous.

Cicuta.—C. virosa, Water Hemlock or Cowbane, is another indigenous plant of a highly poisonous nature. Its poisonous principle has been termed *cicutoxin.—C. maculata*, a native of America, has also very poisonous roots, which from having been mistaken for those of other harmless *Umbelliferæ*, have not unfrequently led to fatal results. The latter plant has been used as a remedy in nervous and sick headaches.

Conium maculatum, Hemlock.—This plant is indigenous; the fresh leaves and young branches and the fully developed green fruit are official in the British Pharmacopœia. In proper doses hemlock is extensively employed in medicine to relieve pain, relax spasm, and compose nervous irritation in general. It owes its properties chiefly to the presence of a colourless oily liquid alkaloid with a penetrating mouse-like odour, to which the name of *Conine* or *coniine* has been given. In improper doses Hemlock is a powerful poison, and fatal accidents have arisen from its having been mistaken for other harmless Umbelliferous plants. Conine is said to be useful in acute mania; and Hydrobromate of Conine has been used successfully in spasmodic affections.

4. Umbelliferæ yielding fœtid Gum-Resins.

The most important of these gum-resins are, *Asafœtida*, *Ammoniacum*, and *Galbanum*; all of which are official in the British Pharmacopœia. *Opoponax* and *Sagapenum* are others, but they are now scarcely ever used in this country. They all possess antispasmodic and more or less stimulant properties; this is especially the case with Asafœtida, which is also extensively used as a condiment in Persia, India, and other parts of the East, in the same way as garlic and other allied plants are employed in Europe. Ammoniacum and Galbanum also possess expectorant properties, more particularly the former, and both are used externally in the form of plasters to promote the absorption of tumours and chronic swellings of the joints. The plants yielding these gum-resins are not in all cases known, but they are exclusively natives of Persia, Afghanistan, Thibet, and the adjacent regions, except the one yielding Opoponax, which is found in the South of Europe, and in Syria. These gum-resins are chiefly imported into this country from India, although sometimes from the Levant. They are commonly seen in two forms—that is, in roundish or irregular tears; or in masses formed by more or less amalgamated tears.

Ammoniacum is yielded by *Dorema Ammoniacum*, Don, and probably other species. It exudes from the stem seemingly to some extent spontaneously, but principally in consequence of punctures produced by innumerable beetles when the plant has attained perfection. It appears to be solely collected in Persia. The root of *D. Ammoniacum* is used in India in the Parsee fire-temples as incense, and is imported from Persia under the name of *Boi*. This root is the source of the Indian Sumbul-root of Pereira.

Asafœtida.—This is obtained by incision from the living roots of *Ferula Narthex*, Boiss., *F. Scorodosma*, Benth. et Hook. fil., and probably other species, as *F. alliacea*, in Thibet, Afghanistan, and Persia. We have, however, no positive evidence of *F. Narthex* having been found except in Thibet. The fruit is also sometimes employed in India under the name of *Anjudan*.

Galbanum.—This gum-resin is principally derived from *Ferula galbaniflua*, Boiss. et Buhse; but also from *F. rubricaulis*, Boiss., and probably from *F. Schaïr*, Boszezow, and other species.

Opoponax appears to be obtained from incisions into the living root of *Opoponax Chironium*, which was formerly called *Pastinaca Opoponax*.

Sagapenum.—Nothing positive is known with respect to the plant yielding this substance. It has been supposed to be derived from the root of *Ferula persica*, or some other species of *Ferula*.

Thapsia garganica is said to be the Silphium plant of the ancients. The gum-resin from which the blistering property has been removed has been highly recommended as a remedy in pulmonary affections, more especially in phthisis. The Silphium plant is, however, sometimes stated to be the *Narthex Silphium*, Oersted.

Order 2. ARALIACEÆ, the Ivy Order.—Character.—*Trees*, *shrubs*, or *herbs*. *Leaves* alternate, exstipulate (*fig.* 225). *Flowers* generally in umbels or capitate, usually perfect (*fig.* 972) or rarely unisexual. *Calyx* more or less superior (*fig.* 972), entire or toothed. *Petals* (*fig.* 972), 2, 4, 5, 10, deciduous, almost always valvate in æstivation or rarely imbricate, generally distinct or rarely monopetalous; occasionally wanting. *Stamens* corresponding in number to the petals and alternate with them (*fig.* 972), or twice as many, inserted on the outside of a disk which crowns the ovary; *anthers* introrse, versatile (*fig.* 972), with longitudinal dehiscence. *Ovary* (*fig.* 972) more or less inferior, usually with more than 2 cells, or very rarely 1-celled, crowned by a disk, each cell with a solitary pendulous anatropous ovule; *styles* as many as the cells, sometimes united; *stigmas* simple. *Fruit* usually 3- or more celled, succulent or dry, each cell with 1 pendulous seed, with fleshy albumen.

FIG. 972.

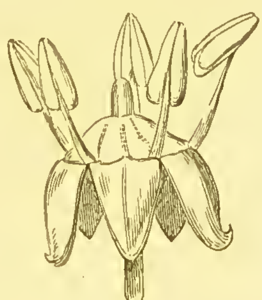


Fig. 972. Flower of the common Ivy (*Hedera Helix*).

Diagnosis.—Closely allied to Umbelliferæ, from which it may be generally distinguished by the valvate æstivation of the corolla; and by the fruit being usually 3- or more celled, the carpels of which do not separate when ripe from a carpophore. There is also a greater tendency among Araliaceæ to form a woody stem than in Umbelliferæ.

Distribution and Numbers.—These plants are universally distributed, being found in tropical, sub-tropical, temperate, and the coldest regions. *Illustrative Genera*:—Panax, *Linn.*; Hedera, *Linn.* The order includes about 300 species.

Properties and Uses.—It must be regarded as a somewhat remarkable fact that, nearly allied as the Araliaceæ are to the Umbelliferæ, they never possess to any degree the poisonous properties which are frequently found in plants of that order. The Araliaceæ are generally stimulant, aromatic, diaphoretic, and somewhat tonic.

Aralia.—*A. nudicaulis* is a native of North America, where its roots are used popularly as an alterative and stimulant diaphoretic in rheumatic affections; they are commonly known under the name of *False, Wild*, or *American Sarsaparilla*, and are sometimes forwarded to this country. Under the name of Rabbit roots they have been also used as a remedy in syphilis by the Crees, in North America. The bark of *A. spinosa*, called *Angelica* or *Toothache Tree* in North America, is used as a stimulant diaphoretic.—*A. racemosa*, *A. spinosa*, and *A. hispida* yield aromatic gum-resins.—*A. edulis* is used in China as a diaphoretic. Its young shoots and roots are also eaten as a vegetable in China and Japan.

Gunnera scabra is remarkable for its enormous leaves, which are sometimes as much as eight feet in diameter; the fleshy petioles resemble those of the Rhubarbs in appearance, and are eaten. Its roots are astringent. *This genus is placed by Bentham and Hooker under Haloragaceæ.*

Hedera Helix, the Ivy, is reputed to be diaphoretic, and its berries are emetic and purgative. It contains a peculiar acid called *hederic acid*, which is supposed to be a glucoside.

Helwingia.—This genus, which contains but one species, *H. ruscifolia*, has been sometimes made a distinct order called Helwingiaceæ. The leaves are used in Japan as a vegetable.

Panax.—*P. Ginseng.*—The root of this plant, which is a native of Northern Asia, constitutes *Ginseng*, which is so highly prized by the Chinese as a stimulant and aphrodisiac, that they will sometimes give for it its weight in gold. The name *Ginseng* signifies 'Wonder of the World.'—*P. quinquefolium* is a native of North America. Its root is known under the name of *American Ginseng*. It has similar properties to the preceding.—*P. Pseudo-Ginseng*, a native of India, also appears to have analogous properties.—*P. fruticosum*, *P. cochleatum*, and *P. Anisum* have aromatic properties.

Tetrapanax (Aralia) papyriferum.—From the pith of this plant, a native of the island of Formosa, the rice paper, which is used by the Chinese for making artificial flowers, &c., is prepared.

Order 3. CORNACEÆ, the Dogwood Order.—Character.—*Shrubs*, *trees*, or rarely *herbs*. *Leaves* simple, opposite or very rarely alternate, exstipulate. *Flowers* perfect or rarely unisexual, arranged in heads, or in a corymbose, or umbellate manner, with or without an involucre. *Calyx* superior, 4-lobed. *Petals* 4, broad at the base, inserted at the top of the calyx-tube; *æstivation* valvate. *Stamens* 4, inserted with the petals and alternate to them. *Ovary* inferior, surmounted by a disk, usually 2-celled; *ovule* pendulous, solitary, anatropous; *style* and *stigma* simple. *Fruit* drupaceous, crowned with the remains of the calyx. *Seed* pendulous; *embryo* in the axis of fleshy albumen.

Diagnosis.—Trees, shrubs, or rarely herbs, with simple exstipulate, and (with but one exception) opposite leaves. Flowers perfect, or sometimes unisexual. Calyx superior, 4-lobed. Corolla with 4 petals, and a valvate æstivation. Stamens 4, alternate with the petals. Ovary inferior, surmounted by a disk, usually 2-celled, with a single pendulous anatropous ovule in each cell; style and stigma simple. Fruit drupaceous. Embryo in the axis of fleshy albumen.

Distribution and Numbers.—Natives of the temperate parts of Europe, Asia, and America. *Illustrative Genera*:—Cornus, *Linn.*; Aucuba, *Thunb.* There are above 70 species.

Properties and Uses.—The plants of this order are chiefly remarkable for tonic, febrifugal, and astringent properties.

Cornus.—The bark of the root of *C. florida* is official in the United States Pharmacopœia, and is used as a substitute for Peruvian bark in the treatment of intermittent and remittent fevers. It is there commonly known under the name of *Dogwood Bark.* The barks of *C. circinata* and *C. sericea* are also official in the United States Pharmacopœia, and have similar properties to the former. The fruit of *C. mascula*, the Cornelian Cherry, is astringent, a property also possessed by the leaves and flowers. The fruit, called *Krania*, is much esteemed by the Turks on account of its agreeable acid flavour. They use the juice in their sherbets and for other purposes. The fruits of *C. suecica* are used by the Esquimaux for food; and in the Highlands of Scotland they are reputed to possess tonic properties, the plant yielding them being there termed *lus-a-chrasis*, or plant of gluttony, in allusion to the supposed effect of the fruits in increasing the appetite. The seeds of *C. sanguinea*, the common Dogwood of our hedges, yield a fixed oil, which has been used for burning in lamps. Charcoal for the manufacture of gunpowder is also prepared from the wood. The fresh twigs of *C. florida* or other species are much used in the United States and in the West Indies to rub on the teeth for the purpose of whitening them.

Order 4. GARRYACEÆ, the Garrya Order.—Character.—Evergreen *shrubs*. *Leaves* opposite, exstipulate. *Flowers* unisexual, apetalous, amentaceous. *Male flower* with 4 *sepals*, and *stamens* alternating with them. *Female flower* with a superior 2-toothed *calyx*, and 1—3-celled *ovary* with 2 styles, and 2 pendulous stalked ovules. *Fruit* indehiscent, baccate, 2-seeded. *Seeds* with a very minute embryo in abundant albumen. *By Bentham and Hooker this order is included in Cornaceæ.*

Distribution and Numbers.—Natives of the temperate parts of North America, or of the West Indies. *Illustrative Genera*:—Garrya, *Dougl.*; Fadgenia, *Endl.* These are the only genera; they include 6 species.

Properties and Uses.—But little is known of the properties of these plants; but *Garrya Fremontii*, a native of California, is known as the Quinine Bush from its leaves being used in fevers and ague.

Order 5. ALANGIACEÆ, the Alangium Order.—Character.—*Trees* or *shrubs*. *Leaves* alternate, entire, exstipulate, without dots. *Calyx* superior, 5-10-toothed. *Petals* 5-10, linear, reflexed. *Stamens* equal in number to, or twice or four times as numerous as, the petals; *anthers* adnate. *Ovary* inferior, 1—2-celled; *style* simple; *ovule* solitary, pendulous. *Fruit* drupaceous, more or less united to the calyx, 1-celled. *Seed* solitary, pendulous, with fleshy albumen, and large flat leafy cotyledons.

Distribution and Numbers.—Natives of various parts of the East Indies and the United States. *Illustrative Genera:*—Alangium, *Lam.*; Nyssa, *Linn.* There are about 8 species. *By Bentham and Hooker they are included in Cornaceæ.*

Properties and Uses.—Of little importance. Some species of *Alangium* are said to be purgative and aromatic; and their succulent fruits are also edible. The fruit of *Nyssa capitata* or *N. candicans* is used occasionally as a substitute for Lime fruit, whence it is called the *Ogechee Lime.*

Artificial Analysis of the Orders in the Sub class Polypetalæ.

Series 3. CALYCIFLORÆ.

1. FLOWERS with more than 20 stamens.

A. Ovary wholly superior.

a. *Leaves without stipules.*

1. *Carpels more or less distinct, (at least as to the styles); or solitary.*
   Stamens distinctly perigynous. Ovules suspended, erect, or ascending . . . *Rosaceæ.*
2. *Carpels wholly combined, (at least as to the ovaries).*
   Sepals more than 2, united into a tube. Ovary with axile placentas . . . . *Lythraceæ.*

b. *Leaves with stipules.*

1. *Carpels more or less distinct, (at least as to the styles); or solitary.*
   Calyx with the odd lobe inferior. Stamens somewhat hypogynous . . . . *Leguminosæ.*
   Calyx with the odd lobe superior. Stamens distinctly perigynous . . . . *Rosaceæ.*
2. *Carpels wholly combined, (at least as to the ovaries).*
   Leaves with circinate vernation. Placentas parietal . . . . . *Droseraceæ.*

B. Ovary inferior, or partially so.

a. *Leaves without stipules.*

1. *Placentas parietal.*
   Petals definite in number, distinct from the calyx . . . . . . *Loasaceæ.*
   Petals indefinite in number, gradually passing into the sepals . . . . *Cactaceæ.*

2. *Placentas in the axis.*
Leaves with transparent dots.
Ovary 1-celled . . . . . . *Chamælauciaceæ.*
Ovary with more than one cell . *Myrtaceæ.*
Leaves without dots.
Petals very numerous . . . . . *Mesembryanthaceæ.*
Petals definite in number.
Petals narrow and strap-shaped . *Alangiaceæ.*
Petals roundish and concave.
Styles united . . . . . *Barringtoniaceæ.*
Styles distinct . . . . *Philadelphaceæ.*

b. *Leaves with stipules.*

1. *Carpels more or less distinct, or solitary* . *Rosaceæ.*
2. *Carpels wholly combined (at least as to the ovaries).*
Leaves opposite . . . . . . *Rhizophoraceæ.*
Leaves alternate.
Placentas axile . . . . . . *Lecythidaceæ.*
Placentas parietal . . . . . *Homaliaceæ.*

2. Flowers with less than 20 stamens.

A. Ovary wholly superior.

a. *Leaves without stipules.*

1. *Carpels more or less distinct, or solitary.*
Carpels with hypogynous scales.
Each carpel having one scale . . . *Crassulaceæ.*
Each carpel having two scales . . . *Francoaceæ.*
Carpels without hypogynous scales.
Carpels solitary, or all but one imperfect.
Leaves without dots.
Ovules collateral, ascending, sessile . *Connaraceæ.*

2. *Carpels wholly combined, (at least by their ovaries).*
Placentas parietal.
Flowers with a ring or crown.
Flowers unisexual . . . . *Papayaceæ.*
Flowers hermaphrodite . . . *Malesherbiaceæ.*
Flowers without a ring or crown . *Turneraceæ.*
Placentas in the axis.
Styles distinct to the base.
Carpels each with one hypogynous scale . . . . *Crassulaceæ.*
Carpels without hypogynous scales . *Saxifragaceæ.*
Styles more or less combined.
Calyx imbricate. Ovules suspended . *Bruniaceæ.*
Calyx valvate.
Leaves simple. Calyx tubular . *Lythraceæ.*

b. *Leaves with stipules.*

1. *Carpels distinct, or solitary.*
Fruit leguminous; odd lobe of the calyx inferior . . . . *Leguminosæ.*
Fruit not leguminous; odd lobe of the calyx superior . . . . *Rosaceæ.*

2. *Carpels wholly combined, (at least by their ovaries).*
Placentas parietal.
Flowers with a ring of appendages . *Passifloraceæ.*
Placentas in the axis.
Styles distinct to the base.
Petals conspicuous.
Leaves opposite . . . . *Cunoniaceæ.*
Leaves alternate . . . . *Saxifragaceæ.*

B. Ovary inferior, or partially so.

a. *Leaves without stipules, or with cirrhose appendages.*

Placentas parietal.
Flowers completely unisexual. Monopetalous . . . . *Cucurbitaceæ.*
Flowers hermaphrodite or polygamous. Petals distinct . . . . *Ribesiaceæ.*
Placentas in the axis.
Flowers in umbels, or capitate.
Styles two . . . . . . *Umbelliferæ.*
Styles three or more . . . *Araliaceæ.*
Flowers not in umbels.
Carpel solitary.
Petals strap-shaped, reflexed . . *Alangiaceæ.*
Petals oblong.
Cotyledons convolute . . . *Combretaceæ.*
Cotyledons flat . . . . *Haloragaceæ.*
Carpels two or more, divaricating at the apex.
Leaves alternate. Herbs . . . *Saxifragaceæ.*
Leaves opposite. Shrubs . . . *Hydrangeaceæ.*
Carpels two or more, not divaricating, combined.
Calyx valvate, or the limb obsolete.
Stamens alternate with the petals if isomerous.
Albumen none. Ovules horizontal or ascending . . . *Onagraceæ.*
Albumen present. Ovules pendulous . . . . . *Haloragaceæ.*
Albumen abundant. Flowers conspicuous . . . . *Cornaceæ.*
Calyx not valvate.
Stamens doubled downwards. Anthers with appendages, Leaves ribbed . . . . . . *Melastomaceæ*
Stamens only curved. Anthers short.
Leaves dotted . . . . *Myrtaceæ.*
Leaves not dotted.
Seeds very numerous, minute . *Escalloniaceæ.*
Seeds few . . . . . *Bruniaceæ.*

b. *Leaves with stipules.*

Placentas parietal.
Stipules cirrhose. Monopetalous . . *Cucurbitaceæ.*
Stipules deciduous. Petals distinct . . *Homaliaceæ.*

Placentas in the axis.
Stamens if equal to the petals, alternate with them.
Leaves opposite . . . . . *Rhizophoraceæ.*
Leaves alternate . . . . . *Hamamelidaceæ*

Although it generally happens that the Calyciflore have dichlamydeous flowers, polypetalous corollas, and perigynous or epigynous stamens, yet many exceptions occur, which should be particularly noted by the student. Thus, we find apetalous plants in the *Leguminosæ*, *Rosaceæ*, *Saxifragaceæ*, *Cunoniaceæ*, *Crassulaceæ*, *Hamamelidaceæ*, *Haloragaceæ*, *Callitrichaceæ*, *Rhizophoraceæ*, *Combretaceæ*, *Samydaceæ*, *Loasaceæ*, *Datiscaceæ*, *Mesembryanthaceæ*, *Araliaceæ*, *Garryaceæ*, *Myrtaceæ*, *Lythraceæ*, *Onagraceæ*, *Passifloraceæ*. Monopetalous corollas occur in *Papayaceæ*, *Cucurbitaceæ*, *Belvisiaceæ*, *Crassulaceæ*, *Droseraceæ*, *Bruniaceæ*, *Melastomaceæ*, *Turneraceæ*, *Cactaceæ*, *Lecythidaceæ*, *Araliaceæ*. In some Calyciflorae, again, the stamens are wholly or in part hypogynous or nearly so, as in *Connaraceæ*, *Leguminosæ*, *Saxifragaceæ*, *Crassulaceæ*, *Francoaceæ*.

Unisexual flowers always occur as a rule in *Callitrichaceæ*, *Papayaceæ*, *Garryaceæ*, and *Cucurbitaceæ*, and sometimes in *Rosaceæ*, *Hydrangeaceæ*, *Passifloraceæ*, *Ribesiaceæ*, *Haloragaceæ*, *Combretaceæ*, *Cornaceæ*, *Hamamelidaceæ*, and *Araliaceæ*.

Sub-class II. *Gamopetalæ or Corollifloræ.*

Series 1. Inferæ or Epigynæ.

Cohort 1. *Rubiales.*—Stamens epipetalous and alternate with the lobes of the corolla. Ovary 1- or more celled, but usually 2-celled; cells of the ovary 1—many-ovuled. Seeds albuminous. Leaves generally opposite.

The orders placed in this series of the Corolliflorae were included by De Candolle in the Calyciflorae; the Corolliflorae being restricted by him to those monopetalous orders in which the ovary was superior, and which are placed in our arrangement in the two series Superæ and Dicarpiæ. But the simplest arrangement for the student is to consider the Monopetalous Corolla as the essential mark of the Gamopetalæ or Corollifloræ, and in accordance with this view we have this series of the Gamopetalæ, called Inferæ or Epigynæ. It should be noticed, however, that some monopetalous plants occur in certain orders of the Polypetalæ, as indicated in our artificial analyses of the three series of that sub-class.

Order 1. Caprifoliaceæ, the Honeysuckle Order.—Character.—Small *trees*, *shrubs*, or rarely *herbs*. *Leaves* opposite (*fig.* 285), usually exstipulate. *Calyx* superior (*fig.* 973), 4—5-cleft. *Corolla* monopetalous (*fig.* 974), 4—5-cleft, tubular or rotate, regular (*fig.* 974) or irregular, rarely polypetalous. *Stamens* (*fig.* 974) 4—5, inserted on the corolla, and alternate with its lobes. *Ovary* inferior (*fig.* 973), 1—6-celled, often with 1 ovule in one cell, and several in the others, pendulous or suspended; *style* filiform or absent; *stigmas* 1—3 (*figs.* 973 and 974) or 5. *Fruit* indehiscent, 1- or more celled, dry or succulent, and crowned by the persistent calycine lobes. *Seeds* solitary or numerous; *embryo* small (*fig.* 975), in fleshy albumen.

Diagnosis.—Small trees, shrubs, or rarely herbs, with opposite usually exstipulate leaves. Calyx superior, 4—5-cleft, persistent. Corolla monopetalous, and bearing commonly as many

FIG. 973.

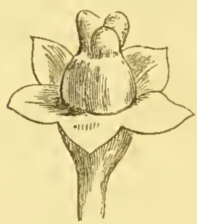


FIG. 974.

FIG. 975.

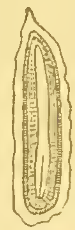


Fig. 973. Pistil of the common Elder (*Sambucus nigra*) surrounded by a superior 5-lobed calyx.——*Fig.* 974. Entire flower of the same.——*Fig.* 975. Vertical section of the seed.

stamens as it has lobes, to which they are alternate; regular or irregular. Ovary inferior, 1—6-celled. Fruit indehiscent. Seeds with fleshy albumen.

Distribution and Numbers.—Chiefly natives of the northern parts of Europe, Asia, and America. They are rare in the southern hemisphere. *Illustrative Genera:*—Lonicera, *Linn.*; Viburnum, *Linn.*; Sambucus, *Linn.* There are about 220 species.

Properties and Uses.—The plants of this order have frequently showy flowers, which are also commonly sweet-scented; hence many are cultivated in our gardens and shrubberies, as Honeysuckles, which are species of *Caprifolium* and *Lonicera*; Guelder Roses (*Viburnum* species), Laurustinus (*Viburnum Tinus*), Snowberry (*Symphoricarpus racemosus*), &c. Some are emetic and purgative; others astringent, sudorific, or diuretic; and some are acrid. A case of poisoning by the berries of the common Honeysuckle has also been recently reported. But the patient (a little boy) recovered; the symptoms resembled those caused by belladonna.

Sambucus nigra, the common Elder.—Several parts of this plant have been long employed in medicine. Its flowers, which are official in the British Pharmacopœia, contain a volatile oil, which renders them mildly stimulant and sudorific. They are chiefly used in the formation of a cooling ointment, and in the preparation of the official Elder-flower Water. The inner bark, buds, and leaves have more or less purgative and emetic properties. The fruit is also mildly aperient and diuretic. It is extensively used for the purpose of adulterating Port-wine, and in the manufacture of Elder Wine. The wood is also employed for making skewers, &c., and the pith in electrical experiments. The flowers of *S. canadensis* have similar properties to those of *S. nigra,* and are official in the United States Pharmacopœia.

Triosteum perfoliatum is a mild purgative and emetic. Its roasted seeds have been used as a substitute for coffee.

Viburnum.—*V. Lantana*, the Mealy Guelder Rose, or Wayfaring Tree, has a very acrid inner bark. It is sometimes considered as a vesicant.—*V. Opulus*, the Guelder Rose, is commonly regarded as emetic and cathartic.—*V. cassinoides.* The leaves of this plant, mixed with those of *Prinos glaber*, are employed in North America as a substitute for Tea, under the name of Appalachian Tea (see *Prinos*). The black fruits of the Himalaya species are edible and agreeable.

Order 2. RUBIACEÆ, the Madder Order.—Character.—*Trees, shrubs,* or *herbs. Stems* rounded or angular. *Leaves* simple, entire, and either opposite and with interpetiolar stipules (*fig.* 382), or whorled and exstipulate (*fig.* 286). (*Although practically we speak of whorled exstipulate leaves, the whorls of apparent*

FIG. 976. FIG. 977. FIG. 978. FIG. 979.

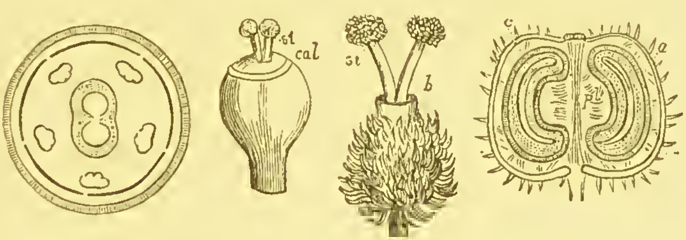


Fig. 976. Diagram of the flower of the Madder (*Rubia tinctorum*).——*Fig.* 977. Pistil of the Madder, with its ovary adherent to the calyx, *cal.* *st.* Styles and stigmas.——*Fig.* 978. Pistil of the Goose-grass or Cleavers (*Galium Aparine*) adherent to the calyx, *b*, by its ovary. *st.* Styles.——*Fig.* 979. Vertical section of the fruit and seeds of the same. *a.* Albumen. *c.* Embryo. *pl.* Placenta.

leaves are in reality partly formed of leaves and partly of stipules which resemble the true leaves in appearance.) *Inflorescence* cymose. *Calyx* superior (*figs.* 977, *cal*, and 978, *b*), with the limb 4—6-toothed or entire, or obsolete. *Corolla* epigynous, monopetalous, regular, tubular or rotate, with its lobes corresponding in number to the teeth of the calyx when the latter is divided ; *æstivation* valvate (*fig.* 976). *Stamens* inserted upon the corolla and equal in number to, and alternate with, its lobes (*fig.* 976). *Ovary* inferior (*figs.* 977 and 978), crowned by a disk, usually 2-celled (*fig.* 976) or sometimes more; *style* 1 or 2 (*figs.* 977 and 978, *st*) ; *stigma* simple or divided. *Fruit* inferior, 2-celled or rarely more, dry or succulent, indehiscent or separating into two or more dry cocci. *Seeds* 1 (*fig.* 979), 2, or more, in each cell ; when few they are erect or ascending, or when numerous, then attached to axile placentas ; *embryo* small, in horny albumen (*fig.* 979, *a*).

Diagnosis.—Trees, shrubs, or herbs, with opposite simple entire leaves, interpetiolar stipules, and rounded stems ; or with whorled exstipulate leaves, and angular stems. Calyx superior. Corolla regular, epigynous, with its lobes valvate. Stamens equal in number to the teeth of the calyx and segments of the corolla, with the latter of which they are alternate, epipetalous. Ovary inferior, 2- or more celled, with an epigynous disk ; ovules anatropous. Fruit inferior. Seeds 1 or more in each cell, with horny albumen.

Division of the Order and Illustrative Genera.—This order was separated by Lindley into two orders, the *Cinchonaceæ* and the *Galiaceæ* or *Stellatæ*, an arrangement formerly adopted by us, but now abandoned as not in accordance with the more generally accepted views of botanists. The Galiaceæ of Lindley were more especially distinguished from the Cinchonaceæ by their whorled exstipulate leaves and angular stems. The order Rubiaceæ is now divided by Hooker and Bentham into three series, each of which is again divided into sub-series and tribes. The Galiaceæ of Lindley are natives of the northern parts of the northern hemisphere, and the mountains of the southern ; while the Cinchonaceæ are almost exclusively natives of tropical and warm regions. There are about 3,000 species in the Rubiaceæ as defined above. *Illustrative Genera :* —Galium, *Linn.* ; Cinchona, *Linn.* ; Ixora, *Linn.*

Properties and Uses.—The properties of the plants of this extensive order are very important to man, furnishing him with many valuable medicinal agents, as well as substances useful in the arts and domestic economy. Thus many possess tonic, febrifugal, astringent, emetic, or purgative properties ; some are diuretic and emmenagogue ; a few are valuable dyeing and tanning agents ; and others have edible fruits and seeds. Some are reputed to possess intoxicating, and in rare cases even poisonous, properties. Various species are also cultivated in our stoves on account of the beauty and fragrance of their flowers.

Cephaëlis Ipecacuanha.—The root of this plant, which is a native of Brazil and New Granada, is termed *annulated Ipecacuanha.* In Brazil, this, as well as other emetic roots, are known under the same name, *Poaya.* The Ipecacuanha plant has become somewhat scarce in Brazil, but is now being cultivated in India, but hitherto not with much success. It is the official Ipecacuanha of the British, Indian, and United States Pharmacopœias. It contains an alkaloid called *emetine,* to which its properties are principally due. Ipecacuanha possesses emetic and purgative properties in large doses, and in small doses it is expectorant and diaphoretic. It is also sedative.

Cinchona.—The plants of this genus are natives exclusively of the intertropical valleys of the Andes, and principally on the eastern face of the Cordilleras, growing commonly at heights varying from about 4,000 to nearly 12,000 feet above the level of the sea. The Cinchona region extends from Santa Cruz de la Sierra, in Bolivia, about 19° S. lat., through Peru and Columbia, nearly to Caracas, in about 10° of N. lat. The Cinchonas are small shrubs, or large forest trees, with opposite evergreen leaves, and commonly showy flowers. The bark of several species and varieties is extensively imported into this country, under the names of *Cinchona*, *Peruvian*, or *Jesuits' Bark.* Some few years since, in consequence of the great destruction of Cinchona trees in South America, and from no care being taken to replace them, it was feared that in a short time our supply of this most valuable bark would have seriously fallen off, or even entirely failed; but, thanks to the energetic labours of Messrs. Markham, Spruce, McIvor, Wilson, and others, the more valuable species have been transported to India, Jamaica, Java, and elsewhere, and are now cultivated in these countries (more especially in India and Java) over large areas, with great success, so that we need no longer fear any deficiency of supply in future years. A large number of commercial varieties of Cinchona barks have been described by Pereira, Weddell, Howard, and others, for a description of which we must refer to works on Materia Medica. About fifteen species of *Cinchona* are known to yield commercial barks, and of these, four are especially mentioned in the British Pharmacopœia; which are the only ones we have space to refer to here. They are *C. Calisaya*, Weddell; *C. officinalis*, Linn.; *C. succirubra*, Pavon; and *C. lancifolia*, Mutis. Of these species, the first three respectively yield the formerly official Yellow Cinchona Bark, Pale Cinchona Bark, and Red Cinchona Bark, and from the latter species is derived the bark which is commonly known as Coquetta Bark. In the British Pharmacopœia of 1885, Red Cinchona Bark, from cultivated plants, is alone official for the ordinary preparations of that volume, but any kind of Cinchona Bark may be used for the preparation of the official salts of the alkaloids. Several alkaloids have been described as constituents of the different kinds of Cinchona barks in varying proportions; but by far the more important are *Quinine*, *Cinchonine*, and *Cinchonidine*. Some salts of all of these are now official in the British Pharmacopœia, and although those of quinine are generally regarded as the most valuable of them all, they are all more or less used in medicine, and possess, in an eminent degree, antiperiodic, febrifugal and tonic properties. The barks themselves, in addition to such properties, are also somewhat astringent, and in some cases have been found to be efficacious as topical astringents and antiseptics.

Coffea arabica, the Coffee Plant.—The seeds of this plant, when roasted, are used in the preparation of that most valuable unfermented beverage—*coffee.* When roasted, coffee essentially consists of the albumen of the seed. Coffee owes its properties chiefly to the presence of *caffeine*, which is identical with *theine* (see *Thea*, p. 472), and to a volatile oil. About 40 millions of pounds are annually consumed in this country, and the consumption for the whole world has been estimated at about 1,200 millions of pounds. Caffeine and its Citrate are official in the British Pharmacopœia, as already noticed under the head of *Thea.* In Sumatra and some of the adjoining islands, an infusion of the roasted leaves is used as a substitute for Tea, under the name of Coffee-Tea. The leaf contains similar ingredients to the seeds, and possesses therefore analogous properties. Medicinally, coffee has been also used with frequently beneficial effects as a nervine stimulant and astringent. In its effects and uses it closely resembles tea, but its astringent action is much less. Besides *C. arabica*, the seeds of other species have similar properties; thus, *C. mauritiana* of Bourbon and Mauritius, *C. zanguebarica* of Mozambique, and especially *C. liberica*, a native of the West Coast of Africa. This last species is now largely cultivated, and becoming a very important source of coffee; it bids fair to supplant *C. arabica* in many tropical countries. It is a larger and more robust plant, and flourishes at a lower elevation; and the seeds are larger and of a finer flavour. It affords the kind of coffee known as *Liberian* or *Monrovian*.

Coprosma.—The fruits of *C. microphylla* and other species are eaten in Australia, where they are called Native Currants. In New Zealand the leaves of *C. fœtidissima* are used by the priests to discover the will of the gods.

Galium.—*G. Aparine*, Goose grass or Cleavers.—The inspissated juice or extract of this plant has been used with success in lepra and some other cutaneous diseases. Its roasted seeds have been employed as a substitute for coffee. The extracts of *G. rigidum* and *G. Mollugo* have been used with beneficial results in epilepsy.

Gardenia.—From the fruits of *G. grandiflora*, *G. florida*, and *G. radicans* beautiful yellow dyes are prepared, which are extensively employed in China and Japan.—*G. lucida* and *G. gummifera*, natives of India, yield a resinous exudation, which is said to be antispasmodic.

Genipa.—The fruit of some species is edible; that of *G. americana*, the Lana tree, is the *Genipap* of South America. In British Guiana a bluish-black dye, called Lana dye, is prepared from the juice of the fruit. The fruits of *G. brasiliensis* also furnish a violet dye.

Guettarda speciosa.—This plant is said by some to furnish the Zebra-wood of cabinet makers, but, according to Schomburgk, this is obtained from *Omphalobium Lamberti*, a native of Guiana. (See *Omphalobium.*) *Tortoise-wood* is also sometimes considered to be derived from a variety of *G. speciosa.*

Morinda.—The roots of *M. citrifolia* and *M. tinctoria* are used in India and some other parts of Asia for dyeing red. They have been occasionally imported into this country, under the names of Madder, Munjeet, and Chay-root; but such names are improperly applied to them. (See *Oldenlandia* and *Rubia.*) The flowers of species of *Morinda* are also employed in India for dyeing, mixed with those of *Grislea tomentosa.* (See *Grislea.*)

Oldenlandia umbellata.—The root is occasionally imported from India under the name of *Chay* or *Che* root. (See *Morinda.*) It is employed to dye red, purple, and orange-brown. The colouring matter is confined to the bark.

Palicurea densiflora, a native of Bolivia, &c., is stated to yield the bark now known in commerce as 'Coto Bark,' and which is reputed to be a valuable remedy in diarrhœa, rheumatism, gout, &c. It is said to owe its active properties to a peculiar crystalline substance named *cotoin.* Nothing certain, however, is known of the botanical source of Coto Bark. Moreover, other barks under the same name are now found in commerce, one of which is termed Paracoto Bark.

Psychotria.—The root of *P. emetica* is called *black* or *large striated Ipecacuanha.* It is occasionally imported, but not used in this country. It would appear that there are two spurious kinds of Ipecacuanha which have been described under the name of *Striated*,—one being derived from this plant; but the botanical source of the other, which is known as *small striated Ipecacuanha*, is undetermined, although doubtless from one nearly allied to it—according to Planchon, a species of *Richardsonia.* Both of these kinds possess emetic properties like the roots of *Cephaëlis Ipecacuanha* and *Richardsonia scabra*, but they are far less active. They contain *emetine.* The roasted seeds of *P. herbacea* have been used as a substitute for coffee.

Remijia.—From the barks of *R. pedunculata*, *R. Purdieana*, and probably other species, which are known in commerce as Cuprea barks, salts of quinine and cinchonine may be obtained, and also the peculiar alkaloids cupreine and homoquinine. The barks of species of *Remijia* are official in the British Pharmacopœia as a source of the salts of quinine and cinchonine.

Richardsonia scabra.—The root is emetic. It contains the same active principle (namely, *emetine*) as that of the official *annulated Ipecacuanha root*, from *Cephaëlis Ipecacuanha*, but it is not so active. It is commonly known as *undulated, white*, or *amylaceous Ipecacuanha*. It is not used in this country.

Rubia.—R. tinctorum.—The dried root is known under the name of Madder, and is one of the most important of vegetable dyes. It is largely cultivated in France, Holland, and other countries. In France it is known under the name of *Garance*. In the Levant, *R. peregrina* is also cultivated, and yields Levant Madder; the roots are also called *Turkey-roots* in commerce. Madder is imported in two forms, namely, entire, and in a ground state. There are four kinds of Dutch Madder, known respectively as *crop* (the best), *ombro, gamene*, and *mull* (the worst). In the living state, madder-root only contains a yellow colouring principle, called *rubian*; but no fewer than five colouring matters have been obtained from the root of commerce, called respectively *madder purple* (*purpurin*), *red* (*alizarin*), *orange, yellow*, and *brown*; it would appear, therefore, that these latter must be all derived from the single yellow colouring principle. *Alizarin* is by far the most valuable of these colouring substances. Besides its use as a dyeing material, Madder was long employed in medicine as a tonic and diuretic, and was also regarded as a valuable emmenagogue; its virtues, however, as a medicine are very trifling, and it is no longer employed by the medical practitioner. Besides the roots of *R. tinctorum* and *R. peregrina*, those of other species are likewise employed in different parts of the world for dyeing: thus, the roots of *R. cordifolia* or *Munjista*, a native of the East Indies, are used in Bengal, &c., and are occasionally imported into this country under the name of *munjeet*. The roots of *R. Relbun* are also employed in Chili for dyeing.

Sarcocephalus esculentus (*Cephalina esculenta*).—The fruit is the Sierra Leone Peach. The bark is said to have astringent, tonic, and febrifugal properties.

Uncaria Gambier.—An extract prepared from the leaves and young shoots of this plant constitutes the kind of Catechu which is known in commerce as *Gambir, Gambier, Pale Catechu*, and *Terra Japonica*, and by druggists as *Catechu in square cakes*; it is official in the British Pharmacopœia, and Pharmacopœia of India. Catechu is one of the most powerful of astringents, and is extensively employed in tanning and dyeing, and also in medicine; it is also largely consumed in the East, as it forms one of the ingredients in the famed masticatory called *Betel.*—*U. acida*, probably only a variety of the preceding, also appears to yield a portion of the Gambier of commerce.

Cohort 2. *Asterales.*—Stamens epipetalous and alternate with the lobes of the corolla when equal to them in number. Ovary 1-celled; ovule solitary. Fruit dry and indehiscent. Seeds usually exalbuminous, but sometimes albuminous. Leaves exstipulate.

Order 1. VALERIANACEÆ, the Valerian Order.—Character.—*Herbs. Leaves* opposite, exstipulate. *Flowers* cymose, hermaphrodite (*figs.* 494 and 495) or rarely unisexual. *Calyx* superior (*figs.* 494, *c*, and 980, *ca*), with the limb obsolete, membranous, or pappose. *Corolla* epigynous, monopetalous (*figs.* 494 and 495), tubular, imbricate, 3—6-lobed, regular or irregular, sometimes spurred at the base (*fig.* 495). *Stamens* 1—5, distinct, fewer than the lobes of the corolla, and inserted in its tube (*figs.* 494 and 495). *Ovary* inferior (*fig.* 980), with

1 fertile cell, and usually 2 abortive or empty ones. *Fruit* dry and indehiscent, frequently pappose (*fig.* 467). *Seed* solitary, suspended, exalbuminous ; *radicle* superior.

FIG. 980.

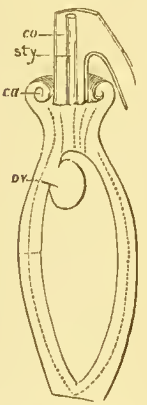


Fig. 980. Vertical section of the ovary, &c., of the Red Valerian (*Centranthus ruber*). *ca.* Calyx. *co.* Corolla. *sty.* Style. *ov.* Ovule.

Distribution and Numbers.—Chiefly natives of the temperate parts of Europe, Asia, and America ; they are rare in Africa. *Illustrative Genera:* — Centranthus, *DC.* ; Valeriana, *Linn.* There are about 190 species.

Properties and Uses. — They are chiefly remarkable for the presence of a strong-scented volatile oil, which renders them stimulant, antispasmodic, and tonic. Some are highly esteemed in the East as perfumes, but they are not generally considered agreeable by Europeans.

Nardostachys Jatamansi is commonly regarded as the *Nardus indicus*, the true Spikenard of the ancients. It is the *Nard* of the Hebrews, and the *Nardos* of the Greeks. It is much esteemed in India both as a perfume and as a remedial agent in epilepsy and hysteria. In some districts, as Leh, its chief use is for incense.

Valerianella olitoria.—The young leaves are occasionally used as a salad both on the Continent and in England. In France they are known under the name of *Mâche*, and in England by that of *Lamb's Lettuce*.

Valeriana.—The rhizome and rootlets of *V. officinalis* form the official Valerian of the British Pharmacopœia. Valerian is much employed as a nervine tonic, stimulant, and antispasmodic. The roots of *V. Dioscoridis*, *V. Phu*, *V. celtica*, *V. Hardwickii*, *V. sitchensis*, and other species, have similar properties. *V. sitchensis* is most esteemed in Russia.

Order 2. DIPSACEÆ, the Teazel Order.—Character.—*Herbs* or *undershrubs*. *Leaves* opposite or verticillate, exstipulate. *Flowers* in dense heads (capitula) (*fig.* 428), surrounded by an involucre. *Calyx* (*fig.* 982) superior, with a membranous or pappose limb, and surrounded by an involucel. *Corolla* (*fig.* 982) tubular, epigynous, monopetalous, the limb 4—5-lobed, generally irregular (*figs.* 428 and 982), and with an imbricate æstivation. *Stamens* 4, epipetalous (*fig.* 982) ; *anthers* distinct. *Ovary* inferior (*fig.* 982), 1-celled ; *ovule* solitary (*fig.* 982), pendulous ; *style* and *stigma* simple. *Fruit* dry, indehiscent, and surmounted by the pappose calyx (*figs.* 468 and 981). *Seed* with fleshy albumen ; *embryo* straight ; *radicle* superior.

Distribution and Numbers.—Chiefly natives of the South of Europe, and of North and South Africa. A few species are found in this country. *Illustrative Genera:*—Dipsacus, *Tourn.* ; Scabiosa, *Linn.* There are about 170 species.

Properties and Uses.—Some are reputed to possess astringent and febrifugal properties, but as remedial agents they are altogether unimportant. *Dipsacus Fullonum* is, however, an important economical species.

Dipsacus Fullonum, Fuller's Teazel.—The dried capitula are used by fullers in dressing cloth, for which they are well adapted, as their hard

FIG. 981.

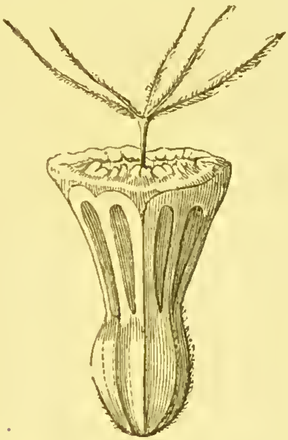


FIG. 982.

Fig. 981. Fruit of *Scabiosa purpurea*, surmounted by the pappose calyx.——*Fig.* 982. One of the central florets of the capitulum of *Scabiosa purpurea*, with the ovary, &c., cut vertically.

stiff hooked bracts raise the nap, without tearing the stuff like metal instruments. In 1860 no less than 20,000,000 teazels were imported into this country from France.

Scabiosa succisa is called the Devil's-bit Seabious, on account of its abruptly terminated rhizome or root. It is said to be astringent, and to yield a green dye. The inflorescence sometimes develops in an umbellate manner, as in a specimen described by the author in the *Pharmaceutical Journal*, ser. i. vol. xvii. p. 363, thus exhibiting a marked deviation from the development in capitula which is the ordinary arrangement in the plants of this order.

Order 3. CALYCERACEÆ, the Calycera Order.—Character.—*Herbs. Leaves* alternate, exstipulate. *Flowers* in capitula, surrounded by an involucre. *Calyx* superior, irregular, 5-lobed. *Corolla* epigynous, monopetalous; regular, valvate, 5-lobed. *Stamens* 5, epipetalous; *filaments* monadelphous; *anthers* partially united. *Ovary* inferior, 1-celled; *ovule* solitary, pendulous. *Fruit* indehiscent. *Seed* solitary, pendulous, with fleshy albumen; *radicle* superior.

Diagnosis.—These plants hold an intermediate position between Dipsaceæ and Compositæ, being distinguished from the former by their alternate leaves, absence of involucel to their individual florets, valvate æstivation of corolla, monadelphous filaments, and partially united anthers; and from the Compositæ in their anthers being only partially united, and in their pendulous albuminous seed, and superior radicle.

Distribution and Numbers.—Exclusively natives of South America, especially the cooler parts. *Illustrative Genera:*—

Calycera, *Cavan.*; Leucocarpus, *Don.* There are about 20 species.

Properties and Uses.—Unknown.

Order 4. COMPOSITÆ, the Composite Order.—Character. *Herbs* or *shrubs*. *Leaves* alternate or opposite, exstipulate. *Flowers* (florets) hermaphrodite (*figs.* 983–985), unisexual (*fig.* 491) or neuter, arranged in capitula (*figs.* 427 and 444), which are commonly surrounded by an involucre formed of a number of imbricate bracts (*phyllaries*) (*fig.* 399); the separate florets are

FIG. 983.

FIG. 984.

FIG. 985.

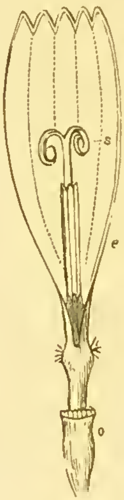


FIG. 986.

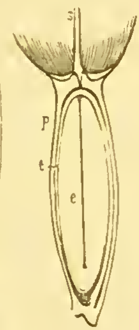


Fig. 983. Labiate floret of *Chælanthera linearis*. *o.* Ovary with adherent calyx. *t.* Tube of the corolla. *l s.* Upper lip of the corolla. *l i.* Lower lip. *e.* Tube formed by the united anthers. *s.* Stigmas.——*Fig.* 984. Vertical section of the floret of *Aster rubricaulis*. *o.* Ovary containing one erect ovule *a.* Pappose limb of the calyx. *p.* Corolla. *s.* Style. *e.* Tube formed by the united anthers.——*Fig.* 985. Floret of the Chicory (*Cichorium Intybus*). *o.* Ovary with adherent calyx. *e.* Tube formed by the united anthers. *s.* Stigmas.——*Fig.* 986. Vertical section of the ripe fruit of the Groundsel (*Senecio*), surmounted by a portion of the style, *s.*; and the pappose limb of the calyx. *p.* Pericarp. *t.* Testa. *e.* Seed. The above figures are from Jussieu.

also frequently furnished with membranous or scale-like bractlets (*paleæ*) (*fig.* 404, *b*, *b*). *Capitula* developing successively in a centrifugal order (*fig.* 444). *Calyx* superior (*figs.* 983–985), its limb either entirely abortive (*fig.* 465) or membranous (*fig.* 466); in the latter case it is entire, toothed, or pappose—that is, divided into bristles, or simple, branched, or feathery hair-like processes (*fig.* 984, *a*). *Corolla* epigynous, monopetalous (*figs.* 983–985), tubular (*fig.* 465), ligulate (*fig.* 985), or bilabiate (*fig.* 983), 4—5-toothed, with a valvate æstivation. *Stamens* (*figs.* 983–985, *c*)

5 or rarely 4, inserted on the corolla, and alternate with its divisions; *filaments* distinct or monadelphous; *anthers* united into a tube (*syngenesious* or *synantherous*) (*fig.* 548), which is perforated by the style and stigmas (*fig.* 985). *Ovary* inferior, 1-celled, with 1 erect ovule (*fig.* 984, *o*); *style* 1, undivided below, and commonly bifid above (*fig.* 987); *stigmas* 2, one being usually placed on the inner surface or margins of each division of the style (*figs.* 983, *s*, 985, *s*, and 987). *Fruit* a cypsela, dry, indehiscent, 1-celled, crowned by the limb of the calyx, which is often pappose (*fig.* 986). *Seed* (*fig.* 986, *e*) solitary, erect, exalbuminous; *radicle* inferior.

Diagnosis. — Herbs or shrubs, with exstipulate leaves. Flowers (called florets) arranged in capitula, which are

Fig. 987.

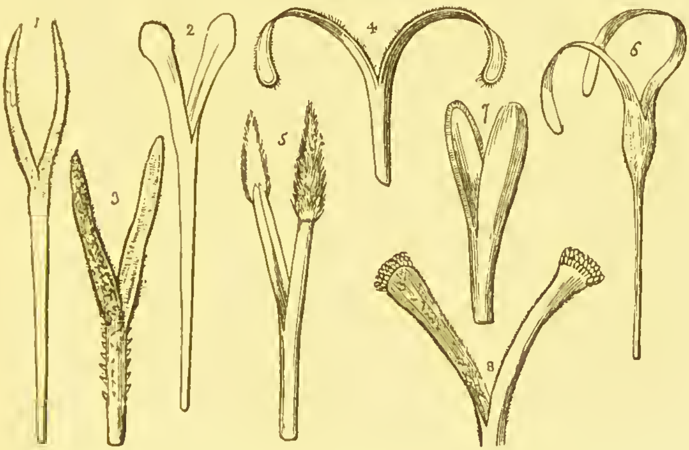


Fig. 987. Styles and stigmas of Composite Flowers to illustrate De Candolle's tribes, after Heyland and Lindley. 1. *Albertinia erythropappa* (Vernonieæ). 2. *Anisochæta mikanioides* (Eupatorieæ). 3. *Blumea senecioides* (Asteroideæ). 4. *Mendezia bicolor* (Senecioideæ). 5. *Lipochæta umbellata* (Senecioideæ). 6. *Aplotaxis nepalensis* (Cynareæ). 7. *Leucomeris spectabilis* (Mutisieæ). 8. *Leuceria tenuis* (Nassauvieæ).

commonly surrounded by an involucre. Capitula developed successively in a centrifugal manner. Calyx superior, its limb abortive, or membranous, or pappose. Corolla epigynous, monopetalous, 4—5-toothed, with a valvate æstivation. Stamens epipetalous, equal in number to the divisions of the corolla (generally 5), and alternate with them; anthers syngenesious. Ovary inferior, 1-celled, with 1 erect ovule, and having but one coat; style simple, bifid above, with stigmatic branches. Fruit 1-celled, dry, indehiscent. Seed solitary, erect, exalbuminous; radicle inferior.

Division of the Order and Illustrative Genera.—This order has been variously divided by authors. By Linnæus, the plants of his class Syngenesia, division Polygamia (which corresponded to the Natural Order Compositæ as above defined), were arranged in five orders, under the names of *Polygamia æqualis*, *P. superflua*, *P. frustranea*, *P. necessaria*, and *P. segregata*. The characters of these have been already stated at page 412. Jussieu separated the Compositæ into three sub-orders as follows :—1. *Corymbiferæ*, the plants of which have either all tubular (*flosculous*) and perfect florets ; or those of the disk (centre) tubular and perfect, and those of the ray (circumference) tubular and pistilliferous, or ligulate (radiant). 2. *Cynarocephalæ*, the florets of which are all tubular and perfect ; or those in the centre perfect, and those of the ray neuter. And 3. *Cichoraceæ*, having all the florets ligulate and perfect. A fourth sub-order was afterwards added, called *Labiatifloræ*, which includes those plants the florets of which were bilabiate, and which were unknown to Jussieu. The arrangement most frequently adopted at the present day is that of De Candolle ; this was founded on that of Lessing. It is as follows :—

Sub-order 1. TUBULIFLORÆ.—Florets all tubular and perfect ; or those of the centre (*disk*) are tubular, and alone perfect, while those of the circumference (*ray*) are tubular or ligulate, and pistillate or neuter; juice watery. This sub-order includes the Corymbiferæ and Cynarocephalæ of Jussieu. It has been divided into five tribes as follows :—

Tribe 1. *Vernonieæ*.—Style cylindrical ; its arms generally long and subulate, sometimes short and blunt, always covered all over with bristles (*fig.* 987, 1). *Illustrative Genera :*—Vernonia, *Schreb.* ; Elephantopus, *Linn.*

Tribe 2. *Eupatorieæ*.—Style cylindrical ; its arms long and somewhat clavate, with a papillose surface on the outside near the end (*fig.* 987, 2). *Illustrative Genera :*—Eupatorium, *Tourn.* ; Tussilago, *Tourn.*

Tribe 3. *Asteroideæ*.—Style cylindrical ; its arms linear, flat on the outside, equally and finely downy on the inside (*fig.* 987, 3). *Illustrative Genera :*—Erigeron, *Linn.* ; Bellis, *Linn.*

Tribe 4. *Senecioideæ*.—Style cylindrical, its arms linear, fringed at the point, generally truncate, but sometimes extended beyond the fringe into a short cone or appendage of some kind (*fig.* 987, 4 and 5). *Illustrative Genera :*—Anthemis, *Linn.* ; Senecio, *Linn.*

The above four tribes correspond to the sub-order Corymbiferæ of Jussieu ; the next or fifth tribe to the Cynarocephalæ of the same author.

Tribe 5. *Cynareæ*.—Style thickened above, and often with a bunch or fringe of hairs at the enlarged portion ; its branches united or free (*fig.* 987, 6). *Illustrative Genera :*—Arctium, *Linn.* ; Centaurea, *Linn.*

Sub-order 2. LABIATIFLORÆ.—Florets with bilabiate corollas, perfect or unisexual. Juice watery. Of this sub-order we have two tribes :—

Tribe 6. *Mutisieæ.*—Style cylindrical or somewhat swollen ; its arms usually blunt or truncate, very convex on the outside, and either covered at the upper part by a fine uniform hairiness, or absolutely free from hairs (*fig.* 987, 7). *Illustrative Genera* :—Mutisia, *Linn. fil.* ; Printzia, *Cass.*

Tribe 7. *Nassauvieæ.*—Style never swollen ; its arms long, linear, truncate, and fringed only at the point (*fig.* 987, 8). *Illustrative Genera* :—Nassauvia, *Juss.* ; Trixis, *R. Br.*

Sub-order 3. Liguliforæ.—Florets all ligulate and perfect. Juice milky. This corresponds to the Cichoraceæ of Jussieu.

Tribe 8. *Cichoreæ.*—Style cylindrical at the upper part ; its arms somewhat obtuse, and equally pubescent. *Illustrative Genera* :—Cichorium, *Linn.*; Taraxacum, *Haller*. Of these sub-orders the Liguliforæ is the best defined.

By Bentham and Hooker the Compositæ are divided into thirteen tribes.

Distribution and Numbers.—Universally distributed ; but the Tubulifloræ are most abundant in hot climates, and the Liguliforæ in cold. The Labiatifloræ are almost entirely confined to the extra-tropical regions of South America. In the northern parts of the world the plants of this order are universally herbaceous ; but in South America and some other parts of the southern hemisphere, they occasionally become shrubby, or even in some cases arborescent. Some years since there were about 9,500 species according to M. Lasègue, who remarks 'that they have steadily continued to constitute about one-tenth of all described plants in proportion as our knowledge of species has advanced. Thus Linnæus had 785 Composites out of 8,500 species ; in 1809 the proportion was, 2,800 to 27,000 ; De Candolle described 8,523 in the year 1838, which was again a tenth ; and now (1845) that the estimate of species has risen to 95,000, Composite plants amount to 9,500.' Lindley calculated the order to contain about 9,000 species ; but Bentham and Hooker have reduced it to about 1,000 genera and 8,000 species.

Properties and Uses.—The properties of the Compositæ are very variable. A bitter principle pervades the greater number of the species in a more or less evident degree, by which they are rendered tonic. Some are laxative and anthelmintic. Many contain a volatile oil, which communicates aromatic, carminative, and diaphoretic properties. Others are acrid stimulants, and the Liguliforæ commonly abound in a bitter-tasted milky juice, which is sometimes narcotic.

Sub-order 1. Tubulifloræ.—The plants of this sub-order are chiefly remarkable for their bitter, tonic, and aromatic properties ; which are due to the presence of a bitter principle, and a volatile oil. Some are esculent vegetables.

Achillæa Millefolium, Yarrow or Milfoil, was formerly extolled as an excellent vulnerary and styptic. It is regarded in the United States of America, where the leaves and flowering tops are official, as tonic, stimulant, sudorific, and antispasmodic. In the form of a warm infusion they are also emetic. According to Linnæus, this plant was employed in his time in Sweden to increase the intoxicating properties of beer. Formerly it had a high reputation as a vulnerary; hence its name of Nose-bleed.—*A. moschata* is known in Switzerland as 'Forest Lady's Herb,' and has been used there for centuries as a stomachic tonic. It is also termed 'Iva.'

Anacyclus.—*A. Pyrethrum*, Pellitory of Spain.—The root is official in the British Pharmacopœia; it is employed as an energetic local irritant and sialagogue, in toothache, relaxation of the uvula, &c.—*A. officinarum* of Hayne, German Pellitory, has similar properties. The root is commonly used in Germany.

Anthemis nobilis, Chamomile or Camomile.—This plant is extensively cultivated for the sake of its flower-heads, which are official in the British Pharmacopœia, and much employed internally for their stimulant, tonic, and antispasmodic properties; and also externally for fomentations. These properties are due to a bitter principle (*anthemic acid*), and a volatile oil. The flowers constitute the Roman or True Chamomiles of the Materia Medica. The oil of Chamomile is also much used as a remedy in flatulence, and as an addition to purgative pills to prevent their griping action. It is official in the British Pharmacopœia.—*A. Cotula*, Mayweed, has similar properties, but its disagreeable odour is an obstacle to its more general use.

Aplopappus discoideus, DC, is said to be the source of a kind of *Damiana*, a drug used in the United States and elsewhere as an aphrodisiac. (See *Turnera.*)

Aplotaxis Lappa (*Aucklandia Costus*).—The root of this plant, which is a native of Cashmere, is said by Falconer to be the *Costus* of the ancients. It is chiefly used as a perfume, and for burning as incense. It is also employed by the Chinese as an aphrodisiac.

Arctium Lappa.—The root is employed in the United States in gouty, rheumatic, scrofulous, and other affections, and is reputed to be aperient, diuretic, and diaphoretic.

Arnica montana, Mountain Arnica, Mountain Tobacco, or Leopard's-bane, is an acrid stimulant. The flowers and rhizome have been employed in typhoid fevers, amaurosis, paralysis, &c. It is termed on the Continent *Panacea lapsorum*, from the power it possesses of absorbing tumours and destroying the effects of bruises, when applied externally. Arnica rhizome and rootlets are official in the British Pharmacopœia.

Artemisia.—*A. Absinthium.*—The dried herb, or the flowering tops, under the name of *Wormwood*, is used as an aromatic bitter tonic, and as an anthelmintic. The tops and leaves are official in the United States Pharmacopœia. They are also employed in the preparation of some liqueurs; particularly of one now very largely consumed in France under the name of 'absinthe,' the excessive use of which is attended with such injurious effects, that they have been designated under the name of *absinthism*. Although doubtless these effects are mainly due to the alcohol which it contains, they appear to be also in some degree attributable to a volatile oil which the wormwood contains.—*A. chinensis.*—According to Lindley, the Chinese and Japanese *moxas* are prepared from the cottony or woolly covering of the leaves of this and other species.—*A. Dracunculus* is Tarragon, the leaves of which are sometimes used in pickles, salads, &c.—*A. maritima*, var. *Stechmanniana* of Besser (*A. pauciflora*, Weber), is the principal, if not the only source of the official Santonica of the British Pharmacopœia. Santonica is the produce of Turkestan, and is known as Levant or Alexandrian

Wormseed. It comes to England by way of Russia. The official part is the dried unexpanded flower-heads. Santonica owes its properties essentially to the presence of a crystalline neutral principle called *santonin*, which is also official in the British Pharmacopœia. Both santonica and santonin are valuable anthelmintics. Another kind of wormseed, very inferior to the above, has been described by pharmacologists under the name of Barbary Wormseed. Wormseed is also known by the names of *Semen Santonici*, *Semen Contra*, *Semen Cynæ*, &c.

Berthelotia lanceolata or *indica*, a native of India, has aperient leaves, which are said to be a good substitute for the official senna.

Blumea grandis or *balsamifera*, a common weed in the Tenasserim provinces of the Burman Empire, yields a kind of camphor. It is also in use in China. It is known as *Blumea* or *Ngai Camphor*. In China it is used in medicine, and for perfuming the finer kinds of Chinese ink.

Calendula officinalis, the Marigold, has yellow florets, which are sometimes employed to adulterate saffron. A strong tincture of the flowers, applied externally to wounds, is said to have a similar effect to that of Arnica.

Carduus, the Thistle.—Some species of this genus, particularly *C. benedictus*, have been used as tonics and febrifuges.

Carthamus.—*C. tinctorius*, Safflower or Bastard Saffron.—The florets are used in the preparation of a beautiful pink dye. The *pink saucers* of the shops are coloured by it. It is also largely employed in the manufacture of *rouge*. Safflower is sometimes used to adulterate *hay saffron*. The substance called *cake saffron* is prepared from it and mucilage. (See *Crocus*.) The fruits, which are commonly called seeds, yield by expression a large quantity of oil, which is known in India under the name of *Koosum Oil*. It is used principally for burning. The fruits are also purgative, and are employed in dropsy. The fruits of *C. persicus* also yield a useful oil.

Cynara.—*C. Scolymus.*—The young succulent receptacles of this plant are used for food, under the name of Artichokes. The edible Cardoons are the blanched stalks of the inner leaves of *Cynara Cardunculus*.

Erigeron, Fleabane.—The leaves and tops of *E. heterophyllum* and *E. philadelphicum* are official in the United States Pharmacopœia. Fleabane possesses diuretic properties, and is much used in gravel and other nephritic complaints. The leaves and tops of *E. canadense*, Canadian Fleabane, are likewise official in the United States Pharmacopœia, and are reputed to be tonic, astringent, and diuretic. The oil which is obtained from them is also esteemed as an internal remedy in uterine and other hæmorrhages.

Eupatorium.—*E. glutinosum.*—The leaves of this plant constitute one of the substances known as Matico in South America, the different kinds of which are employed as styptics. The official matico of this country is, however, derived from *Piper angustifolium* (*Artanthe elongata*), a plant of the Nat. Ord. Piperaceæ. (See *Piper*).—*E. ayapana* and *E. perfoliatum* have been employed as antidotes to the bites of venomous reptiles. They are reputed to possess stimulant, tonic, and diaphoretic properties. The leaves and flowering tops of *E. perfoliatum*, Thoroughwort, are official in the United States Pharmacopœia. Other species, such as *E. purpureum* or Gravel Root, *E. teucrifolium*, *E. ageratoides*, *E. aromaticum*, *E. incarnatum*, *E. cannabinum*, and *E. nervosum*, have also been regarded in the United States and elsewhere as of medicinal value.

Grindelia robusta and *G. squarrosa*, Gum Plants or Rosin Weeds.—The dried stems, leaves, and unexpanded flower-heads of these plants, which are natives of California, are reputed to form a remedy of very great value in asthma, when given internally; and when applied externally in the form of an infusion or decoction, a marvellous effect is said to be produced in the cure of the cutaneous eruptions caused by emanations from the *Rhus Toxicodendron*, or Poison-oak. They are official in the United States Pharmacopœia. They are also said to be very useful in hooping-coughs, catarrhs, and bronchitis. Other species, such as *G. hirsuta*, appear to have similar properties, and are frequently substituted for the former in commerce.

Guizotia oleifera is extensively cultivated in India for its seeds, which are known in commerce under the name of Niger seeds. These yield a thin oil, useful in painting, and for burning, and other purposes, which is known in India as Ram-til, Kala-til, Noog, &c. It may be used for the same purposes in pharmacy as sesamum oil and olive oil.

Helianthus.—H. tuberosus.—The tubers are much eaten under the name of Jerusalem Artichokes. The dried fruits have been employed as a substitute for coffee.—*H. annuus* is the common Sunflower. The pith contains nitrate of potassium, and is therefore sometimes used in the preparation of *moxas* in Europe. The fruits have been lately employed as an ingredient in a kind of soap called Sunflower Soap. They yield by expression a fixed oil which is used largely for food in Hungary and Russia, while the oil-cake furnishes an excellent food for cattle.

Inula Helenium, Elecampane.—The root is an aromatic tonic, expectorant and diaphoretic. It has been employed in chronic catarrh, and in dyspepsia. It was also formerly much used in this country as the basis of a favourite sweetmeat.

Liatris odoratissima, Wild Vanilla or Deer's Tongue.—The leaves of this plant, which is abundant in the southern United States, are used largely to give flavour to tobacco and cigars. They would be probably very useful in perfumery. They owe their properties to *coumarin.*. Other species, more especially *L. spicata*, yield the root known as *Button Snakeroot*, which is reputed to be stimulant, diuretic, and expectorant.

Madia.—The seeds of *M. sativa*, a native of Chili, yield by pressure a large amount of fixed oil, which is edible, and the commoner kinds have also been used for illumination. The plant is now cultivated in Asia Minor, Algeria, and the warmer parts of France and Germany. The oil has also the valuable property of not congealing at 19° below zero of Réaumur, hence it is a valuable lubricating agent for delicate machinery.

Matricaria Chamomilla has similar properties to the true Chamomile. The flower-heads are the *Flores Chamomillæ* of German pharmacologists; they are usually distinguished as Common or German Chamomiles.

Mikania.—M. Guaco has been much used as an antidote to the bites of venomous serpents in South America. It appears to me by far the most efficacious of all the plants known under the name of *Guaco*, for reliable testimony has shown that when promptly and properly administered it is a cure for the bites of the most venomous snakes. Guaco has also been highly spoken of as a remedy for gout and rheumatism.

Notonia.—The freshly gathered stems of *N. grandiflora* and *N. corymbosa* are reputed in India to be preventive of hydrophobia.

Pyrethrum.—The insect powders of commerce are the powdered flower-heads of several species of this genus. Thus those of *P. carneum* and *P. roseum* yield Persian Insect Powder; but the most energetic insecticide is the Dalmatian Insect Powder, which is derived from *P. cinerariæfolium*.

Santolina chamæcyparissus, Lavender Cotton, has long had a reputation as a vermifuge in the case of small worms. Its twigs, which have a strong and somewhat agreeable odour, have also been used for placing in wardrobes &c., to drive away moths.

Silphium.—S. laciniatum, a native of North America, is known as the 'Polar Plant' or 'Compass Plant,' because 'the leaves are said to present their faces uniformly north and south.' Sir J. Hooker states that in travelling by rail any alteration in the direction of the road becomes visible at once by the altered appearance of the leaves of the Compass Plant.

Tanacetum vulgare, the common Tansy, possesses tonic and anthelmintic properties.

Tussilago Farfara, Coltsfoot.—This plant is used as a popular remedy in chronic coughs and other pulmonary complaints.

Vernonia anthelmintica.—The seeds are employed in the East Indies as an anthelmintic.

Xanthium spinosum.—The powdered leaves, &c., of this plant are said to be a most efficient remedy in hydrophobia; but they have been found useless when employed by regular practitioners.

Sub-order 2. LABIATIFLORÆ.—There are no very important plants known to belong to this sub-order; but some have been reputed to possess aromatic, mucilaginous, purgative, and tonic properties

Perezia fruticosa.—The root is much esteemed in Mexico as an agreeable and energetic purgative; its native name is 'raiz del pipitzahuac.' An acid of a brilliant golden yellow colour, called *pipitzahoic acid*, has been obtained from it; it is known popularly as 'vegetable gold.'

Printzia aromatica.—The leaves are sometimes employed at the Cape of Good Hope as a substitute for tea.

Sub-order 3. LIGULIFLORÆ.—The plants of this sub-order generally contain a milky juice, which commonly possesses alterative, aperient, diuretic, or narcotic properties. The roots of some are used as esculent vegetables; and other species, by cultivation with diminished light, become edible as salads.

Cichorium.—*C. Intybus*, Chicory.—The Chicory plant is indigenous in this and many other parts of Europe. It is also extensively cultivated for the sake of its roots, which when roasted and powdered are used as a substitute for, or more frequently as an addition to, ground coffee. Above 100 millions of pounds are annually consumed in Europe. In 1865, the consumption in Great Britain alone was about 13 millions of pounds; and it is now calculated that in proportion to that of coffee it is nearly 40 per cent. It does not, however, possess in any degree the peculiar exciting, soothing, and hunger-staying properties of coffee, and its extensive employment is much to be deprecated, as it is not unfrequently attended with injurious effects. The fresh root has been employed in medicine, and is reputed to have somewhat similar properties to that of Dandelion. A blue dye may be prepared from the leaves.—*Cichorium Endivia* is the Endive plant, the blanched leaves of which are used as a salad.

Lactuca.—*L. sativa* is the garden or common Lettuce. It is largely cultivated for use as a salad. As a medicine it possesses to a slight extent sedative, anodyne, and antispasmodic properties.—*Lactuca virosa*, the Wild Lettuce, possesses much more evident anodyne and antispasmodic properties than the common Lettuce. The inspissated juice of both *L. sativa* and *L. virosa* forms Lactucarium or Lettuce Opium, which is employed for its narcotic properties. *L. virosa* yields the best and the largest quantity of Lactucarium. *L. virosa* is official in the British Pharmacopœia. Other species of *Lactuca*, as *L. Scariola* and *L. altissima*, possess similar properties.

Scorzonera.—*S. hispanica* has esculent roots, which are known under the name of Scorzonera, and are much esteemed. The roots of *S. deliciosa* are also much valued in Sicily, where this plant is a native.

Taraxacum officinale (*Taraxacum dens leonis*) is the common Dandelion. The root, which is official in the British Pharmacopœia, is very extensively employed as a medicinal agent. It is commonly regarded as possessing aperient, diuretic, and alterative properties. It contains a bitter crystalline principle, called *Taraxacin*, to which it seems principally to owe its properties. When roasted, it has sometimes been employed as an addition to coffee, in the same manner as Chicory root. The leaves, when very young and grown in the dark, are sometimes used on the Continent as a salad.

Tragopogon porrifolius.—The roots are eaten under the name of Salsify, and although a very useful vegetable, they are inferior to Scorzonera. In America it is called the Oyster Plant, as the roots when cooked are thought to have the taste of oysters.

Cohort 3. *Campanales.* Stamens epigynous, usually free from the corolla. Ovary generally 2—6-celled, with numerous ovules in each cell. Fruit capsular. Seeds albuminous. Mostly herbs, or rarely shrubs. Leaves nearly always alternate ; exstipulate.

Order 1. STYLIDIACEÆ, the Stylewort Order.—Character.—*Herbs* or *under-shrubs*, not milky. *Leaves* exstipulate. *Calyx* superior, with from 2 to 6 divisions, persistent. *Corolla* with from 5 to 6 divisions ; *æstivation* imbricate. *Stamens* 2, gynandrous. *Ovary* 2-celled, or rarely 1-celled ; *style* forming a column with the filaments ; *stigma* without an indusium. *Fruit* capsular. *Seeds* albuminous.

Distribution and Numbers.—They are chiefly found in the swamps of Australia. *Illustrative Genera* :—Stylidium, *Swartz* ; Forstera, *Linn. fil.* There are about 120 species.

Properties and Uses.—Unknown.

Order 2. GOODENIACEÆ, the Goodenia Order.—Character.—*Herbs*, or rarely *shrubs*, not milky. *Leaves* exstipulate. *Flowers* never collected into heads. *Calyx* generally superior, with from 3—5 divisions, occasionally inferior. *Corolla* irregular, 5-parted ; *æstivation* induplicate. *Stamens* 5 ; *filaments* distinct ; *anthers* distinct or united. *Ovary* 1, 2, or rarely 4-celled ; *placenta* free central ; *style* 1 (*fig.* 644, *t*) ; *stigma* surrounded by a hairy ring or somewhat cup-shaped expansion of the upper part of the style termed an *indusium* (*fig.* 644, *i*). *Fruit* capsular, drupaceous, or nut-like. *Seeds* with fleshy albumen.

Distribution and Numbers.—These plants are principally natives of Australia and the islands of the Southern Ocean ; rarely of India, Africa, and South America. *Illustrative Genera* :—Goodenia, *Sm.* ; Leschenaultia, *R. Br.* There are about 200 species.

Properties and Uses.—Unimportant. Many are cultivated for the beauty of their flowers.

Brunonia.—This genus of Australian plants, consisting of two species, is sometimes made the type of a distinct order, termed Brunoniaceæ ; *but Bentham and Hooker refer them here.* Their principal distinctive characters are the superior ovary, exalbuminous seeds, and capitulate inflorescence. They have no known uses.

Scævola Taccada has a soft and spongy pith, which is used by the Malays to make artificial flowers, and for other purposes. Its young leaves are also eaten as a potherb. Other species of *Scævola* are reputed to be emollient.

Order 3. CAMPANULACEÆ, the Harebell Order.—Character. *Herbaceous plants* or *undershrubs*, with a milky juice. *Leaves* nearly always alternate, exstipulate. *Flowers* scattered, or rarely in capitula. *Calyx* superior (*fig.* 990), persistent (*figs.* 687 and 688). *Corolla* monopetalous, regular (*figs.* 437, *b''*, and 479), marcescent (*figs.* 437, *b'*, and 688); *æstivation* valvate (*fig.* 988). *Stamens* equal in number to, and alternate with, the lobes of the corolla (*fig.* 988); *anthers* 2-celled, distinct or partly united. *Ovary* inferior (*fig.* 990), 2- or more celled (*fig.* 988); *style* undivided (*fig.* 507), hairy; *stigma* naked. *Fruit* dry, capsular, dehiscing by lateral orifices (*fig.* 687, *t*, *t*, and 688) or by valves at the apex; *placentas* axile (*figs.* 630, *pl*, and 988). *Seeds* numerous, with fleshy albumen (*fig.* 989).

Distribution and Numbers.—Chiefly natives of the temperate parts of the northern hemisphere; a good many are, however, found in the southern hemisphere, especially at the Cape of

FIG. 988. FIG. 989. FIG. 990.

Fig. 988. Diagram of the flower of Rampions (*Campanula Rapunculus*).—— *Fig.* 989. Vertical section of the seed.——*Fig.* 990. Vertical section of the flower.

Good Hope. A few species only are tropical. *Illustrative Genera*:—Phyteuma, *Linn.*; Campanula, *Linn.* There are about 550 species.

Properties and Uses.—The milky juice which these plants contain is sometimes of a sub-acrid character, but the roots and young parts of several species, especially when cultivated, are eaten in different parts of the world, as the roots of *Campanula Rapunculus*, which are commonly known under the name of Rampions; those of *Cyphia glandulifera*, in Abyssinia; and those of *Cyphia digitata* by the Hottentots, &c. Some species of *Specularia* have been used in salads. One species, *Campanula glauca*, is reputed to be a valuable tonic, and others are said to be anti-syphilitic. The order, however, does not contain a single plant of any particular importance, either in a medicinal or economic point of view.

Order 4. LOBELIACEÆ, the Lobelia Order.—Character.—*Herbs* or *shrubs*, with a milky juice. *Leaves* alternate, exstipulate. *Calyx* superior *Corolla* monopetalous, irregular, valvate. *Stamens* 5; *anthers* syngenesious (*fig.* 992). *Ovary* inferior, 1—3-celled; *placentas* axile or parietal; *style* 1; *stigma* surrounded by a fringe of hairs (*fig.* 991). *Fruit* capsular, dehiscing at the apex. *Seeds* numerous, albuminous. *This order is especially distinguished from the Campanulaceæ by its irregular corollas and syngenesious anthers. It is made a tribe of the Campanulaceæ by Bentham and Hooker.*

Fig. 992.

Fig. 991.

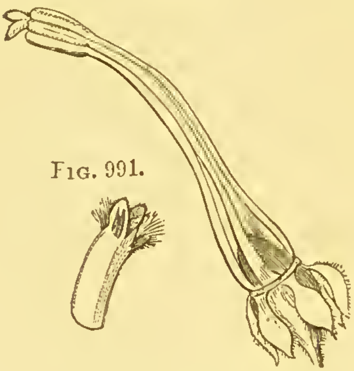


Fig. 991. Stigma of *Lobelia syphilitica.* —*Fig.* 992. The essential organs of the above, with the calyx.

Distribution and Numbers.—They are chiefly natives of tropical and sub-tropical regions; but a few occur in temperate and cold climates. *Illustrative Genera:*—Clintonia, *Doug.*; Lobelia, *Linn.* There are about 400 species.

Properties and Uses.—The milky juice with which these plants abound is commonly of a very acrid nature, hence the species of this order should be regarded with suspicion. Indeed, some, as *Lobelia inflata*, *Tupa Feuillæi*, &c., act as narcotico-acrid poisons; and that of *Isotoma longiflora* is vesicant, and when taken internally it causes such violent purgation as to result in death.

Lobelia.—*L. inflata*, Indian Tobacco.—This species is a native of North America. The flowering herb and seeds have been extensively employed, especially in the United States, for their sedative, antispasmodic, emetic, and expectorant properties. Lobelia resembles tobacco in its action; the dried flowering herb is official in the British Pharmacopœia. Several fatal cases of poisoning have occurred in the United States, and in this country, from its empirical use. The seeds may be distinguished under the microscope by their peculiarly reticulated character. The root of *L. syphilitica* possesses emetic, purgative, and diuretic properties, and, as its specific name implies, it has been reputed to be efficacious in syphilis.—*L. urens* has blistering qualities.—*L. decurrens* is used in Peru as an emetic and purgative, and its employment has been suggested in this country as a substitute for Ipecacuanha.

Series 2. Superæ.

Cohort 1. *Ericales.*—Stamens generally hypogynous (except in Vacciniaceæ), and twice the number of the lobes of the corolla; or equal in number and alternate with the lobes. Ovary with usually more than 2 cells; placentation generally axile; style undivided.

Order 1. Vacciniaceæ, the Cranberry Order.—Character. *Shrubs* or small *trees*. *Leaves* alternate, undivided, exstipulate. *Calyx* superior. *Corolla* 4—6-lobed; *æstivation* imbricate.

Stamens distinct, epigynous, twice as many as the lobes of the corolla; *anthers* (*fig.* 533) appendiculate, with porous dehiscence. *Ovary* 4—10-celled; *style* and *stigma* simple. *Fruit* succulent. *Seeds* with fleshy albumen.

Distribution and Numbers.—Chiefly natives of the temperate regions of the globe. *Illustrative Genera*:—Vaccinium, Thibaudia. There are about 200 species.

Properties and Uses.—They are chiefly remarkable for their astringent leaves and bark, and for their edible sub-acid fruits.

Oxycoccus palustris (*Vaccinium Oxycoccus*).—The fruit of this plant is the Cranberry of Great Britain. It is used in making tarts and for other purposes.—*O. macrocarpus* yields the American Cranberry, of which large quantities are imported into this country.

Vaccinium.—The fruits of several species are edible, thus:—*V. Myrtillus* yields the Bilberry; *V. uliginosum*, the Bog or Black Whortleberry; and *V. Vitis-Idæa*, the Red Whortleberry or Cowberry. (See also *Oxycoccus.*) The fruit of *V. uliginosum* is reputed to be narcotic, and is said to be employed for making beer, &c., heady. When exposed to fermentation, it produces a kind of wine.

Order 2. ERICACEÆ, the Heath Order.—Character.—*Shrubs* or small *trees*. *Leaves* entire, evergreen, opposite, whorled or alternate, exstipulate. *Calyx* 4—5-cleft, inferior (*fig.* 483, *c*), persistent. *Corolla* hypogynous, monopetalous (*figs.* 478 and 993), 4—5-cleft, or rarely distinct; *æstivation* imbricate. *Stamens* hypogynous (*figs.* 993 and 994), as many, or twice as many, as the divisions of the corolla; *anthers* 2 celled (*fig.* 534), opening by pores or slits (*fig.* 532, *r*), appendiculate (*fig.* 532, *a*). *Ovary* 4—5-celled, with numerous ovules, surrounded by a disk or scales; *placentas* axile; *style* 1 (*figs.* 993 and 994); *stigma* simple or lobed. *Fruit* capsular or rarely baccate. *Seeds* numerous, small, anatropous; *embryo* minute in the axis of fleshy albumen.

FIG. 993. FIG. 994.

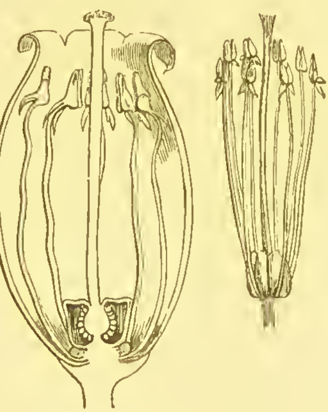


Fig. 993. Vertical section of the flower of a species of Heath (*Erica*).——*Fig.* 994. Essential organs of the same. The stamens are seen to be hypogynous.

Diagnosis.—Shrubs or small trees. Leaves entire, evergreen, exstipulate. Calyx and corolla 4—5-merous. Calyx inferior. Corolla hypogynous, monopetalous, or rarely polypetalous. Stamens hypogynous; anthers 2-celled, appendiculate, dehiscing by pores or slits. Ovary 4—5-celled; style 1; placentas axile. Fruit capsular, or very rarely baccate. Seeds small, anatropous, numerous, with fleshy albumen.

Division of the Order and Illustrative Genera.—The order may be divided into five tribes as follows :—

Tribe 1. *Arbuteæ.*—Corolla deciduous. Fruit baccate. *Illustrative Genus :*—Arbutus, *Linn.*

Tribe 2. *Andromedeæ.*—Buds usually clothed with scales. Corolla deciduous. Fruit capsular, loculicidal. *Illustrative Genus :*—Andromeda, *Linn.*

Tribe 3. *Ericeæ.*—Buds naked. Corolla persistent. Fruit capsular, usually loculicidal, or rarely septicidal. *Illustrative Genera :*—Erica, *Linn.* ; Calluna, *Salisb.*

Tribe 4. *Rhodoreæ.*—Buds scaly, cone-like. Corolla deciduous. Fruit capsular, septicidal. *Illustrative Genera :* — Azalea, *Linn.* ; Phyllodoce, *Salisb.*

Tribe 5. *Pyroleæ.*—Herbs or somewhat shrubby plants. Corolla polypetalous, or the petals united at the base, deciduous. Fruit capsular, loculicidal. *Illustrative Genera :*—Pyrola, *Tourn.* ; Chimaphila, *Pursh.*

Distribution and Numbers.—They are very abundant at the Cape of Good Hope, and are also more or less generally diffused in Europe, North and South America, and Asia. There are over 900 species.

Properties and Uses.—The plants of this order are chiefly remarkable for astringent properties ; others are tonic and diuretic ; and some are narcotic, and even poisonous. This is especially the case with *Kalmia latifolia*, *Rhododendron chrysanthum*, *Andromeda floribunda*, and *Azalea pontica*. The fruits of many are edible. The species of *Erica*, *Rhododendron*, *Kalmia*, *Azalea*, &c., are largely cultivated in this country on account of the beauty of their flowers. The three latter genera are commonly called American Plants. Such plants are not, however, confined to America, as the name would imply.

Andromeda floribunda.—This shrub, which is a native of North America, is poisonous. So recently as 1866 a number of sheep were poisoned by eating it, but nineteen out of thirty-seven attacked recovered under judicious treatment.

Arctostaphylos Uva-Ursi, the Bearberry.—The leaves are astringent, and are official in the British Pharmacopœia. Combined with astringency they also possess mild diuretic properties.

Azalea pontica.—Trebizond honey owes its poisonous properties to the bees feeding on the flowers of this plant. The poisonous honey mentioned by Xenophon, in his account of the 'Retreat of the Ten Thousand,' was of a like nature.

Chimaphila umbellata, Winter-green, Pipsissewa.—This herb possesses diuretic and tonic properties. The leaves are official in the United States Pharmacopœia. In the United States, Chimaphila has been called 'King's Cure,' from its reputed value in scrofula. The fresh leaves are acrid, and when applied to the skin act as a rubefacient.

Epigæa repens, Trailing Arbutus.—The leaves and stems possess similar properties to those of Uva-Ursi, and are used in the United States in similar diseases.

Erica.—From the roots of *E. arborea*, which grows to a large size on the hills of the Maremma, the so-called briar-root or briar-wood pipes are made. The pipes known as *pipes de bruyère* are also made from the roots.

Gaultheria procumbens, Partridge Berry.—The leaves are official in the United States Pharmacopœia. They possess aromatic, astringent, and stimulant properties, which they owe to the presence of a volatile oil and tannic acid. The oil is known under the name of *Oil of Partridge Berry* or *Oil of Winter-green*. An infusion of the leaves is employed in certain parts of North America, as a substitute for China tea, under the name of *Mountain* or *Salvador Tea*. The fruits, known as Partridge Berries or Deer Berries, are much relished by some persons.—*G. leucocarpa* and *G. punctata*.—From the leaves of these two species, both of which are natives of Java, Dr. de Vrij obtained an oil, which he found to be identical with the American Winter-green Oil.

Kalmia latifolia, a common plant in the United States, is reputed to be narcotic and poisonous. The leaves, under the name of 'Mountain Laurel,' are said to be a valuable remedy in obstinate diarrhœa. They have also been used in syphilis and skin diseases. They contain a large amount of tannic acid.

Ledum.—An infusion of the leaves of *L. palustre* and *L. latifolium* is employed in North America as a substitute for China tea, under the name of Labrador Tea or James's Tea. It possesses narcotic properties. This plant has also been recommended as a powerful insecticide.

Rhododendron.—The flowers of *R. arboreum* are used by the hill people of India in the preparation of a jelly. The powdered leaves of *R. campanulatum* are employed as snuff in certain parts of India. The brown pulverulent substance found on the petioles of some Rhododendrons and Kalmias is also in use in the United States of America as a substitute for snuff.—*R. chrysanthum*, a Siberian plant, possesses very marked narcotic properties.

Order 3. MONOTROPACEÆ, the Fir-rape Order.—Character. *Saprophytes* with scale-like leaves. *Sepals* more or less distinct, 4—5, inferior. *Petals* 4—5, distinct or united. *Stamens* twice as many as the petals, hypogynous; *anthers* 2-celled, with longitudinal dehiscence. *Ovary* superior, 4—5-celled at the base, 1-celled with 5 parietal placentas at the apex. *Fruit* capsular, with loculicidal dehiscence. *Seeds* numerous, with a loose testa; *embryo* minute, at the apex of fleshy albumen. *This order is referred to Ericaceæ by Bentham and Hooker. It is closely allied to the Pyroleæ.*

Distribution and Numbers.—They are found growing on Firs chiefly, in the cool parts of Europe, Asia, and North America. *Illustrative Genus*:—Monotropa, *Nutt.* There are about 10 species.

Properties and Uses.—Unimportant.

Order 4. EPACRIDACEÆ, the Epacris Order.—Character.—*Shrubs*, or small *trees*. *Leaves* alternate or rarely opposite, simple, with parallel or radiating veins. *Calyx* and *corolla* inferior, usually 5-partite, or rarely 4-partite. *Stamens* equal in number to the divisions of the corolla, or rarely fewer, hypogynous or adherent to the corolla; *anthers* 1-celled, without appendages, opening longitudinally. *Ovary* superior, many- or 1-celled; *style* simple. *Fruit* fleshy or capsular. *Seeds* with a firm skin, albuminous.

Distribution and Numbers.—Natives of Australia, the Indian Archipelago, and the South Sea Islands, where they are very abundant. *Illustrative Genera:*—Astroloma, *R. Br.*; Epacris, *Smith.* There are about 350 species.

Properties and Uses.—Of little importance except for the beauty of their flowers, on which account they are much cultivated. The fruits of many species are edible, as those of *Astroloma humifusum*, the Tasmanian Cranberry; *Leucopogon Richei*, the Native Currant of Australia; *Lissanthe sapida*, and others.

Cohort 2. *Primulales.*—Stamens generally epipetalous; equal in number to, and opposite, the lobes of the corolla or separate petals. Ovary 1-celled, with a free central placenta and numerous ovules; or with a solitary ovule suspended from a long funiculus arising from the centre of the cell at the base.

Order 1. PLUMBAGINACEÆ, the Thrift Order.—Character. *Herbs* or *undershrubs.* *Leaves* entire, alternate or radical, exstipulate. *Flowers* regular (*fig.* 995). *Calyx* tubular, plaited, persistent, 5-partite (*fig.* 995). *Corolla* (*fig.* 995) membranous, 5-partite or of 5 petals, or rarely absent. *Stamens* (*figs.* 995

FIG. 995.

FIG. 996.

Fig. 995. Diagram of the flower of a species of *Plumbago.*——*Fig.* 996. Essential organs of the same.

and 996) 5, opposite the petals, to which they are attached when the corolla is polypetalous, and hypogynous and opposite to the divisions of the corolla when this is monopetalous (*fig.* 995). *Ovary* 1-celled (*figs.* 637 and 995); *ovule* solitary, suspended from a long funiculus arising from the base of the cell (*fig.* 637); *styles* (*fig.* 996) usually 5, sometimes 3 or 4. *Fruit* utricular, or dehiscing by valves at the apex. *Seed* solitary; *embryo* straight; *albumen* mealy, and small in quantity.

Distribution and Numbers.—Chiefly found growing on the sea-shore and in salt marshes in various parts of the globe, but by far the greater number inhabit temperate regions. *Illustrative Genera:*—Armeria, *Willd.*; Plumbago, *Tourn.* There are about 250 species.

Properties and Uses—Of little importance, but acridity and astringency appear to be the most remarkable properties of the plants of this order.

Armeria vulgaris, Common Thrift.—The dried flowers are commonly reputed to be diuretic.

Plumbago.—The roots of several species are acrid and vesicant when fresh, as those of *P. europæa*, Toothwort, *P. zeylanica*, *P. scandens*, and *P. rosea.*—*P. toxicaria* is used as a poison in Mozambique.

Statice caroliniana is called Marsh Rosemary in the United States, where its root is official and is much employed as an active astringent. The root of *S. latifolia* has similar astringent properties to *S. caroliniana*, and has been used in Russia and Spain as a tanning agent. The roots of *S. mucronata* are said by Holmes to constitute the drug known in Morocco as *Tafrifa*, which is supposed to possess nervine properties. The roots, termed 'Bayeuru' and 'Guaycuru,' and described by Symes and Holmes, are very astringent, and appear to be derived from species of *Statice*; the latter, according to Holmes, from *S. brasiliensis.*

Order 2. PRIMULACEÆ, the Primrose Order.—Character. *Herbs.* *Leaves* (*fig.* 394) cauline, and then simple, opposite,

FIG. 997.

FIG. 998.

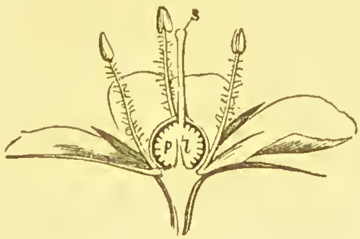


FIG. 999.

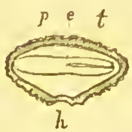


Fig. 997. Flower of the Pimpernel (*Anagallis arvensis*). *c.* Calyx. *p.* Petals. *s.* Stamens.——*Fig.* 998. Vertical section of the flower of the same. *pl.* Free central placenta. *s.* Style and capitate stigma.——*Fig.* 999. Vertical section of the seed of *Primula elatior*. *t.* Integuments. *p.* Albumen. *e.* Embryo. *h.* Hilum.

whorled, or rarely alternate, exstipulate; or radical. *Flowers* regular, perfect (*figs.* 481 and 997). *Calyx* generally 5-cleft (*fig.* 458), or rarely 4—9-cleft, persistent, inferior (*fig.* 998) or semi-superior in *Samolus.* *Corolla* (*figs.* 481, *p*, and 997, *p*) usually 5- or rarely 4—9-cleft, very rarely absent, or rarely of distinct petals. *Stamens* (*fig.* 997, *s*) equal in number to the segments of the corolla or separate petals, and opposite to them, or in apetalous flowers hypogynous and alternating with the divisions of the calyx. *Ovary* superior (*figs.* 458 and 998), or rarely partly inferior, 1-celled (*fig.* 998); *placenta* free central (*figs.* 635, *pl*, and 998, *pl*); *style* 1 (*figs.* 458 and 998); *stigma* capitate (*figs.* 582 and 458). *Fruit* a capsule, dehiscing transversely and forming a pyxis (*fig.* 709), or in a valvular manner. *Seeds* numerous, with fleshy or horny albumen (*fig.* 999, *p*); *embryo* placed transversely to the hilum (*fig.* 999, *e*).

Diagnosis.—Herbs with simple, exstipulate, cauline or radical leaves, and regular perfect flowers. Stamens equal in number to the lobes of the corolla or separate petals and opposite to them. Ovary superior, 1-celled, with a free central placenta; style 1; stigma capitate. Fruit capsular, with transverse or longitudinal dehiscence. Seeds numerous, with albumen, and the embryo parallel to the hilum.

Distribution and Numbers.—These plants principally inhabit cold and temperate regions in the northern parts of the globe. They are rare in the tropics, where they are only found on the sea-shore or in mountainous districts. *Illustrative Genera*:—Primula, *Linn.*; Anagallis, *Tourn.*; Glaux, *Tourn.*; Samolus, *Tourn.* There are about 250 species.

Properties and Uses.—Of no particular importance except for the beauty of their flowers. The flowers of the Cowslip (*Primula veris*) are sedative and diaphoretic, and are sometimes employed in the manufacture of a soporific wine. The roots of Cyclamens are acrid, especially those of *Cyclamen hederæfolium*, which have been used as a drastic purgative and emmenagogue. The Cyclamens are commonly known under the name of Sow-breads, from their being eaten by wild boars in Sicily.

Order 3. MYRSINACEÆ, the Myrsine Order.—Character.—*Trees* or *shrubby plants*. *Leaves* coriaceous, smooth, exstipulate. *Flowers* small, perfect or unisexual. *Calyx* and *corolla* 4—5-partite. *Stamens* usually corresponding in number to the divisions of the corolla and opposite to them, but sometimes there are also 5 sterile petaloid alternate ones; *anthers* dehiscing longitudinally. *Ovary* superior or nearly so, 1-celled; with a free central *placenta*, in which the ovules are imbedded. *Fruit* fleshy. *Seeds* 1, 2, or many; *albumen* abundant, horny.

Distribution and Numbers.—Chiefly natives of the islands of the southern hemisphere. *Illustrative Genera*:—Myrsine, *Linn.*; Theophrasta, *Linn.* There are above 300 species.

Properties and Uses.—Of little importance. The fruits and seeds of some species are pungent; and the seeds of others are said to be purgative. The fruit of *Myrsine africana* is used by the Abyssinians mixed with barley as food for their asses and mules. The seeds of *Theophrasta Jussiæi* are used in St. Domingo in the manufacture of a kind of bread.

~~*Ægicera.*~~—This genus, of which there are five species, is considered by

Ægiceras.

some writers to form a distinct order, the ÆGICERACEÆ. These inhabit sea-shores in tropical regions, and their seeds germinate while the fruits are still attached to the plant, and send their roots down into the mud, like Mangroves. The genus *Ægiceras*, Gärtn., differs from Myrsinaceæ in its anthers dehiscing transversely; in having follicular fruit; and in the seeds being without albumen. *Bentham and Hooker combine it with Myrsinaceæ; and hence it is so placed here.*

Cohort 3. *Ebenales.*—Stamens epipetalous, equal in number to, and opposite, the lobes of the corolla or separate petals; or more numerous. Ovary more than 1-celled; placentation axile. Fruit fleshy. Seeds 1 or few, large. Trees or shrubs; leaves alternate.

Order 1. SAPOTACEÆ, the Sapota Order.—Character.—*Trees* or *shrubs*, often having a milky juice. *Leaves* alternate, simple, entire, coriaceous, exstipulate. *Flowers* small, hermaphrodite. *Calyx* inferior, usually with 5, or sometimes with 4—8 divisions, persistent. *Corolla* with as many divisions as the calyx, or twice or thrice as many. *Stamens* definite, in a single row, half of them sterile and alternating with the fertile ones, the latter being opposite to the segments of the corolla; *anthers* commonly extrorse. *Ovary* 4—12-celled, with a solitary anatropous ovule in each cell; *style* 1. *Fruit* fleshy. *Seeds* large, with a shining bony testa; *embryo* large, usually in albumen, and with a short radicle.

Distribution and Numbers.—Natives chiefly of the tropical parts of Asia, Africa, and America. *Illustrative Genera:*—Chrysophyllum, *Linn.*; Isonandra, *Wight*; Bassia, *König.* There are about 220 species.

Properties and Uses.—Many species yield edible fruits; others are valuable timber trees. The seeds of several contain a fatty oil. Some have bitter astringent febrifugal barks, and the milky juices of others yield a substance analogous in its general characters to caoutchouc or india-rubber.

Achras.—Several species of this genus yield dessert fruits; thus the fruit of *A. Sapota* is the Sapodilla Plum; that of *A. mammosa*, the Marmalade.—*Achras Sapota* has also a febrifugal bark, and diuretic and aperient seeds. Its wood is called Bully-tree Wood or Black Bully. This has a greenish colour, and is very hard. It is imported, and used for ship-building, and other purposes. (See *Mimusops.*) The bark of several other species has been also employed as a substitute for Cinchona.

Argania Sideroxylon.—From the seeds of this species a valuable oil may be obtained.

Bassia.—The ripe kernels of *B. latifolia* and those of *B. longifolia*, the Elloopa-tree, yield fatty oils which are much employed in India, for lamps, culinary purposes, and for soap-making; and externally in cutaneous affections. The flowers of *B. longifolia*, under the name of *Elloopa*, have been imported into London. These flowers are used as food, and also yield an alcoholic spirit which is in much repute in some parts of India. The wood of *B. longifolia* and others is hard and durable, and the bark and leaves are used in medicine. From the seeds of *B. butyracea* a concrete oil is also obtained in India. It is known under the name of *Fulwa Butter.* It is highly esteemed as an external application in rheumatism and other affections.

Butyrospermum.—B. Parkii.—This species, which is a native of West-tropical Africa, is the source of *Shea* or *Galam butter.*

Chrysophyllum.—The fruit of *C. Cainito* is known under the name of Star-apple. It is much esteemed in the West Indies. Other species of *Chrysophyllum* also yield edible fruits.—*C. Buranhem, C. glycyphlœum,* or *Lucuma glycyphlœum,* yields an astringent bark called *Monesia bark,* which has been much employed in France and Germany in diarrhœa and similar affections. It contains a principle called *monesin,* which is analogous to *saponin.* Monesin has been also employed as a medicinal agent. This plant is also the source of the gum or gum-resin known in New York as *Chicle.* It has also been called *Mexican Gum* and *Rubber Juice.* It has been chiefly used for mixing with rubber for insulating telegraph wires.

Dichopsis (*Isonandra*) *Gutta,* the Gutta Percha or Taban-tree.—This is a native of Singapore, Borneo, Sumatra, and other eastern islands. The inspissated juice of this, and probably other species of *Isonandra,* and of other allied genera, as *Chrysophyllum, Sideroxylon, Bassia, Payena, Mimusops, Isonandra,* and *Imbricaria,* constitutes the valuable substance called Gutta Percha. The Gutta Percha tree is now extinct in Singapore, in consequence of the destruction of the trees in order to obtain the juice. The annual importation of Gutta Percha into this country is more than 60,000 cwt. The best Gutta Percha is obtained from *Dichopsis Gutta,* and the second best variety is derived from a tree called 'Gatah Sûndek,' in Perak, which Dr. Trimen believes to be a species of *Payena.* Gutta Percha is official in the British Pharmacopœia.

Lucuma.—Several species yield edible fruits. The plant alluded to above under the name of *Chrysophyllum Buranhem* is now also termed *Lucuma glycyphlœum.* (See *Chrysophyllum.*)

Mimusops.—The fruit of several species is employed as a dessert; that of *M. Elengi* is the Surinam Medlar. The bark of *M. Elengi* also possesses astringent and tonic properties; and in Southern India the fragrant nectar distilled from the flowers is used as a perfume, and as a stimulant medicine. The fruit of *M. Kaki* is also much eaten in India. The seeds of some species yield useful oils. Several species, as *M. Elengi, M. indica, M. hexandra,* produce hard, heavy, and durable timber. The Bully-tree of British Guiana is also by some authors regarded as a species of *Mimusops.*—*M. Balata* (*Achras* or *Sapota Mulleri*), a native of Guiana and Central America, yields a substance resembling Gutta Percha in its properties. It is known as *Balatas.*

Order 2. Ebenaceæ, the Ebony Order.—Character.—*Trees* or *shrubs* without milky juice. *Leaves* alternate, entire, coriaceous, exstipulate. *Flowers* polygamous. *Calyx* 3—7-partite, inferior, persistent. *Corolla* 3—7-partite. *Stamens* equal in number to the lobes of the corolla, or twice or four times as many, epipetalous or hypogynous; *anthers* 2-celled, introrse, opening longitudinally. *Ovary* 3—12-celled, each cell with 1 or 2 ovules suspended from the apex; *style* usually having as many divisions as there are cells to the ovary. *Fruit* fleshy. *Seeds* large, albuminous; *radicle* superior.

Distribution and Numbers.—They are mostly natives of tropical India, but a few occur in colder regions. *Illustrative Genera:*—Royena, *Linn.*; Diospyros, *Linn.* There are nearly 200 species.

Properties and Uses.—Many of the trees of this order are remarkable for the hardness of their wood, which is commonly known under the names of Ebony and Ironwood. Many species have edible fruits, and some have astringent barks.

Diospyros.—Many species of this genus have hard and dark-coloured heart-woods, which form the different kinds of Ebony: thus, from *D. reticulata* is obtained Mauritius Ebony, the best kind; from *D. Melanoxylon*, a native of the Coromandel Coast, that which is commonly known as Black Ebony; from *D. Ebenaster*, the Bastard Ebony of Ceylon, from *D. Ebenum*, the best Ceylon Ebony; and *D. hirsuta* of Ceylon, and other species, also yield inferior kinds of Ebony. Coromandel or Calamander Wood, a beautifully variegated furniture wood, is also procured from Ceylon, and is obtained from *D. quæsita* and *D. oppositifolia.* The fruit of *D. Kaki* is eaten in China, India, and Japan. It is known in Japan under the name of the Keg-fig. It is the *Kaki* of the Chinese. The plant fruits freely in this country in a conservatory or orchard house.—The fruit of *D. virginiana*, the Persimmon or Virginian Date Plum, is sweet and edible when ripe, especially after a frost, but it is very austere in an unripe state; hence it is frequently employed in that condition in the United States, where it is official, as an astringent. In the Southern States an indelible ink is also made from the unripe fruit. The bark has been likewise used as a febrifuge and astringent.—*D. Lotos*, a native of Europe, has edible fruit. The bark of *D. Melanoxylon* possesses tonic and astringent properties. The fresh fruit of *D. Embryopteris* is powerfully astringent, and is official on that account in the Pharmacopœia of India. The ripe fruit is edible. The juice of the fruit is also employed in Bengal for various useful purposes. The raw fruit of *D. mollis* yields a black dye.

Royena hirsuta var. *rigida*, a Cape shrub, has an edible fruit.

Order 3. Styraceæ, the Storax Order.—Character.—*Trees* or *shrubs. Leaves* simple, alternate, exstipulate. *Flowers* axillary, hermaphrodite. *Calyx* inferior or partially superior, 4—5-partite or almost entire, persistent. *Corolla* of from 5—10 petals, either united at the base or distinct; *æstivation* imbricate or somewhat valvate. *Stamens* equal in number to the petals, or twice or thrice as many, more or less united at the base; *anthers* 2-celled, roundish or linear. *Ovary* superior or partially inferior; *style* simple. *Fruit* drupaceous, always more or less fleshy. *Seeds* 1 usually in each cell, sometimes more; *embryo* in the midst of abundant fleshy albumen, with a long radicle.

Miers divides the *Styraceæ* into two orders, called *Symplocaceæ* and *Styracaceæ*, the former of which is distinguished by its partially inferior ovary, imbricate æstivation of corolla, and roundish anthers; the latter having a superior ovary, valvate æstivation of corolla, and linear anthers.

Distribution and Numbers.—These plants are sparingly distributed in warm and tropical regions; but a few are found in cold climates. *Illustrative Genera:*—Symplocos, *Jacq.*; Styrax, *Tourn.* Miers enumerates about 120 species.

Properties and Uses.—These plants are principally remarkable for yielding stimulant balsamic resins. Some yield dyeing agents, but these are of little importance.

Styrax.—The species of this genus frequently yield stimulant balsamic resins.—*S. Benzoin*, the Benjamin tree, is the principal, but probably not the only source of the concrete balsamic resin which is official in the British Pharmacopœia under the name of Benzoin. It is commonly, but improperly, called Gum Benjamin. This is usually obtained after making incisions in the bark. Two kinds are distinguished in commerce under the respective names of *Siam* and *Sumatra Benzoin*. The former is most esteemed in England. Benzoin is used in medicine as a stimulant expectorant. It is, however, chiefly employed in the preparation of the official *benzoic acid*; and on account of its agreeable odour when heated it is a common ingredient in the incense so largely used in Catholic churches. It is also a constituent in aromatic or fumigating pastilles, and in court or black sticking plaster. In Brazil and elsewhere, other species of *Styrax* yield similar balsamic resins.—*S. officinale*, native of Greece, the Levant, and Asia Minor, was long supposed by many to be the source of *Liquid Storax*; but Hanbury proved that while it was the source of the original and classical Storax, this had in modern times wholly disappeared from commerce, and that our *Liquid Storax* is the produce of *Liquidambar orientalis* of Miller. (See *Liquidambar*.) Storax has similar medicinal properties to Benzoin.

Symplocos.—The leaves of *S. Alstonia* are slightly astringent. They have been employed as a tea in New Granada, under the name of Santa Fé Tea. The leaves of *S. tinctoria* (Sweet-leaf or Horse-sugar), a native of North America, have a sweet taste, and are eaten by cattle. They are also used in dyeing yellow. This plant has a bitter and aromatic root. The leaves of other species are also employed in Nepaul for dyeing yellow. The bark of *S. racemosa* is likewise used in India as a dyeing material and as a mordant. It is known under the name of *Lotur bark*.

Series 3. Dicarpiæ or Bicarpellatæ.

Cohort 1. *Gentianales.*—Corolla regular. Stamens generally epipetalous, and equal in number to, and alternate with, the lobes of the corolla, or rarely fewer. Leaves usually opposite and entire; or rarely compound, and very rarely alternate.

Order 1. OLEACEÆ, the Olive Order.—Character.—*Trees* or *shrubs*. *Leaves* opposite, simple or pinnate, exstipulate (*fig.* 438). *Flowers* usually perfect, or rarely unisexual. *Calyx* persistent, 4—8-cleft (*fig.* 1000), sometimes obsolete (*fig.* 30), inferior (*fig.* 1002). *Corolla* regular, 4—8-cleft (*fig.* 1000), or of 4 distinct petals (*fig.* 1001), or absent (*fig.* 30); *æstivation* valvate (*fig.* 1000) or imbricate. *Stamens* usually 2 (*figs.* 30 and 1001), rarely 4. *Ovary* superior (*fig.* 1002), 2-celled (*fig.* 1000), with 1—4 erect, or 2 suspended ovules in each cell (*fig.* 1002). *Fruit* dehiscent or indehiscent, often 1-seeded. *Seeds* with abundant fleshy albumen, or the albumen is small in quantity; *embryo* straight.

The order Jasminaceæ of many botanists is here included in the Oleaceæ. The tribe or sub-order Jasmineæ is more especially distinguished from other Oleaceæ by the imbricate æstivation of the corolla, erect ovules, and the small quantity of albumen in the seed.

Distribution and Numbers.—The plants of this order are principally natives of temperate and warm regions, but some also occur within the tropics. *Illustrative Genera:*—Olea, *Linn.*; Ligustrum, *Tourn.*; Fraxinus, *Tourn.*; Jasminum, *Linn.* There are about 250 species.

Properties and Uses.—The barks of many plants of this order are tonic and febrifugal. The mild purgative called Manna is obtained from a species of Ash. The pericarp of the common Olive yields the well-known Olive Oil Other species are remarkable for the hardness of their wood. The plants of the Jasmineæ have generally fragrant flowers. The volatile oil of Jasmine, which is used in perfumery, is chiefly obtained by distillation from the flowers of *Jasminum officinale* and *J. grandiflorum*. The fragrant flowers of *J. Sambac* are used as votive

Fig. 1000.

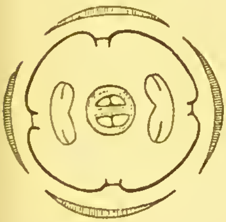


Fig. 1001.

Fig. 1002.

Fig. 1000. Diagram of the flower of the Lilac (*Syringa vulgaris*).——*Fig.* 1001. Flower of the Manna Ash (*Fraxinus Ornus*), with 4-cleft calyx; corolla with 4 distinct petals; 2 stamens; and 2 carpels.——*Fig.* 1002. Vertical section of the calyx and pistil of the Privet (*Ligustrum vulgare*).

offerings in India; they are also said to have much power in arresting the secretion of milk. The leaves and roots of some species of *Jasminum* are reputed bitter, and have been employed for various purposes, but generally speaking this tribe contains no active medicinal plants. The flowers of *Nyctanthes arbor-tristis* are employed in India for dyeing yellow.

Fraxinus.—*F. excelsior*, the common Ash, has a febrifugal bark. The leaves are reputed to possess cathartic properties. This plant also yields a small quantity of Manna, especially when grown in a warm climate, but no commercial Manna is obtained from it. The wood possesses much strength and elasticity combined with lightness, hence it is commonly used for ladders, poles, and agricultural implements. The sweet concrete exudation known as Manna is obtained by making transverse incisions into the stem of *Fraxinus Ornus*; hence this plant is official in the British Pharmacopœia as the source of Manna. It is a native of the South of Europe and Asia Minor, but commercially our supplies of Manna are now entirely derived from Sicily, where the trees are cultivated for that purpose. Manna is a mild agreeable laxative. It owes its properties essentially to *mannite*, and also, probably, to some extent, to a peculiar *resin*.—*Fraxinus chinensis* is the tree upon which the insect (*Coccus Pe-la*) producing the White Wax of China feeds.

Olea.—Olea europæa, the Olive.—The ripe fruit has a very fleshy pericarp; this yields by expression the fixed oil, known as Olive Oil, Salad Oil, and Sweet Oil, which is so largely used for dietetical purposes, in the arts, and in medicine; it is official in the British Pharmacopœia. In medicine, it is principally employed externally, either by itself, or in combination with other substances. When administered internally, it is nutrient, emollient demulcent, and laxative. The *olives* used as a dessert are ordinarily prepared by first soaking the green unripe fruits in water to deprive them of a portion of their bitterness, and then preserving them in a solution of salt slightly aromatised. The *leaves* and *bark* of the Olive-tree have been highly extolled by some writers for their tonic and febrifugal qualities. The febrifugal properties of the bark are said to be due to a peculiar principle which has been named *oliverin*. The substance called *olive gum* or *olivile* is a resinous exudation from the Olive-tree. It was formerly employed in medicine, but at present is not applied to any useful purpose. The *wood* of the Olive is much used for cabinet work. The flowers of *Olea fragrans* are employed in China to give odour and flavour to a particular kind of tea.

Syringa vulgaris, the Lilac, has a tonic and febrifugal bark.

Order 2. SALVADORACEÆ, the Salvadora Order.—Character. —*Shrubs* or small *trees*. *Leaves* opposite, entire, leathery, exstipulate. *Flowers* small, panicled. *Calyx* of 4 sepals. *Corolla* 4-partite, membranous. *Stamens* 4. *Ovary* 1—2-celled; *stigma* sessile. *Fruit* fleshy, 1-celled, with a solitary erect seed. *Seed* exalbuminous.

Distribution and Numbers.—Natives of India, Syria, and North Africa. *Illustrative Genera*:—Salvadora, *Linn.*; Monetia, *L'Hérit.*

Properties and Uses.—Some are acrid and stimulant. The only plant of importance is *Salvadora persica*, supposed by Royle to be the Mustard-tree of the Bible. The fruit of this is edible, and resembles the garden Cress in taste. The bark of the root is acrid, and is employed as a blistering agent in India. The leaves are reputed to be purgative.

Order 3. APOCYNACEÆ, the Dog-bane Order.—Character.—*Trees* or *shrubs*, usually milky and acrid. *Leaves* entire, commonly opposite, but occasionally whorled or scattered, exstipulate. *Calyx* inferior, 5-partite (*fig.* 1004), persistent. *Corolla* (*fig.* 1004) 5-lobed; *æstivation* contorted. *Stamens* (*fig.* 1004) 5, alternate with the lobes of the corolla; *filaments* distinct; *anthers* united to the stigma (*fig.* 1003), 2-celled (*fig.* 528); *pollen* granular. *Ovary* composed of 2 carpels, which are generally merely in contact, but sometimes united so as to form a 2-celled (*fig.* 1004) or more rarely a 1-celled ovary; *styles* 2 or 1 (*figs.* 599, *t*, and 1003); *stigma* 1, expanded at the base and apex, and contracted in the middle, so as to resemble in form an hour-glass or dumb-bell (*fig.* 599, *s*); *ovules* numerous. *Fruit* consisting of 1 or 2 follicles, or a capsule, drupe, or berry. *Seeds* usually with albumen, or rarely exalbuminous, often comose.

Distribution and Numbers.—Natives principally of the tropics, but a few occur in northern regions. *Vinca* is the only British genus. *Illustrative Genera*:—Allamanda, *Linn.*; Urceola, *Roxb.*; Apocynum, *Tourn.* There are about 600 species.

Properties and Uses.—The plants of this order are generally to be suspected, as many of them are intensely poisonous, although the fruits of a few species are edible. Some are drastic purgatives, and in others the bark is tonic and febrifugal. India-rubber or Caoutchouc, now commonly known in commerce as Rubber, is obtained from the milky juice of several species.

Fig. 1003.

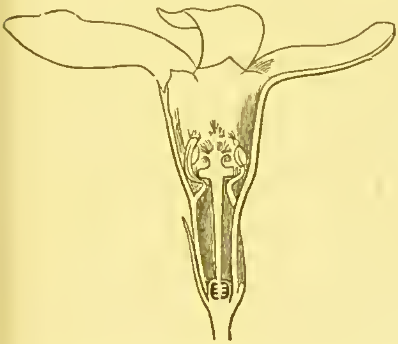


Fig. 1004.

Fig. 1003. Vertical section of the flower of Periwinkle (*Vinca*).——*Fig.* 1004. Diagram of the flower of the same.

Alstonia scholaris, a native of India and the Philippine Islands, has a bitter, tonic, and astringent bark, which is much esteemed as a remedy in chronic diarrhœa and dysentery. It is official in the Pharmacopœia of India, and is known as *Alstonia bark* or *Dita bark.* It is also regarded as a valuable antiperiodic and tonic. There has been obtained from it an uncrystallisable substance called *ditain*, which, administered in the same doses as quinine, is said to be an excellent tonic. Recent experiments have proved, however, that *ditain* is not an alkaloid but a compound substance from which an alkaloid termed *ditamine* may be obtained. More recent investigations also show that *Cortex Alstoniæ* is not derived from the same plant as that yielding Dita bark, but from *A. spectabilis*, a native of Timor, the Moluccas, and the eastern parts of Java. It is known in Java as 'poelé,' and is much used in fevers. It contains a peculiar alkaloid which has been named *alstonine* or *alstonamine.* It also contains *ditamine.* According to Hesse, Australian Alstonia Bark, which is derived from *A. constricta*, contains at least four alkaloids, which he has named *alstonine* (*chlorogenine*), *porphyrine*, *porphyrosine*, and *alstonidine.*

Alyxia stellata has an aromatic bark, which is analogous in its properties to that of Canella and Winter's Bark.

Apocynum.—The roots of *A. cannabinum* and *A. androsæmifolium* are emetic, diuretic, diaphoretic, and purgative; that of the former, under the name of American Indian Hemp, is said to be very useful in Bright's disease and dropsy. The fibre known as *Colorado Hemp* or *Canadian Hemp*, which may be used in the manufacture of the finer kinds of paper, is obtained from *A. cannabinum.*

Aspidosperma Quebracho yields White Quebracho Bark, which has been highly recommended as a febrifuge and antiperiodic. It is also useful in dyspnœa. It contains a crystalline alkaloid, which has been termed *aspidospermine.* The investigations of Dr. Wulfsberg indicate that aspidospermine is identical with the alkaloid *paytine*, described by Hesse in 1870.

which he derived from a bark known as *White Payta Bark*, the source of which is now thought to be a species of *Aspidosperma*. More recent investigations of O. Hesse have however proved to him that *paytine* and *aspidospermine* are quite distinct. Hesse has also found another alkaloid, which he has named *quebrachine.* The bark known as *Red Quebracho Bark* is derived from *Loxopterigium Lorentzii* or *Quebrachia Lorentzii* of Grisebach, a plant of the order Anacardiaceæ.—*A. excelsa*, a native of Guiana, is remarkable for its fluted trunk; this is employed for making paddles. Other spurious Quebracho barks are also known in commerce, one being Copalchi Bark, from *Croton pseudo-China.* (*The genus Aspidosperma is sometimes placed in the Bignoniaceæ.*)

Carissa.—Carissa Carandas bears an edible fruit, which is eaten in the East Indies, where it is used as a substitute for Red Currant jelly. The fruits of *C. edulis* and *C. tomentosa* are also eaten in Abyssinia.

Geissospermum læve (*G. Vellosii*), yields the bark which is employed medicinally in Brazil as a febrifuge and antiperiodic. The tree is known under the name of *Pao-Pereira.*

Hancornia speciosa bears a delicious fruit, which is much esteemed by the Brazilians. It is termed Mangalea or Mangava. The milky juice when hardened forms a kind of India-rubber. Collins says that Pernambuco Rubber is probably derived from this species. This rubber is now imported in large quantities from Pernambuco and Ceara. It is of good quality.

Landolphia.—L. owariensis, L. florida, and other species, yield African Rubber.

Plumieria.—The flowers of *P. alba* and other species, natives of the West Indies and some parts of South America, have a delicious odour; and it is said that the perfume known as 'Frangipani' is distilled from them. —*P. rubra* is called Red Jasmine in the West Indies.

Roupellia grata, a native of Sierra Leone, yields an edible fruit called Cream Fruit.

Tabernæmontana utilis, the Hya-Hya, or Cow-tree of Demerara, has a milky nutritious juice.

Tanghinia venenifera, the Madagascar Poison-nut.—The seeds of this plant are amongst the most deadly of poisons. It is said that one not larger than an almond will destroy twenty persons. It was formerly used as an ordeal in Madagascar.

Thevetia neriifolia.—The bark of this West Indian shrub is reputed to possess valuable antiperiodic properties.

Urceola elastica is one of the principal plants of the order yielding India-rubber. According to Collins it yields Borneo Rubber, and probably other India-rubber imported into Singapore, although some of this is obtained from *Ficus elastica.* (See *Ficus.*)

Vahea gummifera, a native of Madagascar, and other species, yield a kind of rubber. This kind is much valued in France, where it is sometimes known as Mauritius Rubber.

Wrightia.—The bark of *W. antidysenterica* is febrifugal and astringent. It is called Conessi Bark. The seeds have similar properties. Both the bark and seeds are much used in India. From *W. tinctoria* a blue dye resembling Indigo is obtained. The wood of *W. coccinea* and *W. mollissima* are also employed in India for palanquins, and by turners.

Order 4. ASCLEPIADACEÆ, the Asclepias Order.—Character.—*Shrubs* or *herbs*, commonly milky, frequently twining, and sometimes succulent. *Leaves* entire, opposite or whorled or rarely scattered, exstipulate. *Flowers* regular (*fig.* 1005). *Calyx* and *corolla* 5-partite (*fig.* 1005); *æstivation* of the latter imbricate or rarely valvate; the calyx persistent (*fig.* 565), the corolla deciduous. *Stamens* 5 (*fig.* 1005), alternate with the lobes of the corolla; *filaments* usually combined so as to form a tube round the pistil (*fig.* 1006), or sometimes distinct; *anthers* frequently surrounded by horn-like appendages of the filaments (*figs.* 1006, *a*, and 1007, *p*); '*pollen* when the anther dehisces, cohering in masses (*fig.* 565, *b*) and sticking to five processes of the stigma (*fig.* 565, *p*) by twos, or fours, or singly.' *Ovary* superior (*fig.* 1006), formed of 2 carpels, which are more or less adherent below, but distinct above; *styles* 2; *stigmas* united and expanded into a fleshy 5-cornered head, the pollen-masses adhering to gelatinous processes arising from its angles (*figs.* 565, *s*, and 1006). *Fruit* consisting of 2 follicles, or 1 by abortion. *Seeds* numerous, generally comose (*fig.* 755), with thin albumen.

Diagnosis.—This order is at once distinguished amongst the Dicarpiæ by its curiously formed stigma and adhering pollen-masses.

FIG. 1005.

FIG. 1006.

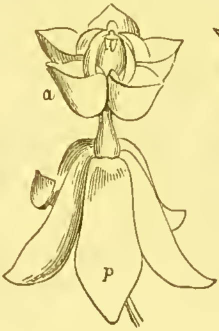


FIG. 1007.

Fig. 1005. Diagram of the flower of *Asclepias nivea.*——*Fig.* 1006. Flower of a species of *Asclepias*, with the stamens united and forming a tube round the pistil. *p.* Corolla. *a.* Appendages of the stamens.——*Fig.* 1007. One of the stamens of the same removed. *f.* Filament. *a.* Anther. *p.* Horn-like appendage of the filament.

Distribution and Numbers.—They are chiefly tropical plants, abounding in southern Africa, India, and equinoctial America. *Illustrative Genera*:—Hemidesmus, *R. Br.*; Asclepias, *Linn.*; Hoya, *R. Br.*; Stapelia, *Linn.* There are about 1,000 species.

Properties and Uses.—The plants of this order are chiefly remarkable for their bitter acrid juice, which renders them stimulant, emetic, purgative, and diaphoretic. Several species are reputed to be antidotes to snake-bites. Some species yield Caoutchouc; but no important commercial kind of Rubber is obtained from them. The parts of some are edible, as the roots of *Gomphocarpus pedunculatus*, and the tubers of *Ceropegia Vignaldiana*, &c.

Asclepias.—The root of *A. Curassavica* is employed in some of the West Indian islands as an emetic, hence it is termed Bastard Ipecacuanha. From the stems of *A. tenacissima*, *Jetee* or *Tongoose* fibres are obtained. The root of *A. tuberosa*, the Butterfly-weed or Pleurisy-root, is employed in the United States as a diaphoretic and expectorant.—*A. incarnata*, Swamp Silk-weed, is used in North America as an anthelmintic, and in asthma and rheumatism; it has also been lately recommended as a good diuretic.

Calotropis.—The dried root bark of *C. gigantea* and *C. procera* forms *Mudar bark*, which is official in the Pharmacopœia of India, and has been much employed in cutaneous affections. It has been also used as a substitute for Ipecacuanha. It contains a bitter principle. According to Royle, *Ak* or *Mudar* fibres are obtained from this bark. The bark of the root of *C. Hamiltonii* possesses similar properties, and is said to yield *Yercum* fibres.

Cynanchum.—The expressed juice of *C. monspeliacum* mixed with other purgative substances constitutes what has been termed *French* or *Montpellier Scammony.*—*C. ovalifolium* yields caoutchouc at Penang.

Gonolobus Cundurango.—Cundurango or Condurango Bark has been introduced into this country and elsewhere as a specific antidote to cancer, but extensive trials have shown that it is as useless as a remedial agent as any of the reputed cancer cures that have preceded it. It is official in the German Pharmacopœia.

Gymnema.—*G. lactiferum* is the Cow-plant of Ceylon. It derives its common name from producing a juice resembling milk in colour and consistency. The leaves when boiled are administered to nurses under the idea that they increase the secretion of milk.—*G. sylvestre*, a native of Northern India, has the singular property when chewed of destroying the power of tasting sugar for twenty-four hours, without in any other way interfering with the sense of taste.

Hemidesmus indicus.—The roots are known under the names of *Indian* or *Country Sarsaparilla*, and as *Nunnari root.* They were originally imported under the name of *Smilax aspera*, from an erroneous idea of their origin. They resemble Sarsaparilla in their properties, and are largely used in India as a substitute for it. Hemidesmus is official in the British Pharmacopœia and in the Pharmacopœia of India.

Marsdenia.—*M. tinctoria*, a native of Silhet, produces a kind of indigo. —*M. tenacissima* has very tenacious fibres, which are used for bow-strings by the mountaineers of Rajmahl.

Solenostemma (Cynanchum) Argel.—The leaves have been much employed to adulterate Alexandrian Senna. (See *Cassia*, p. 536.)

Tylophora asthmatica.—The dried leaves form an efficient substitute for Ipecacuanha. They are official in the Pharmacopœia of India. The root has similar properties.

Order 5. LOGANIACEÆ, the Strychnos Order.—Character. *Shrubs, herbs,* or *trees. Leaves* opposite, entire, stipulate; the latter, however, sometimes exist only in the form of a raised line or ridge. *Calyx* (*fig.* 478, *c*) inferior, 4—5-partite. *Corolla* (*fig.* 478, *t*, *l*) regular, 4—5- or 10-cleft; *æstivation* valvate, contorted, or imbricate *Stamens* epipetalous, usually equal in number, but sometimes unequal, to the lobes of the corolla; *anthers* 2-celled. *Ovary* 2- 3- or 4-celled; *style* simple below, and with as many divisions above as there are cells to the ovary; *stigma* simple (*fig.* 478, *s*). *Fruit* capsular or drupaceous; *placentas* axile, ultimately detached. *Seeds* usually peltate, sometimes winged, with fleshy or cartilaginous albumen. *This order is by no means well defined.*

Distribution and Numbers.—Nearly all natives of tropical regions. *Illustrative Genera:*—Spigelia, *Linn.*; Strychnos, *Linn.* There are about 200 species.

Properties and Uses.—These plants are almost universally poisonous, acting on the nervous system and producing frightful convulsions. Several have been used in medicine in torpid or paralytic conditions of the muscular system, and for their valuable tonic, anthelmintic, and other properties, but they require much caution in their employment, and can generally be only given in very small doses.

Gelsemium nitidum or *G. sempervirens*, Yellow Jasmine.—The dried rhizome and rootlets are official in the British and United States Pharmacopœias, and are regarded as of especial value in neuralgic pains of the face and jaws. Gelsemium is evidently a remedy of great power, and is now largely employed in intermittent, remittent, typhoid, and other fevers, in rheumatism, various obscure nervous diseases, and other affections. The active principle, termed *gelseminine*, exercises a sedative action on the nervous system, and is said to correspond in its action very closely to conium. It is very poisonous.

Spigelia.—*S. marylandica*, Carolina Pink, Wormseed, Perennial Wormgrass. The root and leaves of this plant are much employed in the United States as anthelminties, and the rhizome and rootlets are there official. In large doses they operate as irritant cathartics, and in poisonous doses as narcotics. They are but little used in this country.—*S. Anthelmia*, Demerara Pink Root, is employed for similar purposes in Guiana and the West Indies.

Strychnos.—This genus contains some of the most poisonous plants that are known.—*S. Ignatii.*—This plant yields the seeds known as St. Ignatius's Beans; these come to us from the Philippine Islands, and are official in the United States Pharmacopœia. They are intensely bitter, and contain the alkaloid Strychnine in even larger proportions than Nux-vomica seeds. Their effects are similar to them; they are largely used by homœopathic practitioners. They are also much employed in India in native practice.—*S. Nux-vomica*, the Koochla tree, produces Nux-vomica seeds, so well known for their powerfully poisonous effects. These seeds owe their virulent properties to the presence of the alkaloids *strychnine* and *brucine*, but more especially to the former, brucine possessing, it is said, only $\frac{1}{24}$th the activity of strychnine. It is stated by some authors, but upon what authority we know not, and it seems altogether improbable, that the fruit of *Feuillæa cordifolia* is an antidote to this poison. (See *Feuillæa.*) Both the seeds and the alkaloid strychnine are official in the British Pharmacopœia, and in proper doses they are employed as stimulants of the nervous system in paralysis and as valuable tonics. Nux-vomica seeds are imported from Coromandel, Ceylon, and other parts of India. In consequence of the enormous quantities which have been of late years brought to this country, it was thought that they were employed in the manufacture of *bitter ale* on account of their intense bitterness, but this has been satisfactorily disproved. A large quantity of both nux-vomica seeds and strychnine are employed by gamekeepers, and others, to destroy vermin; and both the seeds and strychnine are also largely exported to Australia, where they are extensively employed for destroying the native dog (*dingo*), and vermin. The large importation of the seeds into this country is therefore satisfactorily accounted for, and need give rise to no further misgivings as to their improper use. The bark of *S. Nux-vomica* is also very poisonous, owing to the presence of brucine chiefly; but it also contains traces of strychnine. As already noticed, it was formerly substituted for *cusparia* or *angustura bark* (see p. 503), hence it is likewise known as *false angustura bark.* This bark is also frequently sold in Calcutta under the name of *Rohun*, from which circumstance it has been substituted for the febrifugal bark of *Soymida febrifuga*, the Rohuna tree (see p. 509). The leaves and wood are also employed medicinally in India. The juice of *Strychnos Tieuté* is the Java poison called Upas Tieuté. It owes its poisonous properties to Strychnine. This poison must not be confounded with the true Upas, which is derived from a species of *Antiaris*. (See *Antiaris*.) The recent investigations of Planchon have shown that the celebrated arrow-poison which is prepared by various Indian tribes in the northern parts of South America, and known as *Wourali*, *Urari*, or *Curare*, is essentially prepared from species of *Strychnos*. Planchon has also proved that different species are employed in its preparation in different districts. Thus in the region of the upper Amazon, *S. Castelnæana* is used; in the upper Orinoco region a species closely allied to *S. toxifera* is the essential element of the Curare; in British Guiana *S. toxifera* is also principally used, but this is associated with *S. cogens* and *S. Schomburgkii*; while the fourth kind, the Curare of upper French Guiana, is prepared from a new species named *S. Crevauxii*. Curare has been employed in tetanus, but with no very satisfactory results, and also in chorea and hydrophobia. The wood of *S. colubrina* and *S. ligustrina*, natives respectively of Malabar and Java, is employed as an antidote to the bites of poisonous snakes, hence it is termed *Lignum colubrinum* or Snake-wood. Several other kinds of wood are, however, known in Asia under the same name. *Lignum colubrinum* has been also employed as a remedy in intermittent fevers, and for other purposes. It contains *strychnine*, and therefore requires much caution in its use. The bark of *S. pseudo-Quina* is extensively employed in Brazil as a substitute for Cinchona Bark. It contains neither strychnine nor brucine, and is devoid of poisonous properties. It is frequently erroneously called *Copalchi bark* (see *Croton* for the source of this bark). The dried ripe seeds of *S. potatorum* are devoid of poisonous properties. They are employed by the Hindoos to clear muddy water, hence the name of *Clearing-nuts* which is commonly applied to them. Their efficacy is due to the presence of albumen and casein, which act as fining agents in a similar manner to analogous agents employed for beer and wine. These seeds are also reputed to be emetic. The pulp of the fruit of *S. potatorum* is edible, as is also that of *S. pseudo-Quina*, *S. innocua*, and some other species; and, according to Roxburgh, that of *S. Nux-vomica* is likewise greedily eaten by birds.

Order 6. Gentianaceæ, the Gentian Order.—Character.—*Herbs*, or rarely *shrubs*, usually smooth. *Leaves* generally simple, entire, opposite, sessile, and strongly ribbed; rarely alternate, or stalked, or compound; always exstipulate. *Flowers* (*fig.* 431) regular, solitary and terminal, or in di—tri-chotomous cymes (*fig.* 435). *Calyx* inferior, persistent, usually with 5 divisions, or occasionally with 4, 6, 8, or 10. *Corolla* withering-persistent, its divisions corresponding in number to those of the calyx; *æstivation* imbricate-twisted or induplicate. *Stamens* as many as the segments of the corolla and alternate with them. *Ovary* 1-celled, or rarely partially 2-celled from the projection inwards of the placentas; *ovules* numerous; *placentas* 2, parietal (*fig.* 680), anterior and posterior to the axis, and frequently turned inwards; *style* 1; *stigmas* 2, right and left of the axis. *Fruit* capsular (*fig.* 680), 1—2-celled, 2-valved, with septicidal dehiscence; or rarely fleshy and indehiscent. *Seeds* numerous (*fig.* 680), small; *embryo* minute, in the axis of fleshy albumen.

Diagnosis.—Usually smooth herbs. Leaves exstipulate. Inflorescence definite. Flowers regular, solitary and terminal, or in cymes. Calyx and corolla persistent, with an equal number of lobes. Stamens alternate to the lobes of the corolla, and equal to them in number. Ovary superior, 1-celled, with 2 parietal placentas placed anterior and posterior, sometimes meeting in the centre and forming a 2-celled ovary; style 1; stigmas 2. Seeds small, numerous, with a minute embryo in the axis of fleshy albumen.

Division of the Order and Illustrative Genera.—The order may be divided into two sub-orders as follows :—

Sub-order 1. GENTIANEÆ.—Leaves opposite, corolla imbricate-twisted. *Illustrative Genera:*—Gentiana, *Linn.*; Chlora, *Linn.*
Sub-order 2. MENYANTHEÆ.—Leaves alternate, corolla induplicate. *Illustr. Genera:*—Menyanthes, *Tourn.*; Villarsia, *Vent.*

Distribution and Numbers.—They are found in nearly all parts of the world, inhabiting both the coldest and hottest regions. There are upwards of 500 species.

Properties and Uses.—A bitter principle almost universally pervades the plants of this order; hence many of them are tonic, stomachic, and febrifugal.

Erythræa Centaurium, the common Centaury, is an indigenous plant possessing similar properties to Gentian. It was till lately official in our pharmacopœias. Other species have similar properties.

Exacum.—Various species, as *E. bicolor*, *E. pedunculatum*, and others, natives of the East Indies, possess the tonic and stomachic properties of Gentian, and may be substituted for it.

Frasera carolinensis.—The root of this plant, which is a native of the United States, is commonly known as American Calumba. It has much less bitterness than Gentian root; and hence, though similar in properties, it is less powerful. It has been sold for Calumba in France, and is sometimes termed *false Calumba.*

Gentiana lutea.—This plant is a native of the mountains of central and southern Europe. Its root is our official Gentian, so well known for its bitter tonic properties. The roots of other species of Gentian are frequently found mixed with it in commerce, as those of *G. purpurea*, *G. punctata*, and *G. pannonica*; but this admixture is of little consequence, as they all possess similar properties. Powdered gentian is sometimes used to give flavour, &c., to cattle foods. From Gentian root, the Swiss and Tyrolese prepare a spirit which is much prized by them as a stomachic. The root of *G. Catesbæi*, a native of the United States, has similar properties to, though less powerful than, those of *G. lutea.*

Menyanthes trifoliata, Buck-bean, Bog-bean, or Marsh Trefoil.—The leaves and rhizome are tonic and astringent, and in large doses cathartic and emetic. The plant has been employed in Lapland, and some parts of Germany, as a substitute for hops. It was till lately official in our pharmacopœias.

Ophelia (Agathotes) Chirata, the Chiretta or Chirayta.—The dried plant possesses great bitterness. Chiretta is used by the natives of India as Gentian is employed in Europe. It is also in use as a tonic, &c., in this country, and is official in the British Pharmacopœia. Other species, natives of the East Indies, have similar properties, but are less valuable. One of these, namely, *O. angustifolia*, is now often substituted in this country for the genuine drug, as was first noticed by the author.

Sabbatia angularis, American Centaury.—The dried herb is employed in the United States on account of its tonic and febrifugal properties.

Cohort 2. *Polemoniales.*—Corolla regular or nearly so. Stamens epipetalous, equal in number to, and alternate with, the lobes of the corolla. Leaves alternate or rarely opposite, usually simple and entire, or sometimes lobed, and rarely compound ; always exstipulate.

Order 1. POLEMONIACEÆ, the Phlox Order.—Character.—*Herbs.* *Leaves* opposite or alternate, simple or compound, exstipulate. *Calyx* inferior, 5-partite, persistent, generally regular. *Corolla* 5-lobed, with contorted or occasionally imbricate æstivation. *Stamens* 5, alternate with the segments of the corolla ; *pollen* usually of a blue colour. *Ovary* 3-celled ; *style* 1 ; *stigma* trifid. *Fruit* capsular, 3-celled, 3-valved ; *placentas* axile. *Seeds* few or many ; *embryo* straight, in the axis of copious horny albumen ; *cotyledons* elliptical, foliaceous.

Distribution and Numbers.—They abound most in the temperate parts of North and South America ; but are far less abundant in Europe and Asia, and altogether unknown in tropical countries. *Illustrative Genera*:—Phlox *Linn* ; Polemonium, *Tourn* ; Cobæa, *Cav.* There are above 100 species.

Properties and Uses.—Of no importance except for the prettiness of their flowers. The seeds of *Collomia* and some other plants of this order have their testa covered with hair-like cells containing spiral fibres ; these fibres in *Collomia* expand in coils when the seeds are moistened. (See pages 45 and 335.)

Orders 2 and 3. DIAPENSIACEÆ and STILBACEÆ.—These are two small orders of shrubby plants which are placed by Lindley in his Gentianal alliance, and regarded by him as nearly allied to Loganiaceæ. The Diapensiaceæ are sometimes regarded, however, as being near to the Ericaceæ ; while others refer them to Convolvulaceæ. They have clearly affinities with both Polemoniaceæ and Hydrophyllaceæ, and hence are placed here. There are but 2 genera, and 2 species, the uses of which are unknown. They are natives of North America and Northern Europe.—The Stilbaceæ, of which there are 3 genera, and 7 species, without any known uses, are natives of the Cape of Good Hope.

Order 4. HYDROPHYLLACEÆ, the Hydrophyllum Order.—Character.—*Herbs*, *bushes*, or small *trees*. *Leaves* usually hairy, lobed, and alternate. *Flowers* either solitary, stalked, and axillary ; or numerous and arranged in a scorpioidal manner. *Calyx* persistent, 5-partite. *Corolla* regular, 5-cleft. *Stamens* equal in number to, and alternate with, the segments of the corolla. *Ovary* 1—2-celled, with two parietal placentas ; *styles* and *stigmas* 2 ; *ovules* 2 or many. *Fruit* capsular, 2-valved, 2- or 1-celled. *Seeds* netted ; *albumen* hard, abundant.

Distribution and Numbers.—Chiefly natives of the northern and most southern parts of the American continent. *Illustrative*

Genera :—Hydrophyllum, *Tourn.* ; Nemophila, *Bart.* There are about 80 species.

Properties and Uses.—Unimportant, except as showy garden plants.

Eriodictyon californicum, Benth., has a reputation among the Spaniards and Indians of California as a remedy for consumption ; and is hence known as the *Consumptive weed.* It has been recommended in the United States as a remedy for pulmonary and bronchial affections.

Order 5. BORAGINACEÆ, the Borage Order.—Character.—*Herbs* or rarely *shrubs*, with more or less rounded, usually rough and hairy stems. *Leaves* (*fig.* 440) alternate, entire, or rarely sinuated, usually rough, exstipulate. *Inflorescence* scorpioid (*figs.* 439—442). *Flowers* regular, symmetrical (*fig.* 1009). *Calyx* (*figs.* 1008 and 1009) persistent, inferior, 4—5-partite, or -lobed. *Corolla* (*figs.* 482, *p*, and 1009) regular or nearly so, 4—5-partite, usually with scales in its throat (*fig.* 482, *r*) ; *æstivation* imbricate. *Stamens* (*fig.* 1009) equal in number

FIG. 1008.

FIG. 1009.

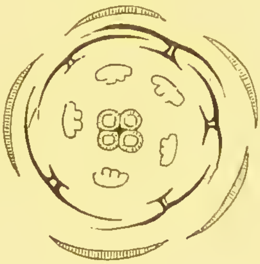


Fig. 1008. Vertical section of the fruit of a species of *Myosotis*. Two achænia are seen, and two have been removed. ——*Fig.* 1009. Diagram of the flower of the Comfrey (*Symphytum officinale*).

to the lobes of the corolla and alternate with them. *Ovary* superior, and composed of two carpels, each of which is 2-lobed and 2-celled (*fig.* 1009), with a solitary pendulous ovule in each cell ; *style* 1 (*fig.* 610, *d*), basilar ; *stigma* simple or bifid. *Fruit* consisting of from 2—4 distinct achænia, placed at the bottom of the persistent calyx (*figs.* 701 and 1008). *Seeds* exalbuminous ; *embryo* straight, with a superior radicle.

Diagnosis.—Herbs with rounded, usually rough stems, and alternate exstipulate leaves. Inflorescence scorpioid. Flowers regular and perfect. Calyx, corolla, and stamens equal in number, the latter being alternate with the divisions of the corolla. Ovary superior, deeply 4-lobed, with one ovule in each lobe ; style 1, basilar. Fruit composed of 2—4 achænia placed at the bottom of the persistent calyx. Seeds exalbuminous.

Distribution and Numbers.—Chiefly natives of temperate regions in the northern hemisphere. *Illustrative Genera* :—Echium, *Linn.* ; Borago, *Tourn.* ; Cynoglossum, *Linn.* There are nearly 700 species.

Properties and Uses.—The plants of this order are chiefly remarkable for their mucilaginous properties; hence they are mostly harmless, and possess little value as medicinal agents. Some species have roots of a reddish colour, which renders them useful as dyeing agents.

Anchusa (*Alkanna*) *tinctoria*, Alkanet, has a dark blood-red root; this is chiefly employed to give colour to oils, &c., which are used in perfumery, and for dyeing woods and other purposes.

Borago officinalis, Borage.—The root is mucilaginous and emollient. The herb imparts coolness to beverages in which it is steeped owing to its containing nitrate of potash.

Echium.—The broken leaves, stems, and flowers of species of *Echium* are employed in India as an alterative, tonic, demulcent, and diuretic. They are sold in the Indian bazaars under the name of *Gouzabán*.

Mertensia maritima is called the Oyster plant, from its leaves having the taste of oysters.

Symphytum.—*S. officinale*, Comfrey, is reputed to be vulnerary. The young leaves and shoots are sometimes eaten as a vegetable. It is said to form a good substitute for spinach. The root contains much starch and mucilaginous matters, and when finely scraped and laid on calico to about the thickness of a crown piece, it forms an excellent bandage for broken limbs. —*S. asperrimum* has been recommended for cultivation in this country as food for pigs, &c. It has long been used as a forage plant in Circassia and in Russia.

Order 6. Ehretiaceæ, the Ehretia Order.—*Diagnosis.*—These plants resemble the Boraginaceæ in most of their characters, but they differ in having their carpels so completely united as to form a 2- or more celled ovary; in their terminal style; and drupaceous fruit. They are usually characterised also by the presence of a small quantity of albumen in their seeds, but this is sometimes absent. *By many authors, as Bentham and Hooker, the Ehretiaceæ are made a sub-order of the Boraginaceæ.*

Distribution and Numbers.—Chiefly tropical plants. *Illustrative Genera*:—Ehretia, *Linn.*; Heliotropium, *Linn.* There are about 300 species.

Properties and Uses.—Unimportant.

Ehretia.—Some species of *Ehretia* have edible fruits. The roots of *Ehretia buxifolia*, when fresh, are employed in India by the native practitioners as an alterative.

Heliotropium.—Some species have a delicious odour, as the Peruvian Heliotrope (*Heliotropium peruvianum*).—*Heliotropium indicum* is known in Liberia under the name of the 'Erysipelas Plant,' from its common use, in the form of an infusion, as a fomentation to inflamed parts.

Order 7. Cordiaceæ, the Cordia Order.—Character.—*Trees* with alternate scabrous *leaves*, exstipulate. *Calyx* and *corolla* 5-merous; *æstivation* of the corolla imbricate-twisted. *Stamens* 5, alternate with the segments of the corolla; *anthers* versatile. *Ovary* superior, 4—8-celled, with 1 pendulous ovule in each cell; *stigma* 4—8-cleft. *Fruit* drupaceous, 4—8-celled, or frequently some of the cells are abortive; *placentas* axile. *Seeds* 1 in each cell, pendulous by a long cord; *albumen* none;

cotyledons plaited longitudinally. *This order is combined by Bentham and Hooker with Boraginaceæ.*

Distribution and Numbers.—Natives almost exclusively of tropical regions. *Illustrative Genera:*—Cordia, *Plum.*; Varronia, *DC.* There are above 180 species.

Properties and Uses.—The fruits of many species are edible, as those of *Cordia Myxa* and *C. latifolia*, which are called Sebestens or Sebesten plums, and are eaten by the natives, and others, in India; those of *Cordia abyssinica*, Wanzey or Vanzey, which are esteemed by the Abyssinians; and the succulent fruits of *Varronia rotundifolia*, which are used to fatten cattle and poultry. The bark of *C. Myxa* is reputed to be a mild tonic and astringent. Some species, as *Cordia Rumphii* and *Cordia Gerascanthus*, yield useful and ornamental timber. The wood of *Cordia Myxa* is said to be that from which the Egyptians constructed their mummy-cases. (See also *Ficus.*) Anacuhuite Wood, a substance imported into this country a few years since, and recommended as a tonic, &c., is derived from *Cordia Boissieri.*

Order 8. NOLANACEÆ, the Nolana Order.—Character.—*Herbs* or *shrubs. Leaves* alternate, exstipulate. *Inflorescence* straight. *Calyx* 5-partite, persistent, with a valvate æstivation. *Corolla* regular, with a plaited æstivation. *Stamens* 5, opposite to the lobes of the calyx. *Ovary* composed of from 5—20 carpels, either distinct or more or less combined into several bundles; *style* on a fleshy disk, simple; *stigma* simple. *Fruit* composed of 5 or more separate or more or less combined achænia, which are enclosed in the persistent calyx. *Seed* with a little albumen; *embryo* curved; *radicle* inferior. *This order is combined by Bentham and Hooker with Convolvulaceæ; and by others it has been referred to Boraginaceæ.*

Distribution and Numbers—Natives exclusively of South America, especially of Chili. *Illustrative Genera:*—Nolana, *Linn*; Alona, *Lindl.* There are about 36 species.

Properties and Uses.—Unknown.

Order 9. CONVOLVULACEÆ, the Convolvulus Order.—Character.—*Herbs* or *shrubs*, generally twining (*fig.* 227) or trailing, or sometimes erect, and frequently milky. *Leaves* (*fig.* 227) or *scales* alternate, exstipulate; sometimes leafless and parasitic (*fig.* 257). *Calyx* inferior, with 5 deep divisions, much imbricate (*figs.* 1010 and 1011), persistent. *Corolla* (*figs.* 1010 and 1011) 5-partite or 5-plaited, regular, deciduous, sometimes with scales in its tube (*fig.* 1013); *æstivation* twisted, plaited or imbricate. *Stamens* 5, alternate with the lobes of the corolla (*fig.* 1011). *Disk* annular, hypogynous. *Ovary* (*fig.* 1011) 2- 3- or 4-celled, or the carpels are more or less distinct; *styles* 1 or 2, usually 2-fid; *ovules* 1—2 in each cell or carpel, erect. *Fruit* capsular, 1—4-celled, with septifragal dehiscence, or bursting transversely at the base. *Embryo* (*fig.* 1012) large, curved or coiled in a small quantity of mucilaginous albumen, with foliaceous crumpled cotyledons; or in *Cuscuta* the embryo (*fig.* 1014) is filiform, spiral, and the cotyledons scarcely perceptible; *radicle* inferior.

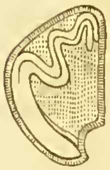
Diagnosis.—Generally twining or trailing milky herbs, with alternate exstipulate leaves; or parasitic and leafless. Calyx of 5 imbricate sepals, inferior. Corolla regular, 5-plaited or 5-lobed. Stamens 5, alternate with the lobes of the corolla. Ovary 2—4-celled. Fruit 2—4-celled, capsular, septifragal. Embryo curved, coiled, or spiral, in albumen; radicle inferior.

FIG. 1010.

FIG. 1011.

FIG. 1013.

FIG. 1012.



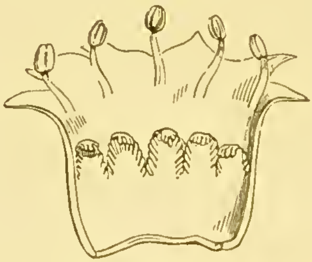


FIG. 1014.

Fig. 1010. Flower of Great Bindweed (*Convolvulus sepium*).——*Fig.* 1011. Diagram of the same flower, showing two bracts on the outside of the calyx.——*Fig.* 1012. Vertical section of the seed of the same.——*Fig.* 1013. Corolla of Dodder (*Cuscuta*) laid open to show five epipetalous stamens and the scales in its tube.——*Fig.* 1014. Spiral embryo of a species of *Cuscuta*.

Distribution and Numbers.—They are chiefly found in the plains and valleys of hot and tropical regions. A few occur in temperate climates, but they are altogether absent in the coldest latitudes. *Illustrative Genera:*—Convolvulus, *Linn.*; Ipomœa, *Linn.*; Cuscuta, *Linn.* There are about 750 species.

Properties and Uses.—They are chiefly remarkable for the presence of an acrid milky purgative juice in their roots, hence the order includes some important medicinal plants. The purgative property of the juice is essentially due to the presence of peculiar glucosides. In the roots of other species this purgative principle is either absent or in but small quantity, and starch or sugar predominates, which renders them edible. The seeds of some species are also purgative. The Cuscuteæ are leafless parasites, which often do great damage in clover- and flax-fields &c. by destroying the plants from which they draw their nourishment.

Convolvulus, Bindweed.—From the incised living root of *C. Scammonia*, a native of Asia Minor and Syria, the purgative gum-resin called Scammony is obtained. This Scammony as also Scammony Root, and Scammony Resin, are official in the British Pharmacopœia. The best and greater part of the Scammony of English commerce is imported from Smyrna. The roots of many other species also possess in a certain degree purgative properties; as those of our native species, *Convolvulus* (*Calystegia*) *sepium*, *C. arvensis*, and *C. Soldanella*. It is said that *Convolvulus dissectus* yields hydrocyanic acid when distilled with water. It is one of the plants used for flavouring *Noyau*.

Ipomœa.—Ipomœa Purga (*Exogonium Purga*) is a native of Mexico, near Chicanquiaco. Its tubercular roots constitute the true Jalap of the Materia Medica, so well known as a purgative; these properties are especially due to the glucoside *convolvulin*. Jalap is official in the British Pharmacopœia. The roots of *I. orizabensis* are sometimes found intermixed with true jalap. This spurious jalap is known in Mexico as *male jalap*, and in English commerce as *woody jalap* or *jalap wood*, and on the Continent as *light* or *fusiform jalap*. It possesses similar, although somewhat less powerful properties to those of true jalap; these properties are due to the glucoside *jalapin*. The roots of *I. Turpethum*, Turpeth, were formerly much used as a purgative. The large roots of *I. macrorhiza* contain much farinaceous matter, and are eaten by the inhabitants of the States of Georgia and Carolina.—*I. pandurata* is the *Mechameck* of the Indians of North America; its roots are said to be purgative and somewhat diuretic. *Tampico jalap*, now frequently employed as a substitute for true jalap, is derived from *Ipomœa simulans*. It appears to be nearly, if not quite, as powerful as the official kind.—*Ipomœa* (*Pharbitis*) *Nil*. The seeds are official in the Pharmacopœia of India, under the name of *Kaladana*. They possess similar medicinal properties to our official jalap, but are not quite so active.—*Ipomœa* (*Batatas*) *edulis*. The tubercular root of this plant constitutes the Sweet-Potato, which is so largely used for food in many tropical countries.

Rhodorrhiza.—From the species of this genus, natives of the Canary Islands, the volatile oil called Oil of Rhodium is commonly said to be obtained; but at the present time the so-called oil of Rhodium of commerce is a mixture compounded according to the taste of the vendor and the pocket of the buyer. The powdered wood is also used for snuff, and for fumigation.

Order 10. SOLANACEÆ, the Solanum Order.—Character.—*Herbs*, or rarely *shrubs*, or *trees*, with a colourless juice. *Leaves* alternate, often in pairs. *Inflorescence* axillary, or frequently extra-axillary (*fig.* 354). *Flowers* isomerous (*fig.* 1015). *Calyx* (*fig.* 1015) with 5 or rarely 4 divisions, usually persistent, often growing during the ripening of the fruit (*accrescent*). *Corolla* (*fig.* 1015) regular or somewhat irregular, 5- or rarely 4-partite; *æstivation* valvate, induplicate, plaited, or imbricate. *Stamens* equal in number to the lobes of the corolla, with which they are alternate (*figs.* 1015 and 1019); *anthers* 2-celled, sometimes connate above, with longitudinal or porous dehiscence (*figs.*

539 and 1016). *Ovary* superior (*figs.* 1016 and 1018), usually 2-celled, in which case the cells are placed anterior and posterior (*fig.* 1019), rarely 3—5-celled; *style* undivided (*figs.* 1016 and 1018); *stigma* simple or 2-lobed. *Fruit* capsular or baccate, 2-

FIG. 1015.

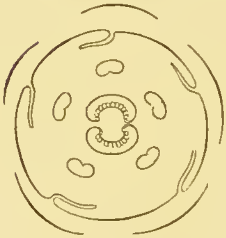


FIG. 1016.

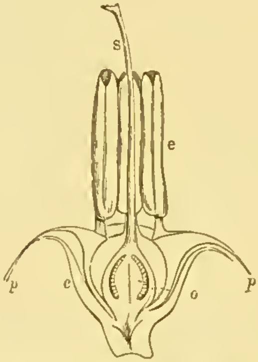


FIG. 1017.

Fig. 1015. Diagram of the flower of the Potato (*Solanum tuberosum*).——*Fig.* 1016. Vertical section of the same. *c.* Calyx. *p, p.* Corolla. *o.* Ovary. *e.* Stamens. *s.* Style and stigma.——*Fig.* 1017. Vertical section of the seed of *Solanum Dulcamara*. *te.* Testa. *ch.* Chalaza. *alb.* Albumen, enclosing the curved embryo.

FIG. 1018.

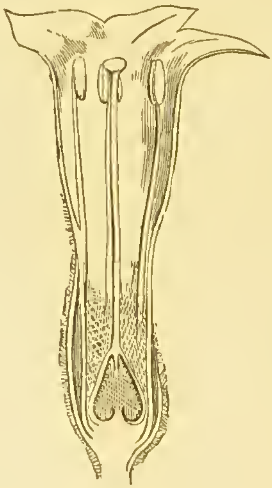


FIG. 1019.

Fig. 1018. Vertical section of the flower of Tobacco (*Nicotiana Tabacum*).——*Fig.* 1019. Diagram of the flower of the same.

or more celled. *Seeds* numerous, albuminous (*fig.* 1017, *alb*); *embryo* straight, or usually curved in a more or less annular or spiral form (*fig.* 1017).

Diagnosis.—Herbs or rarely shrubs or trees, with alternate leaves, and a colourless juice. Flowers isomerous. Calyx and corolla with 5, or rarely 4 divisions. Corolla regular or very slightly irregular; æstivation valvate, imbricate, plaited, or induplicate. Stamens equal in number to the lobes of the corolla, with which they are alternate; anthers 2-celled, with porous or longitudinal dehiscence. Ovary superior, with axile placentation, usually 2-celled, the cells being then placed anterior and posterior; or rarely more celled. Fruit dehiscent or indehiscent, 2- or more celled. Seeds numerous, albuminous.

In some former editions of this Manual, following the views of Miers, we adopted his new order, Atropaceæ; but as this arrangement has not been generally adopted, we have now, in accordance with most authorities, combined the latter order with the Solanaceæ; but on account of the more important medicinal value of the Atropaceæ of Miers, we retain this order as a sub-order, and divide the Solanaceæ as follows:—

Sub-order 1. Solaneæ.—Æstivation of the corolla valvate or induplicate. Stamens equal in number to the lobes of the corolla. *Illustrative Genera:*—Cestrum, *Linn.*; Solanum, *Linn.*

Sub-order 2. Atropeæ.—Æstivation of the corolla imbricate, or some modification of imbricate. Stamens equal in number to the lobes of the corolla, one occasionally sterile. *Illustrative Genera:*—Atropa, *Linn.*; Lycium, *Linn.*

Distribution and Numbers—They are scattered over various parts of the globe except the polar circles, but are most abundant in tropical regions. This order, as defined above, contains about 1,120 species.

Sub-order 1. Solaneæ.—*Properties and Uses.*—The plants of this sub-order frequently possess narcotic properties from the presence of the alkaloid Solanine, but not by any means to the same extent as those of the Atropeæ. Fatal cases of poisoning have, however, occurred from their improper use. Some are pungent and stimulant owing to the presence of an acrid oleo-resin; others contain a bitter tonic principle; and a few have edible fruits, leaves, or tubers. It has been stated that the juice of the Solaneæ does not produce dilatation of the pupil of the eye, as is the case with that of many plants of the Atropeæ; but this is not strictly correct.

Capsicum.—The species of this genus are remarkable for the presence of an oleo-resinous liquid, named *capsicin*, in their fruits, which renders them hot, pungent, and stimulating. This oleo-resin has been proved by Thresh to contain a very minute proportion of a crystalline substance called *capsaicin*, which he has shown to be the real active principle of capsicum fruits. The various species of *Capsicum* are generally supposed to have been originally natives of some warm part of the American continent, from whence they have become distributed over the world. There are several species and varieties of *Capsicum* in common use, one of which is official in the British Pharmacopœia, namely, the *C. fastigiatum* of Blume. The fruits of this are sometimes sold as *Chillies*; but this name is more commonly applied in England to the fruits of *C. annuum*; hence they are better distinguished as *Guinea Pepper.* These fruits are less than an inch in length, and are the most pungent of all Capsicum fruits. Cayenne Pepper is the powdered fruit of probably several species or varieties of *Capsicum*, but principally of *C. fastigiatum.* The fruits of *C. annuum* are frequently two or more inches in length. Hungarian Red Pepper (*paprika*) is obtained from a variety of *C. annuum* with a small pointed fruit. It is highly esteemed, and is said to be much used in the preparation of Cayenne Pepper. Other varieties or species of *Capsicum* in use in different parts of the world are, the *C. cerasiforme* (Cherry Pepper or Round Chilli), *C. grossum* (Bell Pepper), *C. frutescens* (Spice Pepper), *C. baccatum* (Bird Pepper), *C. tetragonum* (Bonnet Pepper). The general name of *Pod Pepper* is sometimes applied to the fruits of the species and varieties of Capsicum.

Lycopersicum esculentum.—This plant produces the fruits called Love-apples or Tomatoes, so much employed in the preparation of sauces, and for other purposes.

Physalis.—*P. peruviana* has an edible fruit which is known as the Peruvian Winter Cherry.—*P. Alkekengi*, Winter Cherry, and some other species, are diuretic.—*Physalis* (*Withania*) *somnifera*, as its name implies, is reputed to possess narcotic properties.

Punneeria (*Withania*) *coagulans.*—The dried fruit is employed in India as a carminative and stomachic, and also as a substitute for rennet in making cheese, &c.

Solanum.—The Common Potato, which is so largely used for food in temperate climates, is the tuber of *S. tuberosum.* Other species, as *S. Maglia. S. Commersoni*, *S. Jamesii*, and other species or varieties, are now being experimentally cultivated in England, the United States, and France, and promise good results. The object is to obtain a plant suitable for moist air and soil, the *S. tuberosum* being best adapted for dry air and soil. A decoction of the stem and leaves has been used as an alterative in cutaneous diseases, and an extract has been also employed as a narcotic and antispasmodic. The leaves when roasted have been used with success for thickening mordants in dyeing. The medicinal properties of the Potato plant are chiefly due to the presence of a small quantity of an alkaloid called *solanine*, which has narcotic properties. Solanine does not produce dilatation of the pupil like the alkaloids of the Atropeæ; and hence the reason why the juice of the Solaneæ generally differs in such respect from that of the Atropeæ. Solanine has been detected in all parts of the Potato plant, but in the tuber all traces of it are entirely removed by the processes of boiling and preparing potatoes for the table. Starch is largely obtained from potatoes, and used for food under the name of *English arrowroot. Bright's nutritious farina*, &c. It is employed to a great extent in the preparation of *Dextrine* or *British gum*, which is used in the arts, &c., as a substitute for gum, size, and paste.—*Solanum Dulcamara*, Woody Nightshade or Bitter-sweet. The dried young branches possess diuretic and diaphoretic properties, and are employed as an alterative in cutaneous diseases, and in other cases. They also possess slight narcotic properties owing to the presence of solanine. The fruits are in rare cases even poisonous, for one or more fatal cases of poisoning by them have been recorded.—*S. nigrum*, Black Nightshade, also possesses alterative and narcotic properties. The fruit is said to be edible; but if such be the case, its use for food requires caution, as solanine has been found in it. In the Mauritius, however, this herb as well as *S. oleraceum* are common pot-herbs and are largely consumed. The fruits of several species of *Solanum* are also eaten in various parts of the world, as those of *S. esculentum* (*S. Melongena*), in France, &c.; those of *S. quitoense*, named Quito Oranges; those of *S. laciniatum* in Australia, where they are termed Kangaroo-apples; those of *S. muricatum* and *S. nemorense* in Peru; and those of *S. anthropophagorum* and *S. repandum* in the Fiji Islands. Those of the first species (*S. esculentum*) are much esteemed in France under the name of *Aubergines* or *Brinjals*. They are about the size and form of a goose's egg and commonly of a purple colour, and are used as a vegetable. The white fruits of a variety of the same plant are known as Egg-apples. The leaves of *S. oleraceum* and *S. anthropophagorum* are likewise eaten by the Fijians. —*S. marginatum* has astringent properties, and is employed in Abyssinia in the process of tanning.—*S. Pseudoquina* is much employed in Brazil as a tonic and febrifuge. Several species of *Solanum* are also reputed to have diuretic properties, as *S. mammosum*, *S. paniculatum*, and others. The flowers and leaves of *S. cernuum* are sudorific, and have been employed in gonorrhœa, syphilis, &c.

Sub-order 2. ATROPEÆ.—*Properties and Uses.*—Many of the plants have powerful narcotic properties from the presence of peculiar and active alkaloids; hence several are very poisonous. The juice of numerous species will produce dilatation of the pupil of the eye. (See *Properties and Uses* of the Solaneæ, page 629.)

Atropa Belladonna, Deadly Nightshade, is a powerful poison; the root, leaves, and young branches are official in the British Pharmacopœia. It is employed internally as an anodyne and antispasmodic, and externally for dilating the pupil of the eye. John Harley regards it as a valuable remedy in scarlatina. It owes its activity to a peculiar alkaloid called *atropine*, which is frequently employed to produce dilatation of the pupil, and for other purposes. Atropine is a most powerful poison. It is official, together with Sulphate of Atropine, in the British Pharmacopœia.

Datura.—*D. Stramonium.*—A narcotic property is possessed by all parts of this plant, and is especially developed in the seeds, which are official in the British Pharmacopœia. Its medicinal effects resemble those of *Atropa Belladonna*. It is employed as an anodyne and antispasmodic. In *spasmodic asthma*, smoking the herb, or inhalation from its infusion in warm water, has frequently given great relief, but its use requires much caution, as it has in some instances produced fatal results. A strong decoction of the leaves is used in Cochin China as a remedy for hydrophobia, in which disease it is reputed to be very efficacious. Stramonium owes its principal activity to the presence of a narcotic alkaloid called *daturine*, which much resembles and is probably identical with *atropine*, the alkaloid of *Atropa Belladonna*. Recent investigations appear to show that it is also identical with *duboisine* and *hyoscyamine* (see *Duboisia*). Daturine is a powerful poison, and strongly dilates the pupil.—*D. alba*, *D. Tatula*, *D. fastuosa*, and other species or varieties, have similar properties to *D. Stramonium*. In India *D. alba* is frequently used by the natives for criminal purposes, the professional poisoners from this drug being called *Dhatureeas*. The fruit of *D. sanguinea*, the Red Thorn Apple, is in use among the Indians of the Andes, and in Central America, for the preparation of narcotic drinks; these, it is believed, produce a peculiar excitement, and enable those who partake of them to have communication with the spirits of their ancestors.

Duboisia myoporoides.—This plant, which is a native of New Caledonia and some parts of Australia, is closely allied to Belladonna in its properties, and contains a closely allied alkaloid which has been named *duboisine*. It is now said that this alkaloid, *hyoscyamine*, and *daturine*, are of the same nature (see *Datura*). It is commonly used medicinally in the form of Sulphate of Duboisine. The leaves, known as 'Pitury,' and used as an Australian substitute for Coca (see *Erythroxylon*), are obtained from *D. Hopwoodii*. They are said to contain an alkaloid analogous to *nicotine*.

Hyoscyamus niger, Henbane.—The whole herb possesses narcotic properties, and is employed medicinally as a narcotic, anodyne, and soporific. Its activity is essentially due to the presence of the alkaloid *hyoscyamine* (see *Duboisia*), which is a powerful poison resembling atropine and daturine, and like them causing dilatation of the pupil. Another powerful alkaloid, named *hyoscine*, has also been found in Henbane. Two varieties of Henbane are commonly cultivated, the Annual and the Biennial; the latter is commonly regarded as the more active, and its leaves and young flowering branches are official in the British Pharmacopœia.—*H. albus*, a native of the Mediterranean region, possesses the same properties as, and is probably of equal value to, that of *H. niger*.—*H. insanus*, a native of Beluchistan, is sometimes used for criminal purposes. It is said by Stocks to be a very poisonous species. It is called Mountain Hemp.

Mandragora officinalis, the true Mandrake.—The roots have a fancied resemblance to the human form, hence their name. This Mandrake must not be confounded with the root of *Bryonia dioica*, which is also sometimes so named (see *Bryonia*). Mandrake is an acro-narcotic poison, and was used by the ancients as an anæsthetic. The plant is called Devil's-apple by the Arabs. Mandrake is considered to be the Dudaim of Scripture.

Nicotiana.—The leaves of various species and varieties supply the different kinds of Tobacco now in such general use in some form or other in nearly every part of the globe. Mr. Crawford estimated the total annual production of tobacco over the whole globe in 1851 at 2,000,000 tons, which, at the value of 2*d*. per pound, would amount to more than 37,000,000*l*. sterling. The consumption of tobacco in this country has enormously increased of late years, and is still increasing. Thus in the year 1841 the quantity of tobacco cleared for consumption in the United Kingdom amounted to 13¾ oz per head of population. In the year 1851 the amount had increased to 1 lb. 0¼ oz. per head; in the year 1861 to 1 lb. 3½ oz.; in the year 1863 to 1 lb. 4½ oz.; and in the year 1865 to 1 lb. 5 oz. In 1874, 45,253,303 lbs. of unmanufactured tobacco were retained for home consumption, and of manufactured cigars and snuff nearly 1,280,154 lbs., or nearly 1½ lbs. per head of the population, and the duty paid on this was nearly 7,500,000*l*. sterling. The total annual production of tobacco over the whole globe at the present time is probably not less than 3,000,000 tons. Tobacco owes its principal properties to the presence of an alkaloid called *nicotine*, which is a most energetic poison. Tobacco has been employed in medicine as a local stimulant, and as a sedative, antispasmodic, emetic, laxative, and diuretic; and the dried leaves of *N. Tabacum* are official in the British Pharmacopœia. The principal kinds of Tobacco are the American, Latakia, Cuba, Manila, and Havannah, from *N. Tabacum*; the Shiraz or Persian, from *N. persica*; the East Indian and Turkish, from *N. rustica*; and Orinoko, from *N. latissima*. The Tobacco plant has lately been cultivated experimentally in this country, but we do not anticipate any very favourable results.

Scopolia japonica.—The root is used in Japan for similar purposes to that of *Atropa Belladonna* in Europe and America. It has been imported into this country under the name of Japanese Belladonna root, and described by Holmes; it is said to contain *solanine*. The leaves of *S. luridus* are stated by Waring to be equal, if not superior, to those of Belladonna in their medicinal properties.

Cohort 3. *Personales*.—Flowers generally anisomerous. Corolla usually irregular. Stamens epipetalous; posterior stamen nearly always suppressed, or appearing as a staminode; generally four and didynamous, or sometimes only two. Ovules usually numerous, or two superposed.

Order 1. SCROPHULARIACEÆ, the Figwort Order.—Character.—*Herbs*, or rarely *shrubby plants*, with alternate, opposite, or whorled *leaves*; generally without, or very rarely with, stipules; sometimes parasitical on roots. *Inflorescence* axillary. *Flowers* (*figs.* 1020 and 1021) anisomerous, irregular. *Calyx* inferior, persistent (*fig.* 710), 4—5-partite. *Corolla* more (*figs.* 488 and 489) or less (*figs.* 492 and 493) irregular, sometimes gibbous (*fig.* 488) or spurred (*fig.* 489), 4—5-partite; *æstivation* imbricate (*fig.* 1021). Stamens generally 4, and didynamous (*fig.* 559), or sometimes 2 (*fig.* 1020), or rarely 5 or with a rudimentary fifth; *anthers* 1—2-celled. *Ovary* usually 2-celled with axile placentation (*fig.* 1021), its component carpels being placed anterior and posterior; *style* 1 (*figs.* 626 and 1020); *stigma* undivided or 2-lobed. *Fruit* usually capsular, with variable dehiscence (*fig.* 710), or rarely baccate, usually 2-celled. *Seeds* generally numerous, small, albuminous; *embryo* straight

FIG. 1020.

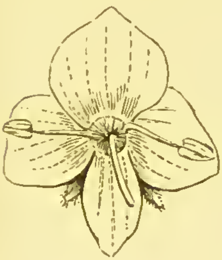


FIG. 1021.

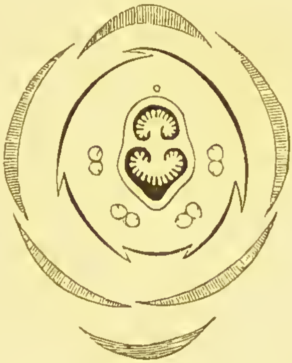


Fig. 1020. Flower of a species of Speedwell (*Veronica*).——*Fig.* 1021. Diagram of the flower of the Great Snapdragon (*Antirrhinum majus*), with one bract below.

or slightly curved. (*The above definition of the Scrophulariaceæ is in accordance with the views of Miers.*)

Diagnosis.—Herbs, or rarely shrubs. Flowers irregular, anisomerous. Inflorescence axillary. Calyx and corolla with 4 or 5 divisions. Corolla more or less irregular, æstivation imbricate. Stamens 4 and then didynamous, or sometimes 2, or rarely 5, or with a rudimentary fifth or staminode; anthers 1—2-celled. Ovary usually 2-celled, the cells placed anterior and posterior, with axile placentation; style 1. Fruit capsular, or rarely baccate. Seeds generally numerous, albuminous.

Distribution and Numbers.—The plants of this order are found in all parts of the globe. *Illustrative Genera*:—Verbascum, *Linn.*; Antirrhinum, *Tourn.*; Scrophularia, *Linn.*; Veronica, *Tourn.* As above defined, there are about 1,700 species.

Properties and Uses.—The plants of this order must be regarded with suspicion, as some are powerful poisons. Many are bitter, others astringent, some purgative, emetic, or diuretic, and a few possess narcotic properties. A great many species are cultivated in our gardens, &c., on account of the beauty of their flowers.

Capraria bifolia is used in Central America as tea.

Digitalis purpurea, Foxglove.—This is by far the most important medicinal plant in the order. The roots, leaves, and seeds are the most active parts, but the dried leaves only are official in the British Pharmacopœia. Foxglove is largely used as a diuretic in dropsies, and as a sedative of the circulation in diseases of the heart, &c. In improper doses it is a deadly poison. It owes its activity essentially to the presence of a powerfully poisonous bitter principle, called *Digitalin*, which in proper doses is used in medicine in the same cases as digitalis itself; but it is a very variable substance, and therefore uncertain in its action. Digitalin is also reputed to be a powerful anaphrodisiac. Other species of *Digitalis* have similar properties to those of *D. purpurea*, but they are not so active.

Gratiola officinalis, Hedge Hyssop, was formerly official in our pharmacopœias. It possesses purgative, emetic, and diuretic properties, and in large doses is said to be an acrid poison.

Leptandra virginica.—The rhizome and rootlets are official in the United States Pharmacopœia. The dried rhizome and more especially the resinoid powder, called *leptandrin*, which is obtained from it, are regarded as excellent cholagogues, and are used largely in the United States and elsewhere as substitutes for mercurials.

Lyperia crocera.—The flowers of this plant, which is a native of South Africa, have been imported into this country from time to time, under the name of African Saffron. They closely resemble true saffron in smell and taste; and have similar medicinal properties. They are also employed for dyeing; they yield a fine orange colour.

Scrophularia.—The fresh leaves of *N. nodosa* are sometimes used, in the form of an ointment or fomentation, in skin diseases and indolent tumours, &c. The leaves and roots of this species and of *S. aquatica* are purgative and emetic, and are supposed to be slightly narcotic.

Verbascum.—The leaves of *V. Thapsus*, Great Mullein, have emollient, demulcent, and slightly narcotic properties. A decoction of the leaves in milk is frequently used as a domestic remedy on the Continent and in Ireland in incipient phthisis. Smoking the dried leaves is also said to be useful in allaying cough in phthisis. Its seeds and those of *V. nigrum* are also stated to be employed by poachers to stupefy fish in order that they may be readily taken.

Veronica.—The leaves of *V. officinalis* have been used in this country, and on the Continent, as a substitute for China Tea, hence the plant is sometimes called *Thé de l'Europe*. They have also been considered diaphoretic, diuretic, expectorant, tonic, &c., and were employed formerly in pectoral, nephritic, and other complaints.

Order 2. OROBANCHACEÆ, the Broom-rape Order.—Character.—*Herbs* of a more or less fleshy character, growing parasitically on the roots of other plants. *Stems* with scale-like leaves. *Calyx* persistent, toothed. *Corolla* irregular, persistent; *æstivation* imbricate. *Stamens* 4, didynamous; *anthers* 1—2-celled. *Ovary* 1-celled; its 2 component carpels being placed right and left of the axis; *placentas* 2—4, parietal; *style* 1; *stigma* 2-lobed. *Fruit* a capsule. *Seeds* very numerous, minute, with fleshy albumen and a very small rudimentary embryo.

Distribution and Numbers.—Principally natives of Europe, Northern Asia, North America, and the Cape of Good Hope. *Illustrative Genera:*—Orobanche, *Linn.*; Lathræa, *Linn.* There are about 120 species.

Properties and Uses.—The presence of bitterness and astringency are the most marked properties of the plants of this order, and some have been said to be escharotic; but they are altogether unimportant in a medicinal point of view.

Epiphegus.—The root of *Epiphegus virginiana* is called Cancer-root, from its having been formerly used as an application to cancers. It formed an ingredient in the once celebrated North American nostrum, called Martin's Cancer Powder.

Order 3. LENTIBULARIACEÆ, the Butterwort Order.—Character.—*Herbs*, growing in water, marshes, or wet places. *Leaves* radical, entire or divided into thread-like filaments bearing little pouches or air-receptacles. *Flowers* irregular, bracteated. *Calyx* persistent, bilabiate. *Corolla* personate or bilabiate, spurred. *Stamens* 2, included; *anthers* 1-celled. *Ovary* 1-celled; *style* 1, short; *stigma* bilabiate; *placenta* free central. *Fruit* a capsule, 1-celled. *Seeds* minute, numerous, anatropous, exalbuminous; *embryo* thick, straight, sometimes undivided.

Distribution and Numbers.—Natives of all parts of the globe, but more particularly of tropical regions. *Illustrative Genera:*—Utricularia, *Linn.*; Pinguicula, *Tourn.* There are about 180 species.

Properties and Uses.—Of little importance. The leaves of *Pinguicula* and the pitchers of *Utricularia* have the property of dissolving and absorbing insects, and other animal matters. (See Physiological Botany.)

Pinguicula.—*Pinguicula vulgaris* is termed Butterwort, from the property its leaves are said to possess of coagulating milk.

Order 4. COLUMELLIACEÆ, the Columellia Order.—Character.—Evergreen *shrubs* or *trees*. *Leaves* opposite, exstipulate. *Flowers* unsymmetrical, yellow, terminal. *Calyx* superior, 5-parted. *Corolla* epigynous, monopetalous, rotate, 5—8-partite, imbricate. *Stamens* 2, epipetalous; *anthers* sinuous, with longitudinal dehiscence. *Ovary* inferior, 2-celled, surmounted by a fleshy disk. *Fruit* capsular, 2-celled, many-seeded. *Seeds* with fleshy albumen; *embryo* minute.

Distribution and Numbers.—Natives of Mexico and Peru. It only contains the genus *Columellia*, Lour., which includes 3 species.

Properties and Uses.—Unknown.

Order 5. GESNERACEÆ, the Gesnera Order.—Character.—*Herbs*, or soft-wooded *shrubs*. *Leaves* wrinkled, exstipulate, generally opposite or whorled. *Flowers* irregular, showy. *Calyx*

5-partite. *Corolla* 5-lobed, perigynous or hypogynous. *Stamens* diandrous or didynamous with the rudiment of a fifth; *anthers* 2-celled, frequently united. *Ovary* of 2 carpels, antero-posterior, superior or half-inferior, 1-celled, surrounded by an annular fleshy disk or by glands; *style* 1. *Fruit* capsular or succulent, 1-celled, with 2-lobed parietal placentas. *Seeds* numerous, with or without albumen; *embryo* with minute cotyledons, and a long radicle.

Division of the Order and Illustrative Genera.—The order has been divided into two sub-orders or tribes as follows:—

Sub-order 1. GESNEREÆ.—Ovary partially adherent to the calyx. Seeds albuminous. *Illustrative Genera:*—Gesnera, *Mart.*; Gloxinia, *Hérit.*

Sub-order 2. CYRTANDREÆ.—Ovary not adherent to the calyx. Seeds exalbuminous. *Illustrative Genera:*—Æschynanthus, *Jack.*; Cyrtandra, *Forst.*

Distribution and Numbers.—Chiefly natives of warm or tropical regions. The Gesnereæ are all American; the Cyrtandreæ are more scattered. There are about 300 species.

Properties and Uses.—Of little importance except for the beauty of their flowers, which are common objects of cultivation in this country. Some Gesnereæ have edible fruits.

Order 6. CRESCENTIACEÆ, the Crescentia Order.—Character.—Small *trees*. *Leaves* simple, alternate or clustered, exstipulate. *Flowers* irregular, growing out of old branches or stems. *Calyx* free, entire at first, afterwards splitting irregularly. *Corolla* somewhat bilabiate. *Stamens* 4, didynamous, with a rudimentary fifth; *anthers* 2-celled. *Ovary* surrounded by an annular disk, 1-celled; *placentas* 2—4, parietal; *style* 1. *Fruit* indehiscent, woody. *Seeds* large, numerous, wingless, exalbuminous; *cotyledons* large, amygdaloid; *radicle* short. *This order is made a tribe of Bignoniaceæ by Bentham and Hooker.*

Distribution and Numbers.—Natives exclusively of tropical regions. *Illustrative Genera:*—Crescentia, *Linn.*; Parmentiera, *DC.* There are about 36 species.

Properties and Uses.—Unimportant.

Crescentia.—The subacid pulp of the fruit of *Crescentia Cujete*, the Calabash Tree, is eaten by the negroes in America, and its hard pericarp is used for bottles, forming floats, &c. The fruit has been lately described as a useful and pleasant aperient.

Parmentiera.—The fruit of *Parmentiera edulis* under the name of *Quandhscilote* is eaten by the Mexicans, and that of *P. cerifera* is likewise greedily devoured by cattle in Panama. The latter resembles a candle in form, and hence the tree bearing it is named the Candle-tree.

Order 7. BIGNONIACEÆ, the Bignonia Order.—Character. *Trees* or *shrubs*, which are often twining or climbing, or rarely *herbs*. *Leaves* exstipulate, usually opposite. *Inflorescence* terminal. *Flowers* irregular. *Calyx* entire or divided. *Corolla*

4—5-lobed. *Stamens* 2 or 4; *anthers* 2-celled. *Ovary* seated in a disk, usually 2-celled; *placentas* axile; *style* 1. *Fruit* 2-valved, capsular. *Seeds* numerous, sessile, large, winged, exalbuminous; *embryo* with large leafy cotyledons.

Distribution and Numbers.—Chiefly tropical plants. *Illustrative Genera:*—Bignonia, *Linn.*; Tecoma, *Juss.*; Jacaranda, *Juss.* There are about 450 species.

Properties and Uses.—The chief interest of the plants of this order lies in their beautiful flowers, although some are used medicinally and in other ways.

Bignonia.—From the leaves of *Bignonia Chica* the Indians of South America obtain a red dye called Chica or Carajuru, which is used for painting their bodies and arrows, and for other purposes. This Chica must not be confounded with Chica or Maize Beer (see *Zea Mays*), and other Chicas which are common drinks of the Indians in South America. An oil is obtained in India from the wood of *Bignonia xylocarpa.* It is reputed to be a valuable external application in skin diseases.

Jacaranda.—The bark of *Jacaranda bahamensis* is employed as an anthelmintic in Panama. The leaves of *J. lancifolia* are said to be useful in urethral inflammation: it has been used in the form of an extract.

Sparattosperma.—The leaves of *Sparattosperma leucantha*, a Brazilian species, have powerful diuretic properties.

Tecoma.—Some species of *Tecoma* have astringent properties. The wood of several plants of the order is used in Brazil.

Order 8. PEDALIACEÆ, the Pedalium Order. — Character.—Glandular *herbs*. *Leaves* entire, exstipulate. *Flowers* axillary, usually large and irregular. *Calyx* 5-partite. *Corolla* bilabiate. *Stamens* didynamous with the rudiment of a fifth, included; *anthers* 2-celled. *Ovary* on a fleshy or glandular disk, 1-celled, with two parietal placentas; sometimes spuriously 4—6-celled; *style* 1; *stigma* divided. *Fruit* bony or capsular. *Seeds* wingless, without albumen; *embryo* with large cotyledons, and a short radicle.

Distribution and Numbers.—Chiefly tropical plants. *Illustrative Genera:*—Pedalium, *Linn.*; Sesamum, *Linn.* There are about 25 species.

Properties and Uses.—Chiefly remarkable for their oily seeds.

Pedalium Murex.—An infusion of the fresh leaves and stems has been employed with success in India in dysuria and gonorrhœa. The fruit under the name of *Gokeroo* or *Gokhru* is also used in India as a remedy for impotence, nocturnal seminal emissions, and incontinence of urine.

Sesamum indicum.—The seeds yield by expression a fixed oil which is largely used in India, Japan, France, &c., where it is regarded as an efficient substitute for Olive Oil. It is also employed in the West Indies; and in Egypt and Ceylon it is used for cleansing the skin and hair. It is also said to be employed to adulterate Almond Oil. The Oil is known as Benne, Sesamé, Til, Teel, Gingili, or Gingelly Oil. This oil is also obtained from *S. orientale*, and both this plant and that of *S. indicum* are official in the Pharmacopœia of India, as its botanical source. Sesamé seeds are also largely used as food in India and Tropical Africa. The leaves of both plants are likewise official in the Pharmacopœia of India, and are employed in the form of an infusion, as a demulcent. In the United States they are also sometimes used in the form of a poultice.

Order 9. ACANTHACEÆ, the Acanthus Order.—Character.—*Herbs* or *shrubs*. *Leaves* opposite or whorled, simple, exstipulate. *Flowers* irregular, bracteated, *Calyx* 4—5-partite, or consisting of 4—5 sepals, persistent, much imbricate; sometimes obsolete. *Corolla* more or less 2-lipped. *Stamens* 2 or 4, in the latter case didynamous. *Ovary* seated in a disk, 2-celled; *placentas* parietal, although extended to the axis; *style* 1. *Fruit* capsular, 2-celled, with a variable number of seeds in each cell. *Seeds* hanging by hard cup-shaped or hooked projections of the placenta, without wings; *albumen* none; *cotyledons* large and fleshy; *radicle* inferior.

Distribution and Numbers.—Chiefly tropical. *Illustrative Genera*:—Acanthus, *Tourn.*; Justicia, *Nees.* There are nearly 1,500 species.

Properties and Uses.—Generally unimportant; but several species are mucilaginous and bitter.

Acanthus.—The species of *Acanthus* have lobed and sinuated leaves, and are said to have furnished the model of the Corinthian capital.

Andrographis.—The dried stalks and root of *Andrographis paniculata* are official in the Pharmacopœia of India. They are known under the name of *kariyât* or *creyat*, and are held in high esteem in India for their bitter tonic and stomachic properties.

Ruellia.—From *Ruellia indigotica* a blue dye is obtained in China.

Cohort 4. *Lamiales.*—Flowers generally anisomerous. Corolla usually irregular. Stamens epipetalous; posterior stamen commonly suppressed; usually four and didynamous, or rarely only two. Carpels or cells each with 1 ovule or with 2 collateral ovules. Leaves always exstipulate.

Order 1. SELAGINACEÆ, the Selago Order.—Character.—*Herbs* or *shrubs*, with alternate exstipulate leaves. *Flowers* irregular, unsymmetrical, sessile, bracteated. *Calyx* persistent, usually monosepalous with a definite number of divisions, or rarely consisting of two distinct sepals. *Corolla* tubular, 5-partite. *Stamens* 4, didynamous, or rarely 2; *anthers* 1-celled. *Ovary* superior; *style* 1, filiform; *ovule* solitary, pendulous. *Fruit* 2-celled, with 1 pendulous seed in each cell. *Seed* with a little fleshy albumen; *embryo* with a superior radicle. In *Globularia* there is but one carpel.

Distribution and Numbers.—Chiefly natives of the Cape of Good Hope. The species of *Globularia* are, however, European plants. *Illustrative Genera*:—Selago, *Linn.*; Globularia, *Linn.* There are about 120 species.

Properties and Uses.—Of little importance.

Globularia.—The *Globularias* are purgative and emetic. The leaves of *Globularia Alypum* form the *Wild Senna* of Germany. In small doses they act as a tonic, and in full doses as a safe, mild, and efficient purgative. They have been sometimes employed on the Continent for the adulteration of the official Senna; and also, it is said, in the process of tanning. They contain both tannic and gallic acids.

Order 2. VERBENACEÆ, the Vervain Order.—Character.—*Herbs, shrubs,* or *trees. Leaves* opposite or alternate, exstipulate. *Calyx* (*fig.* 414) inferior, persistent, tubular. *Corolla* irregular, usually more or less 2-lipped. *Stamens* 4, usually didynamous, or rarely equal; or sometimes there are but 2 stamens; *anthers* 2-celled. *Ovary* (*fig.* 1022) 2—4-celled; *style* 1, terminal (*fig.* 1022); *stigma* undivided or bifid. *Fruit* dry or drupaceous, composed of from 2—4 carpels, which when ripe usually separate into as many 1-seeded achænia. *Seed* erect or ascending, with little or no albumen, and an inferior radicle.

Diagnosis.—Known at once from the Labiatæ by their more united carpels and terminal style.

FIG. 1022.

Fig. 1022. Pistil of the Vervain (*Verbena*).

Distribution and Numbers.—They are found both in temperate and tropical regions. *Illustrative Genera:*—Verbena, *Linn.*; Clerodendron, *Linn.* There are above 660 species.

Properties and Uses.—Many of the plants are slightly aromatic and bitter, but there are no important medicinal plants included in this order. Some are valuable timber trees; other species have fleshy fruits, which are edible; and the leaves of a few are used as substitutes for China Tea. Many are cultivated in our gardens for the beauty of their flowers or for their fragrance, as the different species and varieties of *Verbena*, the *Aloysia citriodora*, the Lemon-plant, &c.

Clerodendron.—The leaves of *C. infortunatum*, an Indian species, possess tonic and antiperiodic properties.

Gmelina parvifolia and *G. asiatica* have demulcent properties.

Lantana pseudo-thea is used in the Brazils as tea, under the name of *Capitão da matto.* Some species of *Lantana* have edible fruits.

Premna.—The inner bark of *P. taitensis*, which is known under the name of 'aro' at Vanua Levu, is said to be one of the constituents of the remedy now used under the name of 'Tonga' in certain forms of neuralgia. (See also *Rhaphidophora.*)

Stachytarpha jamaicensis is reputed to be purgative, emmenagogue, and anthelmintic. It is used medicinally in Liberia in the form of tea to produce abortion, and is there known under the name of 'Abortive Plant.' Its leaves are sometimes employed in Austria as a substitute for, or to adulterate, China tea; this is known under the name of Brazilian Tea.

Tectona grandis, Indian Teak-tree or Indian Oak, is the source of the very hard and durable wood known as East Indian Teak, which is much employed in ship-building, &c.

Verbena.—The roots and leaves of *Verbena hastata* are reputed to have excellent sudorific properties.

Vitex.—Several species of this genus have acrid fruits, as those of *V. trifolia*, Wild Pepper, *V. Negundo*, and *V. Agnus-castus.* The fresh leaves of the two former species are in great repute in India for their discutient properties. They are also regarded as anodyne, diuretic, and emmenagogue.

Order 3. MYOPORACEÆ, the Myopora Order.—*Diagnosis.*—This order is sometimes regarded as a sub-order of the Verbenaceæ, from which it only differs essentially in having two seeds in each cell of the fruit, and by the embryo having a superior radicle.

Distribution and Numbers.—Chiefly natives of the southern hemisphere. *Illustrative Genera:*—Myoporum, *Banks et Sol.*; Avicennia, *Linn.* There are about 40 species.

Properties and Uses.—Unimportant. The bark of *Avicennia tomentosa*, White Mangrove, and other species, is much used in Brazil for tanning.

Order 4. LABIATÆ, the Labiate Order.—Character.—*Herbs* (*fig.* 393) or *shrubby plants*, with usually square stems. *Leaves* opposite (*fig.* 393) or whorled, commonly strong-scented, entire or divided, exstipulate. *Flowers* generally in axillary cymes, which are arranged in a somewhat whorled manner so as to form what are called verticillasters (*fig.* 393). *Calyx* inferior,

FIG. 1023.

FIG. 1024.

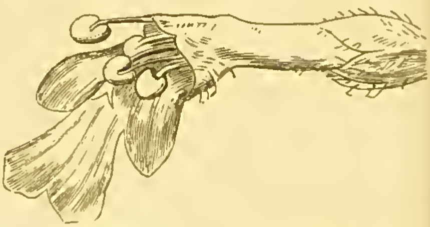


Fig. 1023. Diagram of the flower of the White Dead-nettle (*Lamium album*). ——*Fig.* 1024. Flower of the common Bugle (*Ajuga reptans*).

persistent, either tubular, 5- or 10-toothed, and regular or nearly so, or irregular and somewhat bilabiate, with 3—10 divisions; the odd tooth or division always posterior (*fig.* 1023). *Corolla* (*figs.* 484-487, and 1025) usually more or less bilabiate, with the upper lip undivided (*fig.* 484) or bifid (*fig.* 485), and commonly more or less arched over the lower lip (*fig.* 484), or sometimes nearly suppressed (*fig.* 1024); the lower lip 3-lobed (*fig.* 1024), with the odd lobe anterior (*fig.* 1023); or rarely the corolla is nearly regular. *Stamens* usually 4, and then commonly didynamous (*figs.* 487, 1025, and 1026), or very rarely of nearly equal length, or only two by abortion; *anthers* 2-celled, or 1-celled by abortion; the filament or connective sometimes forked, each branch then bearing a perfect cell, or the cell on one side obsolete or sterile (*fig.* 1028). *Ovary* (*figs.* 609 and 1027) imbedded in the disk or thalamus, and formed of two carpels, each of which has 2 deep lobes, with 1 erect ovule in each lobe; *style* 1, basilar (*figs.* 609 and 1027); *stigma* bifid, (*figs.* 609 and 1027). *Fruit* composed of from 1—4 achænia, enclosed by the persistent calyx. *Seed* erect, with little or no albumen; *embryo* erect, with flat *cotyledons*; *radicle* inferior.

Diagnosis.—Herbs or shrubby plants, with opposite exstipulate leaves. Flowers irregular, unsymmetrical. Calyx persistent. Corolla usually more or less bilabiate, with the odd lobe anterior. Stamens usually 4 and then commonly didynamous, or rarely of equal length; or only 2 by abortion. Ovary deeply 4-lobed; style 1, basilar; stigma bifid. Fruit consisting of

FIG. 1025.

FIG. 1027.

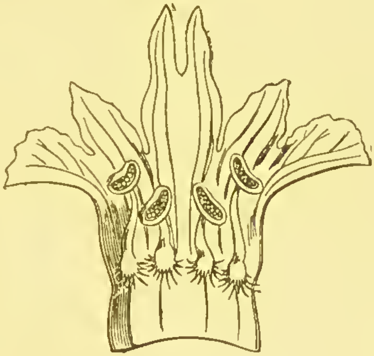


FIG. 1028.

FIG. 1026.

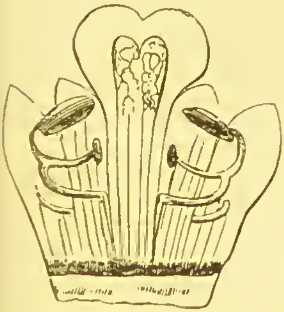


Fig. 1025. Front view of the flower of a species of *Lamium.* ——*Fig.* 1026. The corolla of the Garden Sage (*Salvia officinalis*) cut open.——*Fig.* 1027. The corolla of the Horehound (*Marrubium vulgare*) cut open.——*Fig.* 1028. Lobed ovary, style, and bifid stigma of the Garden Sage (*Salvia officinalis*).

from 1—4 achænia, enclosed by the persistent calyx. Seed erect, with little or no albumen; radicle inferior.

Distribution and Numbers.—Chiefly natives of temperate regions. *Illustrative Genera:*—Mentha, *Linn.*; Salvia, *Linn.*; Origanum, *Linn.*; Lamium, *Linn.* There are nearly 2,600 species.

Properties and Uses.—The plants of this large order are entirely free from any deleterious qualities. They abound in *volatile oil*, and are therefore commonly aromatic, carminative, and stimulant. All labiate plants also contain more or less of a *bitter extractive matter*, and many of them possess an *astringent* *principle*, hence they are frequently tonic and stomachic. Several are used in perfumery on account of their agreeable odours; and many are employed by the cook for flavouring, such as *Thymus vulgaris* (Garden Thyme), *Thymus citriodorus* (Lemon Thyme), *Salvia officinalis* (Sage), *Origanum vulgare* (Marjoram), *Majorana hortensis* (Sweet Marjoram), *Satureia montana* (Winter Savory), *Satureia hortensis* (Summer Savory), &c. The fleshy underground stems of *Stachys palustris* and of a species of *Ocymum* are edible.

Anisomelos malabarica is in great repute in Southern India as a remedy in intermittent fevers, catarrhal affections, &c.

Hedeoma pulegioides, American Pennyroyal, is much used in the United States (where the leaves and tops are official) as an emmenagogue, and also occasionally as a stimulant and carminative.

Lavandula.—The flowers of *L. vera*, Common Lavender, yield by distillation with water English Oil of Lavender, which is official in the British Pharmacopœia; it is largely used in perfumery, and also in medicine as a stimulant, stomachic, and carminative. The flowers and leaves are likewise occasionally employed as a sternutatory. The flowers of *L. spica*, French Lavender, yield Oil of Spike or Foreign Oil of Lavender, which has a much less agreeable odour than the English Oil; it is not employed medicinally, but principally by painters and varnish-makers, and to adulterate English Oil of Lavender.—*L. Stœchas* also yields by distillation an essential oil, which is commonly distinguished as the True Oil of Spike.

Marrubium vulgare, Common Horehound, is much employed as a domestic remedy in coughs, &c. The leaves and tops are official in the United States Pharmacopœia.

Melissa officinalis, Common Balm, possesses mild stimulant properties. It is used as a diaphoretic in fevers, as an exhilarating drink in nervous affections, and as an emmenagogue.

Mentha, Mint.—Several species are employed in medicine, and as sweet herbs. The volatile oils of two species are official in the British Pharmacopœia, namely, of *M. viridis*, Spearmint, and of *M. piperita*, Peppermint.—*M. Pulegium*, Pennyroyal, *M. rotundifolia*, *M. aquatica*, *M. arvensis*, and others, have similar properties. The stearoptene called *menthol*, which is official in the British Pharmacopœia, is said to be derived from *M. arvensis*, vars. *piperascens et glabrata*, and *M. piperita*. It has been largely used as an external application for relieving neuralgia. It has also powerful antiseptic properties; and acts internally as a diffusible stimulant. All the species and varieties are more or less aromatic, stimulant, and carminative.

Micromeria Thea-sinensis is used in France as a substitute for China Tea.

Monarda.—*M. punctata*, Horsemint, is used medicinally in the United States. In its properties it resembles the ordinary mints, but it is more stimulating. This plant is also one of the sources of the official *thymol*. (See *Thymus vulgaris*.)—*M. fistulosa* is said to be febrifugal. The leaves of *M. didyma* and *M. purpurea* are used in North America as tea under the name of Oswego Tea. The flowers of *M. didyma* contain a colouring principle like cochineal, and have been used for the preparation of a kind of carmine.

Nepeta Cataria, Catmint.—The leaves and tops are used in the United States, and resemble the ordinary Mints in their properties.

Ocymum.—*O. album* is used in India as tea, which is known as Toolsie Tea.—*O. sanctum*, *O. Basilicum*, and other species, are reputed throughout India to possess stimulant, diaphoretic, and expectorant properties.

Origanum.—*O. vulgare*, Common or Wild Marjoram, has similar properties to the other labiate plants. The herb is official in the United States

Pharmacopœia. The dried leaves have been employed as a substitute for China Tea. Hanbury first proved that the red volatile oil commonly sold in the shops as *Oleum Origani* or *Oil of Thyme*, is obtained by distillation from *Thymus vulgaris*. This oil is imported from the South of France.—*O. Dictamnus*, Dittany of Crete, is said to have febrifugal properties. The herb *O. Majorana* (*Majorana hortensis*), Sweet Marjoram, possesses similar properties, and was formerly official in this country. Several species of *Origanum* are used by the cook for flavouring, as *O. vulgare*, Common Marjoram, *O. Majorana* or *Majorana hortensis*, Sweet Marjoram, &c.

Pogostemon Patchouli, Pucha-Pat or Patchouly.—This plant is a native of Silhet and the Malayan Peninsula. The dried tops are imported and yield by distillation a strong-scented volatile oil, called Oil of Patchouli, which has been much employed in perfumery. The coarsely powdered herb is also used for making *sachets*.

Rosmarinus officinalis, Common Rosemary. The flowering tops contain a volatile oil which imparts to them stimulant and carminative properties. This oil is official in the British Pharmacopœia. Rosemary is however chiefly used in perfumery, and by the hairdresser. The flavour of Narbonne honey is said to be due to the bees feeding on the flowers of this plant. The dried leaves are sometimes used as a substitute for China Tea.

Salvia officinalis, Common or Garden Sage.—The leaves were formerly much employed as tea. They are official in the United States Pharmacopœia. An infusion of Sage is frequently used in the United States as a gargle in common sore-throat and when the uvula is relaxed. It is also stimulant, carminative, and anti-emetic. Sage is also employed by the cook as a flavouring agent, &c.

Satureia juliana, called in Sicily *erva de ibbisi*, is much used as a remedy in intermittent fevers.—*S. hortensis*, Summer Savory, and *S. montana*, Winter Savory, are in common use by the cook for flavouring.

Scutellaria.—The substance termed *scutellarin* is obtained from *S. lateriflora*. It is said to be a nervine stimulant.

Thymus vulgaris, Common or Garden Thyme, yields by distillation the volatile oil known as Oil of Thyme, which is official in the United States Pharmacopœia; it is a powerful local stimulant. It is chiefly used in veterinary practice. It is also employed for scenting soaps. (See *Origanum.*) The stearoptene obtained from oil of thyme, and known as *thymol*, is a powerful disinfectant, and is employed, like carbolic acid, for surgical dressings. It is official in the British Pharmacopœia, and is derived not only from *Thymus vulgaris*, but also from *Monarda punctata*, another Labiate plant, and *Carum Ajowan*, of the order Umbelliferæ. This and other species of *Thymus* are also employed by the cook as flavouring agents, &c. (See *Properties and Uses*, p. 642.)

Trichostemma lanatum.—A decoction of the leaves of this plant, called by the Mexicans *Romero*, is used to impart a black colour to the hair, and to promote its growth.

Order 5. PLANTAGINACEÆ, the Ribwort Order.—Character.—*Herbs*, generally without aerial stems (*fig.* 1029). *Leaves* commonly ribbed and radical (*fig.* 1029). *Flowers* usually spiked (*fig.* 413) and perfect (*fig.* 1030), or rarely solitary, and sometimes unisexual. *Calyx* persistent, 4-partite, imbricate (*fig.* 1030). *Corolla* dry and membranous, persistent, 4-partite (*fig.* 1030). *Stamens* equal in number to the divisions of the corolla, and alternate with them (*fig.* 1030); *filaments* long and slender; *anthers* versatile. *Ovary* simple, but spuriously 2- or sometimes 4-celled from the prolongation of processes from the placenta; *style* and *stigma* entire (*fig.* 1030), or the latter is rarely cleft. *Capsule* membranous, with transverse dehiscence; *placenta* free central. *Seeds* 1, 2, or more, with a mucilaginous testa; *embryo* transverse, in fleshy albumen.

Distribution and Numbers.—They abound in cold or temperate climates, but are more or less diffused over the globe. *Illustrative Genera:*—Littorella, *Linn.*; Plantago, *Linn.* There are above 100 species.

FIG. 1029.

FIG. 1030.

Fig. 1029. Plant of a species of Rib-grass (*Plantago*), with radical leaves. —— *Fig.* 1030. Flower of the same.

Properties and Uses.—Generally of little importance; but some are demulcent, and others astringent.

Plantago.—The seeds of *Plantago Ispaghula, P. amplexicaulis, P. ciliata, P. Psyllium, P. Cynops*, and others, are demulcent, and may be used in the preparation of mucilaginous demulcent drinks; those of the first species are official in the Pharmacopœia of India, and are commonly there known by the Persian name of *Ispaghul*, or as *Spogel seeds.* The three first species are natives of India, but the two latter are European. The leaves and roots of *P. lanceolata* and some other species are slightly bitter and astringent.

Artificial Analysis of the Orders in the Series of the Sub-class GAMOPETALÆ *or* COROLLIFLORÆ.

*** A few orders belonging to the Sub-class Polypetalæ, the flowers of which are sometimes monopetalous, are also included in this analysis.

Series 1. INFERÆ or EPIGYNÆ.

1. Ovary inferior.

A. Carpel solitary.

a. *Anthers united.*

Ovule solitary, pendulous . . . . . *Calyceraceæ.*
Ovule solitary, erect . . . . . . *Compositæ.*

b. *Anthers distinct.*
Fruit with 1 perfect cell, and 2 rudimentary ones. Seed exalbuminous . . . . . *Valerianaceæ.*
Fruit 1-celled, and without any rudimentary one. Seed albuminous . . . . *Dipsaceæ.*

B. Carpels more than one.

a. *Anthers united.*
Leaves alternate . . . . . . *Lobeliaceæ.*

b. *Anthers distinct.*

1. *Stamens* 2.
Filaments not united to the style . . *Columelliaceæ.*
Filaments united to the style . . . *Stylidiaceæ.*

2. *Stamens more than* 2.
Anthers opening by pores or slits . . *Vacciniaceæ.*
Anthers opening longitudinally.
Stigma with an indusium . . . *Goodeniaceæ.*
Stigma without an indusium.
Leaves without stipules.
Stamens definite.
Leaves alternate. Corolla persistent *Campanulaceæ.*
Leaves opposite. Stem round . *Caprifoliaceæ.*
Leaves verticillate. Stem square . *Rubiaceæ.*
Stamens numerous . . . . *Belvisiaceæ.*
Leaves with stipules.
Stipules interpetiolar. Flowers hermaphrodite . . . . *Rubiaceæ.*
Stipules cirrhose. Flowers unisexual *Cucurbitaceæ.*

Series 2 and 3. SUPERÆ and DICARPIÆ OR BICARPELLATÆ.

2. Ovary superior.

Carpels more than one.
a. *Anthers opening by pores or slits* . . . *Ericaceæ.*
b. *Anthers opening longitudinally.*
1. Anthers 1-celled . . . . . . *Epacridaceæ.*
2. Anthers 2-celled.
Plants with dotted leaves. . . . *Rutaceæ.*
Parasitic brown scaly plants . . . *Monotropaceæ.*

A. Flowers regular.

a. *Ovary lobed.*
Inflorescence scorpioidal. Æstivation of corolla imbricate . . . . *Boraginaceæ.*
Inflorescence straight. Corolla with a valvate æstivation. Leaves exstipulate . . . *Nolanaceæ.*

b. *Ovary not lobed.*

1. *Carpels more than three, distinct or combined.*
Stamens equal in number to the petals and opposite them.
Stems herbaceous. Style 1. Fruit a capsule . . . . *Primulaceæ.*

Stem woody. Style 1. Fruit fleshy, indehiscent . . . . *Myrsinaceæ.*
Stem herbaceous or woody. Styles 5, (rarely 3 or 4). Fruit membranous . *Plumbaginaceæ.*
Stamens not opposite the petals if of the same number.
Carpels distinct.
Seeds numerous . . . . . . *Crassulaceæ.*
Seeds few . . . . . . *Anonaceæ.*
Carpels combined. Ovary 2- or more celled.
Ovules erect or ascending.
Æstivation of the corolla plaited. Fruit dry . . . . . *Convolvulaceæ.*
Æstivation of the corolla imbricate. Fruit fleshy . . . . . *Sapotaceæ.*
Ovules pendulous or suspended, or rarely partly ascending.
Stamens twice or four times as many as the lobes of the corolla, distinct. *Ebenaceæ.*
Stamens equal in number to the lobes of the corolla. Filaments distinct. Anthers adnate . . . . *Aquifoliaceæ.*
Stamens equal in number to the lobes of the corolla. Filaments distinct. Anthers versatile . . . . *Cordiaceæ.*
Some of the ovules occasionally ascending. Filaments more or less cohering . . . . . *Styraceæ.*

2. *Carpels three, combined so as to form a 3-celled ovary.*
Stem herbaceous. Disk hypogynous . *Polemoniaceæ.*
Stem woody. No disk . . . . *Diapensiaceæ.*

3. *Carpels two, combined or more or less distinct.*
Stamens 2 . . . . *Oleaceæ.*
Stamens 4 or more. Inflorescence scorpioidal.
Fruit a capsule, 1-celled or imperfectly 2-celled . . . . . . *Hydrophyllaceæ.*
Fruit drupaceous, 2- or more celled . *Ehretiaceæ.*
Stamens 4 or more. Inflorescence straight.
Leaves alternate.
Calyx in a broken whorl . . . *Convolvulaceæ.*
Calyx in a complete whorl.
Anthers united to the stigma . *Asclepiadaceæ.*
Anthers free from the stigma.
Placentas parietal . . . *Gentianaceæ.*
Placentas axile.
Æstivation of corolla valvate, induplicate-valvate, or imbricate . . . . *Solanaceæ.*
Leaves opposite, whorled, or clustered.
Anthers united to the stigma . . *Asclepiadaceæ.*
Anthers free from the stigma.
Leaves with stipules . . . *Loganiaceæ.*
Leaves without stipules.
Stigma shaped like an hour-glass. Æstivation of corolla contorted *Apocynaceæ.*

Stigma not contracted in the middle like an hour-glass.
Æstivation of corolla imbricate.
Placentas parietal . . . *Gentianaceæ.*
Æstivation of corolla valvate.
Placentas axile . . . *Stilbaceæ.*

4. *Carpel solitary.*
Stamens opposite the lobes of the corolla or petals . . . . *Plumbaginaceæ.*
Stamens alternate to the lobes of the corolla.
Fruit 1-celled. Stigma sessile . . . *Salvadoraceæ.*
Fruit spuriously 2-celled or rarely 4-celled.
Style capillary . . . . . . *Plantaginaceæ.*

B. Flowers irregular.

a. *Ovary 4-lobed* . . . . *Labiatæ.*

b. *Ovary not lobed.*

1. *Carpel solitary* . . . . . . *Selaginaceæ.*

2. *Carpels two.*
Fruit hard or nut-like.
Anthers 1-celled . . . . . . *Selaginaceæ.*
Anthers 2-celled. Ovules erect.
Corolla imbricate in æstivation . . *Verbenaceæ.*
Corolla valvate in æstivation . . *Stilbaceæ.*
Anthers 2-celled. Ovules pendulous . *Myoporaceæ.*
Fruit capsular or succulent.
Placentas parietal.
Leafless scaly brown root parasites . *Orobanchaceæ.*
Leafy plants. Seeds with wings . . *Bignoniaceæ.*
Leafy plants. Seeds without wings.
Fruit a capsule or baccate. Cotyledons minute, radicle long . . . *Gesneraceæ.*
Fruit bony or a capsule. Cotyledons large, radicle short . . . . *Pedaliaceæ.*
Fruit woody with a pulpy interior. Cotyledons large, radicle short . *Crescentiaceæ.*
Placentas axile.
Seeds without wings.
Albuminous . . . . . . *Scrophulariaceæ.*
Exalbuminous. Seeds attached to hard placental processes . . *Acanthaceæ.*
Seeds winged. Exalbuminous . . *Bignoniaceæ.*
Placentas free central . . . . *Lentibulariaceæ.*

There are many exceptions to the characters above given of the Gamopetalæ or Corollifloræ. Thus, among the Inferæ or Epigynæ we sometimes find polypetalous corollas in *Caprifoliaceæ* and *Lobeliaceæ*, and the ovary is sometimes superior in *Goodeniaceæ*. In the Superæ and Dicarpiæ, polypetalous species are more or less found in *Ericaceæ*, *Monotropaceæ*, *Epacridaceæ*, *Styraceæ*, *Oleaceæ*, *Primulaceæ*, *Myrsinaceæ*, and *Plumbaginaceæ*.

Again, among the Superæ and Dicarpiæ we occasionally find the ovary inferior, or partly so, as in *Ebenaceæ*, *Styraceæ*, *Myrsinaceæ*, *Primulaceæ*, and always in *Gesneraceæ* and *Vacciniaceæ*.

In *Oleaceæ* and *Primulaceæ*, apetalous species sometimes occur; and unisexual species are also occasionally found in *Valerianaceæ*, *Compositæ*, *Ebenaceæ*, *Myrsinaceæ*, and *Plantaginaceæ*, and other exceptions have been already noted.

Sub-class III. *Monochlamydeæ or Incompletæ.*

This sub-class is frequently arranged in two sub-divisions, which are called, respectively, the Angiospermia and Gymnospermia; but the plants of the latter group present such striking differences in their characters from those of other Dicotyledones, that they are now more generally placed in a division by themselves, as is the case in this volume, at the end of the Phanerogamia.

In this sub-class we follow in all essential particulars the arrangement of the Orders and characters of the Cohorts, as given by Sir Joseph Hooker in the English edition of Le Maout and Decaisne's 'Traité Général de Botanique,' instead of that adopted by Bentham and Hooker in 'Genera Plantarum,' where the following 'Series' are given instead of 'Cohorts':—1. Curvembryeæ. 2. Multiovulatæ aquaticæ. 3. Multiovulatæ terrestres. 4. Micrembryeæ. 5. Daphnales. 6. Achlamydosporeæ. 7. Unisexuales. 8. Ordines anomali. For a full description of the characters of these Series, and for lists of the Orders grouped under them respectively, reference should be made to 'Genera Plantarum.'

Series 1. Superæ.

Cohort 1. *Chenopodiales.* — Flowers usually hermaphrodite, or sometimes unisexual. Calyx green or coloured, generally regular; tube short or absent; segments imbricate in æstivation. Ovary superior, generally simple, or rarely compound; ovule solitary, basal, or rarely 2 or more. Seeds usually albuminous, or rarely exalbuminous; embryo generally curled or coiled. Usually herbs or shrubs, or very rarely trees.

Order 1. NYCTAGINACEÆ, the Marvel of Peru Order.—Character.—*Herbs*, *shrubs*, or *trees*, with the stems usually tumid at the joints. *Leaves* generally opposite and entire. *Flowers* with an involucre. *Calyx** tubular or funnel-shaped, often coloured, plaited in æstivation, contracted towards the middle, its base persistent and ultimately becoming indurated and forming a spurious pericarp. *Stamens* 1 or many, hypogynous. *Ovary* superior, 1-celled; *ovule* solitary; *style* 1; *stigma* 1. *Fruit* a utricle, enclosed by the hardened persistent base of the calyx. *Seed* solitary; *embryo* coiled round mealy albumen (*fig.* 781), with foliaceous cotyledons, and an inferior radicle.

* When there is but one floral envelope in Dicotyledons, we call that the *calyx*, whatever be its colour or other peculiarity, in which nomenclature we follow the example of Lindley. By most botanists, however, the term *perianth* is employed in such cases, but we use that name only in speaking of Monocotyledons. (See page 223.)

Distribution and Numbers.—Natives exclusively of warm regions. *Illustrative Genera*:—Mirabilis, *Linn.*; Pisonia, *Plum.* There are about 100 species.

Properties and Uses.—Chiefly remarkable for the presence of a purgative property in their roots; which is especially the case with those of *Mirabilis Jalapa* and *M. longiflora*. *M. dichotoma*, Marvel of Peru, is commonly known by the name of the Four-o'clock Plant, from opening its flowers in the afternoon. *Boerhaavia diffusa* is said to possess expectorant properties.

Order 2. AMARANTACEÆ, the Amaranth Order.—Character.—*Herbs* or *shrubs*. *Leaves* simple, exstipulate, opposite or alternate. *Flowers* crowded, spiked or capitate, bracteated, hermaphrodite or occasionally unisexual. *Calyx* of 3—5 sepals, dry and scarious, inferior, persistent, often coloured, imbricate. *Stamens* 5, hypogynous and opposite to the sepals, or a multiple of that number; *anthers* 2- or 1-celled. *Ovary* free, 1-celled, with 1 or more ovules; *style* 1 or none; *stigma* simple or compound. *Fruit* a utricle or caryopsis, or sometimes baccate. *Seeds* 1 or more, pendulous; *embryo* curved round mealy albumen; *radicle* next the hilum.

Distribution and Numbers.—The plants of this order are most abundant in tropical regions; and are altogether unknown in the coldest climates. *Illustrative Genera*:—Celosia, *Linn.*; Amarantus, *Linn.* There are nearly 500 species.

Properties and Uses.—Unimportant. *Amarantus spinosus* and other Indian species possess mucilaginous properties. Another Indian species, *Achyranthes aspera*, is also reputed to be astringent and diuretic. *Gomphrena officinalis* and *G. macrocephala* are used in Brazil in intermittent fevers, diarrhœa, and some other diseases. Some of the species have bright-coloured persistent flowers, and are hence cultivated in our gardens, as *Amarantus caudatus*, Love-lies-bleeding; *Amarantus hypochondriacus*, Prince's-feathers; *Celosia cristata*, Cockscomb; and others.

Order 3. CHENOPODIACEÆ, the Goosefoot Order.—Character.—*Herbs* or *undershrubs*, more or less succulent. *Leaves* exstipulate, usually alternate, rarely opposite. *Flowers* minute, greenish, usually ebracteated, hermaphrodite or unisexual. *Calyx* persistent (*fig.* 696), usually divided nearly to the base (*fig.* 29), imbricate. *Stamens* equal in number to the lobes of the calyx and opposite to them (*fig.* 29), or rarely fewer, hypogynous or inserted into the base of the lobes; *anthers* 2-celled. *Ovary* superior (*fig.* 29) or partly inferior, 1-celled, with a single ovule attached to its base; *style* (*fig.* 29) usually in 2—4 divisions, rarely simple. *Fruit* usually an achænium or utricle (*fig.* 696), or sometimes baccate. *Seed* solitary; *embryo* coiled into a ring or spiral, with or without albumen; *radicle* towards the hilum.

Diagnosis.—They are chiefly distinguished from the Nyctaginaceæ by their habit and commonly ebracteated flowers.

Distribution and Numbers.—More or less distributed over the globe, but most abundant in extratropical regions. *Illustrative Genera:*—Salicornia, *Tourn.*; Beta, *Tourn.*; Salsola, *Linn.* There are above 500 species.

Properties and Uses.—Several plants of this order inhabit salt-marshes, and yield by combustion an ash called *barilla*, from which carbonate of soda was formerly principally obtained; but their use for this purpose has much fallen off of late years, in consequence of soda being more readily extracted from other sources. The plants which thus yield barilla principally belong to the genera *Salsola*, *Salicornia*, *Chenopodium*, and *Atriplex*. Many plants of the order are esculent, as Beet and Mangel-Wurzel or Mangold Wurzel; and some are used as pot-herbs, as Spinach or Spinage (*Spinacia oleracea*), Garden Orache or Mountain Spinach (*Atriplex hortensis*), and English Mercury (*Chenopodium Bonus-Henricus*). The seeds of others are nutritious; and several contain volatile oil, which renders them anthelmintic, antispasmodic, aromatic, carminative, or stimulant.

Beta.—The root of *Beta vulgaris*, the Common Beet, is used as a salad, and as a vegetable. It is largely cultivated on the Continent and elsewhere as a source of sugar. Two varieties of the Beet are commonly grown for sugar; namely, that which is known under the name of *Betterave à Sucre*, and the White or Silesian Beet (*Beta Cicla*); the latter being the most esteemed. In 1868 about 8,000,000 tons of Beet-root were grown, yielding about 650,000 tons of sugar. Attempts have been made of late years to grow Beet in this country, and there can be little doubt but that there are many districts in which it might be cultivated with success. The grated root or sugar cake, and the molasses, which are refuse substances obtained in the manufacture of beet sugar, are also useful; the former for feeding cattle; and the latter, when mixed with water, slightly acidulated with sulphuric acid, and submitted to fermentation, yields from 24 to 30 per cent. of spirit, which is said to be used to adulterate brandy like potato spirit. A variety of the Common Beet (*Beta vulgaris macrorhiza*) is usually regarded as the Mangel-Wurzel, so much employed as a food for cattle; but some look upon *B. maritima* as the source of both the Mangel-Wurzel and the varieties of the Garden Beet.—*B. maritima* is sometimes used as a substitute for spinach or greens. The petioles and midribs of the leaves of the large White or Swiss Chard Beet, *Beta Cycla*, var., form the favourite vegetable of the French termed *Poirée à carde*; it is eaten like Sea Kale or Asparagus.

Chenopodium.—The seeds of *C. Quinoa* contain starch granules, which are remarkable for being the smallest hitherto noticed. These seeds are known under the name of *petty rice*, and are a common article of food in Peru.—*C. Bonus-Henricus*, as already mentioned, may be used as a pot-herb. The fruits of *C. ambrosioides*, Linn., var. *anthelminticum*, Gray, under the name of American Worm-seed, are largely employed in the United States for their anthelmintic properties. They also possess to some extent antispasmodic qualities. The herb generally has similar properties. These effects are due to the presence of a highly odorous volatile oil. Both the oil and fruits are official in the United States Pharmacopœia.—*C. Botrys* is reputed to possess somewhat similar properties, but is not so powerful.—*C. ambrosioides* is also employed in Mexico and Columbia as tea, which is hence known as Mexican

Tea.—*C. Vulvaria* or *olidum*, Stinking Goosefoot, is an indigenous plant. It is a popular emmenagogue and antispasmodic.

Order 4. BASELLACEÆ, the Basella Order.—*Diagnosis.*—This is a small order of climbing herbs or shrubs closely allied to Chenopodiaceæ, but chiefly distinguished by its plants having two rows of coloured sepals, and by their stamens being evidently perigynous. There are about 12 species, all of which are tropical plants. *This is made a sub-order of Chenopodiaceæ by Bentham and Hooker.*

Properties and Uses.—*Basella rubra* and *B. alba* are used in the East Indies as a substitute for Spinach. From the former species a purple dye may be also obtained. The fleshy roots of *Ullucus tuberosus* or *Melloca tuberosa* are largely used in Peru and some of the adjoining countries as a substitute for the Potato.

Order 5. PHYTOLACCACEÆ, the Phytolacca Order.—Character.—*Herbs* or *undershrubs. Leaves* alternate, entire, exstipulate. *Flowers* hermaphrodite or very rarely unisexual, racemose. *Calyx* 4—5-partite. *Stamens* nearly or quite hypogynous, either equal in number to the divisions of the calyx and alternate with them, or more numerous ; *anthers* 2-celled. *Ovary* superior, composed of 2 or more carpels, distinct or more or less combined; *styles* and *stigmas* distinct, equal in number to the carpels. *Fruit* dry or succulent, each carpel of which it is composed containing 1 ascending seed; *embryo* curved round mealy albumen ; *radicle* next the hilum.

Distribution and Numbers.—Natives principally of America, India, and Africa. *Illustrative Genera* :—Giesekia, *Linn.*; Phytolacca, *Tourn.* There are about 80 species.

Properties and Uses.—An acrid principle is more or less diffused throughout the plants of this order; but this is frequently destroyed by boiling in water. Some are emetic and purgative.

Giesekia pharnaceoides.—The fresh plant of this Indian species is reputed to be a powerful anthelmintic in cases of tænia.

Gyrostemon.—This genus, from its unisexual flowers and twin suspended ovules, &c., is sometimes regarded as the type of a distinct order, Gyrostemonaceæ, but it is placed here by Bentham and Hooker. It has no known uses.

Phytolacca.—The roots and fruits of *P. decandra*, Poke or Pocan, are employed in the United States for their emetic and purgative properties. They are also reputed to be somewhat narcotic. The ripe fruits have been used in chronic rheumatism and in syphilitic affections. A substance named *phytolaccin* is prepared from the roots and seeds, and has similar properties. Its young shoots boiled in water are eaten in the United States as Asparagus ; those of *P. acinosa* are also similarly eaten in the Himalayas. A species of *Phytolacca*, which has been named *P. electrica*, a native of Nicaragua, is said to give a sensible shock, as from a galvanic battery, to any person attempting to gather a branch. It is also stated that the needle of the compass is affected by proximity to it.

Order 6. PETIVERIACEÆ, the Petiveria Order.—*Diagnosis*, &c. This is a small order of plants, which is included by some botanists, as Bentham and Hooker, in Phytolaccaceæ, with which it agrees in many particulars. It is distinguished from that order by having stipulate leaves, an ovary formed of a single carpel, exalbuminous seeds, and a straight embryo with convolute cotyledons. These plants are natives of tropical America. There are about 12 species in this order.

Properties and Uses.—Most of the species are acrid, and some have a strong alliaceous odour.

Petiveria.—Petiveria alliacea, Guinea-hen Weed, is reputed to be sudorific and emmenagogue, and its roots are used in the West Indies as a remedy for toothache. It is also commonly put into warm baths which are used to restore the action of paralysed limbs.

Order 7. POLYGONACEÆ, the Buckwheat Order.—Character.—*Herbs* or rarely *shrubs*. *Leaves* alternate, simple, commonly with ochreate stipules above the swollen joints (*nodes*) of

FIG. 1031.

FIG. 1032.

Fig. 1031. Flower of a species of *Polygonum*.——*Fig.* 1032. Pistil of a species of *Rumex*.

the stem (*fig.* 21, *d*), or rarely exstipulate. *Flowers* perfect (*fig.* 1031), or sometimes unisexual. *Calyx* inferior (*fig.* 1031), of from 3—6 sepals, more or less persistent, imbricate. *Stamens* few (*fig.* 1031), hypogynous or rarely perigynous; *anthers* dehiscing longitudinally. *Ovary* superior (*fig.* 1031), 1-celled; *styles* and *stigmas* 2—3 (*fig.* 1031); *ovule* solitary, orthotropous. *Fruit* usually a triangular nut, and commonly enveloped in the persistent calyx. *Seed* solitary, erect (*fig.* 780); generally with farinaceous albumen; *embryo* (*fig.* 780, *pl*) antitropous.

Diagnosis.—Usually herbs with ochreate stipules. Leaves simple, alternate. Calyx inferior, persistent, imbricate. Stamens definite. Ovary 1-celled; styles and stigmas 2—3. Fruit triangular. Seed solitary, erect, usually with mealy albumen, radicle superior.

Distribution and Numbers.—Generally diffused over the globe, and more particularly so in temperate regions. *Illustrative Genera:*—Rheum, *Linn.*; Polygonum, *Linn.*; Coccoloba, *Jacq.*; Rumex, *Linn.* There are about 500 species.

Properties and Uses.—Chiefly remarkable for the presence of acid, astringent, or purgative properties. The acidulous character is principally due to the presence of salts of oxalic acid. The fruits and roots of several species are more or less nutritious.

Coccoloba uvifera, Seaside Grape.—From the leaves, wood, and bark of this species a very astringent extract is obtained, which is commonly known as Jamaica Kino. The fruit is acid and edible, but not much esteemed.

Fagopyrum.—The fruits of *F. esculentum* (*Polygonum Fagopyrum*), Common Buckwheat or Saracen Corn, of *F. tataricum*, and other species, are used as a substitute for corn in the northern parts of Asia and Eastern Europe, and also in Brittany and other parts of the world. The former species is cultivated in Britain as food for pheasants. This plant when in flower produces an effect on many animals resembling intoxication, and a case has been reported within the last few years in which many lambs were in this way stupefied and ultimately killed by it.

Polygonum.—The rhizome of *P. Bistorta*, commonly called Bistort root, is a powerful astringent, which property is due essentially to the presence of tannic acid. Starch is also one of its constituents, hence it possesses, to some extent, nutritive properties, and is sometimes eaten, when roasted, in Siberia. The young shoots and leaves have been used from an early period in the North of England as a pot-herb under the name of Passions, probably from the plant being in perfection for such a purpose about Eastertide. The roots of *P. viviparum* are also used as food by the Esquimaux. The leaves of *P. Hydropiper* are very acrid, hence the common name of Water-pepper which is given to this plant. This species also yields a yellow dye. From *P. tinctorium* a blue dye resembling indigo is obtained in France, &c. The Chinese produce a blue dye from several species of *Polygonum.*

Rheum, Rhubarb.—The species of this genus usually possess more or less purgative and astringent properties; this is especially the case with their roots, and hence these are largely used in medicine. Various species of Rhubarb are indigenous or cultivated in different parts of the world, but until recently the botanical source of our official rhubarb root was unknown, and cannot even now be said to have been absolutely determined. It seems, however, almost certain that whilst the plant described by Baillon under the name of *Rheum officinale* may yield some of it, that the source of the best official rhubarb—namely, that which formerly came to us by way of Kiachta, and commonly known as Russian Rhubarb—is derived from *R. palmatum*, a plant which is a native of Tangut, in Kansu, the extreme north-western province of China. In this province rhubarb is principally obtained from wild plants, but also to some extent from cultivated ones. Rhubarb from this species is also derived from the Chinese provinces of Szechuen and Shensi. The rhubarb thus obtained from *R. palmatum* is chiefly exported by way of Shanghai, but also to a small extent from other ports, as Tientsin, Canton, Amoy, and Foochow. In the British Pharmacopœia the root is said to be derived from *R. palmatum*, *R. officinale*, and probably other species. The kind known as Indian or Himalayan Rhubarb is the produce of several species, but more especially of *R. Moorcroftianum*, *R. australe*, and *R. Emodi*. English Rhubarb is chiefly derived from *R. Rhaponticum*, and is now much used in the hospitals of this country, and in America, but it is not so active as the official rhubarb, although probably equally efficacious when given in sufficient doses. Some English rhubarb is also obtained from *R. officinale*, which is now also cultivated in this country. The petioles of *R. Ribes* are employed in the East for the preparation of sherbet. The petioles of *R. Rhaponticum* and other species are used for tarts and puddings. Their acidulous character is principally due to the presence of oxalic acid. The roots of the species of *Rheum* contain abundance of calcium oxalate crystals (conglomerate raphides). (See page 34.)

Rumex.—Several species possess acid properties owing to the presence of a potassium salt of oxalic acid, commonly termed *salt of sorrel*, especially *R. acetosa*, common Sorrel, *R. Acetosella*, *R. scutatus*, and *R. Patientia*. They have been employed as pot herbs, and for salads.—*R. acetosa* is sometimes used medicinally for its refrigerant, diuretic, and antiscorbutic properties. The root of *R. Hydrolapathum*, Great Water Dock, is astringent and antiscorbutic. The roots of *R. alpinus* are purgative, and were formerly employed instead of Rhubarb under the name of Monk's Rhubarb. The substance known as *rumicin* is prepared from the root of *Rumex crispus*. It is said to possess astringent, tonic, and antiscorbutic properties.

The two following orders have no close affinities to any other orders, and are therefore not put in any cohort by Hooker, but placed under the head of 'Orders of Dubious Affinities.'

Order 1. BATIDACEÆ, the Batis Order.—This supposed distinct order only contains a single plant, the *Batis maritima*, a succulent shrubby species, with opposite leaves, and unisexual flowers arranged in amenta; it is a native of the West Indies, where it is occasionally used as an ingredient in pickles. Its ashes also yield barilla. Some authors regard this genus as belonging to Chenopodiaceæ.

Order 2. PODOSTEMACEÆ, the Podostemon Order.—Character.—Aquatic *herbs* with the aspect of Mosses or Liverworts. *Leaves* minute and densely imbricate, or finely divided. *Flowers* minute, generally hermaphrodite, or very rarely unisexual, spathaceous. *Calyx* absent, or of 3 sepals. *Stamens* 1 or many, hypogynous; *anthers* 2-celled. *Ovary* superior, 2—3-celled; *stigmas* 2—3; *ovules* ascending, numerous. *Fruit* capsular, ribbed, with parietal or axile placentation. *Seeds* numerous, exalbuminous, with a straight embryo.

Distribution and Numbers.—Principally natives of South America. *Illustrative Genera:*—Hydrostachys, *Thouars*; Podostemon, *L. C. R.* There are about 120 species.

Properties and Uses.—Unimportant. Some species of *Lacis* are used for food on the Rio Negro, &c., in South America; and other plants of the order are eaten by cattle and fish.

Cohort 2. *Laurales.*—Flowers unisexual or hermaphrodite. Calyx green or coloured, generally regular. Ovary superior, 1-celled; stigma simple; ovule solitary. Seeds albuminous or exalbuminous; embryo straight.

Order 1. MONIMIACEÆ, the Monimia Order.—*Diagnosis.*—Trees or shrubs, with opposite exstipulate leaves. Flowers axillary, unisexual. The flowers generally resemble those of the Atherospermaceæ, but they differ in always being unisexual; in the longitudinal dehiscence of their anthers; in the absence of feathery styles to the fruit; and in their ovules and seeds being pendulous.

Distribution and Numbers.—They are principally natives of South America, but are found also in Australia, Java, Madagascar, Mauritius, and New Zealand. *Illustrative Genera:*—Monimia, *Thouars*; Peumus, *Pers.* There are about 40 species.

Properties and Uses.—They are aromatic fragrant plants, but their properties are of no great importance.

Peumus Boldus or *Boldoa fragrans.*—The leaves of this plant, which is a native of Chili, under the name of Boldo, have been recommended as a remedy in diseases of the liver, but their use has not been attended with any marked success in European practice. The fruits are edible.

Order 2. ATHEROSPERMACEÆ, the Plume Nutmeg Order.—Character.—*Trees*, with opposite exstipulate *leaves*. *Flowers* axillary, racemose, bracteated, unisexual or rarely perfect. *Calyx* inferior, tubular, with several divisions. *Male flowers* with numerous perigynous stamens; *anthers* 2-celled, opening by recurved valves. *Female flower* usually with abortive scaly *stamens*. *Carpels* superior, numerous, distinct, each with a solitary erect ovule; *styles* and *stigmas* as many as the carpels. *Fruit* consisting of a number of achænia crowned with the persistent feathery styles, and enclosed in the tube of the calyx. *Seeds* erect, with a minute embryo at the base of fleshy albumen. *This order is combined with Monimiaceæ by Bentham and Hooker.*

Distribution and Numbers.—Natives of Australia and Chili. There are but 3 genera: namely, Atherosperma, *Labill.*, and Doryphora, *Endl.*, from Australia; and Laurelia, *Juss.*, from Chili. These include 4 species.

Properties and Uses.—They are fragrant plants. The achænia of *Laurelia* somewhat resemble common Nutmegs in their odour.

Atherosperma.—A decoction of the bark of *Atherosperma moschata* is stated by Backhouse to be used in some parts of Australia as a substitute for China tea. This bark resembles sassafras in flavour and odour, hence it is commonly known under the name of Australian Sassafras; it is occasionally imported into this country. The decoction is likewise employed as a diuretic and diaphoretic. The wood is also valuable as timber.

Order 3. MYRISTICACEÆ, the Nutmeg Order.—Character.—*Trees*. *Leaves* alternate, exstipulate, entire, dotted, stalked, leathery. *Flowers* unisexual. *Calyx* inferior, leathery, 3—4-cleft; in the *female flower*, deciduous; *æstivation* valvate. *Male flower* with 3—12 stamens, or rarely more numerous; *filaments* distinct or monadelphous; *anthers* 2-celled, extrorse, distinct or united, with longitudinal dehiscence. *Female flower* with 1 or many superior distinct *carpels*, or rarely 2; each carpel with 1 erect ovule. *Fruit* succulent. *Seed* arillate, with copious oily-fleshy ruminated albumen; *embryo* small, with an inferior radicle.

Distribution and Numbers.—Natives of tropical India and America. *Illustrative Genera:*—Myristica, *Linn.*; Hyalostemma, *Wall.* There are above 40 species.

Properties and Uses.—Aromatic properties are almost universally found in the plants of this order, and more especially in their seeds. The bark and the pericarp are frequently acrid.

Myristica.—The valuable and well-known spices called Nutmegs and Mace are both derived from *M. fragrans* (*M. officinalis*), the Nutmeg tree. This tree is a native of the Moluccas and other Indian islands, &c., and it is now cultivated in the Banda Islands, also in the Philippines, Bencoolen, Penang and Singapore, in Mauritius, the West India Islands, and South America. At Penang and Singapore, whence formerly the best nutmegs were obtained, its cultivation has declined of late years. The Nutmeg tree bears pear-shaped fruits, commonly about the size of an ordinary peach, with fleshy pericarps; each fruit contains a single seed, surrounded by a laccrated envelope called an *arillode*, or commonly *mace*; this is scarlet when fresh, but usually becomes yellow when dried, as in the mace of commerce. Beneath the arillode we find a hard shell, and within this the nucleus of the seed invested closely by its inner coat, which also penetrates the substance of the albumen, and divides it into lobes (*ruminated albumen*). This nucleus—that is, the dried seed divested of its hard shell and arillode—is the commercial and official Nutmeg of the British Pharmacopœia. The pericarp is used as a preserve. Both nutmegs and mace are largely employed as condiments, but their use requires caution in those subject to apoplexy or other cerebral affections, as they possess somewhat narcotic properties. In medicine they are employed as stimulants, carminatives, and flavouring agents. Nutmegs yield when distilled with water a volatile oil, which is also official in the British Pharmacopœia. Mace under like conditions also yields a volatile oil of nearly similar properties. The substance known as Expressed Oil of Mace, Butter of Nutmegs, or Expressed or Concrete Oil of Nutmegs, is imported chiefly from Singapore, and is prepared by reducing nutmegs to coarse powder, which after exposure to the vapour of hot water is submitted to pressure between heated plates. It consists of a small quantity of *volatile oil* mixed with several *fatty bodies*, the most important of which is *myristicin*; this expressed oil is also official in the British Pharmacopœia. The above Nutmegs are frequently termed the True, Round, or Official Nutmegs, to distinguish them from those of an inferior quality, which are derived from other species of *Myristica*, &c. One of these inferior nutmegs is found in commerce, and is called the Long or Wild Nutmeg. It occurs in three conditions, namely, without the hard shell and arillode, then termed *Long* or *Wild Nutmeg*; enclosed within the shell but divested of the arillode (*Long* or *Wild Nutmeg in the shell*); and within the shell and arillode (*Long* or *Wild Nutmeg covered with Mace*). These long nutmegs are said to be derived from *Myristica fatua*, and probably also, to some extent, from *M. malabarica*. Both the long nutmeg and its mace are very inferior to the similar parts of *M. fragrans*. There are some other kinds of Nutmegs, derived from different species of *Myristica*, which are in use in various parts of the world, but as they are much inferior in their qualities and are not found in commerce, it is unnecessary to allude further to them here. Some other False or Wild Nutmegs are also derived from plants of the order Lauraceæ. (See *Acrodiclidium*, *Agathophyllum*, and *Cryptocarya*.)

Order 4. Lauraceæ, the Laurel Order.—Character.—Aromatic *trees* or *shrubs* (parasitic and twining in *Cassytha*). *Leaves* simple, exstipulate, usually alternate, sometimes dotted

(*Cassytha* has scales instead of foliage leaves). *Flowers* generally hermaphrodite or sometimes unisexual (*fig.* 1033). *Calyx* inferior (*fig.* 1033), deeply 4—6-cleft, coloured, in two whorls, the limb sometimes obsolete; *æstivation* imbricate. *Stamens* perigynous, definite, some always sterile; *filaments* distinct, the inner ones commonly with glands at their base (*fig.* 541, *g*, *g*); *anthers* adnate, 2—4-celled, *l*, *l*, dehiscing by recurved valves, *v*. *Ovary* superior (*fig.* 1033), 1-celled, with 1 or 2 suspended ovules. *Fruit* baccate or drupaceous. *Seeds* exalbuminous; *embryo* with large cotyledons, and a superior radicle.

FIG. 1033.

Fig. 1033. Vertical section of the female flower of *Laurus nobilis*, the Sweet Bay.

Distribution and Numbers.—They are chiefly natives of tropical regions, but a few occur in North America, and one (*Laurus nobilis*) in Europe. *Illustrative Genera:*— Cinnamomum, *Burm.*; Nectandra, *Rottb.*; Laurus, *Tourn.* There are above 450 species.

Properties and Uses.—The plants of this order are almost universally characterised by the possession of aromatic properties, which are due to the presence of volatile oils; many of them are therefore employed as aromatic stimulants. Others are narcotic; some have sudorific properties; and several are tonic, stomachic, febrifugal, or astringent. A few have edible fruits, and many yield valuable timber.

Acrodiclidium Camara yields the False Nutmeg which is called in Guiana the *Ackawa* or *Camara Nutmeg.* Its use is similar to that of the other false nutmegs derived from plants of this order. (See *Agathophyllum* and *Cryptocarya.*)

Agathophyllum aromaticum yields a kind of False Nutmeg, which is the *Clove-Nutmeg of Madagascar* or *Ravensara Nut.* It is used as a spice. (See *Acrodiclidium.*)

Cinnamomum.—*Cinnamomum Camphora* or *Camphora officinarum*, the Camphor tree, is a native of China and Japan, and has been introduced into Java. Commercial camphor is derived entirely from the island of Formosa and Japan, the former being known as *China* or *Formosa Camphor*, and the latter as *Japan* or *Dutch Camphor.* Camphor is procured in a crude state from the wood by a rude process of sublimation, and as thus obtained is termed *crude camphor.* It is exported to Europe, &c., in this condition, where it is afterwards purified by subliming again, after which process it is called *refined camphor*, in which state it is official in the British Pharmacopœia. Camphor is a *stearoptene* or *solid volatile oil.* This kind of camphor is commonly distinguished from other camphors by the name of *Laurel, Common,* or *Official Camphor* (see *Dryobalanops*, p. 475). The *oil of camphor* of commerce, formerly official in the United States Pharmacopœia, is the volatile oil which drains from the crude camphor which is stored in vats before shipment. It is used externally in rheumatism, &c. In proper doses, camphor produces exhilarating and anodyne effects, for which purposes it is principally employed in medicine. In large doses it is narcotic and poisonous. *Cinnamon,* which is so much employed as a condiment, and medicinally as a cordial, stimulant, tonic, astringent, carminative, antispasmodic, and as an adjunct to other medicines, is the inner bark of *C. zeylanicum.* The best comes from Ceylon. It owes its properties essentially to the presence of a volatile oil. This volatile oil is the *Oil of Cinnamon* of commerce. Both the bark and volatile oil are official in the British Pharmacopœia. A concrete fatty substance is obtained in Ceylon by expression from the ripe fruits, which is called *Cinnamon Suet*; this is supposed by Royle to be the *Comacum* of Theophrastus. From the leaves of the Cinnamon tree a volatile oil is also distilled in Ceylon. It has an analogous odour and taste to that of oil of cloves. The Cinnamon tree is the *Kinnemon* or *Kinman* of the Bible.—*C. Cassia* of Blume, yields *Cassia lignea* or the *Cassia bark* of commerce which is obtained from China; this possesses analogous properties to Cinnamon, and like it yields by distillation a volatile oil, called *Oil of Cassia*, to the presence of which its qualities are essentially due. *Cassia buds* of commerce, which are brought from China and occasionally used as a condiment and in medicine, are the flower-buds of the same plant. Cassia buds possess somewhat similar properties to Cassia bark. The Cassia tree is the *Kiddah* or *Cassia* of the Bible. The inner bark of *C. iners* is very similar in its nature to that of Cassia bark. The bark called *Indian Clove Bark* is obtained from *C. Culilawan.* It possesses properties resembling those of Cassia. *Sintoc bark*, which has analogous qualities, is the produce of *C. Sintoc.*—*C. nitidum* (*eucalyptoides*) and *C. Tamala* were probably the sources of the *Folia Malabathri* of the old pharmacologists, formerly so highly esteemed for their stomachic and sudorific properties. The roots of *C. parthenoxylon* and *C. glanduliferum* resemble the official Sassafras in their effects. The latter is the Sassafras of Nepal.

Cryptocarya moschata yields a kind of *False* or *Wild Nutmeg*, which is termed the Brazilian Nutmeg. (See also *Acrodiclidium* and *Agathophyllum*.)

Dicypellium caryophyllatum yields Brazilian Clove-Bark or Clove Cassia Bark. It is occasionally imported, and used for mixing with other spices.

Laurus nobilis, the Sweet Bay, is said to be the *Ezrach* or Green Bay Tree of the Bible. It is the classic Laurel which was used by the ancients to make crowns for their heroes, hence it is frequently called the Victor's Laurel. The fruits, which were formerly official, are commonly known under the name of Bay or Laurel berries. Bay berries are reputed to be aromatic, stimulant, and narcotic, but they are very rarely used in medicine. By distillation with water they yield a volatile oil, commonly known as the *Volatile Oil of Sweet Bay.* The substance called *Expressed Oil of Bay* or *Laurel fat* is obtained from both the fresh and dry fruits by pressing them after they have been boiled in water; this substance is of a green colour and butyraceous consistence, and is a mixture of volatile oil and fatty bodies, like the expressed oil of nutmegs. *Laurel leaves* have somewhat similar properties to the fruit. From their aromatic properties they are used by the cook for flavouring. These leaves must not be confounded with those of the Cherry Laurel, already noticed. (See *Prunus.*)

Mespilodaphne pretiosa, a native of Brazil, yields the aromatic bark called *Casca pretiosa* by the Portuguese.

Nectandra.—*N. Rodiæi* is the Bebeeru or Greenheart Tree of Guiana, the wood of which is very hard and durable, and has been employed in ship-building, &c. *Bebeeru* or *bibiru* bark is obtained from this tree; it has been used in medicine as a substitute for the cinchona barks, possessing, like them, tonic, antiperiodic, febrifugal, and astringent properties. These properties are due essentially to the presence of a peculiar alkaloid called *Beberine*, which has nearly similar medicinal properties to quinine, and is employed by itself, and in the form of a sulphate, as an economical substitute for sulphate of quinine. It is, however, very inferior in its properties to quinine. Bebeeru bark and sulphate of beberine are both official in the

British Pharmacopœia. The *seeds* of the Bebeeru tree contain starch; this when mixed with an equal quantity of a decayed astringent wood, and a similar proportion of cassava pulp, is made into a kind of bread, and used as food by the Indians.—*N. cymbarum* of Nees yields the substance called Brazilian Sassafras. The cotyledons of *N. Puchury major* and *minor* are imported from Brazil under the name of Sassafras Nuts or Puchurim Beans; they are much esteemed as a flavouring for chocolate. Other species of *Nectandra*, as *N. sanguinea*, *N. exaltata*, and *N. leucantha*, yield more or less valuable timber.

Oreodaphne.—Several species of this genus yield valuable timber: thus the *Sweet-wood* is the produce of *O. exaltata*; the *Til* of the Canaries, of *O. fœtens*; and the *Siraballi* of Demerara is derived from a species of *Oreodaphne* or of some nearly allied genus.

Persea.—The fruit of *P. gratissima* is in much repute in the West Indies. It is commonly known as the Avocado or Alligator Pear.—*P. indica*, a native of Madeira, yields a timber somewhat resembling mahogany.

Sassafras.—The root of *S. officinale* is official in the British Pharmacopœia. Sassafras is employed medicinally in this country and elsewhere, as a stimulant, diaphoretic, and alterative. From it the Volatile Oil of Sassafras is obtained. Sassafras pith is largely used in the United States of America, where it is official in the Pharmacopœia, as a demulcent.

Cohort 3. *Daphnales.*—Flowers usually hermaphrodite, or rarely unisexual. Calyx green or coloured, regular or irregular, often tubular. Ovary superior, 1- or rarely 2-celled: stigma simple; ovule usually solitary, suspended or ascending. Seeds generally exalbuminous, but sometimes the albumen is present in small quantity; embryo straight. Almost always trees or shrubs. Leaves exstipulate.

Order 1. THYMELACEÆ, the Mezereon Order.—Character.—*Trees, shrubs*, or very rarely *herbs*, with an acrid very tough bark. *Leaves* entire, exstipulate. *Flowers* hermaphrodite (*fig.* 1034), or rarely unisexual. *Calyx* inferior, regular (*fig.* 1034), coloured, tubular, 4—5-lobed; *æstivation* imbricate. *Stamens* perigynous (*fig.* 1034), twice as many as the divisions of the calyx, or equal in number to them, or fewer, in the two latter cases they are opposite to the lobes of the calyx; *anthers* 2-celled, bursting longitudinally. *Ovary* superior (*fig.* 1034), simple, 1-celled, with a solitary suspended ovule (*fig.* 734). *Fruit* dry and nutlike, or drupaceous. *Seed* suspended; *albumen* none or but small in quantity; *embryo* straight, with a superior radicle.

Distribution and Numbers.—They are found more or less abundantly in all parts of the world, but especially in Australia and the Cape of Good Hope. *Illustrative Genera*:—Daphne, *Linn.*; Pimelea, *Banks et Sol.* There are about 300 species.

Properties and Uses.—The plants of this order are chiefly remarkable for the toughness and acridity of their bark. The fruit of *Dirca palustris* is narcotic, and that of the plants generally of the order poisonous or suspicious; but the seeds of

Inocarpus edulis are said to resemble Chestnuts in flavour when roasted. Several species of *Daphne*, *Pimelea*, and other genera, are handsome shrubby plants.

Fig. 1034.

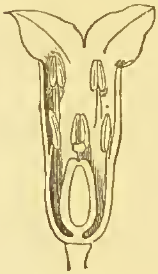


Fig. 1034. Vertical section of the flower of a species of *Daphne.*

Daphne.—The dried barks of *D. Mezereum*, Mezereon, and *D. Laureola*, Spurge Laurel, are official in the British Pharmacopœia. Both the root-bark and stem-bark are authorised, but the former is generally regarded as the more powerful. Mezereon bark may be used as a vesicatory, and also as a masticatory in toothache. It is however principally employed as a stimulant, diaphoretic, alterative, and diuretic. It owes its properties essentially to an acrid resin. The fruit is also very acrid. The bark of *D. Gnidium*, Spurge Flax, is likewise official in the Paris Codex, and is sometimes substituted in this country for our official bark, but it is not so active. The inner bark of *D. cannabina* and other species is used in some parts of the world for making paper, &c.

Edgeworthia papyrifera.—The bark is used in Japan for the manufacture of paper money.

Lagetta lintearia, Lace-bark Tree.—The bark possesses, in some degree, similar properties to that of Mezereon. When macerated it may be separated into thin laminæ, the number of which depends upon the age of the specimen; these have a lace-like appearance, hence its common name of *lace bark.* It possesses great strength, and may be used for making ropes, &c. It was at one time employed in the West Indies for making the slave whips. Sloane states that caps, ruffles, and even whole suits of ladies' clothes, have been made from it. Lagetta cloth has been imported into Liverpool under the name of *guana.*

Passerina Ganpi.—The bark is used in Japan for the manufacture of paper.

Order 2. Aquilariaceæ, the Aquilaria Order.—Character.—*Trees* with entire exstipulate *leaves. Calyx* tubular or top-shaped, 4—5-lobed, imbricate, persistent. *Stamens* perigynous, 10, 8, or 5, opposite the lobes of the calyx when equal to them in number; *anthers* 2-celled, opening longitudinally. *Ovary* superior, usually 2-celled; *ovules* 2, suspended; or rarely 1-celled with parietal placentation. *Fruit* generally 2-valved, capsular, sometimes succulent and indehiscent. *Seeds* usually 2, or rarely 1 by abortion; exalbuminous. *This order is sometimes included in Thymelaceæ.*

Distribution and Numbers.—Natives exclusively of tropical Asia. *Illustrative Genera:*—Aquilaria, *Lam.*; Leucosmia, *Benth.* There are about 10 species.

Properties and Uses.—Some species yield a fragrant stimulant resin.

Aquilaria (*Aleoxylon*).—The substance called *Lign-Aloes*, *Agallochum Aloes-wood*, or *Eagle-wood*, is said to be the *Ahalim* and *Ahaloth* of the Old Testament, and the Aloe or Aloes of the New. It is obtained from *Aquilaria Agallochum*, and probably also from *A. ovata.* It was formerly held in high repute as a medicinal agent in Europe, but its use is now obsolete. It is said to be useful as a cordial, and as a remedy for gout and rheumatism.

Order 3. ELÆAGNACEÆ, the Oleaster Order.—Character.—*Small trees* or *shrubs*, with entire exstipulate usually very scurfy (*fig.* 153) *leaves*. *Flowers* mostly unisexual or rarely perfect. *Male flowers* amentaceous, bracteated. *Sepals* 2—4, distinct or united. *Stamens* definite, perigynous. *Female flowers* with an inferior tubular calyx, and a fleshy disk; *æstivation* imbricate. *Ovary* superior, 1-celled, with a solitary ascending ovule. *Fruit* enclosed in the succulent calyx, indehiscent. *Seed* solitary, ascending, with thin albumen; *embryo* straight, with an inferior radicle.

Distribution and Numbers.—They are generally diffused throughout the northern hemisphere, and rare in the southern. *Illustrative Genera:*—Hippophaë, *Linn.*; Elæagnus, *Linn.* There are about 30 species.

Properties and Uses.—Unimportant. The fruits of *Elæagnus orientalis* are esteemed in Persia under the name of *zinzeyd*; and those of *E. arborea*, *E. conferta*, and others, are eaten in certain parts of India. Those also of *Hippophaë rhamnoides*, the Sea-Buckthorn, which is a native of England, are also edible, and have been employed in the preparation of a sauce for fish, but their use requires caution from containing a narcotic principle.

Order 4. PROTEACEÆ, the Protea Order.—Character.—*Shrubs* or small *trees*. *Leaves* hard, dry, opposite or alternate, exstipulate. *Flowers* usually hermaphrodite. *Calyx* inferior, 4-partite or of 4 sepals; *æstivation* valvate. *Stamens* perigynous, equal in number to the partitions of the calyx and opposite to them; *anthers* bursting longitudinally. *Ovary* simple, superior, 1-celled, with 1 or more ovules, ascending or suspended. *Fruit* dehiscent or indehiscent. *Seeds* exalbuminous; *embryo* straight, *radicle* generally inferior.

Distribution and Numbers.—Natives chiefly of Australia and the Cape of Good Hope. *Illustrative Genera:*—Protea, *Linn.*; Banksia, *Linn. fil.* There are more than 600 species.

Properties and Uses.—They are chiefly remarkable for the beauty or singularity of their flowers and their evergreen foliage. But the fruits and seeds of some species are eaten; and the wood is largely employed at the Cape and in Australia for burning, and occasionally for other purposes; thus, that of *Protea grandiflora* is used at the Cape of Good Hope for waggon-wheels, hence the plant is named Wagenboom. The seeds of *Macadamia ternifolia*, a native of Queensland, are edible.

Cohort 4. *Urticales.* — Flowers usually unisexual, or rarely hermaphrodite. Calyx green, usually regular, rarely absent. Stamens opposite the calyx-lobes or sepals. Ovary superior, 1-celled, or rarely 2-celled; stigmas 1—2; ovule solitary, micropyle always superior. Seeds albuminous or exalbuminous; embryo generally straight. Leaves usually stipulate.

Order 1. URTICACEÆ, the Nettle Order.—Character.—*Herbs, shrubs*, or *trees*, with a watery juice. *Leaves* opposite or alternate, usually rough or with stinging glands (*fig.* 169); stipulate or rarely exstipulate. *Flowers* small, unisexual (*fig.* 1035) or rarely hermaphrodite, scattered or arranged in heads or catkins. *Calyx* inferior (*fig.* 1035, *c*), lobed, persistent. *Male flower* with a few distinct stamens (*fig.* 1035, *e, e*), perigynous, opposite the divisions of the calyx, and with a rudimentary ovary (*fig.* 1035, *pr*); *filaments* at first incurved. *Female flower*

FIG. 1035.

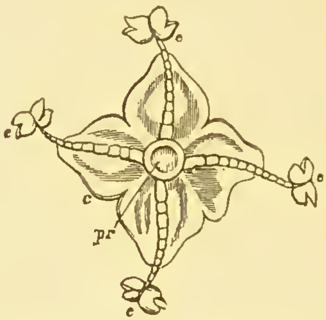


FIG. 1036.

Fig. 1035. Male flower of the Small Nettle (*Urtica urens*). *c*. Calyx. *e, e, e, e*. Stamens, with 2-celled anthers. *pr*. Rudimentary ovary.——*Fig.* 1036. Vertical section of the ovary of the female flower of the same. *p*. Wall of the ovary. *s*. Stigma. *o*. Ovule.

with a superior 1-celled ovary (*figs.* 733 and 1036); *ovule* erect, orthotropous (*figs.* 733 and 1036). *Fruit* indehiscent, surrounded by the persistent calyx. *Seed* solitary, erect (*fig.* 779); *embryo* (*fig.* 779) straight, enclosed in albumen; and with a superior *radicle, r.*

Bentham and Hooker, in 'Genera Plantarum,' include the four succeeding orders—Moraceæ, Cannabinaceæ, Artocarpaceæ, and Ulmaceæ—in Urticaceæ, as sub-orders.

Distribution and Numbers.—These plants are more or less distributed over the world. *Illustrative Genera*:—Urtica, *Tourn.*; Parietaria, *Tourn.* The order contains more than 300 species.

Properties and Uses.—Chiefly remarkable for yielding valuable fibres, and for the acrid stinging juice contained in their glands.

Bœhmeria.—Several species yield valuable fibres, as *B. Puya* (Poonh fibre), in Nepaul and Sikkim, and *B. speciosa* (Wild Rhea). The most celebrated of them all, however, is *B. nivea*, from which the fibres are obtained that are used in the manufacture of the celebrated Chinese grass-cloth, and for other purposes. These fibres are also now employed for textile fabrics, &c. The Rhea fibre of Assam, one of the strongest known fibres, is also derived from this plant.

Laportea pustulata, the Wood Nettle.—This is a native of the Alleghany mountains and some other parts of North America. It has been much recommended for cultivation in Germany, &c., as a textile plant.

Parietaria officinalis, Wall Pellitory, is by many regarded as a valuable diuretic and lithontriptic.

Urtica, Nettle.—The Nettles are well known from their stinging glands. Some of the East Indian species, as *U. crenulata*, *U. stimulans*, and more especially *U. urentissima*, produce very violent effects. Flagellation by a bunch of Nettles (*Urtica dioica* or *U. urens*) was formerly employed in palsy, and other cases.—*U. baccifera* is used as an aperient in the West Indies; the root of *U. pilulifera* is regarded as diuretic and astringent; and an infusion of the leaves of *U. dioica*, commonly known as Nettle Tea, is frequently used in parts of this country as a purifier of the blood. Some Nettles, as *U. tuberosa*, have edible tuberous roots; others yield useful fibres, as *Urtica heterophylla*, Neilgherry Nettle, and *U. tenacissima*.

Order 2. Moraceæ, the Mulberry Order.—Character.—*Trees* or *shrubs*, with a milky juice. *Leaves* with large stipules. *Flowers* unisexual, in heads, spikes, or catkins. *Male flowers* with a 3—4-partite *calyx* (*fig.* 1037) or achlamydeous. *Stamens* 3—4, perigynous (*fig.* 1037) and opposite the segments of the calyx; *anthers* usually inflexed. *Female flowers* with 3—5 *sepals*. *Ovary* superior, 1—2-celled. *Fruit* a sorosis (*fig.* 728) or syconus (*fig.* 406). *Seed* solitary, pendulous (*fig.* 1038); *embryo* hooked (*fig.* 1038), in fleshy albumen, and with a superior radicle.

Fig. 1037.

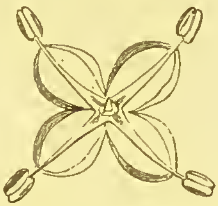


Fig. 1038.

Fig. 1037. Male flower of the Black Mulberry (*Morus nigra*).——*Fig.* 1038. Vertical section of the ovary of the female flower of the same.

Distribution and Numbers.—They are natives of both hemispheres, and occur in temperate and tropical climates. *Illustrative Genera:*—Morus, *Tourn.*; Dorstenia, *Plum.* There are over 200 species.

Properties and Uses.—The milky juice of some species possesses acrid and poisonous properties, while in others it is bland, and may be taken as a beverage. From the milky juice of some Caoutchouc or India-rubber is obtained. The inner bark of other species supplies fibres. Some possess stimulant, sudorific, tonic, or astringent properties. Many yield edible fruits, while the seeds generally of the plants of this order are wholesome.

Broussonetia papyrifera, the Paper Mulberry, is so named from its inner bark being used in China, Japan, &c., for the manufacture of a kind of paper. The Otaheitans, &c., also make a kind of cloth from it.

Dorstenia.—The rhizomes and rootlets of several species have been supposed to be antidotes to the bites of venomous reptiles, and also of many poisonous substances; those of *D. Contrayerva* and *D. brasiliensis* were formerly employed in Britain for their stimulant, tonic, and diaphoretic properties.

Ficus.—*F. Carica* yields the well-known fruit named the Fig. Figs are nutritive, emollient, demulcent, and laxative; they are official in the

British Pharmacopœia. The Fig tree is the *Tecnah* of the Bible.—*F. oppositifolia* and *F. polycarpa*, natives of the East Indies, are said to possess emetic properties.—*F. elastica*, a native of India, yields an inferior kind of India-rubber. It is known in commerce as Assam rubber. It also yields Java rubber. From other species a similar substance is obtained. The juice of *F. toxicaria* and that of *F. dæmona* is a very powerful poison.—*F. Sycomorus* (*Sycomorus antiquorum*), the Sycamore Fig, is said by some authors to have yielded the wood from which mummy-cases were made. (See *Cordia*.) Richard states that the Abyssinians eat the inner bark of *F. panifica*. The brown hairy covering of the leaves of *F. lasiophylla* is used as a styptic at Singapore, &c.—*F. doliaria* is said to have vermifugal properties.

Maclura.—The wood of *M. tinctoria*, a native of the West Indies and South America, is of a golden-yellow colour, and is used in this country and elsewhere as a dyeing agent. It is known as Fustic or Old Fustic, to distinguish it from Young Fustic, already noticed. (See *Rhus*.) The fruit is edible.—*M. aurantiaca* is the source of the fruit called Osage Orange, the juice of which is used by the native tribes in some districts of America as a yellow war paint.

Morus.—The fruit of *Morus nigra* is our common Mulberry; the juice is official in the British Pharmacopœia. Mulberries are well known as a dessert fruit; they are also employed medicinally for their refrigerant and slightly laxative properties, and likewise to give colour and flavour to medicines. The Sycamine tree of the Bible is supposed to be this plant. The leaves of this species, as well as those of *Morus alba*, White Mulberry, and others, are in common use as food for silkworms. The roots of both *M. nigra* and *M. alba* are said to be cathartic and anthelmintic.

Urostigma Vogelii is the source of Liberian Rubber.

Order 3. CANNABINACEÆ, the Hemp Order.—Character.—Rough *herbs*, erect or twining, with a watery juice. *Leaves* opposite or alternate, simple or compound, stipulate, often glandular. *Flowers* small, unisexual, diœcious. *Male flowers* in racemes or panicles. *Calyx* scaly, imbricate. *Stamens* 5, opposite the sepals; *filaments* filiform. *Female flowers* in spikes or strobiles (*fig.* 421), each flower with 1 sepal surrounding the ovary, which is superior and 1-celled, and containing a solitary pendulous campylotropous ovule. *Fruit* dry, indehiscent. *Seed* solitary, pendulous, without albumen; *embryo* curved or spirally coiled, with a superior radicle.

Distribution and Numbers.—Natives of the temperate parts of the northern hemisphere in Europe and Asia. *Illustrative Genera*:—Cannabis, *Tourn.*; Humulus, *Linn.* These are the only genera, and each contains but one species.

Properties and Uses.—The plants of this order yield valuable fibres, and possess narcotic, stomachic, and tonic properties.

Cannabis sativa, the Common Hemp.—The valuable fibre called Hemp is obtained from this plant. It is principally derived from Russia, but the best hemp is produced in Italy. Inferior hemp is obtained from the United States and India. In 1873, no less than 1,251,000 cwts. of hemp were imported into Great Britain. Hemp is chiefly used for cordage, sacking, and sail-cloths. This fibre has been known for more than 2,500 years. The fruits, commonly termed *hemp seeds*, are oleaginous and demulcent. They are used for feeding birds. When submitted to pressure, they yield about

25 per cent. of a fixed oil, which is employed as a varnish, and for other purposes. When the Hemp plant is grown in tropical countries, it varies in some important characters from the ordinary *C. sativa* of colder climates, and is even by some botanists considered as a distinct variety, which has been named *C. sativa* var. *indica*, Indian Hemp. This latter plant produces less valuable fibres than the former, but it acquires marked narcotic properties from producing a much larger quantity of a peculiar resin than is the case with the plant of colder latitudes. The herb and resin are largely employed in Asia, and some other parts of the world, for the purposes of intoxication, and in medicine. The principal forms in which Indian Hemp is found are,—*Gunjah* or *Ganja*, the dried tops after flowering of the female plant, containing the resin; *Bhang*, *Subjee*, or *Sidhee*, the larger leaves and fruits without the stalks; and *Churrus*, the concrete resinous substance which exudes spontaneously from the stem, leaves, and tops. The above forms are in common use in India; and another form called *Hashish* or *Hashash* is largely employed in Arabia. The word 'assassin' is said to be derived from *hashish*, the Arabic word for hemp. Other preparations of Hemp are, *majoon*, in use at Calcutta, *mapouchari* at Cairo, and the *dawames* of the Arabs. Indian Hemp is also used for smoking. This plant is likewise known under the name of *Diamba* in Western Africa, where it is employed for intoxicating purposes under the names of *maconie* and *makiah*. In the form of an extract or tincture, Indian Hemp has been employed medicinally in this country and elsewhere. Pereira calls it an exhilarant, inebriant, phantasmatic, hypnotic or soporific, and stupefacient or narcotic; but as obtained in this country, it varies so much in activity that its effects cannot be depended upon with certainty, and it is consequently not much employed. The dried flowering or fruiting tops of the female plants grown in India, and from which the resin has not been removed (*gunjah* or *ganga*), are official in the British Pharmacopœia. The resin is called *cannabin*, and is usually regarded as the active principle of the plant. Recently, however, a volatile alkaloid analogous to *nicotine* has been indicated as one of the constituents of Indian Hemp. This has, however, since been shown to be incorrect. The presence of another alkaloid, possessing tetanising properties, and termed *tetano-cannabin* by Dr. Hay, has also not been confirmed.

Humulus Lupulus, the Hop.—The collective fruits of this plant are known under the name of strobiles (*fig.* 421), or commonly *hops*, and when dried are official in the British Pharmacopœia. These fruits consist of scales (bracts), and achænia, the latter of which are surrounded by brownish-yellow aromatic glands. These glands, which are usually termed *lupulinic glands*, are the most active part of hops; they are also official in the British Pharmacopœia. They contain a *volatile oil*, and a bitter principle called *lupulin* or *lupulite*, to the presence of which hops principally owe their properties. The bracts also appear to contain a very small proportion of lupulin, and are therefore not devoid altogether of active properties; they also contain tannic acid, and are therefore somewhat astringent. Hops are used medicinally for their stomachic and tonic properties. They are also to some extent narcotic, especially the odorous vapours from them; hence a pillow stuffed with hops is occasionally employed to induce sleep. The chief use of hops, however, is in the manufacture of ale and beer, to which they impart a pleasant aromatic bitter flavour, and tonic and soporific properties. They also prevent beer from rapidly becoming sour. In Belgium, &c., the young shoots of the Hop are used as a vegetable, and when properly prepared for the table they are said to make a most delicate dish.

Order 4. ARTOCARPACEÆ, the Bread-fruit Order.—Character.—*Trees* or *shrubs* with a milky juice. *Leaves* alternate (*fig.* 1039), simple, with large convolute stipules. *Flowers* unisexual, in dense heads (*fig.* 1039, *a*, *b*, *c*) on a fleshy receptacle. *Male flowers* (*fig.* 1039, *b*) achlamydeous, or with a 2—4-lobed or 2 — 4-sepaled calyx. *Stamens* opposite the lobes of the calyx or to the sepals ; *anthers* erect. *Female flowers* arranged on a fleshy receptacle of varying form (*fig.* 1039, *a*, *c*). *Calyx* inferior, tubular, 2—4-cleft or entire. *Ovary* superior, 1-celled. *Fruit* commonly a sorosis. *Seed* erect or pendulous, with little or no albumen ; *embryo* straight, with a superior radicle.

Fig. 1039.

Fig. 1039. Branch of the Bread-fruit tree (*Artocarpus incisa*). *a*, *c*. Heads of female or pistillate flowers. *b*. Head of staminate or male flowers.

Distribution and Numbers.—Exclusively tropical plants. *Illustrative Genera*:—Antiaris, *Leschen.* ; Artocarpus, *Linn.* There are about 60 species.

Properties and Uses.—The milky juice of several species yields India-rubber. This juice is in certain cases poisonous, while in others it forms a nutritious beverage. A few yield valuable timber. The fruits of some are edible, and the seeds generally of plants of this order are wholesome.

Antiaris.—A. toxicaria is the celebrated *Antsjar* or *Upas* poison tree of Java, but most of the stories related concerning it are fabulous. The milky juice is the poisonous product. This poison owes its activity to a peculiar principle named by Pelletier and Caventou *antiarin.—Antiaris saccidora*, a native of the East Indies, has a very tough inner bark, which is used for cordage, matting, &c. Sacks also are made from it as follows :—'A branch is cut corresponding to the length and diameter of the sack wanted. It is soaked a little, and then beaten with clubs until the liber separates from the wood. This done, the sack formed of the bark is turned inside out, and pulled down till the wood is sawed off, with the exception of a small piece left to form the bottom of the sack.' These sacks are commonly used to carry rice, and other substances. The seeds have a very bitter taste.

Artocarpus.—The fruit of *A. incisa* is the important Bread-fruit of the Moluccas and islands of the Pacific. It supplies the place of corn to the natives of those regions. It is also used to some extent in the West Indies, but is not so much valued there for food as the Plantain. In the South Sea Islands the juice is employed as glue, the wood as timber, and the bark for making a coarse kind of cloth.—*A. integrifolia* yields the Jak or Jack-fruit, which is largely used for food by the natives in Ceylon, Southern India, and other warm parts of Asia. The roasted seeds are likewise much esteemed. The inner wood is also employed to dye the Buddhist priests' robes of a yellow colour.

Brosimum.—B. Galactodendron is the celebrated Palo de Vaca or Cow-tree of South America. It is so named from its milky juice being nutritious like milk from the cow. It is the Massaranduba tree of Brazil, and its juice has been also recommended as a source of India-rubber. The fibrous bark of *B. Namagua* is used in Panama for sails, ropes, garments, &c.—*B. Aubletii* (*Piratinera Guianensis*), a native of British Guiana, is the source of the beautiful fancy wood called Snake-wood, Leopard-wood, or Letter-wood.—*B. Alicastrum* yields edible seeds, which are called Bread-nuts in Jamaica. The wood, which somewhat resembles mahogany, is also there used by cabinet makers.

Castilloa elastica.—This is the Cuacho tree of Darien, and, according to Collins, this species and *C. Markhamiana*, yield all the varieties of India-rubber obtained from Central America, Ecuador, New Granada, and the West Indies; and known commercially as West Indian, Carthagena, Nicaragua, Honduras, Guayaquil, Guatemala, &c., rubbers. These are chiefly exported from Carthagena to Great Britain and the United States.

Cecropia peltata is remarkable for its stems being hollow except at the nodes, hence they are used for wind instruments. Cows are said to thrive well on its leaves. Its cultivation has been recommended in Algeria as a forage plant.

Cudrania.—The heart-wood of a species of this genus, which is a native of East Tropical Africa, yields a light yellow colour somewhat between that of quercitron bark and fustic, and may be used for dyeing.

Order 5. Ulmaceæ, the Elm Order.—Character.—*Trees* or *shrubs*, with a watery juice. *Leaves* alternate, simple, scabrous, with deciduous stipules. *Flowers* hermaphrodite or unisexual, in loose clusters. *Calyx* inferior, membranous, imbricate. *Stamens* perigynous, definite; *anthers* erect. *Ovary* superior, 1—2-celled; *styles* or *stigmas* 2. *Fruit* indehiscent, samaroid or drupaceous, 1—2-celled. *Seeds* solitary, pendulous, with little or no albumen; *embryo* straight; *cotyledons* foliaceous; *radicle* superior.

Division of the Order and Illustrative Genera:—This order may be divided into two sub-orders or tribes as follows:—

Sub-order 1. *Celteæ.*—Ovary 1-celled, with drupaceous fruit. *Illustrative Genera:*—Celtis, *Tourn.*; Mertensia, *H. B. K.*

Sub-order 2. *Ulmeæ.*—Ovary 2-celled, with usually samaroid fruit. *Illustrative Genera:*—Planera, *Gmel.*; Ulmus, *Linn.*

Distribution and Numbers.—They are chiefly natives of the northern regions of the world. There are about 60 species.

Properties and Uses.—Some are valuable timber trees. The bark and fruit of others are bitter, tonic, and astringent; and a few possess aromatic properties.

Celtis.—The fruit of *C. australis* has a sweetish astringent taste, and has been used in dysentery, &c. It has been regarded by some writers as the Lotus of the ancients. The fruits are still eaten in Spain and Greece. (See also *Nitraria* and *Zizyphus.*) This plant is commonly known under the names of Nettle-tree and Sugar-berry.—*C. orientalis* has aromatic properties.

Ulmus, Elm.—The inner bark of *Ulmus campestris*, the common English Elm, is regarded as demulcent, tonic, diuretic, and alterative; it has been used in some chronic skin diseases, but as a medicinal agent it is now nearly obsolete, and is no longer official in the British Pharmacopœia. The dried and powdered bark has been mixed with meal in Norway to make bread in times of scarcity. The wood of this species, as also that of *U. montana*, the

Scotch or Wych Elm, and others, is largely employed as timber, which is valuable not only for its toughness, but because it is not readily acted upon by water. The inner bark of *U. fulva*, the Slippery Elm or Red Elm, a native of the United States, where it is official in the Pharmacopœia, is much used as a demulcent for both external and internal use. When ground it is said to form an excellent emollient poultice, like that of Linseed meal. It is also stated to have the property of preserving fatty substances from rancidity, when these are melted and kept in contact with it for some time.

Cohort 5. *Amentales.*—Flowers unisexual, in ordinary amenta or amentaceous heads. Calyx absent, or present and green, or represented by 1 or more bristles, bracts, bracteoles, or scales. Ovary superior, 1—2-celled. Seeds nearly always exalbuminous. Trees or shrubs. Leaves alternate, simple, and usually with deciduous or persistent stipules; or in Casuarinaceæ there are no evident leaves.

Order 1. BETULACEÆ, the Birch Order.—Character.—*Trees* or *shrubs. Leaves* simple, alternate, with deciduous stipules. *Flowers* small, unisexual, monœcious, amentaceous, with no true *calyx*, but in its place small scaly *bracts*, which in some cases are arranged in a whorled manner. *Male flowers* with 2 or 3 *stamens* opposite the bracts. *Female flowers* with a 2-celled *ovary*, and 1 pendulous anatropous *ovule* in each cell. *Fruit* dry, thin, indehiscent, often winged, 1—2-celled, 1-seeded, without a cupule. *Seed* pendulous, exalbuminous; *embryo* straight; *radicle* superior. *Bentham and Hooker include this order in Cupuliferæ as the tribe Betuleæ.*

Distribution and Numbers.—They are principally natives of the colder regions in the northern hemisphere. *Illustrative Genera*:—Betula, *Linn.*; Alnus, *Tourn.* These are the only genera; there are about 70 species.

Properties and Uses.—They are valuable for their timber, and for their astringent, tonic, and febrifugal barks.

Alnus.—*A. glutinosa*, the common Alder.—Its wood is valuable for the piles of bridges, and in other cases where entire submersion in water or damp earth is required. Its bark is astringent, and has been used in medicine, and for tanning and dyeing. The leaves and catkins have similar properties. The wood is also employed for making charcoal, which is much valued for the manufacture of gunpowder. The bark of *A. incana* is used in Kamtschatka for making a kind of bread.

Betula.—*B. alba*, the common Birch, yields the timber known as Norway Birch. The wood is also used for making charcoal. From the bark, rootlets, and twigs of this species the oil known as *Oleum Rusci* or *Birch Tar Oil*, which gives the peculiar odour to Russia leather, is obtained. It has also a high reputation in Russia, Poland, &c., in certain skin diseases, more especially eczema. The sap contains in the spring a good deal of sugar, hence it is then used in the preparation of a kind of wine; this is commonly known as Birch wine, and is employed in domestic practice for those afflicted with stone or gravel.—*B. nigra*, the Black Birch of North America, is also valuable for its timber. Its sap, like that of *B. alba* and *B. lenta*, yields sugar of good quality, and wine may be also prepared from it.—*B. papyracea* has a thick tough bark, which is used by the Indians in North

America for boats, shoe-soles, and other purposes. The bark of *B Bhajapattra* is employed in India as 'a kind of paper. The bark of *B. lenta*, known in the United States as Sweet Birch or Cherry Birch, yields by distillation a volatile oil, which is said to be identical with that obtained from the leaves of *Gaultheria procumbens*. (See *Gaultheria*, page 605.)

Order 2. PLATANACEÆ, the Plane Order.—Character.—*Trees* with a watery juice. *Leaves* alternate, palmately-lobed, with deciduous sheathing stipules (*fig.* 1040). *Flowers* unisexual, monœcious, in globular (*fig.* 1040) amentaceous heads; achlamydeous. *Male flowers* with 1 *stamen* and a 2-celled linear *anther*. *Female flowers* (*fig.* 1040) consisting of a 1-celled *ovary* and a thick *style*; *ovules* 1—2, pendulous. *Fruits* arranged in a compact rounded head, consisting of clavate achænia with persistent styles. *Seeds* 1 or rarely 2, pendulous; *embryo* straight, in very thin albumen, with an inferior radicle.

Distribution and Numbers.—They are natives principally of North America and the Levant. *Platanus*, Linn., is the only genus, of which there are 5 or 6 species.

Properties and Uses.—Of no particular importance, except that, from their being large handsome trees, and flourishing well in large towns, they are commonly planted in our parks and squares. The leaves closely resemble in appearance those of the Sycamore tree. The timber is sometimes used by the cabinet-maker.

FIG. 1040.

Fig. 1040. Branch of the Plane Tree (*Platanus orientalis*), with amentaceous heads of achlamydeous female flowers.

Order 3. MYRICACEÆ, the Bog-myrtle Order.—Character. *Shrubs* or small *trees*, with alternate, simple, resinous-dotted leaves, which are usually exstipulate. *Flowers* unisexual, amentaceous, monœcious or diœcious, both kinds of flowers in the same or in different catkins. *Male flowers* achlamydeous; *stamens* definite *Female flowers* achlamydeous, with a 1-celled sessile *ovary*, 2 *styles*, and 1 erect orthotropous *ovule*; *fruit* drupaceous; *seed* solitary, erect, without hairs; *embryo* without albumen; *radicle* superior.

Distribution and Numbers.—Natives of the temperate parts of Europe and North America, and of the tropical regions of

South America, India, and the Cape of Good Hope. *Illustrative Genera:*—Myrica, *Linn.*; Comptonia, *Banks.* There are about 20 species.

Properties and Uses.—The plants of this order are chiefly remarkable for aromatic and astringent properties.

Comptonia asplenifolia, Sweet Fern, is employed in the United States as an astringent and tonic in diarrhœa.

Myrica.—*M. cerifera*, the Waxberry, Candleberry, or Wax Myrtle. The bark of the root is used in the United States as a stimulant astringent in diarrhœa and dysentery and also in jaundice. The substance termed *myricin* is also derived from it, and is regarded as a good stimulant of the liver. The fruits when boiled yield the kind of wax known as Myrtle Wax. Other species of *Myrica* yield a somewhat similar waxy substance. The fruit of *M. sapida* is eaten in Nepal. Its bark is an aromatic stimulant, and is employed in some parts of India as a rubefacient and sternutatory. —*M. Nagi* is cultivated in Japan for its edible fruit, which is eaten both raw and when cooked.

Order 4. CASUARINACEÆ, the Beef-wood Order.—Character.—*Trees* with pendulous, jointed, striated branches, without evident *leaves*, but sometimes having short toothed sheaths, representing whorls of leaves, at the nodes. *Flowers* in bracteated spikes or heads, unisexual. *Male flowers* with 2 *sepals* united at their points, and 2 alternating *bracts*; 1 *stamen*, and a 2-celled *anther*. *Female flowers* in dense spikes or heads, naked, but each having 2 *bracts*; *ovary* 1-celled or rarely 2-celled, with 1—2 ascending *ovules*, and 2 *styles*. *Fruits* winged, indehiscent, collected together into a cone-shaped body hidden under the thickened bracts. *Seeds* exalbuminous; *radicle* superior.

Distribution and Numbers.—These plants are principally natives of Australia. They are called Beef-wood trees from the colour of their timber somewhat resembling that of raw beef. In general appearance they much resemble the branched *Equiseta*. *Casuarina*, Linn., is the only genus; it contains about 32 species.

Properties and Uses.—The species of *Casuarina* yield very hard and heavy timber, and the bark of some is said to be tonic and astringent.

Casuarina.—Several species produce valuable timber, which is chiefly used in this country for inlaying and marqueterie. The wood has a red colour, and is known under the names of Beef-wood, Botany Bay Oak, Forest Oak, He-Oak, She-Oak, &c. The bark of *C. muricata* is an excellent astringent, and is in use in India.

Order 5. SALICACEÆ, the Willow Order.—Character.—*Trees* or *shrubs*. *Leaves* simple, alternate, deciduous, with persistent or deciduous stipules. *Flowers* unisexual (*figs.* 1041 and 1042), diœcious, amentaceous (*figs.* 415 and 416), naked, or with a membranous or cup-like *calyx*. *Male flowers* (*fig.* 1041) with 1—30 distinct or monadelphous stamens. *Female flowers* sessile or stalked, with a superior (*fig.* 1042) 1-celled *ovary*, and numerous erect anatropous *ovules* on 2 parietal placentas. *Fruit* 1-celled, 2-valved, dehiscing loculicidally. *Seeds* minute, numerous, with long silky hairs (*fig.* 756) springing from a funicle and covering the seed, exalbuminous; *embryo* erect, with an inferior radicle.

Distribution and Numbers. — Chiefly natives of cold and temperate climates. *Illustrative Genera:* — Salix, *Tourn.*; Populus, *Tourn.* These are the only genera; there are about 250 species.

Properties and Uses.—Many species are either valuable for their timber, or for basket-work and other economic purposes. The bark commonly possesses tonic, astringent, and febrifugal properties. The hairs which invest the seeds have been employed for stuffing cushions, and for other purposes. The buds of some species secrete an oleo-resinous substance of a stimulating nature.

Fig. 1041. Fig. 1042.

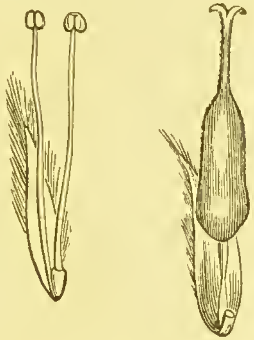


Fig. 1041. Male flower of a species of Willow (*Salix*), with two stamens, and a single bract at their base. —— *Fig.* 1042. Female flower of the same with bract at the base, and a solitary stalked ovary and style surmounted by two stigmas.

Populus, Poplar.—Several species have been used for their timber. The bark is commonly tonic, astringent, and febrifugal, owing to the presence of salicin, which is official in the British Pharmacopœia. (See *Salix*.)

Salix—Several species are used for timber, and for basket-work; and also for the manufacture of charcoal. The timber is white; but is wanting in strength and durability. Osiers and Sallows are the shoots from pollard stumps of different species, as *S. viminalis*, *S. vitellina*, &c. A peculiar neutral principle, a glucoside, resembling the alkaloid quinine in its medicinal properties, called *salicin*, has been obtained from the bark, leaves, or flowers of about twenty species of *Salix*. But the barks of *S. Russelliana*, *S. alba*, *S. Caprea*, *S. fragilis*, *S. pentandra*, and *S. purpurea* yield most of this principle. (See *Populus*.) As an anti-periodic, salicin is far inferior to quinine. Lately, however, salicin has been given successfully in acute rheumatism. *Salicylic acid*, which may be obtained from willow bark, and other vegetable substances, but is now commonly prepared from carbolic acid, has recently, together with its salts, but more especially *salicylate of soda*, been extensively and successfully used in rheumatism. Salicylic acid has also been employed with success as an antiseptic, and in various other ways. Both salicin and salicylic acid are official in the British Pharmacopœia. The decoction of willow bark has likewise been found beneficial as an application to foul and indolent ulcers, and in psoriasis and some other chronic skin affections.

Cohort 6. *Euphorbiales.*—Flowers usually unisexual, or very rarely hermaphrodite, either with a calyx only, or with both a calyx and corolla, or achlamydeous. Ovary superior, 1—many-celled, usually 2-celled; ovules almost always suspended, 1—many in each cell, anatropous. Fruit generally capsular, 1—many-celled. Seeds 1—many in each cell. Seeds albuminous, or very rarely exalbuminous, suspended, or very rarely ascending; embryo straight.

Order 1. EUPHORBIACEÆ, the Spurge Order.—Character.—*Trees*, *shrubs*, or *herbs*, usually with an acrid milky juice. *Leaves* alternate or opposite, simple (*fig.* 332) or rarely compound, stipulate or exstipulate. *Flowers* unisexual (*figs.* 512, 551, 627, and 1043), monœcious (*fig.* 1043) or diœcious, axillary or terminal, sometimes enclosed in a calyx-like involucre (*fig.* 1043, *i*); achlamydeous (*fig.* 627), or with a lobed (*figs* 551, 641, *c*) inferior calyx having on its inside glandular or scaly appendages (*fig.* 641, *t*, and 1043, *b*), or even evident petals (*figs.* 551, *p*, and 641, *p*), which are either distinct or united. *Male flowers* consisting of 1 (*figs.* 512 and 1043, *fm*) or more *stamens* (*fig.* 551, *e*), distinct or united into one or more bundles (*fig.* 551, *a*); *anthers* 2-celled. *Female*

FIG. 1043.

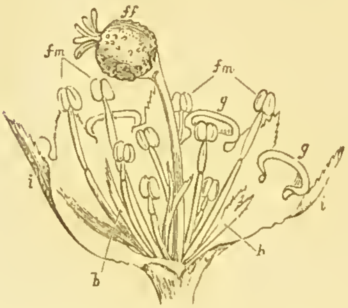


FIG. 1044.

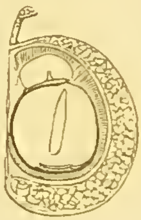


Fig. 1043. Monœcious head of flowers of a species of *Euphorbia*. *i*. Involucre, a portion of which has been removed in front. *g*, *g*. Glands on the divisions of the involucre. *b*, *b*, Scales or bracteets at the base of the flowers. *fm*, *fm*. Male flowers, each consisting of a stamen supported on a pedicel to which it is articulated. *ff*. Female flower, supported on a stalk. From Jussieu.—— *Fig.* 1044. Vertical section of the pericarp and seed of a carpel (*coccus*) of a species of *Euphorbia*.

flowers with a superior *ovary* (*figs.* 641 and 642), which is either elevated upon a stalk (*fig.* 1043, *ff*) or sessile (*figs.* 611 and 642), 1- 2- 3- or many-celled; *styles* either absent or corresponding in number to the cells of the ovary, entire or divided (*figs.* 627, 641, and 642); *stigmas* equal in number to the cells of the ovary, or, when the styles are divided, corresponding in number to their divisions (*figs.* 627, 641, and 642); *ovules* 1 or 2 in each cell, suspended from the inner angle (*fig.* 1044). *Fruit* either dry, and its component carpels then separating from each other and from the axis (*figs.* 675 and 711) and usually opening with elasticity; or succulent and indehiscent. *Seeds* 1 or 2 in each cell, suspended (*fig.* 1044), often carunculate; *embryo* (*fig.* 1044) straight, in fleshy albumen, with flattened cotyledons, and a superior radicle.

Diagnosis.—Herbs, shrubs, or trees, commonly with an acrid milky juice. Flowers unisexual, monœcious or diœcious.

Calyx absent, or present and inferior. Petals rarely present. Male flowers with one or more stamens, distinct or united, and 2-celled anthers. Female flowers with a superior, sessile or stalked, 1- or more celled ovary, and with 1 or 2 suspended ovules in each cell. Fruit of 1, 2, 3, or many dry carpels, which separate from the axis and from each other, and usually open with elasticity; or fleshy and indehiscent. Seeds suspended; embryo in fleshy albumen, straight, with flattened cotyledons, and a superior radicle.

Distribution and Numbers.—They are more or less distributed over the globe, and are especially abundant in equinoctial America. *Illustrative Genera:*—Euphorbia, *Linn.*; Mercurialis, *Linn.*; Ricinus, *Tourn.*; Buxus, *Tourn.* There are above 2,500 species.

Properties and Uses.—These plants generally contain an acrid poisonous principle or principles, which is found more or less in all their parts. Some are very deadly poisons. But in proper doses many are used medicinally as emetics, purgatives, diuretics, or rubefacients. A pure starch, which is largely employed for food, may be obtained from some plants of the order; while India-rubber may be procured from the milky juice of others. A few are entirely devoid of any acrid or poisonous principle, and are used medicinally as aromatic tonics. Some have edible roots; others yield dyeing agents; and several are valuable on account of their wood.

Acalypha indica.—The expressed juice of the leaves possesses emetic and expectorant properties. The root is purgative.

Aleurites triloba, the Candle-nut tree.—This plant is a native of the Moluccas, Cochin China, New Caledonia, &c.; it yields a fruit called the *Bancoul Nut* or *Candle Nut*. The seeds yield by expression an oil called *Kekui* or *Kekune*; this is largely employed in some parts of the world, and has been imported into London. It is used as an artist's oil, and has also been recommended as a purgative. It is said to resemble castor oil in its action. Corewinder states that its illuminating power is superior to that of Colza oil; but other observers say that its purgative power is very feeble, and that it is useless for illuminating purposes.—*A. lactifera*, a native of Ceylon, yields Gum-lac.

Anda brasiliensis.—The seeds yield by expression a fixed oil. Both the oil and seeds possess active cathartic properties. The oil is also said to possess drying qualities superior to even that of boiled linseed oil. The juice of the bark is used in Brazil for stupefying fish.

Buxus.—*B. sempervirens*, the Box-tree, is valuable for its timber, which is much used by wood engravers. Its leaves are purgative.—*B. balearica*, the Turkey Box, also yields valuable timber. The best is known as Turkey Boxwood, and is obtained from regions round the Black and Caspian Seas.

Croton.—The seeds of *C. Tiglium* constitute the *croton seeds* of the Materia Medica; these yield by expression the official *croton oil* of the British Pharmacopœia, which is a powerful hydragogue carthartic in doses of from one-third to one minim. It is also employed externally as a rubefacient and counter-irritant. The seeds are used in India as purgative pills, under the name of *Jamalgata pills*. The seeds of *C. Roxburghii*, *C. Pavana*, and *C. oblongifolius* have also purgative properties.—*C. Eluteria* of Bennett, a native of the Bahama Islands, yields the aromatic, bitter, and tonic bark commonly known as *Cascarilla* bark, which is official in the British Pharmacopœia. It has an agreeable smell when burned, hence it is also used for fumigation and as an ingredient in pastilles.—*C. Pseudo-China* yields the *Quilled Copalche bark* of Pereira, and *C. suberosum* is probably the source from whence *Corky Copalche bark* of the same author is obtained. Copalche barks in their medicinal properties resemble Cascarilla. The aromatic tonic bark known as *Malambo bark* is the produce of *C. Malambo.* It is a favourite medicine in Columbia for diarrhœa, and as a vermifuge, and is likewise used externally in the form of an alcoholic tincture in rheumatism. It has been also employed with good effect in intermittent and some other fevers. In the United States it is reported to be used for adulterating ground spices.—*C. lacciferum*, a native of Ceylon, and *C. Draco*. a native of Mexico, yield resins which are useful for making varnishes, &c. The spirituous liquor known in the West Indies as *Eau de Mantes,* and useful in irregular menstruation, is obtained from *C. balsamiferum.*

Crozophora tinctoria, a native of the South of France, yields by expression a green juice, which becomes purplish under the combined action of ammonia and the air. This purplish dye is known under the name of *turnsole.*

Elæococca or *Dryandra Vernicia* is a native of China and Japan. The seeds yield by expression a fatty oil (the Wood Oil of China), which is enormously used in China for painting, and for preserving wood-work, varnishing furniture, and in medicine. It is also largely exported from Hankow.

Euphorbia.—Some of these plants have succulent stems, much resembling the Cactaceæ; but their milky juice will, in most cases, at once distinguish them. The acrid resin, commonly called *gum euphorbium,* the botanical source of which has been referred to various species of *Euphorbia*, as *E. canariensis*, *E. officinarum*, *E. antiquorum*, and *E. tetragona*, has now been traced to *Euphorbia resinifera* of Berg. This drug is a dangerous acrid emetic and cathartic when taken internally, and externally it is a powerful rubefacient; its use medicinally is now solely confined to veterinary practice. It is, however, very largely used as an ingredient in a kind of paint employed for the preservation of ships' bottoms. The seeds of *E. Lathyris*, Caper Spurge, are purgative, and yield by expression a very active cathartic oil. They were formerly called *Semina Cataputiæ minoris.* This plant is called the Caper Spurge, from the use of its pickled fruits by housekeepers as a substitute for ordinary capers. But their employment for such a purpose is not altogether free from danger, although the process of pickling would seem, in a great measure to destroy the acrid purgative nature which the fruit possesses in a fresh state. The root of *E. Ipecacuanha* is commonly known as American Ipecacuanha, from its use in the United States as an emetic. The root of *E. corollata*, called Milk-weed in the United States, has similar properties.—*E. Petitiana* and *E. Schimperiana* have very purgative qualities. The root of *E. neriifolia* is in great repute in India as a remedy in snake-bites.—*E. pilulifera*, a native of Queensland, &c., is reputed to be useful in asthma. The acrid milky juice of *E. antiquorum*, *E. Nivulia*, and *E. Tirucalli* possesses cathartic and anthelmintic properties. Species of *Euphorbia*, as *E. helioscopia*, *E. Peplis*, and *E. dendroides*. are used in Greece to stupefy fish. The milky juice of *E. Cattimandoo*, a native of the Madras Presidency, yields a kind of Caoutchouc.

Fontainea Pancheri.—From the seeds of this plant, which is a native of New California, a drastic oil may be extracted, which Dr. Haeckel says closely resembles croton oil in its properties.

Hevea Guayanensis (*Siphonia elastica*), *Hevea brasiliensis*, *H. Spruceana*, and probably other species, natives of Brazil and Guiana, are the sources of Para India-rubber, the best commercial variety and the one mostly used in this country. The principal source is, however, *H. brasiliensis*. The commercial kind of rubber known as Maranham is also probably obtained from one or more species of *Hevea.*

Hippomane Mancinella is the famous Manchineel tree. The juice is a virulent poison. It would seem probable that the poisonous principle of this plant is volatile, as it has been asserted that some persons have died from simply sleeping under it. Seemann states, that if sea-water be applied to the eyes when affected by the poison, it allays the inflammation in an effectual manner.

Jatropha.—The seeds of *J. purgans* (*Curcas purgans*), and those of *J. multifidus* (*Curcas multifidus*), are called Physic Nuts. They yield by pressure fixed oils, and both the seeds and oils are drastic cathartics. The seeds of *J. multifidus* under the name of *Purguira* or *Purquira nuts*, are largely exported from the Cape de Verd Islands. They are almost all sent to Marseilles to be used in the manufacture of soap. The oil may also be used for burning, &c.; it is known as *Purguira Oil,* and in English commerce as *Pulza Oil* or *Seed Oil.* The oil of *J. purgans* is commonly distinguished as *Oil of Wild Castor Seeds* or *Jatropha Oil,* and is well adapted for burning. It is said to be employed for adulterating East Indian Croton oil. A decoction of the leaves is used by the natives of the Cape de Verd Islands to excite a secretion of milk. The seeds of *J. gossypifolia,* Bastard French Physic Nut, also possess purgative properties.

Mallotus philippinensis (*Rottlera tinctoria*).—The fruit of this plant is covered by a red powder which consists of small glands and stellate hairs. It is designated in the Indian bazaars, *Kamala.* Kamala is much employed in India as an anthelmintic, and externally in certain cutaneous diseases. The Arabs also use it in leprosy, &c. Kamala is official in the British Pharmacopœia, and is said to be especially useful for the expulsion of tænia. But in this country its employment has not been attended with any great success. Kamala has also been used externally in this country in herpetic ringworm. Other kinds of Kamala have also been described possessing similar properties, and which are also probably derived from species of *Mallotus.* (See also *Flemingia,* page 533.)

Manihot utilissima (*Jatropha Manihot*), Bitter Cassava.—*Cassava Meal,* which is largely employed in making the *Cassava Bread* or *Cakes,* in common use by the inhabitants of tropical America as food, is obtained by grating the washed roots, and then subjecting the pulp to pressure and drying it over a fire. The roots and expressed juice are virulent poisons, owing chiefly to the presence of hydrocyanic acid; but their poisonous nature is destroyed by washing and the application of heat. *Cassava Starch, Tapioca Meal* or *Brazilian Arrowroot,* and *Tapioca,* are also prepared from the roots of *Manihot utilissima*: thus the fecula, which is deposited from the washed pulp after the juice has been expressed, when dried, constitutes Cassava Starch; and Tapioca is prepared by submitting Cassava Starch while moist to heat on hot plates. Tapioca is largely employed as a dietetical substance in this country and elsewhere. The sauce called *Cassareep* in the West Indies, &c, is the juice concentrated by heat and flavoured with aromatics.—*Manihot Aipi,* Sweet Cassava, has none of the poisonous properties of the preceding plant. It is now generally considered as a variety of *Manihot utilissima.* The root is a common article of food in the West Indies and some parts of South America. It is as mealy as a potato when boiled. Cassava meal and bread, as well as Cassava starch and Tapioca, are also prepared from the roots of this plant, which are distinguished as Sweet Cassava roots.—*M. Glaziovii* is the source of Ceara India-rubber.

Oldfieldia africana is the source of the valuable timber known as African Oak or African Teak.

Omphalea triandra.—The juice is sometimes employed in Guiana as a substitute for black ink. The seed from which the embryo has been extracted is said to be edible.

Phyllanthus.—Phyllanthus Emblica (*Emblica officinalis*).—The fruits of this Indian plant constitute *Emblic Myrobalans*. (See *Terminalia*.) When in a dry state they are employed for tanning, and as an astringent in medicine. The fruits are likewise used as a pickle, or preserved in sugar. The bark is also astringent, and the flowers are reputed to be refrigerant and aperient.—*P. Niruri* and *P. urinaria* are employed as diuretics in India.

Ricinus communis, the Castor Oil Plant, or Palma Christi.—The plant called *Kikayon* in the Bible, and translated Gourd, is by some considered to refer to this species. This plant and other species or varieties are largely cultivated in the East and West Indies, America, Italy, and some other parts of the world, for their seeds, which are commonly called Castor seeds, from which the official Castor Oil is obtained. The leaves have been recommended as an external application, and for internal administration to promote the secretion of milk. *Castor oil* is obtained from the seeds, either by expression with or without the aid of heat, or by decoction, or by the aid of alcohol. The oil employed in India, England, the United States, and with few exceptions now in other parts of the world, is obtained solely by expression. Castor seeds when taken whole are extremely acrid, and have produced death; but the oil obtained from them is a mild and most efficient non-irritating purgative. This oil is supposed to owe its purgative properties to the presence of some acrid principle which is contained in both the albumen and embryo, but at present this matter has not been isolated. The so-called *concentrated castor oil*, which is sold in gelatine capsules, is generally adulterated with croton oil, and hence may produce serious effects when given in particular cases. The Castor-oil plant is cultivated in Algeria for the purpose of feeding silkworms upon its leaves. The oil has also been used there for burning.

Stillingia.—S. sebifera is called the Chinese Tallow Tree, from its seeds being covered by a white sebaceous substance, which, when separated, is found to be a pure vegetable tallow; it is used for candles, &c. The plant has now been successfully acclimatised in Algeria.—*S. sylvatica*, Queen's Delight. The root is official in the United States Pharmacopœia. It is known as Queen's root, and is used as an emetic, cathartic, and alterative. It is reputed to be very serviceable in several skin diseases, jaundice, some forms of dropsy, piles, &c.

Order 2. Scepaceæ, the Scepa Order.—*Diagnosis.*—This order is closely allied to Euphorbiaceæ, *in which it is included by Bentham and Hooker*; but from which as here defined it is readily distinguished by its flowers being *amentaceous*.

Distribution, Numbers, and Properties.—Natives of the East Indies. There are 6 species. The wood of *Scepa* (*Lepidostachys*) *Roxburghii* is called Cocus or Kokra. It is very hard, and is chiefly employed for flutes and similar musical instruments.

Order 3. Empetraceæ, the Crowberry Order.—Character.—Small Heath-like evergreen *shrubs*. *Leaves* exstipulate. *Flowers* axillary, small, unisexual. *Calyx* of 4—6 persistent, imbricate, hypogynous scales, the innermost occasionally petaloid and combined. *Stamens* alternate with, and equal in number to, the inner sepals or scales. *Ovary* superior, placed on a disk, 2—9-celled; *ovules* solitary. *Fruit* fleshy, composed of from 2—9 nuts. *Seed* solitary in each nut, ascending; *embryo* with an inferior radicle in fleshy-watery albumen.

This order is variously placed by botanists. We put it near to Euphorbiaceæ in accordance with the views of Lindley.

Distribution and Numbers.—Mostly natives of Northern Europe and North America. *Illustrative Genera:*—Empetrum, *Linn.*; Corema, *Don.* There are 4 species.

Properties and Uses.—The leaves and fruit are generally slightly acid. The berries of *Empetrum nigrum*, the Crowberry, are eaten in the very cold parts of Europe, and are also employed in Greenland in the preparation of a fermented liquor. In Portugal, the berries of *Corema* are used in the preparation of a beverage which is said to be useful in febrile complaints.

Order 4. STILAGINACEÆ, the Stilago Order.—Character.—*Trees* or *shrubs*. *Leaves* alternate, simple, leathery, with deciduous stipules. *Flowers* minute, unisexual, in scaly spikes. *Calyx* 2—5-partite. *Male flowers* consisting of 2 or more *stamens* on an enlarged thalamus; *anthers* usually 2-lobed, with a fleshy connective, and dehiscing transversely at the apex. *Female flowers* with a superior 1—2-celled *ovary*, each cell with 2 suspended *ovules*. *Fruit* drupaceous. *Seeds* suspended, albuminous; *embryo* straight, with leafy cotyledons, and a superior radicle. *This order is made a tribe of Euphorbiaceæ by Bentham and Hooker.*

Distribution and Numbers.—Natives of Madagascar and the East Indies. *Illustrative Genera:*—Stilago, *Linn.*; Falconeria, *Royle.* There are about 20 species.

Properties and Uses.—Unimportant. The fruits of *Antidesma pubescens* and *Stilago Bunias* are subacid and agreeable.

Order 5. PENÆACEÆ, the Penæa Order.—Character.—Evergreen *shrubs*, with opposite, exstipulate, imbricate leaves. *Flowers* hermaphrodite. *Calyx* inferior, bracteated, 4-lobed; *æstivation* valvate or imbricate. *Stamens* perigynous, 4 or 8, alternate with the divisions of the calyx when equal to them in number. *Ovary* superior, 4-celled; *style* 1; *stigmas* 4, with appendages on one side. *Fruit* 4-celled, dehiscent or indehiscent. *Seeds* varying in position, exalbuminous; *embryo* with very minute cotyledons.

This order is sometimes placed near Proteaceæ, but it is especially distinguished from that order by its 4-celled ovary and 4-celled fruit.

Distribution and Numbers.—They are only found at the Cape of Good Hope. *Illustrative Genera:*—Penæa, *Linn.*; Geissoloma, *Lindl.* There are over 20 species.

Properties and Uses.—Unimportant.

Penæa.—The gum called Sarcocolla is commonly said to be derived from *Penæa Sarcocolla*, *P. mucronata*, and other species of Penæa. It was formerly employed as an external application to wounds and ulcers, under the idea that it possessed the property of agglutinating the flesh, whence its name. It is imported into Bombay from the Persian port of Bushire; and Dymock thinks there can be little doubt that the Sarcocolla plant will prove to be a species of Astragalus, or of some nearly allied genus. (See *Astragalus.*)

Order 6. LACISTEMACEÆ.—The Lacistema Order.—Character.—*Shrubs.* *Leaves* simple, alternate, dotted, stipulate. *Flowers* in axillary catkins, perfect or unisexual. *Calyx* inferior, with several divisions, enclosed by a bract. *Stamen* 1, hypogynous, with a 2-lobed connective, each lobe bearing 1 cell of the anther, which bursts transversely. *Ovary* superior, seated in a disk, 1-celled, with numerous ovules attached to parietal placentas. *Fruit* capsular, 1-celled, 2—3-valved. *Seeds* generally 2 or 3, arillate, suspended, with fleshy albumen.

Distribution, Numbers, and Properties.—Natives of woody places in tropical America. *Illustrative Genera:*—There are 2 genera, namely, Lacistema, *Swartz,* and Synzyganthera, *R. et P.*, which contain 6 species. Their properties and uses are unknown.

Cohort 7. *Piperales.*—Flowers hermaphrodite or unisexual, generally arranged in a spike or a spadix. Calyx usually absent, or when present rudimentary. Ovary superior, generally 1-celled, 1-ovuled, or 3—4-celled with a few ovules. Seed albuminous (except in *Ceratophyllum*); embryo usually minute.

Order 1. PIPERACEÆ, the Pepper Order.—Character.—*Herbs* or *shrubs* with jointed stems. *Leaves* opposite, whorled, or alternate, and with or without stipules. *Flowers* spiked, hermaphrodite or sometimes unisexual, achlamydeous, bracteated. *Stamens* 2 or more; *anthers* 1—2-celled. *Ovary* simple, 1-celled, with one erect orthotropous ovule; *stigma* sessile. *Fruit* more or less fleshy, 1-celled, 1-seeded. *Seed* erect; *embryo* in a distinct fleshy sac at the apex of the seed, and on the outside of abundant albumen.

Distribution and Numbers.—Natives exclusively of tropical regions, especially in America and the islands of the Indian Archipelago. *Illustrative Genus:*—Piper, *Linn.* There are above 600 species.

Properties and Uses.—The plants of this order are chiefly remarkable for acrid, pungent, aromatic, and stimulant properties. These qualities are principally found in their fruits, and are essentially due to the presence of an acrid volatile oil and resin. Some are narcotic, and others are reputed to be astringent and febrifugal.

Piper.—The dried leaves of *Piper angustifolium* (*Artanthe elongata*) constitute the official Matico of the British Pharmacopœia. Matico has been recommended as a topical application for arresting hæmorrhage from wounds, &c. It has been also employed internally as a styptic, but its effects thus administered are very feeble. Its action appears to be more especially mechanical, like lint, felt, &c. In Peru Matico is employed for the same affections as Cubebs. It should be noticed that the name Matico is applied by the inhabitants of Quito, &c., to *Eupatorium glutinosum* (see *Eupatorium*). Other plants are also similarly designated in different parts of South America. The dried fruits of *Piper aduncum* and other species are used in America as pepper; and its leaves, as first noticed by the author, are frequently substituted in this country for those of *Piper angustifolium*. The fruits of *P. crocatum* are employed for dyeing yellow. The dried unripe fruits of *Piper Cubeba* (*Cubeba officinalis*) constitute the official Cubebs of the British Pharmacopœia. Cubebs are the produce of Java and the adjoining islands. They are extensively employed in affections of the genito-urinary organs, upon which they are generally supposed to have a specific effect. In the East they are used as a stomachic. Their properties depend principally upon two resins, but also to some extent upon the presence of a volatile oil. This oil is also official in the British Pharmacopœia. They are frequently distinguished by the name of Tail Pepper, from the dried fruits having a short stalk attached to them. The dried unripe fruits of *Piper Clusii*, African Cubebs or Black Pepper of Western Africa, are employed by the negroes of Sierra Leone, &c., as a condiment, and also in medicine. Their effects in genito-urinary affections do not appear to resemble those of the official Cubebs. According to Stenhouse they contain *Piperine*, and not the peculiar alkaloid of Cubebs, which has been termed *Cubebine*.—*P. nigrum*, Black Pepper. The dried unripe fruits of this plant constitute the Black Pepper of the shops, and that which is official in the British Pharmacopœia. White Pepper is the same fruit in a ripened state divested of its external pulpy covering. The former is the more acrid and pungent, as these properties are lost to some extent in the process of ripening. Both kinds are extensively used as condiments, and medicinally as stimulants and correctives. They are also regarded as somewhat febrifugal. They contain an acrid resin and volatile oil, to which their acrid, pungent, aromatic, and stimulant properties are essentially due; and *Piperine* which possesses to some extent febrifugal properties.—*P. methysticum* or *Piper trioicum*, and probably other species, also produce good pepper. The dried unripe spikes of fruit known in commerce as Long Pepper are chiefly imported from Singapore and Calcutta, and are the produce of *Piper officinarum* or *Chavica officinarum*, and *Piper longum* or *Chavica Roxburghii*. Long Pepper contains an acrid resin, a volatile oil, and the crystalline alkaloid called Piperine. It resembles Black Pepper in its effects, and is used in similar cases. It is chiefly employed for culinary purposes. Dried slices of the root are in great repute among the natives of India under the name of *Peepla Mool*, as a stomachic. The leaves of *P. Betle*, Betel Pepper, and *P. Siriboa* are chewed by the Malays and other Eastern races, mixed with slices of the Betel Nut (*Areca Catechu*), and a little lime. Betel as thus prepared is considered to impart an ornamental red hue to the lips and mouth, and an agreeable odour to the breath, and is also supposed to possess stimulant and narcotic properties, and to be a preservative against dysentery. (See *Areca*.)—*P. Jaborandi* is one of the plants yielding a kind of Jaborandi. (See *Pilocarpus*.)

Macropiper methysticum.—The large rhizome of this plant is known in the South Sea Islands under the name of Ava, where it is largely used in the preparation of an intoxicating and narcotic liquor, called Ava or Cava. It is also employed medicinally in chronic rheumatism, erysipelatous eruptions, and venereal affections. It has been lately tried successfully in France as a remedy in gonorrhœa.

Order 2. SAURURACEÆ, the Saururus Order.—Character.—Marshy *herbs*. *Leaves* entire, alternate, stipulate. *Flowers* spiked, achlamydeous, hermaphrodite. *Stamens* 3—6, hypogynous, persistent. *Ovaries* 3—4, usually more or less distinct, and each with a solitary erect ovule, or sometimes united and with a few ascending ovules. *Fruit* either consisting of 4 fleshy indehiscent achænia, or capsular and 3—4-celled. *Seeds* ascending, with a minute embryo in a fleshy sac on the outside of hard mealy albumen. *This order is included by Bentham and Hooker in Piperaceæ, as the tribe Saurureæ.*

Distribution and Numbers.—Natives of North America, Northern India, and China. *Illustrative Genera:*—Saururus, *Linn.*; Houttuynia, *Thunb.* There are about 7 species.

Properties and Uses.—They have acrid properties, and are reputed to be emmenagogue. Some are also astringent.

Anemopsis californica is known in California as 'Yerba Mansa,' and an infusion of its roots and the external application of these in powder are regarded as very valuable remedies in venereal sores. The powder is very astringent and is also used as an application to cuts and sores.

Saururus cernuus, a native of North America, is said to be a valuable remedy in inflammatory affections of the genito-urinary organs, and also externally as a soothing discutient cataplasm.

Order 3. CHLORANTHACEÆ, the Chloranthus Order.—Character.—*Herbs* or *undershrubs* with jointed stems, which are tumid at the nodes. *Leaves* simple, opposite, sheathing, with small interpetiolar stipules. *Flowers* in terminal spikes, achlamydeous, with scaly *bracts*, hermaphrodite or unisexual. *Stamens* 1, or more and united. *Ovary* 1-celled, with a solitary pendulous ovule. *Fruit* drupaceous. *Seed* pendulous, with a minute embryo (not enclosed in a distinct sac) at the apex of fleshy albumen; *radicle* inferior.

Distribution and Numbers.—Natives of tropical regions. *Illustrative Genera:*—Hedyosmum, *Swartz*; Chloranthus, *Swartz*. There are about 15 species.

Properties and Uses.—Aromatic stimulant properties are the principal characteristics of the plants of this order.

Chloranthus.—The roots of *C. officinalis* and *C. brachystachys* have been employed in Java as a stimulant in malignant fevers, and for their antispasmodic effects. The flowers of *C. inconspicuus* are used in China to perfume tea. (See *Thea*.)

Order 4. CERATOPHYLLACEÆ, the Hornwort Order.—Character.—Aquatic *herbs*. *Leaves* verticillate, very finely divided. *Flowers* minute, axillary, sessile, monœcious. *Calyx* or rather *involucre* of bracts, inferior, 8—12-partite. *Male flower* consisting of 12—20 *stamens*; *anthers* sessile, 2-celled. *Female flower* with a superior 1-celled *ovary*, and 1 pendulous orthotropous *ovule*. *Fruit* hard or nut-like, indehiscent. *Seed* exalbuminous, pendulous; *embryo* with a large many-leaved plumule, and a very short inferior radicle.

Distribution and Properties.—Natives of the northern hemisphere. *Ceratophyllum*, Linn., is the only genus. The properties and uses of the species are unknown.

Cohort 8. *Nepenthales.*—Flowers unisexual, diœcious. Calyx 4-partite, imbricate. Stamens monadelphous. Ovary superior, 3—4-celled. Ovules very numerous, attached to the sides of the septa. Fruit a loculicidal capsule. Seeds very minute, albuminous. Climbing plants. Leaves alternate, terminated by pitchers.

Order 1. NEPENTHACEÆ, the Pitcher-plant Order.—Character.—*Herbs* or somewhat *shrubby plants. Leaves* alternate, and when perfect terminated by a pitcher which is provided with an articulated lamina (*fig.* 390). *Flowers* terminal, racemose, unisexual, diœcious. *Calyx* inferior, with 4 divisions. *Stamens* usually 16, united into a column; *anthers* 2-celled, extrorse. *Ovary* superior, 4-angled, 4-celled. *Fruit* a capsule, 4-celled, with loculicidal dehiscence. *Seeds* very minute, numerous, albuminous; *embyro* with an inferior radicle.

Distribution, Numbers, and Properties.—Natives of swampy ground in China and the East Indies. *Nepenthes*, Linn., is the only genus; it includes about 14 species. Their properties are unknown; but they are remarkable from their pitchers entrapping and digesting insects and other animal matters, from the formation of a digestive ferment by their glands.

Series 2. Inferæ or Epigynæ.

Cohort 1. *Asarales.*—Flowers hermaphrodite or unisexual. Calyx usually coloured. Stamens epigynous in the hermaphrodite flowers. Ovary inferior, 1—many-celled. Ovules numerous. Fruit baccate or capsular. Seeds usually albuminous; embryo minute, and sometimes amorphous.

Order 1. ARISTOLOCHIACEÆ, the Birthwort Order.—Character.—*Herbs* or climbing *shrubs. Leaves* alternate. *Flowers* axillary, hermaphrodite (*fig.* 1045), dull-coloured, regular or irregular. *Calyx* tubular, superior (*fig.* 1045), with a valvate æstivation. *Stamens* 6—12, arising from the top of the ovary, and more or less attached to the style (*fig.* 1046); *anthers* adnate, extrorse. *Ovary* inferior (*fig.* 1045), 3—6-celled with numerous ovules; *style* simple; *stigmas* radiating (*fig.* 1046), and corresponding in number to the cells of the ovary. *Fruit* capsular or succulent, 3—6-celled. *Seeds* numerous, albuminous (*fig.* 1047); *embryo* very minute (*fig.* 1047).

Distribution and Numbers.—Sparingly distributed in several parts of the world, but most common in tropical South America. *Illustrative Genera*:—Asarum, *Tourn.*; Aristolochia, *Tourn.* There are about 130 species.

Properties and Uses.—These plants contain a bitter principle and a volatile oil, and generally possess tonic, stimulant, and acrid properties. Many of the species are regarded in various parts of the world as useful in curing the effects of snake-bites.

Aristolochia, Birthwort.—Several species have been employed for centuries in medicine, principally on account of their supposed emmenagogue properties, and hence the name of Birthwort which is applied to the genus. The roots of *A. longa*, *A. rotunda*, *A. Clematitis*, and others, have been thus used. They all possess stimulant and tonic properties. The powdered root of *A. longa* was an ingredient in the once celebrated *Duke of Portland's powder for gout*. Several of the species have been reputed specifics for snake-bites, but without any satisfactory proof.—*A. anguicida* is supposed by Lindley to be the celebrated Guaco of the Columbians. The juice of its root, as well as that of many other species, is said so to stupefy snakes that they may be handled and played with.—*A. Serpentaria*, Virginian Snake-root. The dried rhizome and rootlets are official, together with the similar parts of *A. reticulata*, in the British Pharmacopœia, under the name of Serpentary Rhizome. Serpentary rhizome was originally introduced into this country and elsewhere as an antidote to snake-bites, but it has no efficacy in such cases. It is, however, a valuable stimulant, tonic, and diaphoretic, and is especially useful in fevers of a low or typhoid character. The allied species, *A. reticulata*, is a native of the Western United States, and is also now official, as already stated, in the British Pharmacopœia. It yields *Texan* or *Red River Snake-root*, which has similar properties to the ordinary Virginian Snake-root. —*A. indica* is in high repute in India as a stimulant, tonic, and emmenagogue.—*A. bracteata* is regarded in India as an anthelmintic.—*A. recurvilabra* is the source of the drug which is highly esteemed by the Chinese, and known as 'Green Putchuk.' It is reputed to be a powerful purgative, emetic, and anthelmintic. It is principally employed as an antidote against snake-bites, and likewise as a remedy for burns and indigestion. It is also largely used for the purpose of making incense sticks.

Fig. 1045. Fig. 1046.

Fig. 1047.

Fig. 1045. Vertical section of the flower of the common Birthwort (*Aristolochia Clematitis*).——*Fig.* 1046. The gynœcium and andrœcium of the same. ——*Fig.* 1047. Transverse section of the seed.

Asarum.—*A. europæum*, Asarabacca, possesses acrid properties. It has been employed in medicine as an emetic, and as an errhine in headache and ophthalmia. Its powder is supposed to constitute the chief ingredient in *cephalic snuff*.—*A. canadense*, Canada Snake-root or Wild Ginger, has aromatic properties. The rhizome is used in the United States as a tonic, diaphoretic, and aromatic stimulant.

Bragantia.—The juice of the leaves of *B. Wallichii* is regarded as an antidote in snake-bites, but more especially of those of the cobra.—*B. tomentosa* is used by the Japanese as an emmenagogue.

Order 2. Cytinaceæ, the Cistus-rape Order.—Character.—Root-parasites destitute of chlorophyll, and with a fungoid texture. *Flowers* hermaphrodite or unisexual, and either solitary and sessile, or clustered at the end of a scaly stem. *Calyx* tubular at the base, 3—6-partite. *Anthers* sessile, opening longitudinally. *Ovary* 1-celled, inferior; *ovules* very numerous; *placentas* parietal. *Fruit* 1-celled, with numerous seeds imbedded in pulp. *Seeds* with or without albumen; *embryo* minute, amorphous or dicotyledonous. *This and the next order are frequently combined together in one order, Cytinaceæ.*

Distribution and Numbers.—Parasitic on the roots of *Cistus*, and upon fleshy Euphorbiaceæ and other succulent plants. They occur in the South of Europe and Africa. *Illustrative Genera:*—Cytinus, *Linn.*; Hydnora, *Thunb.* There are about 7 species.

Properties and Uses.—Some have astringent properties, as *Cytinus Hypocistus.* A kind of extract is made from this plant in the South of Europe, and used, under the name of *Succus Hypocistidis*, in diarrhœa, and for arresting hæmorrhage.—*Hydnora africana* has a putrid-animal odour, but when roasted it is eaten by the native Africans at the Cape of Good Hope.

Order 3. RAFFLESIACEÆ, the Rafflesia Order.—Character.—*Root-parasites*, devoid of chlorophyll, without evident stems or leaves, and with a fungoid texture. These plants consist essentially of flowers (*fig.* 258) sessile upon the branches of trees, and surrounded by scaly bracts. The *flowers* are hermaphrodite, or unisexual and diœcious. *Calyx* 5-partite (*fig.* 258), tubular; the throat surrounded by a number of thickened scaly processes, which are either distinct from each other or united into a ring. *Anthers* placed upon a column which adheres to the calyx, 2-celled; and either distinct, and each opening by a pore, or united into a many-celled body, and opening by a common pore. *Ovary* 1-celled, inferior; *ovules* very numerous; *placentas* parietal. *Fruit* indehiscent. *Seeds* very numerous, with or without albumen; *embryo* amorphous or dicotyledonous. *This order, as mentioned above, is sometimes included in Cytinaceæ.*

Distribution and Numbers.—Parasitic upon the stems of *Cissi* in the East Indies, and on Leguminous plants in South America. *Illustrative Genera:*—Rafflesia, *R. Br.*; Brugmansia, *Blum.* There are about 16 species.

Properties and Uses.—Some have styptic and astringent properties. They are chiefly remarkable for their flowers, some of which are of gigantic size. (See page 132).

Cohort 2. *Quernales.*—Flowers unisexual; male clustered or in catkins; female solitary, clustered, or in catkins. Calyx green, in the male flowers reduced to a scale, or lobed; in the female flowers 2—6-lobed or toothed. Ovary inferior, 1—6-celled. Ovule 1, erect, or 1 or more, pendulous. Fruit usually 1-seeded. Seeds exalbuminous. Trees or shrubs. Leaves simple or pinnate, alternate.

Order 1. JUGLANDACEÆ, the Walnut Order.—*Trees. Leaves* alternate, pinnate, exstipulate. *Flowers* unisexual (*fig.* 1048). *Male flowers* in amenta (*fig.* 1048); with an irregular calyx, or a simple scale. *Female flowers* solitary, or in small terminal clusters, or amenta, without a cupule; *calyx* superior, regular, 3—5-lobed; *ovary* inferior, 2—4-celled at the base, 1-celled above; *ovule* solitary, erect, orthotropous. *Fruit* called a tryma (page 318). *Seed* (*fig.* 1049) 2—4-lobed, exalbuminous; *embryo* with sinuous oily cotyledons, and a short superior radicle.

Distribution and Numbers.—Chiefly natives of North America, but a few are found in the East Indies, Persia, and the Caucasus. *Juglans regia*, the Walnut tree, is a native of

FIG. 1048.

FIG. 1049.

Fig. 1048. Staminate amentum of the Walnut tree (*Juglans regia*): the flowers are separated by scaly bracts.——*Fig.* 1049. Seed of the Walnut tree.

the countries between Greece and Cashmere. *Illustrative Genera*:—Juglans, *Linn.*; Carya, *Nutt.* There are about 30 species.

Properties and Uses.—Chiefly important for their valuable timber, and for their oily edible seeds.

Carya.—*Carya alba* is the common Hickory, valuable for its timber, and for its edible seeds, which are known as *Hickory Nuts.*—*C. olivæformis* yields an olive-shaped or somewhat elliptical seed resembling the Walnut and Hickory in flavour, which is known as the *Peccan Nut.* These nuts have the finest flavour of any species of this genus; they also yield a fixed oil by pressure, which is palatable. Both Hickory and Peccan nuts are occasionally imported into this country.—*C. porcina* yields an edible seed which is termed the *Pig* or *Hog Nut.* It is consumed by pigs, squirrels, &c. Its wood is regarded as superior to that of either of the other species of *Carya.*

Juglans.—*J. regia*, the Walnut, is valuable for its hard rich deep brown beautifully marked wood. This is much employed in ornamental furniture work, and for gun stocks. The unripe fruit is also used for pickling. The seed of this plant is our well-known edible Walnut. This yields by expression a useful fixed oil of a drying nature like Linseed oil. It may be employed for burning in lamps and in cookery. The pericarp has had a reputation as a vermifuge from the time of Hippocrates. The bark possesses cathartic properties.—*J. nigra*, the Black Walnut, a native of North America, is also esteemed for its timber.—*J. cinerea*, the White Walnut or Butter-nut, is another useful timber tree. The inner bark of its root, which is official in the United States Pharmacopœia under the name of *Butter-nut*, is employed as a mild purgative. When applied to the skin it also acts as a rubefacient. The substance termed *juglandin* is obtained from this bark; it is regarded as a useful remedy in habitual constipation. The unripe fruit is used for pickling; and the ripe seed is edible like our common walnut.

Order 2. CORYLACEÆ or CUPULIFERÆ, the Oak Order.—Character.—*Trees* or *shrubs*. *Leaves* (*fig.* 205) alternate, usually feather-veined (*figs.* 312 and 313), simple, with deciduous stipules. *Flowers* monœcious. *Male flowers* clustered or in amenta (*fig.* 397), and with or without bracts; *stamens* 5—20 (*fig.* 1050), inserted into the base of a membranous calyx, or of scales or bracts. *Female flowers* solitary or amentaceous, and surrounded by an involucre of bracts (*fig.* 1051), which ultimately form a cupule (*figs.* 400 and 401) round the ovary and fruit; *ovary* inferior, surmounted by a rudimentary calyx, 3- (*fig.* 1052) or more celled; *ovules* 2 in each cell or solitary, pendulous or

FIG. 1050.

FIG. 1051.

FIG. 1052.

Fig. 1050. Male flower of a species of Oak (*Quercus*).——*Fig.* 1051. Female flower of the same.——*Fig.* 1052. Transverse section of the female flower.

peltate; *stigmas* almost sessile. *Fruit* a glans or nut (*figs.* 400 and 401), 1-celled by abortion, more or less enclosed by the cupule. *Seeds* large, 1 or 2, exalbuminous; *cotyledons* thick, fleshy or farinaceous; *radicle* superior.

Bentham and Hooker include the order Betulaceæ in the Cupuliferæ (see page 668), and divide the order as thus constituted into three tribes as follows:—Tribe 1. Betuleæ. Tribe 2. Coryleæ. Tribe 3. Quercineæ.

The Betuleæ are at once distinguished by their superior ovary, and the absence of a cupule from the two latter; and the Coryleæ from the Quercineæ by the male flowers being achlamydeous, and having one ovule in each cell of the ovary; the latter having a 3—7- lobed ovary, and 2 ovules in each cell.

Some authors, again, divide this order into two orders—Corylaceæ and Cupuliferæ.

Distribution and Numbers.—They abound in the forests of temperate regions. A few occur in the high lands of tropical and hot climates. *Illustrative Genera:*—Carpinus, *Tourn.*; Corylus, *Tourn.*; Quercus, *Tourn.* There are nearly 300 species.

Properties and Uses.—Most important on account of their valuable timber. Many yield edible seeds, and some have highly astringent barks and cupules.

Carpinus.—*C. Betulus*, the Hornbeam, and *C. americanus*, are well known for their timber, which is principally employed for making agricultural implements, and for the cogs of mill wheels.

Castanea.—*C. vulgaris* (*vesca*) is the Spanish Chestnut, which is much cultivated for its timber, and for its edible fruits or nuts. These nuts are principally imported from Spain, where they are largely employed as an article of food by the agricultural classes.—*C. americana*, a native of the United States, also yields a much smaller, but very sweet, kind of Chestnut, which has been occasionally imported.

Corylus Avellana, the common Hazel, is the origin of the most anciently used and most extensively consumed of all our edible nuts. There are several varieties of the Hazel, as the White, Red, and Jerusalem Filberts; the Great and Clustered Cobs; the Red Smyrna, the Black Spanish, the Barcelona Nuts, &c. The importation of these alone into this country is, on an average, 150,000 bushels a year. The oil which is obtained from them by expression is occasionally employed by artists and watchmakers. Good charcoal is also obtained from the branches of the Hazel.

Fagus.—*F. sylvatica*, the Common Beech, is well known for its timber. The fruits (Beech-mast) form a food for pigs. The fruit of *F. ferruginea* is eaten in North America. The seeds of some species yield by expression a fixed oil.

Ostrya vulgaris (*virginica*) possesses a very hard wood, which in America has been called in consequence Iron-wood. It is also termed Lever-wood from its being used for making levers.

Quercus.—The timber of several species of this genus is employed for ship-building, and other important purposes; namely, that of the *Q. Robur*, the common British Oak, of which there are two varieties, which by some are regarded as distinct species, and called *Q. pedunculata* and *Q. sessiliflora*; that of the *Q. Cerris*, Turkey or Adriatic Oak; of the *Q. alba*, White Oak; the *Q. rubra*, Red Oak; the Black Oak (*Q. tinctoria*); the *Q. Ilex*; and the Live Oak (*Q. virens*), and others. Many Japanese species also yield valuable timber. The bark of several species is astringent, and largely employed in tanning, &c.; that of *Quercus Robur* var. *pedunculata* is most esteemed. The dried bark of the smaller branches and young stems of this plant is official in the British Pharmacopœia, and is employed in medicine as an astringent and tonic. The fruits (*acorns*) of this and the other species or varieties which are natives of this country have been also generally recommended as food for cattle, but recent experience would seem to show that they possess injurious properties. The outer bark of *Quercus Suber*, the Cork Oak, constitutes the cork of commerce. The bark obtained from the younger branches of the same tree is also imported into this country from Spain. It is commonly known as European Alcornoque Bark, and is used for tanning purposes. (See *Bowdichia.*) The inner bark of older stems is also imported as *cork-tree bark*, and similarly employed.—*Quercus Ægylops.* The acorn-cups (*cupules*) of this species are imported from the Levant under the name of *Valonia*; the dried half-matured acorns of the same plant are also imported under the name of *Camata*; and the very young ones as *Camatina*. These three articles are valuable for their tanning properties.—*Quercus tinctoria*, the Black Oak, has already been noticed as a valuable timber tree. Its bark is called Quercitron Bark; it is used for tanning, and in this country its inner portion is also employed for dyeing yellow. The bark of *Quercus alba* is official in the United States Pharmacopœia, where it is employed for its astringent, febrifugal, and tonic properties. The bark of *Q. aquatica*, a North American species, and that of *Q.*

Ilex, a South European species, is also employed by tanners.—*Quercus sinensis*, a native of China, yields a dye.—*Quercus coccifera*, the Kermes Oak, has its young branches attacked by a species of *Coccus*, by which little reddish balls are formed upon their surface, which were formerly much used as a crimson dye. The young branches of Oak trees are especially liable to be punctured by insects, by which the morbid excrescences commonly called *galls* are produced. The more important of these excrescences form the *Nut Galls* of commerce; they are produced on the branches of *Quercus lusitanica*, var. *infectoria* by the *Cynips Gallæ tinctoriæ*. They are alone official in the British Pharmaeopœia; and are also extensively employed in tanning, for the preparation of the official tannic and gallic acids, for making ink, and for other purposes in the arts. They likewise possess tonic, astringent, and antiperiodic properties. Pereira also regarded them as a valuable antidote in poisoning by tartar emetic. The best Nut Galls come from the Levant. Two kinds are commonly distinguished under the names of *blue* and *white* galls. The dark-coloured galls, which are imperforate, are the most valuable. The round smooth galls, now frequently found on the lower branches of the Oaks in this country, although containing tannic acid, are far less valuable than commercial nut-galls. These are formed by the *Cynips Kollari* of Giraud. The large Galls known as *Mecca* or *Bussorah Galls*, *Dead Sea Apples*, and *Apples of Sodom*, are said to be produced on *Q. lusitanica* by *Cynips insana* The acorns of some species of *Quercus*, as *Q. Ballota*, *Q. Gramuntia*, *Q. Æsculus*, and *Q. Hindsii*, are edible; also those of *Q. cornea* in China, and of *Q. cuspidata* in Japan.

Cohort 3. *Santalales.*—Flowers hermaphrodite or unisexual. Calyx usually conspicuous, coloured, valvate in æstivation. Stamens equal in number to, and opposite the lobes of, the calyx. Ovary inferior, mostly 1-celled; ovules 1 or more, devoid of integuments. Fruit usually baccate or drupaceous. Seed solitary, albuminous. Usually parasitic herbs or shrubs. Leaves, when present, entire.

Order 1. LORANTHACEÆ, the Mistletoe Order.—Character.—*Parasitic shrubs.* *Leaves* greenish, commonly opposite, exstipulate. *Flowers* hermaphrodite, or unisexual and diœcious. *Calyx* superior, with 4—8 divisions; *æstivation* valvate; sometimes absent. *Stamens* equal in number to, and opposite the lobes of, the calyx. *Ovary* inferior, 1-celled, with 3 ovules, suspended from a free-central placenta, or 1 erect and arising from the base of the ovary. *Fruit* commonly succulent, 1-celled, with a solitary seed; *embryo* in fleshy albumen, with the radicle remote from the hilum.

Distribution and Numbers.—They are principally found in the hotter parts of America and Asia. Three species are natives of Europe, and a few occur in Africa and some other regions. *Illustrative Genera:* — Myzodendron, *Sol.*; Viscum, *Tourn.*; Loranthus, *Linn.* There are above 400 species.

Properties and Uses.—Unimportant. Some are astringent.

Loranthus tetrandus, a native of Chili, produces a black dye.

Viscum album is the common Mistletoe. It is parasitic on many trees in this country, as Willows, Thorns, Limes, Elms, Oaks, Firs, and especially the Apple tree. The Mistletoe of the Oak, which is very rare, was an object of superstitious veneration by the Druids. The fruit has a viscid pulp, which is sometimes employed for making bird-lime. It is said that the fruits when eaten produce severe poisoning symptoms, the effects resembling those of alcoholic intoxication. Its bark has astringent properties. The plant is now out of use as a medicinal agent, but was formerly in great repute as an antispasmodic. The leaves of *V. monoicum*, a plant which is parasitic on *Strychnos Nux-vomica*, were found in India to possess similar poisonous properties to that plant, from growing upon it, and to be useful in like cases to it in medicine.

Order 2. SANTALACEÆ, the Sandal-wood Order. —Character.—*Herbs*, *shrubs*, or *trees*. *Leaves* entire, alternate. *Flowers* usually hermaphrodite. *Calyx* superior, 4—5-cleft, valvate in æstivation. *Stamens* perigynous, equal in number to, and opposite the segments of, the calyx. *Ovary* 1-celled, inferior; *ovules* 1—4, usually suspended; *placenta* free-central. *Fruit* indehiscent, 1-seeded. *Seed* with a quantity of fleshy albumen; *embryo* straight, minute; *radicle* superior.

Distribution and Numbers.—Natives of various parts of the world. The species found in North America and Europe are inconspicuous herbs; those of India, Australia, &c., are trees or shrubs. The genus *Thesium* is partially parasitic on the roots of other plants. *Illustrative Genera*:—Thesium, *Linn.*; Santalum, *Linn.* There are about 120 species.

Properties and Uses.—Some of these plants, as *Thesium*, are slightly astringent; others have a fragrant wood; and a few produce edible fruits and oily seeds.

Fusanus acuminatus (*Santalum cygnorum*) is the Quandang Nut of Australia. The fruit is edible, and resembles Almonds in flavour. This tree also yields a kind of Sandal-wood. (See *Santalum.*)

Santalum.—*S. album* is a native of India. The wood called Sandal-wood is remarkable for its fragrance. It is sometimes used as a perfume; but its chief consumption is for incense in the Chinese temples, and in India in the celebration of sepulchral rites, where pieces of Sandal-wood are placed by the wealthy in the funereal pile. The wood is also much used by cabinet makers for caskets and other purposes. In India and other parts of the East it is also employed medicinally as a sedative and for its refrigerant properties. By distillation it yields a fragrant volatile oil, which is esteemed as a perfume, and also medicinally as a remedy for gonorrhœa, gleet, &c. It is official in the British Pharmacopœia.—*S. Freycinetianum* and *S. pyrularium* produce the Sandal-wood of the Sandwich Islands; *S. Yasi*, a kind of Sandal-wood from the Fiji Islands; *S. austro-caledonicum*, that from New Caledonia; and *S. cygnorum* (*Fusanus acuminatus*) and *S. spicatum*, that from Western Australia. (See *Fusanus.*)

Order 3. BALANOPHORACEÆ, the Balanophora Order.—Character.—Leafless root-parasites with amorphous fungoid stems of various colours, but never green; and underground more or less fleshy tubers or rhizomes. *Peduncles* naked or scaly, bearing spikes of flowers, which are commonly unisexual, bracteated, and of a white colour. *Male flowers* very evident, each with a tubular *calyx*, which is either entire or 3—5-lobed.

Stamens usually 3—5, or sometimes 1, in the former case more or less united or distinct. *Female flowers* very minute, with a tubular superior *calyx*, the limb either wanting or present and bilabiate. *Ovary* inferior, usually 1-celled; *styles* 2; *ovule* solitary, pendulous. *Fruit* small, more or less compressed, indehiscent. *Seed* solitary, albuminous, with a lateral undivided or amorphous *embryo*.

Distribution and Numbers.—These plants are parasitical on the roots of various Dicotyledonous plants, especially in the tropical and sub-tropical mountains of Asia and South America. Other species are found in different parts of Africa, Australia, &c. *Illustrative Genera*:—Cynomorium, *Michel*; Balanophora, *Forst.* There are, according to Sir Joseph Hooker, 37 species.

Properties and Uses.—Many are remarkable for their astringent properties; others are edible, as *Ombrophytum*, a native of Peru, and *Lophophytum* of Bolivia; and some secrete a kind of wax.

Balanophora.—In the mountainous districts of Java the natives make candles from a species of *Balanophora*, as follows:—The parasite is heated in an iron pan, after which bamboo sticks covered with cotton are dipped into the melted mass, when the waxy substance of the plant adheres to them. This so-called wax is, according to Dr. de Vrij, a mixture of at least two resins and a vegetable fat.

Cynomorium coccineum is the *Fungus melitensis* of pharmacologists. It has had a great reputation as a styptic.

Langsdorffia hypogæa.—This species yields so large a quantity of wax, that candles are made of it in New Granada. The stems are also said to be collected near Bogota, 'and sold under the name of *Siejos*, and used as candles on saints' days.'

Artificial Analysis of the Orders in the Sub-class MONOCHLAMYDEÆ OR INCOMPLETÆ.

(*Modified from Lindley.*)

1. Achlamydeous Flowers.

A. Leaves stipulate.

a. Flowers unisexual.

Ovary 1-celled.
  Ovules numerous . . . . . *Salicaceæ.*
  Ovules 1—2.
    Ovule erect . . . . *Myricaceæ.*
    Ovule pendulous . . . . *Platanaceæ.*
Ovary 2- or more celled.
  Seeds few, not winged . . . . *Euphorbiaceæ.*

b. Flowers hermaphrodite.

Carpel solitary.
  Ovule erect. Embryo in a vitellus . . . . *Piperaceæ.*
  Ovule suspended. Embryo naked . . . . *Chloranthaceæ.*
Carpels several.
  Ovule erect. Embryo in a vitellus . . . . *Saururaceæ.*

B. Leaves exstipulate.

a. Flowers unisexual.

Ovules very numerous . . . . . . *Podostemaceæ*

Ovules solitary, or very few.

Flowers naked.

Ovary 1-celled . . . . . . *Myricaceæ.*

Flowers in an involucre.

Anther-valves recurved . . . . *Atherospermaceæ.*

Anther-valves slit.

Embryo on the outside of the albumen . *Monimiaceæ.*

Embryo enclosed in the albumen . . *Euphorbiaceæ.*

b. Flowers hermaphrodite.

Embryo in a vitellus . . . . . . *Piperaceæ.*

Embryo without a vitellus . . . . . *Podostemaceæ.*

2. Monochlamydeous Flowers.

A. Ovary inferior, or partially so.

a. Leaves stipulate.

1. Flowers hermaphrodite . . . . . *Aristolochiaceæ.*

2. Flowers unisexual . . . . . . *Corylaceæ.*

b. Leaves exstipulate.

1. Flowers hermaphrodite.

Ovary 3—6 celled. Ovules numerous . . *Aristolochiaceæ.*

Ovary 1-celled. Ovules definite.

Ovules with a naked nucleus. Leaves opposite . *Loranthaceæ.*

Ovules with a naked nucleus. Leaves alternate . . . . *Santalaceæ.*

Ovules with a coated nucleus . . . . *Chenopodiaceæ.*

2. Flowers unisexual.

Amentaceous . . . . *Juglandaceæ.*

B. Ovary superior.

a. Leaves stipulate.

1. Flowers hermaphrodite.

a. Carpel solitary.

Stipules ochreate . . . . . . *Polygonaceæ.*

Stipules distinct . . . . . . *Petiveriaceæ.*

b. Carpels more than one, combined.

Seeds exalbuminous.

Calyx imbricate . . . . . . *Ulmaceæ.*

Seeds albuminous.

Styles or stigmas 2. Leaves not dotted . *Ulmaceæ.*

2. Flowers unisexual.

a. Carpel solitary.

Cells of anther perpendicular to the filament . *Stilaginaceæ.*

Cells of anther parallel to the filament.

Embryo straight.

Sap watery. Stipules small. Seeds albuminous . . . . . . *Urticaceæ.*

Sap milky. Stipules large. Seeds exalbuminous . . . . . . *Artocarpaceæ.*

Embryo hooked.
Sap watery. Seeds without albumen . *Cannabinaceæ.*
Sap milky. Seeds with albumen . . *Moraceæ.*

b. Carpels more than one, combined.
Flowers amentaceous.
Seeds arillate.
Stamen 1 . . . . *Lacistemaceæ.*
Stamens more than 1 . . . . *Scepaceæ.*
Seeds not arillate . . . . . *Betulaceæ.*
Flowers not amentaceous . . . . *Euphorbiaceæ.*

b. Leaves exstipulate.

1. Flowers hermaphrodite.

a. Carpel solitary.
Anther-valves recurved . . . . . *Lauraceæ.*
Anthers slit.
Leaves covered with scales . . . . *Elæagnaceæ.*
Leaves not scaly.
Calyx long or tubular.
Hardened at base . . . . . *Nyctaginaceæ.*
Not hardened in any part.
Stamens in the points of the sepals . *Proteaceæ.*
Stamens not in the points of the sepals . . . . *Thymelaceæ.*
Calyx short, not tubular, or but slightly so.
Flowers in involucels . . . . *Polygonaceæ.*
Flowers not in involucels.
Calyx dry and coloured . . . *Amarantaceæ.*
Calyx herbaceous or succulent.
Stamens hypogynous or nearly so . *Chenopodiaceæ.*
Stamens perigynous . . . *Basellaceæ.*

b. Carpels more than one, either distinct or combined.
Carpels distinct . . . . *Phytolaccaceæ.*
Carpels combined.
Seeds exalbuminous.
Calyx tubular.
Ovary 2-celled . . . . . *Aquilariaceæ.*
Ovary 4-celled . . . . . *Penæaceæ.*
Calyx tubular, or imperfect . . . *Podostemaceæ.*
Seeds albuminous . . . . . *Phytolaccaceæ.*

2. Flowers unisexual.

a. Carpels solitary, or quite distinct.
Calyx tubular.
Anthers opening by recurved valves . . *Atherospermaceæ.*
Anthers opening longitudinally . . . *Myristicaceæ.*
Calyx not tubular.
Seeds exalbuminous. Embryo straight.
Leaves verticillate . . . . *Ceratophyllaceæ.*
No evident leaves . . . . . *Casuarinaceæ.*
Seeds albuminous.
Embryo curled round the albumen . *Chenopodiaceæ.*
Embryo straight. . . . . *Monimiaceæ.*

b. Carpels more than one, combined.
Ovules indefinite.
Leaves with pitchers . . . . . *Nepenthaceæ.*

Ovules definite.
Fruit fleshy. Seeds ascending . . . *Empetraceæ.*
Fruit dry. Seeds suspended . . . *Euphorbiaceæ.*

Root Parasites of Fungoid Texture (Rhizogens of Lindley).

A. Ovary inferior. Ovules solitary . . . . *Balanophoraceæ.*

B. Ovary superior. Ovules indefinite.
Anthers opening longitudinally . . . . *Cytinaceæ.*
Anthers opening by pores . . . . . *Rafflesiaceæ.*

Monochlamydeous or Achlamydeous flowers also occasionally, or in some orders always, occur, as already noticed, in plants belonging to the following orders of the Sub-classes Polypetalæ and Gamopetalæ :—

Sub-class 1. Polypetalæ :—

Series 1. Thalamifloræ :—*Ranunculaceæ, Menispermaceæ, Papaveraceæ, Flacourtiaceæ, Caryophyllaceæ, Scleranthaceæ, Paronychiaceæ, Sterculiaceæ, Byttneriaceæ, Tiliaceæ.*

Series 2. Disciform :—*Malpighiaceæ, Rutaceæ, Chailletiaceæ, Xanthoxylaceæ, Geraniaceæ, Celastraceæ, Rhamnaceæ,* and *Anacardiaceæ.*

Series 3. Calycifloræ :—*Leguminosæ, Rosaceæ, Lythraceæ, Saxifragaceæ, Cunoniaceæ, Begoniaceæ, Datiscaceæ, Mesembryaceæ, Passifloraceæ, Myrtaceæ, Onagraceæ, Samydaceæ, Haloragaceæ, Combretaceæ, Hamamelidaceæ,* and *Araliaceæ.*

Sub-class 2. Gamopetalæ :—*Oleaceæ* and *Primulaceæ.*

Class II. Monocotyledones.

In the class Monocotyledones, as in the sub-class Monochlamydeæ, we follow in all essential particulars the arrangement of the Orders and characters of the Cohorts as given by Sir Joseph Hooker in the English edition of Le Maout and Decaisne's 'Traité Général de Botanique,' instead of that adopted by Bentham and Hooker in 'Genera Plantarum,' where the following Series are given instead of Cohorts :—1. Microspermæ. 2. Epigynæ. 3. Coronarieæ. 4. Calycinæ. 5. Nudifloræ. 6. Apocarpæ. 7. Glumaceæ. The characters of these Series are given in detail, and lists of the Orders grouped under them respectively, in 'Genera Plantarum.'

Sub-class I. *Petaloideæ.*

Series 1. Inferæ or Epigynæ.

Cohort 1. *Hydrales.*—Flowers regular, usually unisexual. Inner whorl of perianth petaloid. Ovary 1—6-celled; placentation parietal. Stamens 3 or more. Fruit baccate. Seeds numerous; embryo distinct; exalbuminous. Aquatic herbs.

Order 1. HYDROCHARIDACEÆ, the Hydrocharis or Frog-bit Order.—Character.—Aquatic plants. *Flowers* spathaceous, regular, unisexual or polygamous. *Perianth* superior, in 1 or 2 whorls, each composed of 3 pieces, the inner petaloid. *Stamens* few or numerous. *Ovary* inferior, usually 1—6-celled; placentation parietal. *Fruit* indehiscent. *Seeds* numerous, exalbuminous.

Distribution, Numbers, and Properties.—Inhabitants of fresh water in Europe, North America, East Indies, and New Holland. *Illustrative Genera:*—Anacharis, *Rich.*; Vallisneria, *Mich.* There are about 25 species. Their properties are unimportant.

Cohort 2. *Amomales.*—Flowers usually hermaphrodite and very irregular (regular in Bromeliaceæ). Perianth inferior, except in some Bromeliaceæ. Stamens 6, 1 or 5 with anthers, the rest petaloid, or all antheriferous in Bromeliaceæ. Ovary usually 3-celled, with axile placentation. Fruit baccate or capsular. Seeds with farinaceous albumen; embryo distinct. Leaves usually large and pinnately-veined.

Order 1. ZINGIBERACEÆ or SCITAMINACEÆ, the Ginger Order.—Character.—Aromatic *herbs*, with creeping rhizomes, and broad simple, stalked, sheathing leaves, with parallel curved veins springing from the midrib. *Flowers* arranged in a spiked or racemose manner, and arising from among spathaceous membranous bracts. *Perianth* superior, irregular, each whorl consisting of 3 pieces. *Stamens* 6, in 2 whorls, all abortive except the posterior one of the inner whorl; *anther* 2-celled; *filament* not petaloid. *Ovary* inferior, 3-celled; *placentas* axile; *style* filiform. *Fruit* 1—3-celled, capsular or baccate. *Seeds* numerous, albuminous; *embryo* enclosed in a vitellus.

By Bentham and Hooker the two succeeding orders, Marantaceæ and Musaceæ, are included in Zingiberaceæ.

Distribution and Numbers.—Chiefly natives of tropical regions. *Illustrative Genera:*—Zingiber, *Gärtn.*; Curcuma, *Linn.*; Elettaria, *Rheed.* There are about 250 species.

Properties and Uses.—They are principally remarkable for the stimulant aromatic properties possessed by their rhizomes and seeds, owing to the presence of resins and volatile oils; hence several are used as condiments, and in medicine as aromatic stimulants and stomachics. Some contain starch in large quantities, which when extracted is employed for food.

Alpinia.—The rhizome known as the *greater* or *Java Galangal root* is derived from *A. Galanga*, Willd., a native of Java. The *lesser* or *Chinese Galangal* has been traced by Hance to a new species, which he has termed *A. officinarum.* The lesser Galangal is now the only kind known in European commerce. It is not used in this country; but principally in Russia, where it is employed for flavouring the liqueur called *nastoika*, and vinegar;

and also as a cattle medicine, a spice, and as a popular medicine. The Tartars use it to prepare a kind of tea.—The source of the *light Galangal* of Guibourt is altogether unknown. The Galangals have similar properties to Ginger. The *ovoid China Cardamom* is the fruit of *A. alba*; its seeds are used as a condiment in China.

Amomum.—Several species of this genus have aromatic and stimulant seeds, which are used as spices and medicinal agents in various parts of the world. The only species which is employed in this country is the *A. melegueta*, which yields the *Grains of Paradise* of the shops. It is a native of the Western Coast of Africa. These seeds are much employed in Africa as a spice. The common notion that they are very injurious is erroneous. They are principally employed in this country in veterinary medicine, and for giving pungency to beer, wine, spirits, and vinegar.—*A. Cardamomum* yields the fruit known as the *round Cardamom*. The fruits of *A. maximum* constitute Java Cardamoms; those of *A. Korarima* Korarima Cardamoms; and those of *A. globosum* the *large round* and the *small round* China Cardamoms. The latter are much employed in China. Many other species have similar properties.

Curcuma.—*C. longa.*—The dried tubers or rhizomes of this plant constitute the turmeric of the shops. They are official in the British Pharmacopœia as a test. Turmeric is used as a condiment, as a test, and for dyeing yellow. It is largely employed in India, China, and other parts of the East. It forms an ingredient in curry powder, &c. Unsized white paper steeped in tincture of Turmeric, when dried, is employed as a test to detect free alkalies, which change its colour from yellow to reddish-brown.—*C. angustifolia*: the rhizomes contain a large quantity of starch, which, when extracted, forms East Indian Arrowroot or Curcuma Starch. This kind of arrowroot may be also obtained from other species of *Curcuma*, as *C. leucorrhiza*, *C. rubescens*, &c. In its effects and uses it resembles West Indian Arrowroot or Maranta Starch (see *Maranta*); but it is not so pure a starch. —*C. aromatica* yields the Round Zedoary of pharmacologists.—*C. Zedoaria* is supposed to yield the so-called Cassumunar roots, the Long Zedoary, and the Zerumbet roots of commerce; they all possess aromatic and tonic properties. But Professor Archer believes that Zerumbet and Cassumunar are derived from *C. Zerumbet*. (See *Zingiber*.)

Elettaria.—*E. Cardamomum* yields the capsular fruits which constitute the small or Malabar Cardamoms, the seeds of which are official in the British Pharmacopœia, and are in common use in medicine in this country on account of their cordial and stimulating properties, and also as flavouring agents. In the East Indies they are extensively used as a condiment and for chewing with betel. In parts of the Continent, as Russia, Germany, &c., they are also much employed for flavouring, and in the preparation of liqueurs, &c.—*E. major* yields Ceylon Cardamoms, which are much used on the Continent; their uses and effects are similar, but they are of less value than the former.

Zingiber.—*Z. officinale*, the Ginger Plant.—The so-called Ginger-root or Ginger of the shops is the rhizome of this species. The rhizomes when very young, or the young shoots of the old rhizomes, are used for preserving, and form in this state Preserved Ginger. The Ginger of the shops is found in two states, one being called *white ginger* or *uncoated ginger*, and the other *black ginger* or *coated ginger*. The former is prepared from the rhizomes of about a year old, which when dug up are washed, scraped, and dried: this kind is generally preferred, and is alone official in the British Pharmacopœia. The latter is prepared from the rhizomes in a similar manner, but not submitted to the scraping process. The essential distinction between the two consists, therefore, in White Ginger having its integument removed, while in Black Ginger it remains on the surface as a shrivelled membrane. Ginger is extensively used as a condiment, and also in medicine as a stimulant and stomachic internally, and externally as a rubefacient.—*Z. Cassumunar* is supposed by some to be the plant from which *Cassumunar root* is obtained. (See *Curcuma.*)

Order 2. MARANTACEÆ or CANNACEÆ, the Maranta Order.—Character.—*Herbaceous plants*, without aromatic properties. They have a close resemblance to the Zingiberaceæ. Their distinctive characters are, in their more irregular perianth; in one of the lateral stamens of the inner whorl being fertile, and the other two abortive; in the fertile stamen having a petaloid filament, an entire or 2-lobed anther, one lobe of which is sterile, and the anther therefore 1-celled; in the style being petaloid or swollen; and in the embryo not being enclosed in a vitellus.

Distribution and Numbers.—Exclusively natives of tropical regions. *Illustrative Genera*:—Maranta, *Plum.*; Canna, *Linn.* There are about 160 species.

Properties and Uses.—The rhizomes of some species contain starch, which when extracted is extensively used for food.

Canna.—One or more species of this genus yield 'Tous les mois,' a very pure and useful starch, although little used in this country or elsewhere. The exact species of *Canna* from which this starch is obtained is not positively known; it is said to be *C. edulis*, but it is just as probable to be derived also from *C. glauca* and *C. Achiras*. *C. lutea* is stated in the 'Bombay Flora' to yield 'Tous les mois.' *C. indica* and *C. discolor* also yield a similar starch.—*C. indica.*—The seeds are commonly known under the name of Indian Shot, from their black colour and hardness. These seeds and those of other species are made use of as beads. The rhizomes or tubers of some species are eaten as a vegetable; they contain much starch, which, as already stated, resembles 'Tous les mois.'

Maranta.—*M. arundinacea.*—The rhizomes or tubers of this plant contain a large quantity of starch, which, when extracted, constitutes West Indian Arrowroot, one of the purest and best known of the starches used as food. As this arrowroot is now obtained from *M. arundinacea*, which is cultivated for that purpose in other parts of the world besides the West Indies, it is best distinguished as *Maranta Starch*. It forms a very firm jelly, and is perhaps the most palatable and digestible starch known. The best arrowroot is the Bermuda kind, but this is becoming more scarce every year. The name Arrowroot is generally said to have been derived from the fact of the bruised rhizomes of this plant having been employed by the native Indians as an application to the poisoned wounds inflicted by arrows. Others give, however, different derivations for this name. Thus T. Greenish believes that it is derived from the Indian word 'ara-ruta,' a term signifying 'mealy root.' The name of arrowroot is now given to various other starches which are used as food in this country and elsewhere.

Order 3. MUSACEÆ, the Banana Order.—Character.—*Herbaceous plants*, often of large size. *Leaves* large, with parallel curved veins springing from the midribs (*fig.* 318), and long sheathing petioles, which together form by their union a spurious aerial stem. *Flowers* irregular, spathaceous. *Perianth* irregular, 6-partite, petaloid, superior, arranged in 2 whorls. *Stamens* 6, inserted upon the divisions of the perianth, some abortive; *anthers* 2-celled. *Ovary* inferior, 3-celled. *Fruit* capsular, dehiscing loculicidally, or succulent and indehiscent, 3-celled. *Seeds* usually numerous, rarely 3, with mealy albumen; embryo not enclosed in a vitellus.

Distribution and Numbers.—Generally diffused throughout tropical and sub-tropical regions. *Illustrative Genera*:—Musa, *Tourn.*; Ravenala, *Adans.* There are about 20 species.

Properties and Uses.—The fruits of some species and varieties form important articles of food in tropical regions. Others yield valuable textile materials; and the large leaves of many are used for various purposes, such as to form a kind of cloth, and as thatching for cottages, &c. The seeds and fruits of others are used as dyeing agents in some countries.

Musa.—The fruits of some species, as those of *M. paradisiaca*, the Plantain, and *M. sapientum*, the Banana, of both of which there are numerous varieties, are well known as important articles of food in many tropical regions. They owe their value in this respect chiefly to the presence of starch and sugar, but they also contain some nitrogenous substances. Dr. Shier states that a new Plantain walk will yield 17 cwt. of starch per acre. According to Humboldt, the produce of Bananas to that of Wheat is as 133 to 1, and to that of Potatoes as 44 to 1. Some of the finer varieties are also used as dessert fruits in this country and elsewhere. The expressed juice is in some parts made into a fermented liquor. The fibrous materials obtained from the spurious stems and flower-stalks of the different species of *Musa* may be used for textile fabrics and in paper-making. The fibres from *Musa textilis* constitute the Manila Hemp of commerce. From the finer fibres of this plant the celebrated Indian muslins are manufactured. The young shoots of the Banana and other species of *Musa* when boiled are eaten as a vegetable; and the large leaves are used for various domestic purposes. The young leaves of the Banana and Plantain are also in common use in India for dressing blistered surfaces.

Ravenala speciosa has been called the Water-tree and Traveller's tree on account of its large sheathing petioles storing up water. Its seeds are edible.

Order 4. BROMELIACEÆ, the Bromelia Order.—Character.—*Herbs* or somewhat *woody plants*, commonly epiphytical. *Leaves* persistent, crowded, channelled, rigid, sheathing at the base, and frequently scurfy and with spiny margins. *Flowers* showy. *Perianth* regular, superior, or nearly or quite inferior, arranged in two whorls, the outer of which has its parts commonly united into a tube; and the inner has its parts distinct, imbricate, and of a different colour to those of the outer whorl. *Stamens* 6; *anthers* introrse. *Ovary* 3-celled; *style* 1. *Fruit* capsular or indehiscent (*fig.* 292). *Seeds* numerous; *embryo* minute, at the base of mealy albumen, with the radicle next the hilum.

Distribution and Numbers.—They are mostly found in the tropical regions of America, West Africa, and the East Indies. They appear to have been originally natives of America and the adjoining islands, but are now naturalised in West Africa and the East Indies. *Illustrative Genera*:—Ananassa, *Lindl.*; Tillandsia, *Linn.* There are about 180 species.

Properties and Uses.—They are chiefly important for yielding edible fruits and useful fibrous materials. Some are anthelmintic, and others contain colouring matters.

Ananassa sativa, the Pine-apple.—The fruit (*sorosis*) of this species is the well-known and delicious fruit called the Pine-apple. A large number of these fruits are now imported into Britain, chiefly from the Bahama Islands, but in flavour they are very inferior to those produced by cultivation in this country. The unripe fruit possesses anthelmintic properties. The fibre obtained from the leaves of this species, as well as that from one or more species of *Bromelia* and *Tillandsia*, is known under the name of *Pine-apple fibre*, and has been used for various textile fabrics, and for the manufacture of paper, cordage, &c.

Billbergia tinctoria.—In Brazil a yellow colouring agent is obtained from the roots of this plant.

Bromelia Pinguin possesses vermifuge properties. Its leaves yield useful fibres. The fibres of *B. sylvestris* under the name of *Ixtle fibre* or *Mexican Grass* are used for brush-making, ropes, and textile fabrics, and would probably form a good paper material.

Tillandsia usneoides is commonly called Tree-beard or Old Man's Beard, from the fact of its forming a mass of dark-coloured fibres, which hang from the trees in South America, like certain Lichens in cold climates. This article has been imported under the name of Spanish Moss, and employed for stuffing cushions, &c., mixed with horsehair. It has been also used for stuffing birds, for packing, and for paper-making. About 10,000 bales are annually shipped from New Orleans.

Cohort 3. *Orchidales.*—Flowers hermaphrodite and very irregular. Perianth of 6, or rarely 3, segments. Stamens, 1, 2, or 3, confluent with the style (gynandrous). Ovary 1-celled with parietal placentation, except in Apostasiaceæ where it is 3-celled with axile placentation. Fruit capsular. Seeds very minute ; exalbuminous ; embryo very obscure.

Order 1. ORCHIDACEÆ, the Orchis Order.—Character.—*Herbs* or *shrubs*, terrestrial (*figs.* 261 and 262) or epiphytical (*fig.* 256). *Roots* fibrous or tuberculated (*figs.* 262 and 261) ; no true stem or a pseudo-bulb (*fig.* 256). *Leaves* entire (*fig.* 316), generally sheathing. *Flowers* irregular (*figs.* 546 and 1053), solitary or numerous, with a single bract, hermaphrodite. *Perianth* superior (*figs.* 546 and 1053), usually petaloid and composed of six pieces (*fig.* 1054), which are commonly arranged in two whorls ; the *outer whorl*, *s*, *sl*, *sl*, formed of three pieces (*sepals*), more or less united below or distinct ; one, *s*, being anterior, or when the ovary is twisted posterior (*figs.* 546 and 1053), and two, *sl*, *sl*, lateral ; the *inner whorl* (*fig.* 1054, *pi*, *pl*, *ps*) usually consists of three pieces (*petals*), (or rarely of but one), alternating with the pieces in the outer whorl ; one (the *labellum* or *lip*) (*fig.* 1054, *ps*) posterior, or by the twisting of the ovary anterior (*fig.* 1053), usually longer and larger than the other pieces, and altogether different to them in form (*fig.* 1053), often spurred (*fig.* 546) ; sometimes the labellum exhibits a division into three regions of which the lowest is then termed the *hypochilium*, the middle the *mesochilium*, and the upper the *epichilium*. *Andrœcium* united to the style (*gynandrous*) (*figs.* 546, 566, and 1053) and forming with it a central column (*gynostemium*); the *column* usually bearing 1 perfect anther and two lateral abortive ones, or in *Cypripedium* two lateral perfect anthers and one abortive anther in the centre. *Pollen* powdery, or more or less collected into grains or waxy or mealy masses (*pollinia*) (*fig.* 564, *p*); the masses free, or attached by their stalk, *c* (*caudicle*), to a gland or glands (*retinacula*) at the apex (*rostellum*) of the stigma (*fig.* 566, *a*). *Ovary* inferior, 1-celled, with 3 parietal placentas (*figs.* 622 and 1054) bearing a number

FIG. 1053.

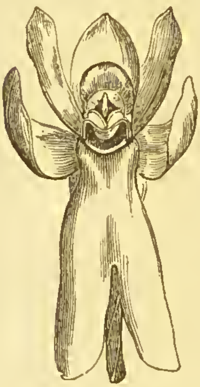


FIG. 1054.

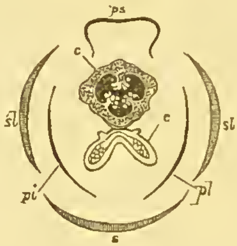


FIG. 1055.

FIG. 1056.

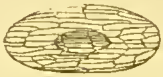


Fig. 1053. Front view of the flower of the Tway-blade (*Listera ovata*), showing the bifid labellum at the anterior part of the flower, and the other five divisions of the perianth; the essential organs of reproduction forming a column (*gynostemium*).——*Fig.* 1054. Diagram of the flower of an Orchid. *s*, *sl*, *sl*. The three outer divisions of the perianth; *s* being anterior or inferior, *sl*, *sl* being lateral. *pl*, *pi*. The two lateral divisions of the inner whorl of the perianth. *ps*. The superior or posterior division (*labellum*) of the inner whorl; this by the twisting of the ovary becomes ultimately inferior or anterior. *c*. The fertile stamen, with two anther lobes. *c*. Transverse section of the ovary, with three parietal placentas. ——*Fig.* 1055. Fruit of an Orchid dehiscing by three valves, each valve bearing a placenta and numerous very minute seeds.——*Fig.* 1056. Seed of an Orchid, with a loose reticulated testa.

of anatropous ovules; *style* united with the andrœcium and forming with it a column or *gynostemium* (*figs.* 546 and 1053); *stigma* a viscid space in front of the column (*fig.* 566). *Fruit* usually capsular, 3-valved (*fig.* 1055), the valves bear the placentas in their middle, and separating when the fruit is ripe from the central parts or midribs of the component carpels, which are left as an open framework; or rarely fleshy and indehiscent. *Seeds* very minute and numerous, with a loose netted (*fig.* 1056) or rarely hard crustaceous testa, exalbuminous; *embryo* a fleshy solid mass.

Diagnosis.—This order is readily known by its irregular flowers; by the peculiar form which the labellum in many cases assumes, so as to cause the flower to resemble some insect, reptile, bird, or other living object; by its gynandrous stamens; its frequently more or less coherent pollen; and by its 1-celled inferior ovary with three parietal placentas.

Division of the Order.—This order has been divided by Lindley and others into several tribes, the characters being derived from the number and position of the anthers, the number and nature of the pollen-masses, and other characters; but the description of these does not come within the scope of this volume.

Distribution and Numbers.—They are more or less abundantly distributed in nearly every region of the globe, except in those which have a very cold or dry climate. Some species are terrestrial and occur chiefly in temperate regions; others are epiphytical and are confined to hot climates. *Illustrative Genera:* —Malaxis, *Swartz*; Dendrobium, *Swartz*; Oncidium, *Swartz*; Stanhopea, *Frost*; Orchis, *Linn.*; Cypripedium, *Linn.* The order contains about 5,000 species, 2,000 being in cultivation.

Properties and Uses.—These plants, which present so much interest from the singularity, beauty, and fragrance of their flowers, are of little importance in an economic or medicinal point of view. Some are aromatic and fragrant, and are used as flavouring agents, several possess nutritious roots, and a few are antispasmodic and aphrodisiac.

Angræcum fragrans.—The dried leaves of this fragrant species are used as a kind of tea in the Mauritius; it is commonly known as *Faham* or *Bourbon tea.* It has been introduced into London and Paris, but is not much esteemed. This tea should be prepared by boiling, and is recommended to be taken with milk and rum. It is said to produce a soothing effect, but without causing sleeplessness.

Cypripedium pubescens.—The root is official in the United States Pharmacopœia. It is regarded as an antispasmodic, and is employed for similar purposes as valerian, but is less powerful. In the Chicago 'Pharmacist' for 1874, it is stated that *C. pubescens* and *C. spectabile* possess powerful poisonous properties, the effects produced resembling the poisoning from *Rhus Toxicodendron* and *R. venenata*; but this seems improbable. From the rhizome and rootlets of *C. pubescens*, and probably also of *C. spectabile* and *C. humile*, the eclectic remedy termed *cypripedin* is obtained. This is regarded as a gentle nervine stimulant, and useful in epilepsy, chorea, and other nervous diseases.

Eulophia vera and *E. campestris.*—The tubercules of these species are used in some parts of India in the preparation of the nutritious substance known by the names of *Salep*, *Salop*, and *Saloop*, which is there very highly esteemed. (See *Orchis.*)

Orchis.—The dried tubercules of several species, as those of *O. mascula*, *O. latifolia*, *O. Morio*, and others, form European or Indigenous Salep; that prepared from *O. mascula* is said to be the best. Salep contains *bassorin* and a little *starch*, and possesses similar properties to those of other amylaceous substances. (See *Eulophia.*)

Sobralia.—The fruit of a species of *Sobralia*, a native of Panama, is said to yield a kind of Vanilla which is called *Chica.*

Vanilla planifolia, *V. aromatica*, *V. guianensis*, *V. palmarum*, *V. pompona*, and other species, are remarkable for their fragrant odoriferous fruits, which constitute the *Vanilla* of the shops. Vanilla is extensively used for flavouring chocolate, and also in confectionery and perfumery. It has been also employed on the Continent as a medicinal agent, in hysteria, &c. It is also regarded as an aphrodisiac. The fruits of *V. planifolia* and *V. aromatica* are commonly regarded as the most fragrant. (See also *Sobralia*.)

Order 2. Apostasiaceæ, the Apostasia Order.—Character.—*Herbs*, with regular hermaphrodite flowers. *Perianth* superior, regular, with 6 divisions. *Stamens* 2 or 3, united by their filaments with the lower part of the style into a column; *anthers* sessile upon the column, 2 or 3. *Ovary* inferior, 3-celled, with axile placentation; *ovules* numerous; *style* united below with the filaments into a column, but prolonged above into a filiform process. *Capsule* 3-celled, 3-valved. *Seeds* very numerous. *By Bentham and Hooker this order is included in Orchidaceæ.*

Distribution and Numbers.—Natives of damp woods in tropical India. *Illustrative Genus*:—Apostasia, *Blume*. There are about 5 species. Their properties are altogether unknown.

Cohort 4. *Taccales.*—Flowers hermaphrodite, regular. Perianth 6-lobed. Stamens 3 or 6, inserted on the tube of the perianth. Ovary 1- or 3-celled; placentation usually parietal, or sometimes axile. Fruit capsular or baccate. Seeds very minute and exalbuminous, or larger and albuminous; embryo very obscure.

Order 1. Burmanniaceæ, the Burmannia Order.—Character.—*Herbaceous plants*, without true leaves, or with tufted radical ones. *Flowers* hermaphrodite, regular. *Perianth* petaloid, tubular, regular, superior, usually with 6 divisions. *Stamens* distinct, inserted into the tube of the perianth, either 3 with introrse anthers, and opposite the inner segments of the perianth, or 6 with extrorse anthers. *Ovary* inferior, 1-celled with 3 parietal placentas, or 3-celled with axile placentas; *style* 1; *stigmas* 3. *Fruit* capsular, 1—3-celled. *Seeds* numerous, very minute; *embryo* solid.

Distribution and Numbers.—They are principally found in the tropical parts of Asia, Africa, and America. *Illustrative Genera*:—Burmannia, *Linn.*; Thismia, *Griff.* According to Miers, there are 38 species. Their properties are unimportant, but some are reputed to be bitter and astringent.

Order 2. Taccaceæ, the Tacca Order.—Character.—Perennial *herbs*, with fleshy roots. *Leaves* large, with parallel veins, radical, stalked. *Flowers* hermaphrodite. *Perianth* tubular, regular, 6-partite, superior. *Stamens* 6, inserted into the base of the divisions of the perianth, with petaloid filaments, incurved and hooded at the apex; *anthers* 2-celled, placed in the concavity below the apex of the filaments. *Ovary* inferior, 1-celled, with 3 parietal placentas projecting more or less into the interior; *styles* 3. *Fruit* baccate. *Seeds* numerous, with fleshy albumen.

Distribution and Numbers.—Natives of mountainous regions in India, the Malayan Archipelago, the Philippines, Australia, Polynesia, Madagascar, Guiana. According to Hance, there are three genera—*Tacca*, Forst.; *Ataccia*, J. S. Presl; and *Schizocapsa*, Hance—which contain twelve or more species.

Properties and Uses.—The roots are bitter and acrid, but when cultivated they become larger and lose in some degree their acridity and bitterness, and contain much starch, which when separated is used for food.

Tacca.—The roots of *T. oceanica* yield the starch known as Tacca Starch or Tahiti Arrowroot. It may be employed as a substitute for Maranta starch. Cakes made from this starch are eaten by the natives of Otaheite and the other Society Islands, where this plant is commonly cultivated.—*T. pinnatifida* is by some considered to be identical with the former species. Like it, the roots contain starch, which is used as food by the inhabitants of China, Cochin China, Travancore, &c.

Cohort 5. *Narcissales.*—Flowers hermaphrodite, regular or irregular. Perianth usually petaloid. Stamens 3 or 6, inserted on the perianth or summit of the ovary. Ovary 3-celled; placentation axile. Seeds with copious fleshy, cartilaginous, or horny albumen; embryo distinct. Leaves parallel-veined.

Order 1. IRIDACEÆ, the Iris Order.—Character.—*Herbs*, usually with bulbs, corms (*figs.* 244 and 245), or rhizomes (*fig.* 233). *Leaves* with parallel venation, generally equitant. *Flowers* spathaceous (*fig.* 1057). *Perianth* superior (*fig.* 1060), petaloid, 6-partite (*fig.* 1058), in two whorls, which are equal or nearly so (*fig.* 1058), or unequal (*figs.* 1057 and 1060), in the size of their segments; or sometimes the parts are entirely distinct; convolute in æstivation. *Stamens* 3, inserted on the outer segments of the perianth (*fig.* 1058); *anthers* 2-celled, innate, extrorse. *Ovary* inferior (*fig.* 1060), 3-celled, with axile placentation (*fig.* 1057); *style* 1 (*figs.* 1058 and 1059); *stigmas* 3, often petaloid (*figs.* 643, *stig*, and 1060, *s*, *s*). *Fruit* capsular, 3-celled, 3-valved, with loculicidal dehiscence (*fig.* 712). *Seeds* numerous, with horny or fleshy albumen (*fig.* 1061, *p*).

Diagnosis.—Herbs. Leaves with parallel veins. Flowers on scapes, spathaceous. Perianth petaloid, superior, 6-partite, or rarely the parts are quite distinct, in 2 equal or unequal whorls. Stamens 3, distinct or monadelphous; anthers innate, extrorse. Ovary 3-celled, with axile placentation, inferior. Fruit capsular, with loculicidal dehiscence, 3-celled, 3-valved. Seeds numerous, albuminous.

Distribution and Numbers.—Chiefly natives of temperate and warm climates. They are found in various parts of the globe, but are most abundant at the Cape of Good Hope.

FIG. 1057.

FIG. 1058.

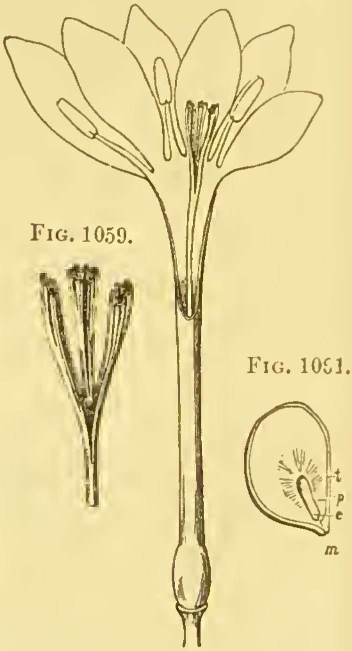


FIG. 1059.

FIG. 1060.

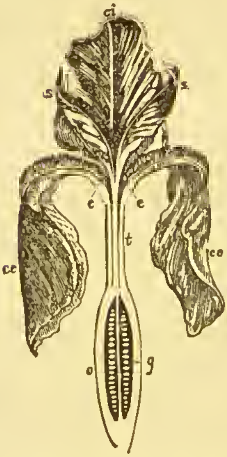


FIG. 1061.

Fig. 1057. Diagram of the flower of a species of *Iris*, showing solitary bract below, six divisions to the perianth arranged in two whorls, three stamens, and a three-celled ovary with axile placentation.——*Fig.* 1058. A flower of the Spring Crocus (*Crocus vernus*) cut open to show the three extrorse stamens attached to the outer segments of the perianth.——*Fig.* 1059. The three petaloid stigmas of the same with the end of the style. ——*Fig.* 1060. Vertical section of the flower of *Iris germanica*. *ce, ce.* Two of the external and larger divisions of the perianth. *ci.* One of the internal and smaller divisions. *t.* Tube formed by the union of the divisions of the perianth. *e, e.* Stamens, covered by the petaloid stigmas, *s, s.* *o.* Inferior ovary, with numerous ovules, *g*, attached to placentas in the axis. ——*Fig.* 1061. Vertical section of the seed of the same. *t.* Integuments of the seed. *p.* Albumen. *e.* Embryo. *m.* Micropyle. (From Jussieu.)

Illustrative Genera:—Iris, *Linn.*; Gladiolus, *Tourn.*; Crocus, *Linn.* There are about 560 species.

Properties and Uses.—The rhizomes of several species possess acrid properties, which causes them to be purgative, emetic, &c. Some are poisonous, and a few have fragrant rhizomes. Others are employed as colouring agents, and some are commonly regarded as antispasmodic, carminative, &c. Many contain starch in large quantities, but as this is usually combined with acridity, they are not generally available for food, although some are stated to be thus employed in Africa.

Crocus sativus, the Saffron Crocus.—This plant is the *Karcom* of the Bible. The dried stigmas with the end of the style (*figs.* 1058 and 1059) constitute *Hay Saffron*, or when pressed together into a mass they form *Cake Saffron.* The latter kind, however, is not now found in the shops in this country; the substance sold under that name being the compressed florets of *Carthamus tinctorius* (see *Carthamus*). Saffron contains a colouring principle called *polychroite.* Saffron is also said to be obtained in Greece of good quality from *C. Sellerium*; and the dried stigmas of other species, as *C. aureus*, *C. odorus*, *C. luteus*, *C. vernus*, &c., are likewise employed to some extent for obtaining saffron in other parts of the Continent, &c. Saffron is much in request as a flavouring agent on the Continent and in the East. It was also formerly much used in this country for a similar purpose, but at present is but little employed in this way except in Cornwall. It is official in the British Pharmacopœia, and is principally used as a colouring agent in this country, but also to some extent in certain nervous affections, and as an emmenagogue. Bird-fanciers also use it, as they believe it assists the moulting of birds.

Iris, Flower de Luce.—The rhizomes of several species are more or less purgative and emetic. The so called Orris-root of the shops is in reality the dried trimmed rhizomes of *I. florentina*, *I. pallida*, and *I. germanica.* These rhizomes possess a violet odour, and are principally used in perfumery, and also for imparting a pleasant odour to the breath; and by the French, especially, for making issue-peas. The roasted seeds of *I. Pseud-acorus*, the Yellow Flag of this country, have been recommended as a substitute for coffee, but they are altogether wanting in the important properties which render that substance so valuable for the preparation of an unfermented beverage. The rhizome and rootlets of *I. versicolor*, Blue Flag, are official in the United States Pharmacopœia; and are regarded as purgative, emetic, and diuretic. The resinous substance termed *iridin* or *irisin* by the Eclectics in the United States is obtained from these rhizomes, and from those of allied species; it is regarded as possessing cathartic, alterative, and diuretic properties.

Moræa (*Homeria*).—Some species of this genus, more especially that of *M. collina*, and of other Iridaceous plants known under the name of 'Tulp' at the Cape, have poisonous properties, and have been the cause of fatal results to cattle which have chanced to eat it. Tulp is also poisonous to human beings.

Order 2. AMARYLLIDACEÆ, the Amaryllis Order.—Character.—Bulbous or fibrous-rooted plants, without any aerial stem, or sometimes with a woody one. *Leaves* with parallel venation, and usually linear-ensiform, sometimes dry and harsh. *Flowers* usually on scapes, and spathaceous (*fig.* 402). *Perianth* regular or nearly so (*figs.* 402 and 1062), petaloid, superior (*fig.* 1064) with six divisions, and with (*figs.* 502 and 1063, *n*) or without a corona (*fig.* 1064); æstivation imbricate or valvate. *Stamens* 6, inserted on the perianth (*fig.* 1063) or summit of the ovary (*fig.* 1064); *anthers* 2-celled, introrse. *Ovary* inferior (*fig.* 1064), 3-celled (*fig.* 1062); *placentas* axile. *Fruit* capsular, 3-celled, 3-valved, with loculicidal dehiscence, and numerous seeds; or baccate, with 1—3 seeds. *Seeds* with fleshy or horny albumen, sometimes carunculate; *embryo* with the radicle turned to, or remote from, the hilum (*fig.* 1065).

Diagnosis.—Leaves with parallel veins. Flowers spathaceous. Perianth superior, petaloid, commonly regular, 6-partite, frequently with a corona. Stamens 6; anthers introrse. Ovary inferior, 3-celled, with axile placentation. Fruit capsular, 3-valved, with loculicidal dehiscence, or baccate. Seeds numerous, albuminous.

FIG. 1062.

FIG. 1063.

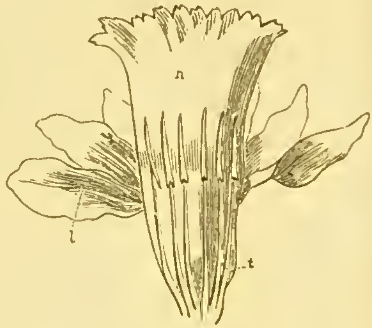


Fig. 1062. Diagram of the flower of the Spring Snowflake (*Leucojum vernum*), with six divisions to the perianth arranged in two whorls, six stamens, and a 3-celled ovary with axile placentation.——*Fig.* 1063. The perianth of the Daffodil (*Narcissus Pseudo-narcissus*) cut open in a vertical manner. *t.* Tube bearing six stamens. *l.* Limb of the perianth. *n.* Corona.

Distribution and Numbers.—Natives of many parts of the world, but, like the Iridaceæ, most abundant at the Cape of Good Hope. *Illustrative Genera*:—Galanthus, *Linn.*; Amaryllis, *Linn.*; Narcissus, *Linn.*; Agave, *Linn.*; Hypoxis, *Linn.* There are above 400 species.

Properties and Uses.—Several plants of this order possess poisonous qualities. This property is especially evident in *Hæmanthus toxicarius*, the juice of which is used by the Hottentots to poison their arrow-heads. Some yield excellent fibres. The juice of some few species is saccharine, and is employed in the preparation of fermented liquors. Starch may be obtained from certain species of *Alstrœmeria*. Some are bitter and aromatic. Medicinally, several have been used as emetics and purgatives.

Agave americana, the American Aloe, Maguey, or Hundred-years' Plant. The latter name was given under the erroneous idea that this species of Agave lived a hundred years before flowering. From the leaves of this and other species the useful fibre known as Aloe Fibre, Pita or Pité Hemp is obtained. It is employed for textile fabrics and for paper-making. The juice of the leaves of *Agave americana* and other species just before flowering contains much sugar and mucilage, and when fermented yields a vinous acid beverage called Pulque, which is highly esteemed by the Mexicans. It has an odour something like putrid meat. A very intoxicating spirit or brandy may be also obtained from *pulque*. To this spirit the name of *mexical* or *aguardiente de maguey* has been given. The unfermented juice is called *Aguamiel* or *honeywater*. It is regarded as useful for the prevention of scurvy. Its roots are reputed to possess alterative and diuretic properties. The leaves from the heart of *A. Utahense* and other species of *Agave* are cooked by the Pah-Utes, and form a very nourishing and palatable food.

Alstrœmeria pallida and some other species have succulent roots containing much starch, which, when extracted, is used as a kind of Arrowroot in certain parts of South America.

Crinum asiaticum, var. *toxicarium* of Herbert.—The fresh root (or more properly bulb) is official in the Pharmacopœia of India. It possesses emetic and diaphoretic properties, and its therapeutic uses are said to be analogous to those of Squill. The dried root has similar qualities, but it is not so powerful in its action.

Fig. 1064.

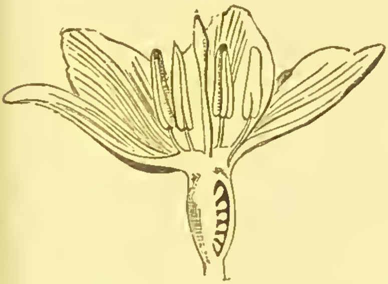


Fig. 1065.

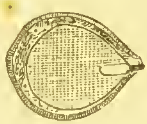


Fig. 1064. Vertical section of the flower of the Spring Snowflake (*Leucoium vernum*).——*Fig.* 1065. Vertical section of the seed of the same.

Curculigo.—The roots of *Curculigo orchioides* are used in Travancore by the native doctors in gonorrhœa, menorrhagia, and other affections.

Narcissus Pseudo-narcissus.—From the bulbs of this plant A. W. Gerrard has obtained a crystalline neutral principle and an amorphous alkaloid, the latter of which he has named *pseudo-narcissine*. This alkaloid was found to produce profuse salivation, vomiting, and slight diarrhœa, when given hypodermically to warm-blooded animals.

Order 3. HÆMODORACEÆ, the Blood-root Order.—Character.—*Herbs* or rarely *shrubs*, with fibrous roots. *Leaves* usually equitant, ensiform. *Perianth* more or less superior, tubular, 6-partite, regular, the divisions usually scurfy or woolly on their outside. *Stamens* 3 or 6, when 3 they are opposite the inner segments of the perianth ; *anthers* introrse. *Ovary* inferior, or partially so, 3-celled. *Fruit* dehiscent or indehiscent, covered by the withered perianth. *Seeds* few or numerous, with cartilaginous albumen, and radicle remote from the hilum.

Distribution and Numbers.—Natives of America, the Cape of Good Hope, and Australia. *Illustrative Genera*:—Hæmodorum, *Smith*, Vellozia, *Mart.* There are about 50 species.

Properties and Uses.—The roots of some species are used as dyeing agents in North America, others are edible, and a few are bitter and astringent.

Aletris farinosa is remarkable for its bitterness. It is reputed to possess tonic and stomachic properties.

Hæmodorum.—The roots of several species, as those of *H. paniculatum* and *H. spicatum*, when roasted, are eaten by the natives in some parts of Australia. The root contains a red colouring matter.

Lachnanthes tinctoria has a blood-red root which is used for dyeing in North America.

Cohort 6. *Dioscorales*.—Flowers unisexual and diœcious, regular. Perianth herbaceous. Stamens 6, inserted at the base of the perianth-segments. Ovary 3-celled ; placentation axile. Fruit baccate or capsular. Seeds with abundant fleshy albumen and a distinct included embryo. Climbing herbs or small twining shrubs, with netted-veined leaves.

Order 1. DIOSCOREACEÆ, the Yam Order.—Character.—Climbing *herbs*, or small *shrubs*, with twining stems rising from tuberous rootstocks or tubers, placed above or under the ground. *Leaves* net-veined, stalked. *Flowers* unisexual, diœcious, small, bracteated. *Male flower* :—*Perianth* 6-cleft. *Stamens* 6, inserted at the base of the perianth-segments. *Female flower* :—*Perianth* superior, 6-partite. *Stamens* sometimes present, but very short and abortive. *Ovary* inferior, 3-celled ; *styles* 3, distinct, or 1, and then deeply trifid ; *ovules* 1—2 in each cell, suspended. *Fruit* dehiscent and compressed, or fleshy and indehiscent, 1—3-celled. *Seeds* albuminous ; *embryo* small, in a cavity in the albumen.

Distribution and Numbers.—Chiefly tropical plants. *Tamus communis* is, however found in Britain and other temperate regions. *Illustrative Genera* :—Tamus, *Linn.* ; Dioscorea, *Linn.* There are above 150 species.

Properties and Uses.—The plants generally contain an acrid principle. The tuberous rootstocks of many species of *Dioscorea* are, however, when boiled, used for food in tropical countries.

Dioscorea.—The tuberous rootstocks of several species, as those of *D. alata*, *D. sativa*, and *D. aculeata*, when boiled, are eaten in tropical countries, as potatoes are in Europe. The Chinese Yam (*D. Batatas*) is now cultivated in this country, and when properly boiled is esteemed by many as an esculent. Some species of *Dioscorea* are very acrid even when boiled, and cannot therefore be used for food. The rhizome of *D. villosa*, the Wild Yam of the United States, is regarded as a valuable remedy in Virginia in rheumatism, and is hence commonly known as 'rheumatism root.' It has also been recommended in bilious colic.

Tamus.—*T. communis*, Common Black Bryony, has a large fleshy root which when fresh possesses considerable acridity. It is sometimes used as a topical application to bruised parts to remove the marks. Taken internally, it acts as a diuretic, and also, it is said, as an emetic and cathartic. The young shoots of this species and those of *T. cretica*, when thoroughly boiled, so that their acridity is destroyed, have been eaten like asparagus.

Testudinaria elephantipes, a native of the Cape of Good Hope, has a very peculiar tuberous stem, hence it has been called Elephant's Foot or the Tortoies plant ; the inner part of this stem is very mealy, and is used for food by the Hottentots

Series 2. Superæ.

Sub-series 1. *Apocarpæ.*

Cohort 1. *Triurales.*—Flowers unisexual. Perianth 6-lobed or 6-partite. Stamens 6. Carpels 1-ovuled. Seeds minute, with very dense albumen and rudimentary embryo. Minute, leafless, slender herbs.

Order 1. TRIURIDACEÆ, the Triuris Order.—*Diagnosis.*—This is a small order of plants allied to Naiadaceæ, but usually to be distinguished by its rudimentary embryo. The flowers are, also, sometimes perfect.

Distribution, Numbers, and Properties.—Exclusively found in warm and tropical regions. *Illustrative Genera:*—Triuris, *Miers*; Sciaphila, *Blume.* There are 8 species. Their properties and uses are unknown.

Cohort 2. *Potamales.*—Flowers hermaphrodite or unisexual. Perianth with usually 6 segments, or rarely 2 or 4, or absent. Stamens 1, few, or numerous. Seeds exalbuminous; embryo conspicuous. Usually water plants.

Order 1. BUTOMACEÆ, the Butomus Order.—Character.—Aquatic plants with parallel-veined leaves, sometimes milky. *Flowers* hermaphrodite (*fig.* 1066), showy. *Perianth* inferior, of six pieces, arranged in two whorls (*fig.* 1066), the inner being coloured. *Stamens* few (*fig.* 1066) or numerous. Carpels 3—6 (*fig.* 593) or more, more or less distinct; *ovaries* superior (*fig.* 1066); *ovules* numerous, arranged all over the inner surface of the ovaries (*fig.* 636). *Fruit* many-seeded, separating more or less when ripe into as many parts as there are component carpels. *Seeds* without albumen (*fig.* 1067). *This order is included by Bentham and Hooker in Alismaceæ.*

FIG. 1066. FIG. 1067.

Fig. 1066. A flower of the Flowering Rush (*Butomus umbellatus*), with an inferior perianth arranged in two whorls, nine stamens, and six carpels.——*Fig.* 1067. Vertical section of the seed of the same.

Distribution and Numbers.—A few plants of this order occur in tropical countries, but the greater number inhabit the northern parts of the world. *Illustrative Genera:*—Butomus, *Tourn.*; Limnocharis, *H. et B.* There are 7 species.

Properties and Uses.—Of little importance. *Butomus umbellatus*, the Flowering Rush, possesses acrid and bitter properties, and was at one time used in medicine. The roasted rhizomes are edible.

Order 2. ALISMACEÆ, the Alisma Order.—Character.—Swamp or floating plants. *Leaves* narrow or with an expanded lamina, parallel-veined. *Flowers* hermaphrodite (*figs.* 1068 and 1069) or very rarely unisexual. *Perianth* inferior, arranged in two whorls, each consisting of three parts (*fig.* 1068); the outer whorl herbaceous, the inner coloured. *Stamens* few or numerous; *anthers* introrse. *Carpels* distinct, several (*fig.* 1068); *ovaries* superior, 1-celled; *ovules* solitary or 2 superposed; *placentas* axile or basal (*fig.* 1069). *Fruit* dry. *Seeds* without albumen; *embryo* undivided, curved.

FIG. 1068.

FIG. 1069.

Fig. 1068. Flower of a species of *Alisma*, with an inferior perianth arranged in two whorls each consisting of three parts, six stamens, and numerous separate carpels.——*Fig.* 1069. Vertical section of the same flower.

Distribution and Numbers.—These plants are principally found in the northern parts of the world. *Illustrative Genera:* Alisma, *Juss.*; Actinocarpus, *R. Br.* There are about 50 species.

Properties and Uses.—Of little importance. Many have fleshy or mealy rhizomes, which are edible when cooked. Others possess astringent properties. *Alisma Plantago* had formerly a reputation as a remedy in hydrophobia.

Order 3. JUNCAGINACEÆ, the Arrow-grass Order.—Character.—*Herbs*, growing in marshes. *Leaves* with parallel veins. *Flowers* hermaphrodite, whitish or greenish. *Perianth* small, more or less scaly, inferior, in two whorls, each containing three pieces. *Stamens* 6, perigynous, *anthers* usually extrorse. *Carpels* 3—6, separate or more or less united; *ovules* 1—2. *Fruit* dry, ultimately separating into as many parts as there are carpels. *Seeds* attached to axile or basal placentas, exalbuminous; *embryo* straight, with a lateral cleft (*figs.* 766 and 777). *This order is included by Bentham and Hooker in Naiadaceæ.*

Distribution and Numbers.—The plants of this order are found more or less in nearly all parts of the world, but are most abundant in temperate and cold regions. *Illustrative Genera:*—Triglochin, *Linn.*; Potamogeton, *Linn.* There are about 50 species.

Properties and Uses.—Of little importance.

Ouvirandra fenestralis, a native of Madagascar, is commonly known under the name of the Lattice-leaf plant, from its leaves resembling open lattice-work. Its roots are of a fleshy farinaceous nature, and form an article of food; hence the name *Ouvirandram* by which the plant is known in Madagascar, the literal meaning of which is Water-yam.

Order 4. NAIADACEÆ, the Pondweed Order.—Character. Aquatic plants with jointed cellular stems. *Leaves* with interpetiolar membranous stipules. *Flowers* small, unisexual (*figs* 1070 and 1071), monœcious or diœcious, solitary or in spikes. *Perianth* either wanting, or present and composed of 2 or 4

FIG. 1070.

FIG. 1071.

FIG. 1072.

FIG. 1073.

Fig. 1070. Two flowers of the Horned Pondweed (*Zannichellia palustris*), one staminate, the other pistillate.——*Fig.* 1071. The gynœcium of the same, composed of four perfect carpels, and one imperfect.——*Fig.* 1072. Vertical section of one of the carpels.——*Fig.* 1073. Vertical section of the fruit and seed. All magnified. After Lindley.

parts, which are then free and scale-like. *Stamens* 1 or few, hypogynous; *pollen* globose or tubular. *Carpels* 1 or more, distinct, with superior *ovaries* (*fig.* 1071); *ovule* solitary (*fig.* 1072). *Fruit* 1-celled, 1-seeded (*fig.* 1073). *Seed* exalbuminous; *embryo* with a lateral cleft.

Distribution.—They are widely distributed, but are chiefly found in extra-tropical regions. *Illustrative Genera:*—Naias, *Willd.*; Zannichellia, *Michel*; Zostera, *Linn.*

Properties and Uses.—Their properties are of little importance.

Zostera marina, Sea-wrack, is in common use for packing, and for stuffing chairs, mattresses, &c., under the name of *Alva* (*Ulva* or *Alga*) *marina*. It has also been recommended for paper-making, but it is a very unsuitable material for that purpose.

Sub-series 2. *Syncarpæ.*

Cohort 1. *Palmales.*—Flowers unisexual or hermaphrodite, usually arranged on a branched spadix, and enclosed in a spathe. Perianth 3-merous, in two whorls, commonly green, but rarely coloured. Fruit indehiscent, 1- or rarely 2-seeded. Seed albuminous. Shrubs or trees.

Order 1. PALMACEÆ, the Palm Order.—Character.—*Trees* or *shrubs*, with simple unbranched (*fig.* 199, 1), or rarely dichotomously branched trunks (*fig.* 200). *Leaves* terminal (*fig.* 199, 1), large, mostly compound, with sheathing stalks. *Flowers*

FIG. 1074.

FIG. 1076.

FIG. 1077.

FIG. 1075.

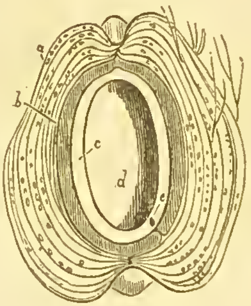


FIG. 1078.

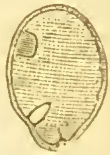


FIG. 1079.

Fig. 1074. Diagram of a staminate flower of the Fan Palm (*Chamærops*), with six divisions to the perianth, and six stamens.——*Fig.* 1075. Diagram of a pistillate flower of the same, with six divisions to the perianth, and a 3-celled ovary.——*Fig.* 1076. Hermaphrodite flower of the Blue Palmetto (*Chamærops hystrix*), with the perianth removed. *ov.* Carpels. *st.* Stamens.——*Fig.* 1077. The same, with three of the stamens removed, so as to exhibit more completely the three carpels composing the pistil. *st.* Stamens. *c.* Carpels.——*Fig.* 1078. Vertical section of the fruit of the Cocoa-nut Palm (*Cocos nucifera*). *a.* The two outer layers or husk of the pericarp. *b.* Endocarp or inner layer. *c.* Albumen. *d.* Cavity in the albumen. *e.* Embryo.——*Fig.* 1079. Vertical section of the seed of the Fan Palm.

hermaphrodite (*figs.* 1076 and 1077) or unisexual (*figs.* 1074 and 1075), arranged generally on a branched spadix (*fig.* 417), which is enclosed by a spathe. *Perianth* usually green, inferior, in two whorls, each of which is composed of three parts (*figs.* 1074 and 1075). *Stamens* usually 6 (*figs.* 1074 and 1076), hypogynous or perigynous. Carpels 1—3 (*figs.* 1076 and 1077), generally united, but sometimes distinct; *ovary* superior; *ovules* solitary, or rarely 2. *Fruit* (*fig.* 1078) nut-like, baccate, or drupaceous. *Seeds* with a minute embryo (*fig.* 1078, *e*), in a pit of the albumen, *d*; *albumen* fleshy or horny (*fig.* 1079), often ruminate (*fig.* 763, *p*).

Distribution and Numbers.—Most of the plants are tropical, but a few occur in temperate regions. *Illustrative Genera:*— Areca, *Linn.*; Chamærops, *Linn.*; Attalea, *Humb.*; Cocos, *Linn.* There are above 600 species.

Properties and Uses.—Of all orders of plants there is none, with the exception of that of the Grasses, so valuable to man as regards their dietetical and economic applications as that of the Palm Order. These plants supply him with sugar, starch, oil, wax, wine, resin, astringent matters, and also edible fruits and seeds. Their terminal leaf-buds, when boiled, are eaten as a vegetable. Their leaves are applied in various ways, as for thatching, materials for writing upon, and in the manufacture of hats, matting, &c.; their wood is applied to many useful purposes; the fibres of their petioles and fruits supply materials for cordage, cloth, and various other textile fabrics; and the hard albumen of their seeds is applicable in many ways. But in a medicinal point of view they are of very much less importance; indeed, they do not supply any important article of the materia medica used in Europe, although in tropical countries they are of more value, and in frequent use as medicinal agents.

Areca.—*A. Catechu*, the Betel Nut Palm.—The seeds are known under the name of Betel Nuts or Areca Nuts. In the South of India an extract is made from these nuts, which is said to constitute the commercial variety of Catechu known as Colombo or Ceylon Catechu, although it is doubtful whether any Catechu is prepared in Ceylon. It is the Betel Nut Catechu of Pereira. In its properties and uses this Catechu resembles that obtained from *Acacia Catechu*, and the official Catechu from *Uncaria Gambier*. (See *Uncaria*.) Areca nuts are regarded as astringent, and valuable therefore as a remedy in diarrhœa. The powdered seeds or nuts have been long employed as an anthelmintic for dogs, and Areca was introduced into the last British Pharmacopœia, on account of its supposed efficacy in promoting the expulsion of the tapeworm, and of the round worm in the human subject, but has now been omitted from possessing little or no value in such cases as a remedial agent. Charcoal prepared from the Areca nut is termed *Areca-nut charcoal*, and is sometimes used in this country as a tooth-powder; but it does not appear to have any value over that of ordinary charcoal. The Betel Nut is one of the ingredients in the famed masticatory of the East called *Betel*. (See *Piper*.) The dried expanded leaf-stalks have been used in India as splints.—*A. oleracea* is known as the West Indian Cabbage Palm, its young terminal bud when boiled being eaten as a vegetable.

Arenga saccharifera or *Saguerus saccharifer*, the Areng or Gommuti Palm, supplies abundance of palm sugar in the Moluccas and Philippines. Palm sugar is usually obtained by boiling the juice which flows out from this and many other Palms upon wounding their spathes and surrounding parts; it is commonly known in India by the name of Jaggery. The juice (toddy) of the Gommuti Palm, when fermented, produces an intoxicating liquid. In Sumatra it is termed *neva*, and a kind of spirit (*arrack*) is distilled from it in Batavia. From the trunk of this Palm, when exhausted of its saccharine juice, a good deal of our commercial Sago is obtained. A single tree will yield from 180 to 200 pounds of Sago. (See also *Metroxylon*.) The juice of the fruit is very acrid. The stiff strong horsehair-like fibre known under the name of Gommuti or Ejow fibre is derived from the leaf-stalks of this palm.

Attalea.—A. funifera, Mart.—The fruits of this species are largely imported; they constitute the Coquilla Nuts of commerce. They are also termed *Urucuri Nuts*. Their pericarps are very hard, and form a useful material for the handles of doors, drawers, sticks, umbrellas, &c. The pendulous fibres of the petioles supply the coarser variety of Piassaba, known in commerce as Bahia Piassaba, the other and finer kind being derived from *Leopoldinia Piassaba*. (See *Leopoldinia*.) This coarser kind is obtained from Bahia. Other species of *Attalea* appear to yield similar fibres. From the seeds of *A. Cahouni*, the Cahoun Palm, a fatty oil may be obtained. They have been imported for this purpose. The seeds of *A. Compta*, the Pindova Palm, are much esteemed in Brazil, and the leaves are also used for making hats, &c.

Borassus flabelliformis, the Palmyra Palm.—From the juice of this Palm toddy and arrack are procured in large quantities in India. Palmyra fibres are also obtained from its leaves, and Palmyra wood from the trunk.

Calamus.—Several kinds of walking-canes are obtained from species of this genus, as *C. Scipionum*, the Malacca cane; *C. Rotang* and *C. Rudentum*, Rattan canes. Partridge canes and 'Penang lawyers' are also the produce of undetermined species.—*C. verus*, *C. viminalis*, and other species, are likewise botanical sources of the canes now largely used for walking-sticks, and for chair bottoms, couches, &c. About twenty millions are annually imported, the value of which is probably not less than 40,000*l*. The fruit of *C. Draco*, and of probably other species, is the chief source of the astringent resinous substance known as Dragon's Blood. (See also *Pterocarpus Draco* and *Dracæna Draco*.)

Caryota urens.—From this palm sugar may be procured, and its juice forms a kind of toddy or palm wine. From the trunks of the old trees a kind of Sago is obtained in Assam.

Ceroxylon andicola.—The trunk and axils of the leaves of this palm secrete wax, which may be applied to many useful purposes. It is a native of New Granada.

Chamærops.—C. humilis is the only Palm found wild in Europe. It supplies fibres which have been used as a substitute for horsehair, and in Sicily its different parts are applied to various purposes, as walking-canes, and for the making of hats, baskets, &c. The leaves, under the name of Palmetto leaves, have been imported and used for paper-making. Its young leaves or buds are also eaten as cabbage. Palm wine or toddy is likewise collected from the spathes. The material employed for the Brazilian chip or grass hats is obtained from *C. argentea*.

Cocos nucifera, the Cocoa-nut Palm.—This is perhaps the most valuable of all the Palms. An impure sugar, called Jaggery, is largely obtained from the juice which flows out when its spathes and their neighbouring parts are injured. The fresh juice is termed *Toddy*. A spirit called *arrack* is also prepared to a great extent from the fermented juice, as also vinegar. The albumen of the seeds, which are commonly known as *Cocoa-nuts*, and the liquid portion within this (cocoa-nut milk), form an important part of the food of the inhabitants of tropical regions. In large doses this milk when fresh has been used in India as an aperient. The Cocoa-nut is also largely consumed in this country. From the albumen the concrete oil known as *Cocoa-nut oil* or *Cocoa-nut butter*, is obtained. It is extensively employed for making candles and soap; the imports into this country alone being nearly 100,000 tons annually. In India it is much esteemed as a pomatum; but its unpleasant odour, and the rancid character which it soon acquires, prevent its use in this country for such a purpose. The oleine obtained by pressure from the crude oil, and afterwards purified by alkalies, &c., has been recommended as a substitute for cod-liver oil, but although its employment has been favourably reported upon by some physicians, it has not been generally approved. From the fibrous portion of the pericarp the strong fibre called Coir or Cocoa-nut fibre is obtained. Coir is remarkable for its durability, and is accordingly much used for cordage, fishing-nets, matting, scrubbing-brushes, &c. The wood of the Cocoa-nut Palm is very hard, handsome, and durable, and is employed for several purposes under the name of Porcupine Wood.

Copernicia cerifera, the Carnauba Palm, is a native of the Brazils. On the lower surface of its leaves wax is secreted, which is occasionally imported under the name of Carnauba or Brazilian Wax. The root is said to resemble Sarsaparilla in its medicinal properties, and has recently been imported into this country.

Corypha umbraculifera, the Talipot Palm, yields a kind of Sago in Ceylon, but this is not an article of commerce.

Elais guineensis and *E. melanococca*, the Guinea Oil Palms.—The sarcocarp of the drupaceous fruits of these Palms abounds in oil, which when extracted is known as Palm Oil. This is a solid butter-like oil, of a rich orange-yellow colour, and is extensively used in this country and elsewhere in the manufacture of soap and candles, and for lubricating the wheels of railway-carriages, &c. The imports amount to at least 50,000 tons annually. In Africa Palm Oil is used as food by the natives. The hard stony putamen of the same fruits also yields a limpid oil. Palm wine or toddy is likewise obtained from the wounded spathes of these Palms.

Euterpe.—*E. montana* is one of the Cabbage Palms. It is so called from the circumstance of its young terminal leaf-bud being boiled and eaten as a vegetable. From the fruits of other species, as *E. edulis* and *E. Assai*, pleasant beverages are prepared.

Hyphæne thebaica, the Doum Palm of Egypt (*fig.* 200). The pericarp of the fruit of this Palm resembles gingerbread; hence this plant is sometimes known as the Gingerbread tree.

Leopoldinia Piassaba.—The persistent petiole-bases of this Palm terminate in long pendulous beards of bristle-like fibres; these are cut off from the young plants after having been previously combed out by means of a rude comb, and now form an important article of commerce in Brazil. The fibres are known under the names of Piassaba or Piaçava, Para Grass, or Monkey Grass. They are chiefly used as a substitute for bristles by brush-makers, and for making the stout brooms now commonly employed for cleaning the streets, &c. Two kinds of Piassaba fibre are known in commerce—one, the finer variety, imported from Para, and therefore known in commerce as Para Piassaba, which is derived from this plant; and a coarser kind obtained from *Attalea funifera*. (See *Attalea*.) According to Spruce, the pulp of the ripe fruit yields a delicious drink, resembling cream in colour and taste.

Mauritia vinifera, the Muriti Palm, and *M. flexuosa*, yield a large quantity of toddy.

Metroxylon (*Sagus*).—From the trunks of *M. Sagu* or *M. læve*, and *M. Rumphii*, the principal part of our Sago is obtained; from the former as much as 800 pounds may be procured from a single plant. Sago is principally imported into this country from Singapore. The average importation for some years has exceeded 4,000 tons. All the Sago consumed in this country is derived from these palms and *Arenga saccharifera*. (See *Arenga* and *Cycas*.)

Phœnix.—*P. dactylifera* is the Date Palm. The fruits called dates are nutritious, and afford the principal food of the inhabitants of some parts of Africa and Arabia. Animals are also fed upon them. They are imported into this country, and used for dessert, but they are not so much esteemed as they deserve. They have been lately employed as a food for cattle, but at present their price is too high to allow of any great consumption for such a purpose. They were also much used a few years since in the preparation of what was called 'Date Coffee.' The Date Palm is the Palm commonly referred to in Scripture. The juice (toddy) affords sugar, and an intoxicating beverage termed *lagbi* is also sometimes obtained from it. The leaves, the fibres obtained from the leaf stalks, the wood, and in fact nearly every part of this palm, are applied to some useful purpose.—*P. sylvestris*, the Wild Date Palm, is the plant from which the largest quantity of palm sugar is obtained. It is a native of India, where it is said 130,000,000 pounds of sugar are annually extracted from it. Palm sugar resembles cane sugar in flavour. The total amount of palm sugar obtained from the different kinds of Palms has been estimated by Johnston at 220,000,000 pounds.—*P. farinifera* yields an inferior kind of Sago, which is used in some parts of India.

Phytelephas macrocarpa.—The hard albumen of the seeds of this Palm constitutes the Vegetable Ivory of commerce; this is used extensively by the turners; but its principal consumption is for button-making. These seeds are usually imported from Guayaquil. The fruits are supposed to present some resemblance to negroes' heads, and are hence termed *Cabeza del negro.*

Raphia Ruffia.—The integument peeled from the young leaves of this Palm is said to constitute the substance known as *Manila Bast* or *Raphia Bast*, which is used as a tying material by gardeners.

Seaforthia elegans.—This Palm produces the Moreton Bay Canes of commerce.

Cohort 2. *Arales.*—Flowers hermaphrodite or unisexual, arranged on a spadix, spike, or head, and with or without a spathe; or sunk in pits of a minute scale-like frond. Perianth absent or scaly. Fruit a drupe or baccate. Seeds 1, few or many, almost always albuminous; embryo minute, usually straight. Herbs, often very large, or rarely trees.

Order 1. PANDANACEÆ, the Screw-pine Order.—Character.—Palm-like *trees* (*fig.* 199, 2) or *shrubs*. *Leaves* amplexicaul, linear-lanceolate, and then imbricate, and spirally arranged in 3 rows; or pinnated or fan-shaped. *Flowers* unisexual or polygamous, numerous, arranged on a simple or branched spadix, with many spathaceous bracts. *Perianth* absent or scaly. *Stamens* numerous; *anthers* 2—4-celled. *Ovaries* 1-celled; *ovules* solitary or numerous, on parietal placentas. *Fruit* consisting of a number of 1-seeded fibrous drupaceous carpels, or baccate, and many-celled, and many-seeded. *Embryo* minute, imbedded at the side near the base of fleshy albumen. *By Bentham and Hooker this order is separated into two orders, the Pandanaceæ and the Cyclanthaceæ.*

Distribution and Numbers.—Exclusively tropical plants. *Illustrative Genera*:—Pandanus, *Linn. fil.*; Carludovica, *R. et P.* There are about 75 species.

Properties and Uses.—None possess any very active properties. *Pandanus* has edible seeds. The juice which flows from the wounded spadices of *Nipa*, when fermented, furnishes a kind of wine. The fruit of *Nipa fruticans* is the Atap of India. The young unexpanded leaves of *Carludovica palmata* furnish the material employed in the manufacture of Panama hats.

Order 2. TYPHACEÆ, the Bulrush Order.—Character.—*Herbs* growing in watery places. *Leaves* rigid, linear, sessile, parallel-veined. *Flowers* monœcious, arranged on a spadix, or in heads, without a spathe. No true *perianth*, merely scales or hairs. *Male flower* with 1—6 distinct or monadelphous *stamens*, with long *filaments*, and innate *anthers*. *Female flower* a solitary 1-*celled carpel*, with a single pendulous *ovule*. *Fruit* indehiscent. *Seed* with mealy albumen; *embryo* axile; *radicle* next the hilum.

Distribution and Numbers.—A few are found in tropical and warm climates, but they are most abundant in the northern parts of the world. *Illustrative Genera:*—Typha, *Linn.*; Sparganium, *Linn.* These are the only genera; they include about 13 species.

Properties and Uses.—Unimportant.

Typha.—The young shoots of *T. latifolia* and *T. angustifolia* are sometimes boiled, and eaten like Asparagus; their rhizomes are also edible; and their pollen is inflammable. The pollen of some species of *Typha* is edible; thus, that of *T. elephantina* is made into a kind of bread in Scinde, and that of *T. utilis* in New Zealand. Some species are said to be astringent and diuretic.

Order 3. AROIDACEÆ, the Arum Order.—Character.—*Herbs* or *shrubs*, with commonly an acrid juice, and subterranean tubers, corms (*fig.* 1080, *b*), or rhizomes. *Leaves* sheathing (*fig.* 1080, *l*), usually net-veined, simple or rarely compound. *Flowers* unisexual and monœcious, or hermaphrodite, arranged on a spadix (*figs.* 403 and 1081) within a spathe (*fig.* 403), or the spathe is absent. *Perianth* none (*fig.* 1081) or composed of scales which are inferior. *Male flower*:—*Stamens* few or numerous; *anthers* extrorse, sessile (*fig.* 504) or upon very short filaments. *Female flower*:—*Ovary* (*fig.* 1082) 1- or more celled, superior. *Fruit* succulent (*fig.* 1080, *c*). *Seeds* pulpy, with abundant mealy, horny, or fleshy albumen (*fig.* 1083), or rarely exalbuminous; *embryo* various.

Diagnosis.—Flowers on a spadix, and with or without a true spathe. Flowers naked, unisexual and monœcious; or hermaphrodite, and then frequently with a scaly inferior perianth. Anthers extrorse. Fruit succulent.

Division of the Order and Illustrative Genera:—The order may be divided into two sub-orders as follows:—

Sub-order 1. *Aroideæ* or *Araceæ*.—Flowers unisexual, monœcious. Spadix surrounded by a spathe. Perianth none. *Illustrative Genera:*—Arum, *Linn.*; Caladium, *Vent.*

Sub-order 2. *Acoreæ* or *Orontieæ*.—Flowers hermaphrodite.

Spadix surrounded by a spathe or naked. Perianth absent, or more generally present, and then scaly. *Illustrative Genera:*—Acorus, *Linn.*; Orontium, *Linn.*

This order was divided by Lindley into two separate orders—the Araceæ and Acoraceæ—on account of the hermaphrodite flowers of the latter. In accordance, however, with the more general views of botanists, we make but one order, and place the two orders of Lindley as sub-orders.

Distribution and Numbers.—They abound in tropical countries, but also occur in cold and temperate regions. There are about 250 species.

FIG. 1080.

FIG. 1081.

FIG. 1082.

FIG. 1083.

Fig. 1080. A plant of the Cuckoo-pint (*Arum maculatum*) in fruit. *b.* Corm. *l.* Leaf. *s.* The remains of the spathe. *c.* Fruit.——*Fig.* 1081. The spadix of the same with the spathe removed; the flowers are all naked and unisexual, a number of pistillate flowers or ovaries being below; above which are some rudimentary ovaries, then a number of sessile anthers and above these are some staminodes or abortive stamens.——*Fig.* 1082. Vertical section of the ovary of the same.——*Fig.* 1083. Vertical section of the seed.

Properties and Uses.—The plants of this order are all more or less acrid, and often highly poisonous. But this acrid principle is frequently volatile, or decomposed by heat; hence it may be in such cases more or less destroyed by drying or exposing to heat the parts in which it is found. The best method of getting rid of the acridity is, however, by boiling in water, as the acrid matter is also commonly soluble in that fluid.

Starch is usually associated with the acrid principle, and when extracted, may be used for food like other starches. The underground stems or corms of many species, when cooked, are eaten in different parts of the world. Some are aromatic stimulants; others expectorant, antispasmodic, or diaphoretic.

Acorus Calamus, Sweet Flag.—The rhizome is an aromatic stimulant, and is regarded by many as a valuable medicine in agues, and as a useful adjunct to other stimulants and bitter tonics. It is official in the United States and German Pharmacopœias. It is reputed to be sometimes employed by the rectifiers of gin. The candied rhizomes are employed by the Turks as a preventive against contagion. In India the rhizome is occasionally used as an insectifuge and insecticide, more especially in relation to fleas. The volatile oil which may be obtained from it by distillation is employed for scenting snuff, and in the preparation of aromatic vinegar.

Arisæma atrorubens, Dragon Root, Indian Turnip.—From the corm of this plant a nutritious fecula is obtained in the United States. The corm is also given internally as a stimulant, in rheumatism, and in bronchial and other affections, and is likewise used extensively as an application to aphthous affections in children.

Arum.—The underground stems or corms of some of the species of this genus contain a large quantity of starch: thus those of *A. maculatum*, Wake-Robin, Cuckoo-pint, or Lords and Ladies, a common native of this country, are the source of what has been called Portland Sago or Arrowroot; a peck of corms yielding about 3 lbs. of starch. But the preparation of this starch is now, in a commercial point of view, given up. Formerly the corms were also used medicinally as diuretics and expectorants. When fresh, they act as an irritant poison.—*A. campanulatum* and *A. indicum* produce edible corms.

Caladium bicolor.—The corms of this and other species, when cooked, are edible. They are sometimes, but improperly, called 'Yams' in tropical countries. (See *Dioscorea.*)

Calla palustris has acrid rhizomes, but by drying, washing, grinding, and baking, these have been made into a kind of bread in Lapland.

Colocasia.—*C. esculenta* and other species have large fleshy corms which are much used in the West Indies, Madeira, &c., as food, under the names of Yams (see *Caladium bicolor*), Cocoes, or Eddoes.—*C. himalensis* has also edible corms. They are used for food in the Himalayas.—*C. antiquorum* is applied to a like purpose in Egypt, and the corms of *C. macrorhiza* are also eaten in the South Sea Islands under the name of Tara.

Dracontium.—The fresh roots of *D. polyphyllum* are in repute in Malabar for their antispasmodic properties.

Rhaphidophora vitiensis, which is probably a variety of *R. pertusa*, is said by Holmes to be the botanical source of the fibrous portion of the remedy now known under the name of 'Tonga,' which is used as a remedy in neuralgia. Its native name is 'Nai Yalu,' or 'Walu.' A. W. Gerrard has found this portion to contain a volatile alkaloid, which he has named *tongine*. The other constituent of Tonga is said to be the inner bark of *Premna taitensis*. (See *Premna.*)

Symplocarpus fœtidus, Skunk Cabbage.—The root has a very fœtid odour, especially when fresh. It is considered in the United States as an efficacious nervine stimulant, and has been used in spasmodic asthma, whooping-cough, catarrh in old people, and in other diseases. Its properties are much impaired by keeping.

Order 4. LEMNACEÆ, the Duckweed Order.—Character.—Floating aquatic plants (*fig.* 252), with lenticular or lobed leaves or fronds. *Flowers* 2 or 3, enclosed in a spathe (*fig.* 1084), monœcious, placed on the margin (*fig.* 252) or surface of the frond, or in the axils of leaves. *Perianth* none. *Male flower* with 1 (*fig.* 1080) or a few stamens, which are often monadelphous. *Female flower* consisting of a 1-celled ovary (*fig.* 1085), with 1 or more erect ovules. *Fruit* 1- or more seeded,

FIG. 1084.

FIG. 1085.

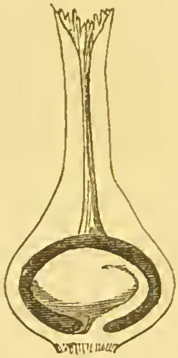


Fig. 1084. A monœcious head of flowers of a species of Duckweed (*Lemna minor*), consisting of two male flowers, each of which is composed of a solitary stamen with a quadrilocular anther; and one pistillate flower in the centre; the whole surrounded by a spathe.——*Fig.* 1085. Vertical section of the pistil of the same.

membranous or baccate, indehiscent or sometimes dehiscent. *Embryo* straight, cleft, in the axis of fleshy albumen.

Distribution, Numbers, and Properties.—They inhabit cool, temperate, and tropical regions. *Illustrative Genera*:—Lemna, *Linn.*; Pistia, *Linn.* There are above 20 species. Their properties are unimportant.

Cohort 3. *Liliales.*—Flowers hermaphrodite or very rarely unisexual, in spikes, racemes, umbels, or panicles, or solitary; or rarely capitate. Perianth in 6, or very rarely 4, 8, or 10 nearly similar distinct pieces, or united and commonly 6-lobed, regular or rarely irregular, usually all petaloid or green, or sometimes coriaceous or subglumaceous. Embryo immersed in copious albumen (not external to or in a lateral cavity). Leaves usually parallel-veined, or very rarely net-veined.

Order 1. LILIACEÆ, the Lily Order.—Character.—*Herbs* (*fig.* 242), *shrubs* (*fig.* 409), or *trees* (*fig.* 196), with bulbs (*figs.* 239-242), rhizomes (*fig.* 234), tubers, or fibrous roots. *Stem* simple or branched (*fig.* 196). *Leaves* with parallel or rarely reticulated veins, sessile or sheathing, sometimes succulent (*fig.* 1087, *l*). *Flowers* regular (*figs.* 28, 429, and 1086), variously arranged or solitary. *Perianth* green or petaloid, inferior (*figs.* 28 and 1089), usually regular and 6-leaved (*figs.* 28

and 1086) or 6-partite (*fig.* 1087). *Stamens* 6 (*figs.* 28 and 1086), or rarely more, or 3 in *Ruscus*, inserted on the perianth (*fig.* 1089), or rarely on the thalamus; *anthers* introrse (*figs.* 523 and 1089). *Ovary* superior (*figs.* 28, 523 and 1084), 3-celled, or very rarely 4—6-celled, with numerous ovules on axile placentas (*figs.*

FIG. 1086.

FIG. 1087.

FIG. 1089.

FIG. 1088.

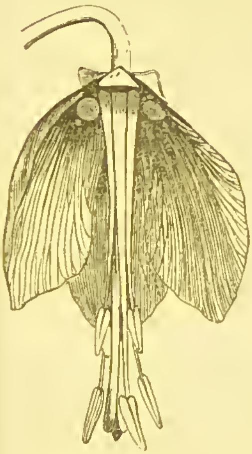


FIG. 1091.

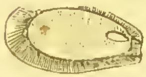


FIG. 1090.

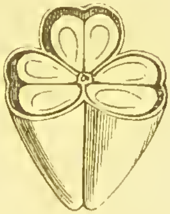


Fig. 1086. Diagram of the flower of a species of Lily. *s.* The three outer divisions of the perianth. *p.* The three inner. *e.* The stamens. *c.* Three-celled ovary.——*Fig.* 1087. Raceme of flowers *f*, and portion of the succulent leaf *l*, of a species of *Aloe*.——*Fig.* 1088. Flower of the Crown Imperial (*Fritillaria imperialis*) with half the perianth removed.——*Fig.* 1089. Vertical section of the flower of the Solomon's Seal (*Polygonatum multiflorum*).——*Fig.* 1090. Transverse section of the ovary of the White Lily (*Lilium candidum*).——*Fig.* 1091. Vertical section of the seed of the Crown Imperial.

1086 and 1089); *style* 1 (*figs.* 28 and 1089), or very rarely 3 or more, or absent; *stigma* generally simple (*fig.* 28) or 3-lobed (*fig.* 646). *Fruit* a loculicidal capsule, or succulent and indehiscent, usually 3-celled. *Seeds* with fleshy albumen (*fig.* 1091), numerous.

Diagnosis.—Leaves with usually parallel straight veins, or succulent. Perianth inferior, generally 6-leaved or 6-partite, and regular. Stamens 6, or rarely more, or 3 in *Ruscus*; anthers introrse. Ovary superior, with axile placentation; style 1, usually undivided, or very rarely divided, and sometimes absent. Fruit indehiscent or a loculicidal capsule. Seeds numerous, albuminous.

Division of the Order and Illustrative Genera:—This order has been divided by Baker into three tribes as follows:—

Tribe 1. *Lilieæ.*—Anthers introrse (*fig.* 1089). Styles united (*fig.* 646). Fruit a loculicidal capsule. *Illustrative Genera:* Lilium, *Linn.*; Tulipa, *Linn.*; Scilla, *Linn.*

Tribe 2. *Colchiceæ.*—Anthers extrorse. Styles separate (*fig.* 1092). Fruit a septicidal capsule (*fig.* 669). *This tribe forms the order Melanthaceæ or Colchicaceæ of this volume.*

Tribe 3. *Asparageæ.*—Fruit baccate. *Illustrative Genera:*—Asparagus, *Linn.*; Convallaria, *Linn.*

By Bentham and Hooker this order has been divided into 20 *tribes arranged in* 3 *series, and includes the Colchicaceæ, Smilaceæ, and Philesiaceæ of this volume.*

Distribution and Numbers.—They are widely distributed throughout the temperate, warm, and tropical regions of the globe. There are over 1,360 species.

Properties and Uses.—The plants of this order frequently possess important properties, but there is no great uniformity in them. Some are purgative; others emetic, diuretic, diaphoretic, stimulant, acrid, &c. Several yield astringent substances, and many produce valuable fibres. The bulbs, young shoots, roots, and seeds of others are highly esteemed, and largely consumed as articles of food and condiments.

Allium.—The bulbs of several species of this genus are well known dietetical articles, and are extensively used as condiments under the names of Onion, Garlic, Leek, &c. Garlic and Onion are also sometimes employed in medicine; thus, externally applied, they are rubefacient, &c., and internally administered they are stimulant, expectorant, diuretic, and somewhat anthelmintic. Garlic is still official in the United States Pharmacopœia. All the species yield an acrid volatile oil, containing sulphur as one of its ingredients. Some species when cultivated in warm dry regions lose much of their acridity and powerful taste, as the Portugal, Spanish, and Egyptian Onions.—*A. sativum* is the common Garlic; *A. Cepa.* the Onion; *A. Porrum*, the Leek; *A. Schœnoprasum*, the Chive; *A. Scorodoprasum*, the Rocambole; *A. ascalonicum*, the Shallot.

Aloe.—The species of this genus have succulent leaves (*fig.* 1087, *l*). The purgative drug Aloes is the inspissated juice obtained from the parallel brownish-green vessels found beneath the epidermis of the leaves. Several commercial varieties of Aloes are known, but the origin of some is not accurately determined.—*Aloe vulgaris* yields the kind called Barbadoes Aloes.—*A. Perryi* has been proved to be the principal, if not the only, source of Socotrine Aloes, and also of the kind commonly known as Hepatic Aloes, for, as was first shown by Pereira, the difference between these two kinds may be readily accounted for by difference of preparation in the two respectively. Socotrine and Barbadoes Aloes are official in the British

Pharmacopœia.—*Cape Aloes* is yielded by *A. spicata*, *A. ferox*, and several other species. Other commercial varieties of Aloes are known as Natal Aloes, Indian Aloes, Aden or Black Aloes, Curaçoa Aloes, &c. Their sources are not accurately known. Aloes is used in small doses as a tonic, and in larger doses as a purgative and emmenagogue. Aloes contains a crystalline principle termed *aloin*, to which its purgative properties are in a great measure due. Aloin is official in the British Pharmacopœia.

Asparagus.—*A. officinalis*, Asparagus.—The young succulent shoots, called *turios*, when boiled, are highly esteemed as an article of food. These and the roots and flowering stems are sometimes employed as diuretics. The juice of Asparagus has marked diuretic properties, and is deserving of more attention than it has of late years received. Asparagus is also popularly employed as a lithontriptic. The roasted seeds have been used as a substitute for coffee.

Asphodelus ramosus, a native of Turkestan, yields a tuber called *Schiresch*, which is employed as a diuretic and emmenagogue The Morocco drug called *Ablaluz* is also said by Leared and Holmes to be derived from this plant.

Camassia esculenta has edible bulbs, which are used by the North American Indians under the name of *Quamash.* They are also known as Biscuit-roots.

Convallaria majalis, Lily of the Valley.—All parts of this plant have long had a reputation in Russia in the treatment of dropsy, and have been much employed of late years in this country and elsewhere, and frequently with good effects, in organic diseases of the heart, &c. Convallaria appears to resemble digitalis, more than that of any other substance, in its action, but is not identical with it. Its properties seem to be principally due to a glucosidet, ermed *convallamarin*, but also to some extent to another glucoside—*convallarin.*

Dracæna Draco, the Dragon Tree of Teneriffe (*fig.* 196), yields a red resin resembling Dragon's Blood, but it is not now known in commerce. (See *Calamus* and *Pterocarpus.*) The roots of *D. terminalis*, the Ti Plant, are baked, and eaten largely by the inhabitants of the Sandwich Islands. A fermented beverage is also obtained from the juice of this plant; and its leaves are employed as fodder for cattle, and for clothing and other domestic purposes.

Lilium.—The bulbs of some species, as those of *L. tenuifolium*, *L. kamtschaticum*, and *L. spectabile*, are commonly eaten in Siberia.

Phormium tenax.—This plant is a native of New Zealand. The fibre obtained from its leaves possesses great strength; it is commonly known under the name of New Zealand Flax. It is much used for twine and cordage, and occasionally for linen, &c. It was recommended many years ago for paper-making, but although a very strong paper may be prepared from it, very little commercial progress has been made with this material. Its root has been recommended as a substitute for Sarsaparilla; and recently it and the leaves have been stated to possess vulnerary properties.

Polygonatum officinale or *vulgare.*—The rhizomes of this, and probably those of *P. multiflorum*, are sold in the herb shops under the name of Solomon's Seal. They are employed as a popular application to remove the marks from bruised parts of the body.

Ruscus aculeatus, Butcher's Broom (*fig.* 409), has aperient and diuretic roots, which were formerly much employed in visceral diseases. The roasted seeds have been used as a substitute for coffee.

Sanseviera zeylanica and other species produce very strong and tough fibres, which are known under the names of African Hemp and Bowstring Hemp.

Trillium.—The root of *T. erectum* (*pendulum*), under the name of Beth Root, is used in the United States, and is regarded as astringent, tonic, and antiseptic. It is especially useful in menorrhagia.

Urginea.—U. Scilla (*Scilla maritima*).—The bulb of this species is the official Squill. It is a valuable medicine; in small doses acting as an expectorant and diuretic, and in larger doses as an emetic and cathartic. In excessive doses it is a narcotico-acrid poison. Two active principles have been known for some time as contained in Squill, one of which has been reputed to possess expectorant and diuretic properties and not poisonous; and the other without any value in medicine, but acting simply as an irritant poison: the former has been called *scillitin*, the latter *sculein*. Merck has more recently, however, found three principles, which he terms *scillitoxin*, *scillipicrin*, and *scillin*, and he infers that the medicinal activity of Squill depends upon the two former.—*U. indica* and some other species appear to have similar properties to the official Squill.

Xanthorrhœa.—The species of this genus are commonly known in New South Wales, where they are natives, under the name of Grass-trees. Their tops afford fodder for cattle, and their young leaves and buds are eaten as a vegetable. From *X. arborea*, *X. hastilis*, and others, two resins are obtained; one of which is known as the Yellow Resin of New Holland or Botany Bay Resin, the other as the Red Resin of New Holland or Black-boy Gum. The latter appears to be the produce of *X. hastilis*. Both resins exude spontaneously from the trunks of the trees, and both possess a fragrant balsamic odour. They have been recommended for use in the preparation of pastilles, and medicinally in those cases where tolu and other balsams are employed.

Yucca gloriosa and other species which are commonly known under the name of Adam's Needle yield fibres, but these are little used. The leaves of *Y. baccata*, *Y. brevifolia*, *Y. Whipplei*, and *Y. angustifolia*, natives of New Mexico, Arizona, and of South California, have been recommended recently as a valuable material for paper manufacture.

Order 2. COLCHICACEÆ or MELANTHACEÆ.—The Colchicum Order.—Character.—*Herbs*, with bulbs, corms (*figs.* 246 and 1092), tubers, or fibrous roots. *Flowers* regular (*figs.* 1092 and 1093), usually hermaphrodite, or rarely unisexual. *Perianth* inferior, white, green, or purple (*fig.* 1092), 6-partite or 6-leaved. *Stamens* 6 (*figs.* 519 and 1093); *anthers* extrorse (*fig.* 519). *Ovary* superior or nearly so, 3-celled, with axile placentation (*fig.* 1093); *style* 3-partite (*fig.* 1092); *stigmas* 3. *Fruit* 3-celled (*fig.* 1094), 3-valved, with usually septicidal dehiscence (*fig.* 669). *Seeds* numerous: *embryo* minute, in fleshy albumen (*fig.* 1095).

By Bentham and Hooker the plants of this order (see Liliaceæ) are now placed, according to the views of Baker, in the Liliaceæ.

Diagnosis.—Herbs. Flowers regular, hermaphrodite or rarely unisexual. Perianth inferior, 6-partite or 6-leaved. Stamens 6; anthers extrorse. Ovary superior; style 3-partite. Fruit a septicidal or very rarely a loculicidal capsule, 3-celled, 3-valved, membranous. Seeds numerous, albuminous.

Distribution and Numbers.—Generally diffused, but most abundant in Europe, North America, and the northern parts of Asia. *Illustrative Genera:*—Colchicum, *Linn.*; Tofieldia, *Hudson*. There are about 150 species.

Properties and Uses.—The plants of this order are almost universally poisonous owing to the presence of powerful alkaloids. But in proper doses several are valuable medicines, possessing emetic, purgative, diuretic, acrid, and narcotic properties.

Schœnocaulon officinale (*Asagræa officinalis*).—This plant, a native of Mexico, is the source of the official Cevadilla or Sabadilla, of the British Pharmacopœia. Cevadilla is principally employed as a source of the alkaloid *veratrine*, which appears to be contained only in the seeds; these are therefore alone official for its preparation. The alkaloid is also official, but as obtained by the Pharmacopœia process it is not quite pure, but is probably a mixture of alkaloids. Veratrine has been used externally, as a rubefacient, in rheumatism, gout, and neuralgic affections, and also internally in similar affections in doses of one-twelfth to one-sixth of a grain. It is a most powerful poison. Cevadilla seeds have been employed internally as an anthelmintic. They are sometimes called *lice seeds*, because when powdered and applied externally they destroy vermin.

Colchicum.—*C. autumnale*, Colchicum or Meadow Saffron.—Both the seeds and corms of this plant are official in the British, Indian, and United

FIG. 1092.

FIG. 1093.

FIG. 1094.

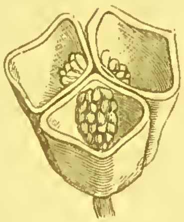


FIG. 1095.

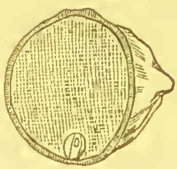


Fig. 1092. Flowering plant of the Colchicum or Meadow Saffron (*Colchicum autumnale*).——*Fig.* 1093. Diagram of the flower of the same, with six divisions to the perianth arranged in two whorls, six stamens, and a 3-celled ovary.——*Fig.* 1094. Transverse section of the capsule.——*Fig.* 1095. Vertical section of the seed.

States Pharmacopœias. They are employed medicinally in gout and rheumatism; but in improper doses they act as a narcotico-acrid poison. They owe their properties essentially to a peculiar alkaloid, called *colchicine*, which has been also used medicinally in similar diseases to colchicum. In chronic rheumatism and in neuralgic affections of the joints, hypodermic injections of colchicine have also been found useful. The once celebrated French nostrum for gout, called *Eau médicinale d'Husson*, owed its properties to Colchicum. The flowers and leaves, more especially the latter, are poisonous to cattle, and hence this plant, which, moreover, occupies a considerable space, as it has large leaves, should be eradicated as far as possible from the pastures in which it is found. The *Hermodactyls* of the Greek physicians and Arabians, and which were largely employed by them in diseases of the joints, have been shown by Planchon to have been the corms of *C. variegatum*, the source also of the Hermodactyls of the present day. Some other Hermodactyls had a different origin.

Veratrum.—The rhizomes and rootlets of *V. album* are commonly known as White Hellebore roots. They contain several bases, the more important being the alkaloid *veratrine*, and another peculiar alkaloid termed *jervine*. White Hellebore is a narcotico-acrid poison. It has been employed as an errhine, and for destroying vermin; and internally as a purgative and anodyne in gout, &c. The dried rhizome and rootlets of *V. viride*, Green Hellebore, are now much employed in the United States, and to some extent elsewhere, under the name of American Hellebore or Green Hellebore, as an arterial sedative in inflammatory affections. John Harley describes its action as occupying a position intermediate between colchicum and digitalis. Green Hellebore rhizome and rootlets are official in the British, Indian, and United States Pharmacopœias.

Order 3. SMILACEÆ, the Sarsaparilla Order.—Character.—*Herbs* or *shrubs*, more or less climbing (*fig.* 1096). *Leaves* petiolate (*fig.* 1096), net-veined, articulated. *Flowers* regular, unisexual and diœcious, or hermaphrodite. *Perianth* inferior, 6-partite, with all its divisions alike. *Stamens* 6, perigynous or rarely hypogynous; *anthers* introrse. *Ovary* superior, 3- 5- or

FIG. 1096.

Fig. 1096. Portion of a branch, with leaves and fruit, of *Smilax papyracea*.

rarely 1-celled, with orthotropous ovules; *stigmas* 3. *Fruit* baccate (*fig.* 1096), few or many-seeded. *Seeds* with a minute embryo, in hard albumen. *This order, as we have already noticed, is included in Liliaceæ by Bentham and Hooker.*

Distribution and Numbers.—The species of this order are scattered over various parts of the world, both in tropical and temperate climates; they are, however, most abundant in tropical America. *Illustrative Genera:*—Smilax, *Linn.*; Ripogonum, *Forst.* These are the only genera; there are probably about 120 species, but some botanists make the number considerably more.

Properties and Uses.—The plants of this order generally possess alterative properties.

Ripogonum parviflorum has similar properties to Sarsaparilla. (See *Smilax.*) It is a native of New Zealand, where it is much used as a remedial agent.

Smilax.—The roots of several species or varieties of *Smilax* constitute the Sarsaparilla of the Materia Medica, which is commonly regarded as a valuable alterative. It is extensively employed in syphilis, various cutaneous diseases, rheumatism, and many other affections. Several kinds of Sarsaparilla are known, of which the most esteemed is that called Jamaica Sarsaparilla, although it is not the produce of that island, but of Central America. It is obtained from *S. officinalis.* This kind is alone official in the British Pharmacopœia. Other kinds of Sarsaparilla distinguished in commerce, are Mexican or Lean Vera Cruz, from *S. medica*; Lisbon, Para, or Brazilian, from *S. papyracea*, and probably also from *S. officinalis*; Guatemala, from *S. papyracea*; Honduras, from also, I believe, *S. papyracea*; and Guayaquil, from an unknown species. Several other species of *Smilax* are likewise in use in different parts of the world, as *S. aspera* in the South of Europe, where its roots are termed Italian Sarsaparilla; *S. glabra*, *S. lancifolia*, *S. ovalifolia*, and *S. prolifera* in India; *S. glycyphylla* in Australia, *S. Macabucha* in the Philippines, and *S. anceps* in the Mauritius, &c.—*S. China* is commonly regarded as the source of the China Root of the Materia Medica; but others refer it to *S. ferox* of Wallich. Several spurious China Roots are in use in America; their sources are doubtful.

Order 4. ROXBURGHIACEÆ, the Roxburghia Order.—Character.—Twining *shrubs* with tuberous roots. *Leaves* net-veined, leathery, broad. *Flowers* large and showy, solitary, hermaphrodite. *Perianth* inferior, with 4 petaloid divisions. *Stamens* 4, hypogynous, with enlarged connectives; *anthers* introrse, apicilar. *Ovary* superior, 1-celled, with a basal placenta; *stigma* sessile. *Fruit* 2-valved, 1-celled. *Seeds* numerous, in 2 stalked clusters, anatropous; *embryo* in the axis of fleshy albumen.

Distribution, Numbers, and Properties.—They are natives of the hotter parts of the East Indies. There is but one genus, Roxburghia, *Dryand.*, which includes 4 species. Their properties are unimportant.

Order 5. PHILESIACEÆ, the Philesia Order.—*Diagnosis, &c.*—The plants of this order are closely allied to the Roxburghiaceæ, from which, however, they are readily distinguished by their hexamerous perianth and andrœcium, perigynous stamens, parietal placentation, long style, and semi-anatropous ovules. They are natives of Chili. There are 2 genera—Philesia, *Commers.*; and Lapageria, *R. et P.*—and 2 species. In their properties they are said to resemble Sarsaparilla. (See *Smilax.*) *This order is included in Liliaceæ by Bentham and Hooker.*

Order 6. JUNCACEÆ, the Rush Order.—Character.—Sedge or grass-like *herbs*, rhizomatous or with tufted or fibrous roots. *Leaves* with parallel veins, fistular or more or less flattened and grooved. *Flowers* regular (*fig.* 1097). *Perianth* inferior, 6-partite (*fig.* 1097), scale-like or coriaceous, greenish or brown, persistent. *Stamens* 6 (*fig.* 1097), or rarely 3, perigynous; *anthers* introrse, 2-celled. *Ovary* superior (*fig.* 1097), 1—3-celled; *style* 1 (*fig.* 1097), *stigmas* 3 (*fig.* 1097) or 1. *Fruit* a loculicidal capsule, 3-celled, 3-valved, and with 1 or many seeds in each cell; rarely 1-celled, 1-seeded, and indehiscent; *embryo* very minute, in fleshy or horny albumen (*fig.* 1098); *radicle* inferior.

Distribution and Numbers.—A few are found in tropical regions, but the mass of the order inhabit cold and temperate climates. *Illustrative Genera:*—Juncus, *DC.*; Luzula, *DC.* There are about 200 species.

Properties and Uses.—Their medicinal properties are unimportant, although some have a reputation as anthelmintics and

FIG. 1097.

FIG. 1098.

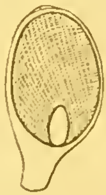


Fig. 1097. Flower of a species of Wood-rush (*Luzula*), having an inferior perianth with 6 divisions, 6 stamens, and a superior ovary with 1 style and 3 stigmas.——*Fig.* 1098. Vertical section of the seed of the same.

diuretics. The pale cellular tissue at the base of some of the leaves of certain species is occasionally eaten. The chief use, however, to which the plants of this order are applied, is in making floor mats, and the bottoms of chairs, &c. The leaves of the species of *Juncus* are employed for these purposes. The internal cellular substance of the fistular leaves of *Junci*, which is commonly called the pith, is employed for the wicks of rush-lights. In China, a decoction of this cellular matter is also much used as a cooling medicine in febrile affections. It is likewise employed in the manufacture of sun-hats, resembling those made in India from *Æschynomene aspera*, but they are not so durable as the *Sola* or *Shola* hats of Calcutta. (See *Æschynomene.*)

Cohort 4. *Pontederales.*—Flowers hermaphrodite, in spikes, panicles, or heads. Perianth of 2 segments or 6 in two whorls, all petaloid. Style simple. Fruit capsular; placentation axile. Seeds with abundant mealy or fleshy albumen;

with the embryo immersed—that is, not external to, or in a lateral cavity of the albumen. Marsh or water herbs.

Order 1. PONTEDERACEÆ, the Pontederia Order.—Character.—Aquatic *herbs*. *Leaves* sheathing at the base, with occasionally dilated petioles. *Flowers* hermaphrodite, irregular, spathaceous. *Perianth* inferior, 6-partite, petaloid, tubular, persistent, rolling inwards after flowering. *Stamens* 3 or 6, inserted on the segments of the perianth ; *anthers* introrse. *Ovary* superior ; *style* 1 ; *stigma* simple. *Fruit* capsular, occasionally somewhat adherent to the persistent perianth. *Seeds* numerous, with mealy albumen.

Distribution, Numbers, and Properties.—They are natives of the East Indies, Africa, and America. *Illustrative Genera* :—Leptanthus, *L. C. R.* ; Pontederia, *Linn.* There are above 30 species. Their properties are unimportant.

Order 2. PHILYDRACEÆ, the Water-wort Order.—Character.—*Herbs*, with fibrous roots. *Leaves* equitant, ensiform, sheathing. *Flowers* surrounded by a spathaceous persistent bract, hermaphrodite. *Perianth* inferior, 3-partite, petaloid, the two upper segments united so that it appears to consist of 2 segments. *Stamens* 3, 2 of which are barren and petaloid, and all united to the anterior lobe of the perianth ; *pollen* united in masses of four. *Ovary* superior, 3-celled, with axile placentas ; *style* simple ; *stigma* capitate. *Fruit* a loculicidal capsule. *Seeds* numerous, with an embryo in the axis of fleshy albumen.

Distribution, Numbers, and Properties.—They are natives of China, Cochin China, and Australia. There are 2 genera (Philydrum, *Banks*, and Hetæria, *Endl.*) and 2 species. Their properties and uses are unknown.

Cohort 5. *Commelynales.*—Flowers hermaphrodite, in spikes, panicles, heads, or solitary. Perianth regular or irregular, of 6 segments in two whorls, 3 outer green or sub-glumaceous, 3 inner petaloid. Fruit capsular ; placentation parietal or axile. Embryo outside the albumen, or in a distinct cavity in its side.

Order 1. COMMELYNACEÆ, the Spiderwort Order.—Character.—*Herbs*, with flattened, narrow, usually sheathing *leaves*. *Perianth* inferior, more or less irregular, in six parts arranged in two whorls ; the outer parts being green, persistent, and opposite to the carpels ; the inner petaloid. *Stamens* 3 or 6, some generally abortive, hypogynous ; *anthers* 2-celled, introrse. *Ovary* 3-celled, superior ; *style* 1. *Capsule* 2—3-celled, 2—3-valved, with loculicidal dehiscence and axile placentation. *Seeds* few, with a linear hilum ; *embryo* shaped like a pulley, remote from the hilum, in dense fleshy albumen.

Distribution and Numbers.—They are chiefly natives of India, Africa, Australia, and the West Indies. *Illustrative Genera:*—Commelyna, *Dill.*; Tradescantia, *Linn.* There are above 260 species.

Properties and Uses.—Their properties are unimportant. The rhizomes of some species, as those of *Commelyna tuberosa*, *C. angustifolia*, and *C. striata*, contain much starch, and when cooked are edible. Others have been reputed astringent and vulnerary, and some emmenagogue, &c.

Order 2. Mayaceæ, the Mayaca Order.—*Diagnosis.*—Small Moss-like plants growing in damp places. They are closely allied to Commelynaceæ, from which they differ in their habit; their 1-celled anthers; their 1-celled ovary and capsule with parietal placentas; and in their carpels being alternate to the outer segments of the perianth.

Distribution, Numbers, and Properties.—They are found in America from Brazil to Virginia. *Mayaca*, Aubl., is the only genus, of which there are 4 species. Their properties and uses are unknown.

Order 3. Xyridaceæ, the Xyris Order.—Character.—Sedge-like *herbs*. *Leaves* radical, sheathing, ensiform or filiform. *Flowers* hermaphrodite, in scaly heads. *Perianth* inferior, 6-partite, arranged in two whorls,—the outer sub-glumaceous or scaly, distinct, and opposite the carpels; the inner petaloid, regular, and united. *Stamens* 3, inserted into the base of the outer lobes of the perianth, or sometimes 6; *anthers* 2-celled, extrorse. *Ovary* superior, 1-celled, with parietal placentas. *Capsule* 1-celled, 3-valved. *Seeds* numerous; *embryo* minute, in fleshy or mealy albumen.

The genus Rapatea is sometimes made the type of a distinct order—the Rapateaceæ—which is placed in the cohort Pontederales.

Distribution and Numbers.—Exclusively natives of tropical and sub-tropical regions. *Illustrative Genera:*—Xyris, *Linn.*; Rapatea, *Aubl.* There are about 70 species.

Properties and Uses.—Unimportant. The leaves and roots of some species of *Xyris* have been employed in cutaneous affections.

Cohort 6. *Restiales.*—Flowers hermaphrodite or usually unisexual. Perianth of 2—6 glumaceous or membranous segments in 1—2 whorls, or reduced to scales, or absent. Stamens 1—6; anthers 1—2-celled. Ovary superior, 1—3-celled, usually 3. Ovules solitary, pendulous in each cell, orthotropous. Fruit capsular, rigid, or membranous. Seeds albuminous. Embryo terminal, outside and at the end of the albumen remote from the hilum.

The orders included in Restiales are placed by Bentham and Hooker in their series Glumaceæ. They form a connecting link between the Glumaceæ of this volume and the Petaloideæ.

Order 1. ERIOCAULACEÆ, the Eriocaulon or Pipewort Order. Character.—Aquatic or marsh plants.—*Leaves* clustered, linear, usually grass-like. *Flowers* minute, unisexual, in dense heads, each flower arising from the axil of a membranous bract. *Perianth* membranous, tubular, 2—3-toothed or lobed. *Stamens* 2—6; *anthers* 2-celled, introrse. *Ovary* superior, 2—3-celled. *Fruit* dehiscent, 2—3-celled, 2—3-seeded. *Seeds* pendulous, albuminous, hairy or winged; *embryo* lenticular, at the end of the albumen remote from the hilum.

Distribution, Numbers, and Properties.—Mostly natives of tropical America, and the North of Australia. One species is found in Britain—*Eriocaulon septangulare*, With. The order contains about 200 species. Their properties are unimportant.

Order 2. RESTIACEÆ, the Restio Order.—Character.—*Herbs* or *undershrubs*. *Leaves* simple and narrow, or entirely absent. *Stems* stiff, either naked, or more commonly with slit convolute leaf-sheaths. *Flowers* with glumaceous *bracts*, spiked or aggregated, generally unisexual. No true *perianth*, its place being usually supplied by 2—6 *glumes*. *Stamens* 2—3, adherent to the inner glumes, or the latter are sometimes absent; *anthers* generally 1-celled. *Ovary* 1—3-celled, with 1 pendulous ovule in each cell. *Fruit* capsular or nut-like. *Seed* solitary, pendulous, albuminous; *embryo* lenticular, terminal.

Distribution and Numbers.—Natives principally of South Africa, South America, and Australia. Some are also found in the tropical parts of Asia; but none occur in Europe. *Illustrative Genera*:—Leptocarpus, *R. Br.*; Restio, *Linn.* There are about 180 species.

Properties and Uses.—Unimportant. The wiry stems of some species have been used for basket-making, &c., and for thatching.

Order 3. DESVAUXIACEÆ, the Bristlewort Order.—Character.—Small Sedge-like *herbs*, with setaceous sheathing *leaves*. *Flowers* glumaceous, enclosed in a terminal spathe. *Glumes* 1 or 2. *Paleæ* none, or 1 or 2 scales parallel with the glumes. *Stamens* 1 or very rarely 2; *anthers* 1-celled. *Carpels* 1—18, distinct or partially united, with 1 stigma and 1 pendulous ovule in each ovary. *Fruit* composed of as many utricles as there are carpels. *Seeds* albuminous; *embryo* lenticular, terminal.

Distribution, Numbers, and Properties.—Natives of Australia and the South Sea Islands. *Illustrative Genera*:—Desvauxia, *R. Br.*; Aphelia, *R. Br.* There are about 15 species. Their properties and uses are unknown.

Sub-class II. *Glumaceæ.*

Cohort 1. *Glumales.*—Flowers hermaphrodite or unisexual, and arranged in spikelets, or rarely solitary, in the axils of glumes. No true perianth, but its place supplied by minute scales, hairs, or bristles, or these are absent. Stamens usually 1—3, rarely more; anthers 2-celled. Ovary superior, 1-celled, with 1 erect or ascending ovule. Fruit a caryopsis. Seeds with mealy or fleshy albumen. Embryo enclosed in the base of the albumen, or outside at the base.

Order 1. CYPERACEÆ, the Sedge Order.—Character.—Grass-like or Rush-like, usually perennial *herbs* (*fig.* 235). *Stems* solid, without joints or partitions, frequently angular (*fig.* 1099). *Leaves* without ligules, and with entire or closed sheaths round the stem (*fig.* 1099). *Flowers* spiked, imbricate, hermaphrodite (*fig.* 1102) or unisexual (*figs.* 1100 and 1101), each arising from the axil of 1—3 bracts or glumes. (*The lower-*

FIG. 1099.

FIG. 1100.

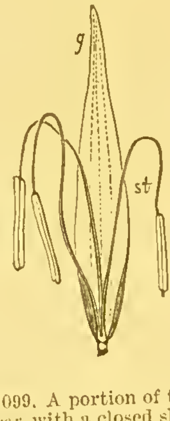


FIG. 1101.

Fig. 1099. A portion of the angular stem of a species of *Carex*, with a closed sheath.——*Fig.* 1100. Staminate flower of a species of *Carex*. *st.* Stamens, with long filaments and pendulous innate anthers. *g.* Glume.——*Fig.* 1101. Pistillate flower of a species of *Carex*, consisting of a glume at the base, and a pistil surrounded by an urn-shaped tube (*perigynium*), *u*. *st.* Style, terminated by three stigmas.

most glumes are frequently empty, that is, without flowers in their axils.) *Perianth* absent, or existing in the female flowers in the form of a tube (*perigynium*) (*fig.* 1101, *u*), or as hypogynous scales or bristles (*fig.* 1102, *b*). *Stamens* hypogynous (*fig.* 1102), 1—12, commonly 3 (*figs.* 1100 and 1102): *anthers* 2-celled, innate (*figs.* 1100 and 1102). *Ovary* 1-celled, superior, (*fig.* 1102), with 1 erect anatropous ovule. *Fruit* indehiscent, 1-seeded (*fig.* 1103). *Seed* with fleshy or mealy albumen (*fig.* 1103, *alb*) : *embryo* lenticular (*figs.* 1103, *pl*, and 1104), enclosed in the base of the albumen (*fig.* 1103).

Diagnosis.—Grass-like or Rush-like herbs with solid and usually angular stems. Leaves without ligules and with entire sheaths. Stamens few, hypogynous ; anthers innate, 2-celled. Ovary superior, 1-celled ; ovule solitary, erect, anatropous. Fruit indehiscent, 1-celled, 1-seeded. Embryo enclosed in the base of the albumen.

Distribution and Numbers.—Natives of all parts of the world, and found especially in marshes, ditches, and about running

FIG. 1102.

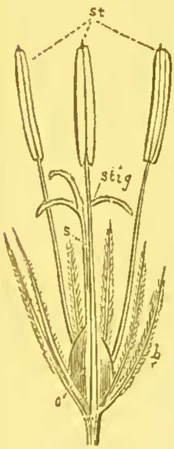


FIG. 1103.

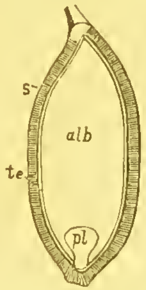


FIG. 1104.

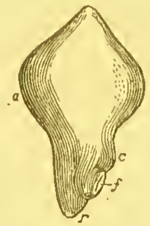


Fig. 1102. Hermaphrodite flower of a species of Club-rush (*Scirpus*), the glume having been removed. *b*. Hypogynous setæ or bristles forming a kind of perianth. *st*. Hypogynous stamens with 2-celled innate anthers. *o*. Ovary. *s*. Style. *stig*. Stigmas.——*Fig.* 1103. Vertical section of the fruit of a species of *Carex*. *s*. Pericarp. *te*. Integuments of the seed. *alb*. Albumen. *pl*. Embryo.——*Fig.* 1104. Embryo of a species of *Carex* removed from the albumen. *a*. Lateral swelling. *r*. Radicle. *c*. Cotyledon. *f*. Slit corresponding to the plumule.

streams. *Illustrative Genera* :—Carex, *Linn.* ; Cyperus, *Linn.* ; Scirpus, *Linn.* There are about 2,000 species.

Properties and Uses.—Although closely allied in their botanical characters to the Graminaceæ, the Cyperaceæ are altogether deficient in the nutritive and other qualities which render the plants of the Graminaceæ so eminently serviceable to man and other animals. Indeed the order generally is remarkable for the absence of any important properties. Some of the plants are slightly aromatic, stomachic, and diaphoretic, others demulcent and alterative, and a few have been used for economic purposes. The underground stems of certain species are edible when roasted or boiled. Some of the species by spreading and interlacing their subterranean stems through the sand of the sea-shore, and thus binding it together, prevent it from being washed away by the receding waves, and in this way protect the neighbouring coast from encroachments of the sea. (See also *Properties and Uses of the Graminaceæ.*)

Carex.—The creeping stems of *C. arenaria* and some allied species have been used medicinally as substitutes for sarsaparilla, under the name of German Sarsaparilla.—*C. hirta*, *C. præcox*, and others, are known in different districts under the name of 'Carnation Grasses.' They have erroneously been supposed to cause the disease termed 'Rot' in sheep.

Cyperus.—The rhizomes, tubers, or corms of *C. longus*, *C. rotundus*, *C. pertenuis*, and *C. esculentus*, have been employed in medicine, and regarded as aromatic, tonic, diaphoretic, diuretic, and astringent. The corms or tubers of *C. esculentus* are, under the name of *Chufa* or *Earth Almonds*, used for food in the South of Europe, more especially in Spain, and when roasted have been proposed as a substitute for coffee and cocoa. They are known by the French as Souchet Comestible (Rush Nut). Their chief use in hot European climates is for making an *orgeat*, a refreshing acid drink in hot weather. The boiled corms of *C. bulbosus* are also edible, and are said to taste like potatoes.—*C. textilis* is used for making ropes, &c., in India.—*C. tegetiformis* is much used in China for making hats, matting, &c.

Eriophorum.—The species of this genus are commonly known under the name of Cotton-grasses, from their fruits being surrounded by cottony or downy hairs. These hairs are sometimes used for stuffing cushions, &c. Their leaves are reputed to possess astringent properties.

Papyrus.—*P. nilotica* or *P. ægyptiaca*, the Bulrush of the Nile and the Paper Reed of the ancients, is the true Papyrus of the Egyptians, and the one commonly grown in botanical gardens under that name is the Syrian or Sicilian species (*P. syriaca* or *P. siciliana*). The plant is celebrated on account of the soft cellular tissue contained in its stems having been in common use by the ancients for making a kind of paper. These sheets of papyrus paper are remarkable for their durability. The Papyrus was also used for making ropes, boats, mats, &c. The Sicilian species, *P. siciliana*, has likewise been employed for making paper.—*P. corymbosus* is extensively used in India for the manufacture of the celebrated Indian matting.

Scirpus.—Various species of this genus, as *S. lacustris* and *S. Tabernæmontana*, &c., are much employed, like the true Rushes, for mats, chair-bottoms, baskets, &c., and also by coopers for filling up the intervals in the seams of casks. They are commonly known as Club-rushes or Bulrushes. The root of *S. lacustris* was formerly used as an astringent and diuretic.

Order 2. GRAMINACEÆ, the Grass Order.—Character.—*Herbs*, *shrubs*, or *arborescent plants*, with round, commonly hollow (*fig.* 201), jointed stems. *Leaves* alternate, with parallel veins and split sheaths (*figs.* 374, *g*, and 1105), and with a ligule at the base of the lamina (*fig.* 374, *lig*). *Flowers* hermaphrodite or unisexual, arranged in spiked (*fig.* 418), panicled (*fig.* 419), or racemose locustæ; or solitary. *No true perianth*, its place being supplied by imbricate bracts, of which there are commonly 2, called *glumes*, or rarely 1; these glumes are placed at the base of the solitary flower, or at the base of each locusta (*figs.* 405 and 1106, *gl*, *gl*, and 1107, *ge*, *gi*). *Occasionally the glumes are altogether absent.* Each flower is also usually furnished with two other alternate bracts (*paleæ*) (*figs.* 1107, *pe*, *pi*.), (or sometimes the inner palea *pi* is wanting), the outer palea is frequently termed the *flowering glume*; and 2 or 3 hypogynous scales (*lodiculæ*, *squamulæ*, or *glumellules*) (*figs.* 1106, *p*, *p*, and 1108, *p*); these scales also are occasionally absent. *Stamens* 1—6, usually 3 (*figs.* 1108-1110); *filaments* capillary (*figs.* 505 and 1109); *anthers* 2-celled, versatile (*figs.* 500 and 601). *Ovary* superior (*fig.* 1108), 1-celled, with a solitary ascending ovule; *stigmas* feathery or hairy (*figs.* 601 and 1108). *Fruit* a caryopsis (*figs.* 704 and 705). *Seed* with mealy albumen (*fig.* 704, *a*); *embryo* lenticular (*fig.* 1111), lying on one side of the base of the albumen (*fig.* 705, *c*, *g*, *r*).

FIG. 1105.

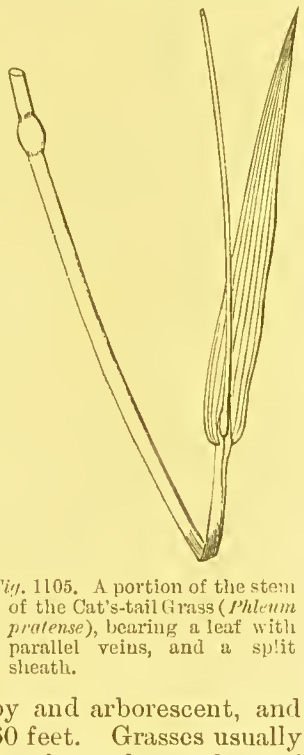


Fig. 1105. A portion of the stem of the Cat's-tail Grass (*Phleum pratense*), bearing a leaf with parallel veins, and a split sheath.

Diagnosis.—Leaves alternate, with split sheaths, and a ligule at the base of the lamina. Flowers generally arranged in spikelets or locustæ, or rarely solitary. Flowers glumaceous; paleæ usually two in each flower. Stamens hypogynous, few, usually 3, with capillary filaments, and versatile anthers. Ovary superior, with a solitary ascending ovule; stigmas feathery or hairy. Fruit a caryopsis. Seed with mealy albumen, with the embryo on one side at the base.

Distribution and Numbers.—Grasses are universally distributed over the globe. In temperate and cold climates they are herbaceous and of moderate height, while in tropical countries they become shrubby and arborescent, and sometimes grow to the height of 50 or 60 feet. Grasses usually grow together in large masses, and thus form the verdure of great tracts of soil, and hence have been termed social plants. *Illustrative Genera*:—Panicum, *Linn.*; Anthoxanthum, *Linn.*; Phleum, *Linn.*; Agrostis, *Linn.*; Dactylis, *Linn.*; Bromus, *Linn.* There are over 4,000 species.

Properties and Uses.—Of all the orders in the Vegetable Kingdom this is the most important to man, as it affords the various fruits, commonly known as Cereal Grains, which supply the principal material of his daily bread in most countries of the world; besides being eminently serviceable in other respects, by supplying fodder for cattle, and yielding sugar and other very useful products. It is a remarkable fact that the native countries of our more important Cereals or Corn producing plants are altogether unknown. A few of the Grasses yield fragrant volatile oils. Paper has long been made from the Bamboo in India, China, and some other parts of the world; and straw is now largely employed for a like purpose in this country and elsewhere. Other Grasses have also, within the last few years, been used to a great extent for making paper. Almost all Grasses are wholesome, but one or more species of *Bromus* have been erroneously reputed to be purgative,

FIG. 1106.

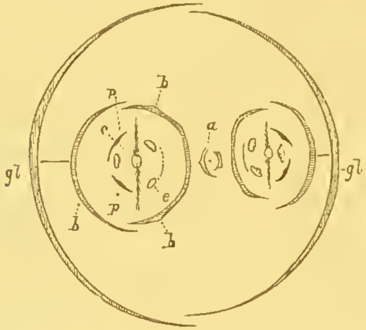


FIG. 1107.

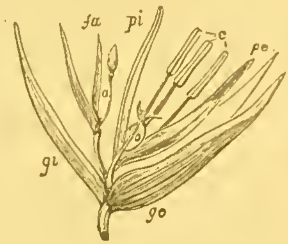


FIG. 1108.

FIG. 1109.

FIG. 1110.

FIG. 1111.

Fig. 1106. Diagram of a spikelet of the Oat (*Avena*). (From Le Maout.) *gl*, *gl*. Two glumes, enclosing two hermaphrodite flowers, and one, *a*, abortive. *b*. The outer palea or flowering glume. *b*, *b*. The inner palea. *p*, *p*. Two scales (*squamulæ* or *glumellules*); the dotted curved line on the right marks the position of a third abortive scale. *e*. Stamens. *c*. Ovary.——*Fig*. 1107. A spikelet (locusta) of the Oat (*Avena sativa*). *ge*. Outer glume. *gi*. Inner glume. *pe*. Outer palea or flowering glume of the fertile flower. *pi*. Inner palea of the same. *e*. Stamens. *o*. Ovary. *fa*, and *a*. Abortive flowers.——*Fig*. 1108. Fertile flower of the Oat, without the paleæ. *p*. Glumellules. *e*. Stamens. *o*. Ovary. *s*, *s*. Feathery stigmas.——*Fig*. 1109. One of the florets of a species of Meadow Grass (*Poa pratensis*).——*Fig*. 1110. One of the florets of the Hard Fescue Grass (*Festuca duriuscula*).——*Fig*. 1111. The embryo of the Oat. *a*. Lateral swelling. *c*. Cotyledon. *r*. Radicle. *f*. Slit corresponding to the plumule.

and one, *Lolium temulentum*, is said to be narcotic and poisonous. The powerful properties of the latter grass may possibly be due to its becoming ergotised, as its effects upon the system closely resemble those produced by the common Ergot.

Paspalum scrobiculatum, an Indian species, is also said to be sometimes unwholesome. *Stipa sibirica* in Kashmir, *Stipa inebrians* in Mongolia, and several of the *Melicæ* of South Africa, have likewise been recently described as deleterious Grasses. Further experiments upon *Lolium* and the other supposed deleterious Grasses are desirable. Some of the species serve to bind together the sand on the seashore, and thus prevent the encroachment of the sea on the neighbouring coast. (See also *Properties and Uses of the Cyperaceæ.*)

Ægilops ovata.—This grass has of late years become noted in consequence of M. Esprit Fabre having stated that the varieties of cultivated Wheat were derived from it and *Ægilops cordata.* This is not strictly correct, however, for the plants grown by M. Fabre, and the grains of which ultimately assumed the form of cultivated Wheat, were produced by hybridisation between a species of *Triticum* and *Ægilops ovata*, the result being the formation of a variety of *Ægilops*, called *Ægilops triticoides.* The seeds of this, by cultivation for about twelve years, are said to have produced a grass like ordinary Wheat; but it is not clear that prolonged cultivation for a series of years has shown any tendency in *Ægilops ovata* towards improvement.

Andropogon.—Several species of this genus are remarkable for their agreeable odours. This fragrance is due to the presence of volatile oils, of which several are used medicinally and in perfumery. These oils are commonly known under the general name of *Grass Oils* or *Indian Grass Oils.* Those which are distilled from the fresh plants of *A. Nardus*, Linn., *A. citratus*, DC., and *A. pachnodes*, Trin. (*A. Schœnanthus*, Linn.), are official in the Pharmacopœia of India.—*Andropogon citratus*, Indian Lemon Grass, is the source of *Lemon-Grass Oil*, which is also termed *Oil of Verbena* and *Indian Melissa Oil.* The plant yielding it is largely cultivated in Ceylon and in the gardens of India. Lemon-Grass Oil is much employed in perfumery under the name of *oil of verbena*, from its odour resembling the Sweet Verbena or Lemon Plant of our gardens. (See *Aloysia* (*Lippia*) *citriodora.*) It is spoken highly of in India as an external application in rheumatism, &c., and for internal use in cholera. It possesses stimulant, carminative, antispasmodic, and diaphoretic properties. The fresh leaves are sometimes used as a substitute for tea, and the centre of the stems for flavouring curries, &c.—*Citronella Oil* or *Oil of Citronelle* is the produce of *Andropogon Nardus.* It is employed in perfumery in England, &c., and in its medicinal properties it closely resembles Lemon-Grass Oil.—*A. pachnodes* is the source of the oil known in India as *Rúsa ka-tel*, or *Rusa Oil.* It is also known as *Oil of Geranium, Oil of Ginger Grass*, or sometimes as *Grass Oil of Namur.* Oil of Geranium is extensively employed in Turkey to adulterate *Otto* or *Attar of Rose.* (See *Pelargonium* and *Rosa.*) It has similar properties and uses to the two preceding volatile oils.—*A. muricatus* has fragrant roots, which are known under the names of *Cuscus* or *Vetti-ver.* It is imported into this country and elsewhere, and used for scenting baskets, drawers, &c. It is also reputed in India to possess stimulant and diaphoretic properties.—*A. laniger*, Desf., is the source of the drug known as *Schœnanthus* or *Juncus odoratus.* (See also *Holcus.*)

Anthistiria.—*A. australis* is the 'Kangaroo Grass' of Australia.—*A. ciliata* is an esteemed Indian fodder-grass.

Arundo Phragmites, the Common Reed.—The culms of this and some other species are much used for thatching and other useful purposes.

Avena sativa, the common Oat.—A great number of varieties of this species are cultivated in the North of Europe, &c., on account of the grains (fruits), which are called Oats. These are extensively used as food for man and other animals. Oats deprived of their husk and coarsely ground form *Oatmeal*. When divested of their husk and integuments they are called *Groats*; and these when crushed constitute *Embden* and *Prepared Groats*. Oats are also employed for the production of alcohol.

Bambusa.—B. arundinacea, the Bamboo, and other species of *Bambusa*, are applied to many useful purposes in warm climates and elsewhere. Good paper is made from them in India, China, &c. The bamboo has been also largely exported from the West Indies to America, &c., for the purpose of being manufactured into paper, and some of very good quality has been made from it. The very young shoots are boiled and eaten like Asparagus, and are also used for pickles and sweetmeats. Their hollow stems are variously employed. In India and China the leaves are reputed to possess emmenagogue properties. Sir Joseph Hooker says, that in some districts 'a very large kind of Bamboo is used for water-buckets, another for quivers, a third for flutes, a fourth for walking-sticks, a fifth for plaiting-work (baskets), a sixth for arrows; while a larger sort serves for bows. The young shoots of one or more are eaten; and the seeds of another, either raw or cooked, are made into a fermented drink. In China the Bamboo is used for numerous purposes—for water-pipes, fishing-rods, for making hats, shields, umbrellas, soles of shoes, baskets, ropes, paper, scaffolding-poles, trellis-work, sails, covers of boats, and katamarans.' The above extract will give some idea of the various uses to which the Bamboos are applied. A solid silicious matter is commonly found in the hollow joints of the bamboo, to which the name of *tabasheer* has been given.

Coix lachryma is remarkable for its hard stony fruits, called Job's tears, which are used for beads. They are also reputed to be diuretic.

Dactylis cæspitosa (*Festuca flabelloides*) is the celebrated Tussac Grass of the Falkland Islands. It is an excellent fodder grass for cattle and horses. It is now grown to some extent in Shetland and some other parts of Britain.

Eleusine.—E. coracana.—The grains of this plant constitute one of the millets of India; in Coromandel it is called *Natchnee*. It is also cultivated in Japan as a corn crop. In Sikkim a kind of beer, called *murwa* or *millet beer*, is prepared from the grains, and is in general use by the natives. (See *Panicum* and *Holcus*.)—*E. Tocussa* is an Abyssinian plant. Its grains are used for food under the name of *Tocussa*.

Gynerium.—G. argenteum is the elegant Pampas Grass.—*G. saccharoides*, a Brazilian species, contains much sugar.

Holcus.—H. saccharatus, *Sorghum saccharatum*, or *Andropogon saccharatum*, is the North China Sugar Cane or Sweet Sorgho. It is cultivated in China and other countries for the purpose of extracting its sugar, of which it is said to yield from 10 to 15 per cent. Its grain is eaten in Africa, and is termed *Dochna*. The plant has been introduced into this country, and has been highly recommended for cultivation as a summer forage for cattle, but at present our knowledge respecting it will not allow of any positive conclusions upon its merits being arrived at. It is now, however, extensively cultivated in the southern and central parts of France as a fodder crop.—*H. Sorghum*, *Sorghum vulgare*, or *Andropogon Sorghum*, of which there are several varieties, is extensively cultivated in Africa, India, &c., for the sake of its grain, which is known as Egyptian Corn, Ivory Wheat, Guinea Corn, Durra, Turkish Millet, and Jaar. This grain is much used for food in warm countries. In this country it has also been employed for feeding poultry. The stems are used in the manufacture of carpet brooms, whisks, &c. A kind of beer called Bouza is also prepared from the grains.

Hordeum, Barley.—Several species or varieties are commonly cultivated in cold and temperate climates for their grains: as *H. distichon*, Two-rowed or Long-eared Barley; *H. vulgare*, Bere, Bigg, Four-rowed or Spring Barley; *H. hexastichon*, Six-rowed Barley; and *H. zeocriton*, Sprat or

Battledore Barley. Barley is used dietetically in the manufacture of bread, and in the form of malt most extensively in the production of ale, beer, and ardent spirits. It is the common grain in use for the latter purposes in this country. *Malt* is Barley which has been made to germinate by moisture and heat, and afterwards dried, by which the vitality of the seed is destroyed. Barley deprived of its husk constitutes *Scotch*, *Hulled*, or *Pot Barley*. When both husk and integuments are removed, and the seeds rounded and polished, they form *Pearl Barley*, which is official in the British Pharmacopœia; this, when ground, is called *Patent Barley*.

Lygeum Spartum, a Spanish grass, yields the fibre known as *albardin*, which is frequently mistaken for Esparto. (See *Stipa*.) It is used like it for paper-making.

Molinia cærulea is said to be equal in value to Esparto Grass (see *Stipa*) for paper-making. Its especial value resides in the tenacity of its fibre, and the comparatively minute quantity of silica it contains.

Oryza sativa is the Rice plant, the grain of which is more extensively used for food than that of any other cereal. Starch is also largely prepared from rice; it is official in the British Pharmacopœia under the head of Amylum, together with Wheat Starch and Maize Starch. From forty to fifty varieties of the Rice plant are known and cultivated in India alone; others have distinguished as many as 160 varieties. Rice appears to be less nutritive than the other cereal grains, and to be of a more binding nature, hence its use in diarrhœa, &c. Spirit is sometimes distilled from the fermented infusion of rice. This spirit is frequently called *arrack*, but that name is properly used only in reference to the spirit distilled from Palm wine or Toddy.

Panicum.—*P. miliaceum* yields Indian Millet. The grain is called Warree and Kadi-kane in the East Indies.—*P. spectabile*, a Brazilian species, grows six or more feet in height. It is a favourite fodder grass, and is commonly known as the Angola grass.—*P. jumentorum* is another fodder grass called Guinea grass.—*P. pilosum* yields a grain known in India as Bhadlee. The grain of *P. frumentaceum* is also nutritious. It is termed Shamoola in the Deccan. Some of the Tartar tribes are said to prepare a kind of beer from a species of Millet, which is called Bouza, Murwa, or Millet-beer, but this is probably not obtained by them from a species of *Panicum*, but from a species of *Eleusine*. (See *Eleusine*.)

Paspalum.—*P. exile* yields the smallest known cereal grain. This grain is known on the West Coast of Africa, where it is used as food, under the name of Fundi or Fundungi. It is also commonly called in Sierra Leone, Millet.—*P. scrobiculatum* also yields a kind of grain, known in India as Menya or Kodro. A variety of this grass is reputed to be injurious to cattle.

Penicillaria spicata (*Panicum spicatum*) is called Caffre Corn. It yields a serviceable grain, which is commonly distinguished as African Millet.

Pennisetum dichotomum.—The grains of this grass are known in some parts of Western Africa under the name of *kasheia*. They are used there as food. In Egypt and Arabia this grass is employed as fodder for camels and other animals, and also for thatching and other purposes.

Phalaris canariensis, Canary Grass, is cultivated for its grain, which is employed as food for birds, under the name of Canary seed. Its straw is also valued as fodder for horses.

Poa abyssinica is an Abyssinian corn plant, known under the name of *Teff*. The grains are sometimes employed in the preparation of Bouza or Millet beer. (See *Eleusine* and *Panicum*.)

Saccharum officinarum is the Common Sugar-cane, so extensively used for the preparation of Cane-sugar or Sucrose. *Molasses* is the drainings from raw sugar; and *treacle* the thick juice which has drained from refined sugar in the sugar-moulds. *Caramel* is burnt sugar. *Sugar-candy*, *pulled* *sugar*, *barley-sugar*, and *hard-bake*, are all familiar preparations of sugar. Both molasses and treacle are capable of fermentation by yeast; and then yield by distillation rum. Refined sugar and treacle are official in the British Pharmacopœia.

Secale cereale, Common Rye, is much cultivated in the northern parts of the world for its grain, which is extensively employed for making bread. Rye bread retains its freshness for a much longer time than wheaten bread. Quass or Rye Beer is a favourite drink in Russia. Rye is also used by the distillers. When roasted it has been employed as a substitute for coffee. Rye is subject to a disease called Ergot, produced by the attack of a fungus (see *Claviceps*), when its grains assume an elongated and somewhat curved form. The diseased grains are commonly known as Ergot of Rye or Spurred Rye, which in certain doses is poisonous to man and other animals. Medicinally, ergot is given to excite uterine contractions in labour, and for other purposes; it is official in the British Pharmacopœia.

Setaria.—*S. germanica* is the source of German Millet, and *S. italica* of Italian Millet. The latter is also much used in India. The Millets are largely used as food.

Stipa.—*S. tenacissima* or *Macrochloa tenacissima*, yields the fibre known under the name of *Esparto* or *Alfa*. (See *Lygeum*.) This has been, of late years, very extensively employed for paper-making. The imports of Esparto are probably over 150,000 tons annually. It is collected in Spain, Tunis, &c. Esparto is also largely used in Spain for making matting, card baskets, &c., and has been so employed since the time of the Phœnicians, who are said to have used it extensively for like purposes.—The grain of *S. pennata*, Feather Grass, is stated to be very nutritious.

Triticum.—*T. sativum* (*vulgare*) is the common Wheat.—A great many varieties of *Triticum* are cultivated, as *T. æstivum*, Spring or Summer Wheat; *T. hybernum*, Winter Wheat; *T. compositum*, Egyptian Wheat or Many-eared Wheat; *T. polonicum*, Polish Wheat, and others.—*T. Spelta*, yielding the Spelt varieties, is a distinct species. The grains of the several varieties of *Triticum* are commonly used in this and some other temperate countries for making bread, and for their starch. Wheat starch is official in the British Pharmacopœia, together with Rice and Maize Starch, under the common name of 'Amylum.' Both 'Wheaten Flour' and Crumb of Bread are also official. Various nutritious foods are also prepared from wheat grains, as Semolina, Soujee, Manna Croup, Vermicelli, Maccaroni, Cagliari or Italian Paste, &c.—*T. repens.*—A decoction of the creeping stems has been used with success in mucous discharge from the bladder.

Zea Mays is the Indian Corn or Maize Plant. The grain is extensively used in warm countries. It is the most fattening of all the cereals, but it frequently produces diarrhœa. The roasted cobs or ears are sold in India, as chestnuts similarly treated are in this country. The immature ears are sometimes eaten as a vegetable. Maize meal is sold under the name of *polenta*, and the fine flour as *maizena*, both of which are much used as food here and elsewhere. In South America a kind of beer, called Chica or Maize Beer, is made from the grain, and is extensively used. Maize starch is also official in the British Pharmacopœia, under the name of 'Amylum,' with Rice and Wheat Starch. In Western Africa a favourite fermented beverage is also prepared from Maize, called *pitto* or *peto*. The silky styles and stigmas of this plant have been recommended as of service in gravel and nephritic colic.

Zizania aquatica yields a serviceable grain known as Canada Rice or Swamp Rice. Zizania straw has been recommended as a very valuable paper material, and a company has been formed to work it in the province of Ontario, the only province in which the plant grows to any useful extent.

Artificial Analysis of the Orders in the Class MONOCOTYLEDONES.

(*Modified from Lindley.*)

Sub-class I. *Petaloideæ.*

1. FLOWERS WITH AN EVIDENT PERIANTH.

A. Ovary inferior (*Inferæ* or *Epigynæ*).

a. *Flowers gynandrous.*

Ovary 1-celled. Placentas parietal . . . *Orchidaceæ.*
Ovary 3-celled. Placentas axile . . . *Apostasiaceæ.*

b. *Flowers not gynandrous.*

1. Veins of leaves diverging from the midrib, and parallel to each other.
   Embryo enclosed in a vitellus.
   Anther 2-celled. Filament one, not petaloid . . . . *Zingiberaceæ.*
   Embryo not enclosed in a vitellus.
   Anther 1-celled. Filament one . . . *Marantaceæ.*
   Anther 2-celled. Filaments more than one. *Musaceæ.*
2. Veins of leaves diverging from the base, and parallel to the midrib.
   Stamens 3.
   Anthers extrorse . . . . . . *Iridaceæ.*
   Anthers introrse . . . . . . *Burmanniaceæ.*
   Stamens 6.
   Anthers extrorse . . . . . . *Burmanniaceæ.*
   Anthers introrse.
   Leaves equitant . . . . . . *Hæmodoraceæ.*
   Leaves flat.
   Fruit 1-celled . . . . . . *Taccaceæ.*
   Fruit 3-celled.
   Outer whorl of the perianth petaloid *Amaryllidaceæ.*
   Outer whorl of the perianth not petaloid . . . . . . *Bromeliaceæ.*
   Stamens more than 6 . . . . . . *Hydrocharidaceæ.*
3. Veins of leaves reticulated.
   Flowers unisexual . . . . . . *Dioscoreaceæ.*

B. Ovary superior (*Superæ*). Leaves parallel-veined.

a. *Outer whorl of the perianth herbaceous or glumaceous.*

Carpels more or less distinct.
Seeds attached over the whole inner walls of the fruit . . . . *Butomaceæ.*
Seeds attached to axile or basal placentas.
Flowers conspicuous. Embryo curved, without a slit . . . . . . *Alismaceæ.*
Flowers inconspicuous. Embryo straight, with a lateral slit . . . . . . *Juncaginaceæ.*
Carpels combined.

Inner whorl of the perianth different from the outer.
  Placentas axile. Anthers 2-celled. Capsule 2—3-celled . . . . . . *Commelynaceæ.*
  Placentas parietal.
    Anthers 2-celled. Capsule 1-celled . *Xyridaceæ.*
    Anthers 1-celled. Capsule 1-celled . *Mayaceæ.*
The outer and inner whorls of the perianth alike.
  Flowers on a spadix. Embryo with a lateral slit . . . . *Aroidaceæ.*
  Flowers not on a spadix. Embryo without a slit . . . . . . *Juncaceæ.*

b. *Outer whorl of the perianth petaloid, or the whole petaloid when only one whorl is present.*

Carpels more or less distinct.
  Seeds solitary. Flowers on a spadix . . *Pa'maceæ.*
  Seeds numerous. Flowers not on a spadix.
    Anthers extrorse . . . . . *Colchicaceæ.*
    Anthers introrse.
      Perianth of 6 parts. Seeds without albumen . . . . . *Butomaceæ.*
      Perianth of 2 parts. Seeds with albumen *Philydraceæ.*
Carpels combined.
  Flowers on a spadix . . . . . *Palmaceæ.*
  Flowers not on a spadix.
    Perianth rolled inwards after flowering. Aquatics . . . . . *Pontederaceæ.*
    Perianth not rolled inwards after flowering, conspicuous . . . . *Liliaceæ.*

C. Ovary superior. Leaves net-veined.
  a. *Placentas basal* . . . . . . *Roxburghiaceæ.*
  b. *Placentas axile* . . . . . . *Smilaceæ.*
  c. *Placentas parietal* . . . . . *Philesiaceæ.*

2. Flowers either naked, or with a whorled scaly Perianth, generally unisexual.

A. Flowers on a spadix.
  a. *Flowers bisexual.*
    Embryo cleft . . . . *Aroidaceæ.*
    Embryo solid . . . . *Pandanaceæ.*
  b. *Flowers unisexual.*
    Embryo solid . . . . *Pandanaceæ.*
    Embryo cleft on one side.
      Flowers with a true spathe. Fruit succulent.
        Anthers sessile, or nearly so . . . *Aroidaceæ.*
      Flowers without a true spathe. Fruit dry.
        Anthers on long filaments . . . *Typhaceæ.*

B. Flowers not arranged on an evident spadix.
  a. *Flowers bisexual.*
    Ovary superior . . . . . . *Juncaginaceæ.*
    Ovary inferior . . . . . . *Hydrocharidaceæ.*
  b. *Flowers unisexual.*
    Ovules erect.

Embryo perfect.
Seed without albumen . . . . *Naiadaceæ.*
Seed with albumen . . . . . *Pistiaceæ.*
Embryo rudimentary . . . . *Triuridaceæ.*
Ovules pendulous.
Carpel solitary.
Seed without albumen.
Pollen globose or tubular . . . . *Naiadaceæ.*
Seed with albumen . . . . . . *Restiaceæ.*
Carpels several, distinct.
Anthers 2-celled . . . . . . *Naiadaceæ.*
Anthers 1-celled . . . . . . *Desvauxiaceæ.*
Carpels several, combined.
Anthers 1-celled.
Stamens 2—3 . . . . *Restiaceæ.*
Stamen 1 . . . . *Desvauxiaceæ.*
Anthers 2-celled. Placentas axile.
Seeds with rows of hairs . . . . *Eriocaulaceæ.*
Seeds without rows of hairs . . . *Restiaceæ.*
Anthers 2-celled. Placentas parietal . . *Xyridaceæ.*

Sub-class II. *Glumaceæ.*

Stem solid. Leaf-sheaths not slit. Embryo basilar, within the albumen . . . . . *Cyperaceæ.*
Stem hollow. Leaf-sheaths slit. Embryo basilar, outside the albumen . . . . . . *Graminaceæ.*

Division II. GYMNOSPERMIA.

Order 1. Coniferæ or Pinaceæ, the Coniferous or Pine Order.—Character.—Resinous *trees* or evergreen *shrubs*, with

Fig. 1112.

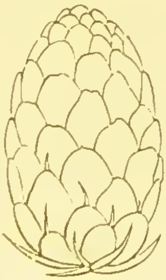


Fig. 1113.

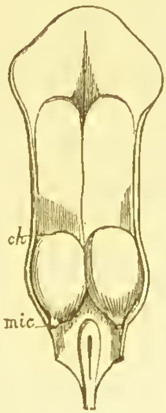


Fig. 1114.

Fig. 1112. A ripe cone of the Larch (*Pinus* (*Abies*) *Larix*). ——*Fig.* 1113. A mature carpel or scale of the Scotch Fir (*Pinus sylvestris*), with two winged naked seeds at its base. *mic.* Micropyle. *ch.* Chalaza.——*Fig.* 1114. A scale of the Larch bearing one naked winged seed; the other seed has been removed.

branched continuous stems. *Leaves* linear, acicular (*fig.* 341) or lanceolate, parallel-veined, fascicled (*fig.* 288) or imbricate alternate. *Flowers* naked, monœcious or diœcious. *Male flowers* arranged in deciduous amenta. *Stamens* 1 or several, in the latter case monadelphous; *anthers* 1- or more celled, opening longitudinally. *Female flowers* in cones (*fig.* 420), consisting of flattened imbricate carpels or scales arising from the axil of membranous bracts; *ovules* naked, 2 (*fig.* 730) or more, on the upper surface of each carpel. *Fruit* a woody cone (*figs.* 293 and 1112) or a galbulus (*figs.* 725 and 726). *Seeds* naked (*figs.* 1113 and 1114), with a hard crustaceous integument, albuminous; *cotyledons* 2 or many (*fig.* 772).

Division of the Order and Illustrative Genera.—This order has been subdivided as follows:—

Sub-order 1. *Abieteæ.*—Ovules inverted, with the micropyle next the base of the carpel (*figs.* 730 and 1113). Pollen curved. *Illustrative Genera*:—Pinus, *Linn*; Araucaria, *Juss.*

Sub-order 2. *Cupresseæ.*—Ovules erect, with micropyle superior. Pollen spheroidal. *Illustrative Genera*:—Juniperus, *Linn.*; Cupressus, *Tourn.*

The order Taxaceæ is now frequently included in the Coniferæ, forming the tribe or sub-order Taxeæ or Taxineæ.

Distribution and Numbers.—The plants of this order occur in all parts of the world; but they abound most in temperate climates. There are about 250 species.

Properties and Uses.—They possess very important properties. Many supply valuable timber, and most of the species contain an oleo-resinous juice or turpentine, which is composed of a volatile oil and resin.

Araucaria.—*A. imbricata*, from Chili, and *A. Bidwillii*, from Moreton Bay, have edible seeds. Those of the former are extensively used for food by the natives of Chili and Patagonia. It is said that 'the fruit of one large tree will maintain eighteen persons for a year.' Both species also yield hard and durable timber.

Callitris quadrivalvis, the Arar Tree, yields the resin called Sandarach, Juniper Resin, or Gum Juniper. It is imported from Mogador, and is employed in the preparation of varnishes. When powdered it is called *pounce*. The wood of this tree is also very durable, and is used by the Turks for the floors and ceilings of their mosques.

Cedrus.—*Cedrus Libani*, the Cedar of Lebanon, and *C. Deodara*, the Deodar, which is probably only a variety of the former species, are most valuable timber trees. The turpentine obtained from the latter is used in India, where it is in great repute in skin diseases and as an application to ulcers, under the name of *kelon-ke-tel*.

Cupressus, the Cypress.—The wood of some species is very durable. It is supposed that the Gopher-wood of the Bible was obtained from species of *Cupressus* and other allied Coniferæ.

Dammara.—*D. australis*, the Kawrie or Cowdie Pine of New Zealand, produces a timber which is much valued for making masts and spars. A gum-resin known under the names of Australian Copal, Kawrie Gum, and Australian Dammar, is largely imported into this country; it is chiefly used in the preparation of varnishes.—*D. orientalis* yields a somewhat similar gum-resin, known as Indian Dammar.

Juniperus.—*J. communis*, the common Juniper. The fruit and the volatile oil obtained from it and other parts of this plant, have stimulant and diuretic properties. The oil distilled in Britain from the unripe fruit is official in the British Pharmacopœia. Oil of Juniper is also used to flavour the spirit known as Hollands; turpentine being commonly employed for a similar purpose for English Gin on account of its comparative cheapness. Juniper wood has a reddish colour, and is used occasionally for veneers.—*J. Oxycedrus.*—In France, a tarry oil, called Huile de Cade or Juniper Tar, is obtained by dry distillation from the wood of this plant; it is principally used in the form of an ointment for skin diseases, more especially in psoriasis and eczema; it is also employed in veterinary practice. The wood is very durable.—*J. bermudiana* is the Red or Pencil Cedar, and *J. virginiana*, the Virginian Red Cedar. The wood of these is employed for Cedar pencils; that of the former is considered the best. The tops or leaves of *J. virginiana* are official in the United States Pharmacopœia, where they are used for similar purposes, and in like preparations to savine, but they are not so effectual in their operation.—*J. Sabina*, the common Savine. The fresh and dried tops and the oil obtained from the former are official in the British Pharmacopœia; they have acrid, stimulant, diuretic, and emmenagogue properties. In large doses they are irritant poisons, and have been frequently taken to cause abortion. When locally applied in the form of the official ointment, as a dressing to blisters and to issues and setons, they keep up and promote the discharge.

Pinus.—Several species of this genus are valuable timber trees; as *P. sylvestris*, the Scotch Fir, which yields the timber known as Dantzic or Riga Fir, and Russian Deal; *P. Strobus*, the White Pine or Deal of the United States; *P. mitis* and *P. australis*, the Yellow Pine or Deal; *P. rigida*, *P. Lambertiana*, &c., &c. The wood of these trees is used to an enormous extent in this country, and elsewhere.—*Pinus australis* (*palustris*), the Swamp Pine or Long-leaved Pine, furnishes by far the greater proportion of the crude oleo-resin known as turpentine which is consumed in the United States, or sent from thence to other countries.—*P. Tæda*, the Frankincense Pine, and *P. Pinaster*, the Cluster Pine, more especially the former, are also sources from which we derive our supplies of turpentine. The concrete turpentine known as Galipot is also obtained from *P. Pinaster*; but the analogous concrete turpentine known as *Terebinthina, Thus Americanum*, or *Common Frankincense*, and which is official in the British Pharmacopœia, is derived from *P. australis* and *P. Tæda*. The crude oleo-resin turpentine yields by distillation the essential oil called *oil of turpentine* or *spirits* or *essence of turpentine*, and yellow and black resin. This oil is official in the British Pharmacopœia, and is said to be derived from *P. australis*, *P. Tæda*, *P. Pinaster*, and *P. sylvestris.*—*Pinus sylvestris*, the Scotch Fir, likewise produces some turpentine, and the wood of this and other species of *Pinus* yields by destructive distillation the official Pix liquida or Tar, which is commonly known as Wood Tar; and Creasote, which is a product of the distillation of Wood Tar. Tar is a useful application in some skin diseases. Pitch or Black Pitch is another valuable product obtained from tar. The inner bark of the Scotch Fir is used in Norway for making bark bread. From the leaves also of this species the substance called Pine-wool, Forest-wool, or Fir-wool is prepared. It is used for stuffing cushions, &c.; and is said to be repulsive to vermin. &c. Various other articles of domestic utility are also manufactured from pine-wool. A volatile oil called Fir-wool Oil or Oil of Pine Leaf is also obtained by distillation from these leaves; and is useful in rheumatism, neuralgia, &c. It is official in the British Pharmacopœia. Paper of good quality is now made from the wood of this and some other species of *Pinus* and *Abies*. (See *Abies excelsa.*)—*P. Pinea*, the Stone Pine, has edible seeds, which are used as a dessert under the name of *pine-nuts.*—*P. Cembra*, the Siberian Stone Pine, has also edible seeds. The young shoots by distillation yield the so-called Carpathian Balsam.—*P. Pumilio*, the Mugho or Mountain Pine, produces by spontaneous exudation an oleo-resin called Hungarian Balsam.—*Pinus Gerardiana*, found in Thibet and Afghanistan, has edible seeds.—*P. longifolia*, a Himalayan species, yields a very good turpentine.

The following plants are frequently placed in the genus Abies of Tournefort; *but more commonly they are included in the genus Pinus.*

Several species supply valuable timber, as *Abies* (*Pinus*) *excelsa*, the Norway Spruce, *Abies* (*Pinus*) *alba*, the White Spruce, *A.* (*Pinus*) *canadensis*, the Hemlock Spruce, *A.* (*Pinus*) *Larix*, the Common Larch, &c.—*Abies* or *Pinus excelsa*, the *Pinus Picea* of Du Roi, yields by spontaneous exudation a resinous substance which is the original *Thus* of the Materia Medica. This when melted and strained constitutes our official Burgundy Pitch. The official 'Thus' is described under *Pinus australis*. Good paper has been made from the wood of this species. The leaf-buds are used on the Continent in the preparation of a kind of beer, which is employed in scorbutic and rheumatic complaints.—*Abies* or *Pinus balsamea*, the Canadian Balsam or Balm of Gilead Fir, yields our official Canada Balsam.—*Abies* or *Pinus canadensis*, the Hemlock Spruce Fir, yields an oleo-resin resembling Canada Balsam. This is official in the United States Pharmacopœia, and is commonly known as Canada Pitch.—*Abies* or *Pinus Picea* of Linnæus, the *Pinus Abies* of Du Roi, the Silver Fir, yields Strasburg turpentine. Its leaf-buds, like those of *A. excelsa*, are employed in the preparation of a kind of beer, which is used for similar purposes.—*Abies* (*Pinus*) *nigra*, the Black Spruce Fir. The young branches of this when boiled in water, and the solution afterwards concentrated, yield Essence of Spruce, which is employed in the preparation of Spruce Beer.—*A. Larix* of Lambert, or *Pinus Larix*, the *Larix europæa* of De Candolle, yields Larch or Venice turpentine, and a kind of Manna, called Larch Manna or Manna de Briançon. The bark is sometimes used in tanning. This bark, deprived of its outer layer, is official in the British Pharmacopœia, and is regarded as stimulant, astringent, and diuretic. It has been recommended to check profuse expectoration in chronic bronchitis, and for various forms of internal hæmorrhage: but it is little used.

Thuja.—The young shoots of *T. occidentalis* are used to prepare a tincture which is employed externally to remove warts, &c., and internally for worms, amenorrhœa, &c.

Order 2. TAXACEÆ, the Yew Order.—Character.—*Trees* or *shrubs*, with continuous branches. *Leaves* usually narrow, rigid, and veinless; sometimes broad, with forked

FIG. 1115.

FIG. 1116.

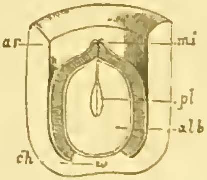


Fig. 1115. Male flower of the Common Yew (*Taxus baccata*), with numerous monadelphous stamens.——*Fig.* 1116. Vertical section of the seed of the same. *ar.* The succulent cup-shaped mass which surrounds the seed. *pl.* Embryo. *alb.* Albumen. *ch.* Chalaza. *mi.* Micropyle.

veins. *Flowers* unisexual, naked, bracteated. *Male flowers* several together, each with one or several stamens, which, in the latter case, are united (*fig.* 1115) or distinct; *anthers* bursting longitudinally. *Female flowers* solitary, and consisting of a single erect naked ovule, which is either terminal or placed in the axil of a bract. *Seed* small, usually more or less surrounded by a cup-shaped fleshy mass or aril (*figs.* 727 and 1116, *ar*), albuminous (*fig.* 1116, *alb*); *embryo* straight (*fig.* 1116, *pl*). *This order is now frequently included in the Coniferæ, forming the tribe or sub-order Taxeæ or Taxineæ.*

Distribution and Numbers.—Natives of the mountains of tropical countries, and of temperate regions. *Illustrative Genera:*—Taxus, *Linn.*; Salisburia, *Smith.* There are about 50 species.

Properties and Uses.—In their general properties they resemble the Coniferæ.

Dacrydium.—*D. Franklinii*, the Huon Pine of Australia.—The wood is valuable for ship-building. Other species, as *D. taxifolium*, the Kakaterro of New Zealand, and *D. cupressinum*, the Dimon Pine, are also valuable timber trees.

Podocarpus Totarra and some other New Zealand species are valuable timber trees.—*P. cupressina* (*imbricata*), a native of Java, yields a crystalline resin.

Taxus baccata, the common Yew, produces extremely durable and valuable timber. Its leaves and young branches act as a narcotico-acrid poison, both to the human subject and other animals. But they would seem to be most injurious to horses and cows; indeed, it is stated that sheep, deer, and turkeys will crop Yew trees with impunity. But this is certainly incorrect so far as sheep and deer at least, as these animals have been killed by eating Yew leaves. It is also frequently said that animals may feed upon the young growing shoots without any injurious effect being produced, but that when these have been cut off, and left upon the ground for a short time, they are then poisonous. This notion is, however, altogether erroneous, for the shoots are poisonous whether fresh or dried. Fatal cases of poisoning have also occurred from eating the so-called fruit. (See page 323.) The red succulent cup of this fruit is, however, harmless, the contained seed alone being poisonous. Yew leaves and the fruits, have been given medicinally for their emmenagogue, sedative, and antispasmodic effects. According to Dr. Taylor, 'Yew-tree tea' is sometimes taken to cause abortion.

Order 3. GNETACEÆ, the Jointed Fir Order.—Character. Small *trees* or *shrubs*, with usually jointed stems and branches. *Leaves* opposite, entire, net- or parallel-veined, or sometimes small and scale-like. *Flowers* unisexual or rarely hermaphrodite, in catkins or heads. *Male flowers* with a 1-leaved *calyx*; *anthers* 2—3-celled, with porous dehiscence. *Female flower* naked or surrounded by 2 more or less combined scales; *ovules* 1—2, naked, pointed by a style-like process. *Seed* succulent; *embryo* dicotyledonous, in the axis of fleshy albumen.

Distribution and Numbers.—These plants occur in both tropical and temperate regions. There are 3 genera—Ephedra, *Linn.*; Welwitschia, *Reichb.*; and Gnetum, *Linn.*; and about 30 species.

Properties and Uses.—Unimportant. The seeds and leaves of several species are eaten. Some *Ephedras* are astringent. A new drug from Texas, known under the name of *Canutillo*, has been lately recommended in cases of urethral inflammation, and in renal diseases; it is said to be derived from *Ephedra trifurca.*

Order 4. CYCADACEÆ, the Cycas Order.—Character.—Small Palm-like unbranched *trees* or *shrubs*, or occasionally dichotomous, with their surface marked by the scars of fallen leaves. *Leaves* clustered at the summit, pinnate, parallel-veined, hard and woody; leaflets sometimes circinate in vernation. *Flowers* quite naked, unisexual, diœcious. *Male flowers* in cones, consisting of scales, from the under surface of which 1-celled anthers arise. *Female flowers* consisting of naked ovules placed on the margins of altered leaves, or of ovules arising from the base of flat scales or from the under surface of peltate ones. *Seeds* hard or succulent, with 1 or several embryos contained in fleshy or mealy albumen.

Distribution and Numbers.—Natives principally of the temperate and tropical parts of America and Asia; and occasionally of the Cape of Good Hope, Madagascar, and Australia. *Illustrative Genera:*—Cycas, *Linn.*; Zamia, *Lindl.* There are about 50 species.

Properties and Uses.—The stems and seeds of the plants of this order yield mucilage and starch.

Cycas.—From the stems of *Cycas circinalis* and *C. revoluta* a starch may be obtained. Of this a kind of sago is prepared; that from *C. revoluta* is said to constitute Japan Sago, which is esteemed as an article of food where it is obtained. But this sago is not an article of European commerce, all the sago imported into Europe being derived from species of Palms. (See *Metroxylon* and *Saguerus.*) The seeds of the above species are also edible.

Dion edule has large mealy seeds from which the Mexicans prepare a kind of arrowroot.

Encephalartos.—Various species contain starch, and form what is called Caffre-bread.

Zamia.—In the Bahamas and other West Indian islands, excellent arrowroot is prepared from the starch obtained from the stems of *Z. integrifolia* and other species. It is sold in the West India markets, but is not known as a commercial article in this country or in any other part of Europe. Florida arrowroot is also obtained from this plant.

Artificial Analysis of the Orders in the GYMNOSPERMIA.

1. *Stem jointed, branched* . . . . . *Gnetaceæ.*
2. *Stem not jointed.*
   Branched. Leaves simple.
      Carpels collected in cones . . . . *Coniferæ.*
      Seed solitary, usually surrounded by a succulent coat . . . . *Taxaceæ.*
   Not branched, or dichotomous. Leaves pinnate *Cycadaceæ.*

SUB-KINGDOM II.

CRYPTOGAMIA OR FLOWERLESS PLANTS.

DIVISION I. CORMOPHYTA.

Class I. VASCULARES.

Sub-class I. *Isosporia.*

Order 1. FILICES, the Fern Order.—Character.—*Herbs* with *rhizomatous stems* (*fig.* 14); or *arborescent plants* with cylindrical stems (*fig.* 15), usually unbranched, but sometimes forked (*fig.* 204). *Leaves*, or *fronds* as they are commonly called, arising irregularly from the rhizome (*fig.* 14), or placed in tufts at the apex of the stem or caudex (*fig.* 15); almost always circinate in vernation (*figs.* 14, 15, and 297); simple (*fig.* 1117, *a*) or compound (*figs.* 14 and 804). *Fructification* consisting of *sporangia* or *capsules* (*figs.* 802 and 804), collected in heaps (*sori*), which are placed usually on the under surface (*figs.* 802, *sp*, and 803, *s*) or at the margins of the fronds (*fig.* 1117, *b*), or rarely on the upper surface, or occasionally arranged in a spiked manner on a simple or branched rachis (*fig.* 804); the *sori* are either naked (*fig.* 802, *sp*) or covered by a membranous scale (*indusium*) (*fig.* 803, *s*). *Sporangia* stalked (*fig.* 805, *s*) or sessile (*fig.* 1117, *b*), and either annulate (*fig.* 805) or exannulate (*fig.* 1117, *b*). *Spores* enclosed in the sporangia (*fig.* 805). (For further particulars upon the fructification of Ferns, see pp. 365–367.)

FIG. 1117.

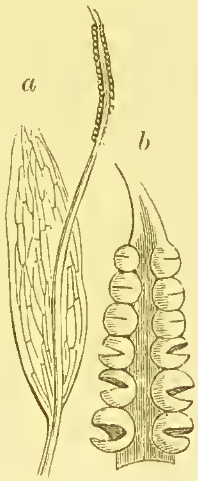


Fig. 1117. *a*. Barren and fertile fronds of the common Adder's-tongue (*Ophioglossum vulgatum*). *b*. Portion of the fertile frond of the same, with 2-valved distinct, burst sporangia or capsules on its margins.

Division of the Order and Illustrative Genera.—This order has been variously divided; but the more common arrangement is into three sub-orders, which are frequently regarded as distinct orders. These sub-orders are called Polypodieæ, Danæeæ, and Ophioglosseæ. Their characters are as follows:—

Sub-order 1. *Polypodieæ* or *Polypodiaceæ*, the Polypody Sub-order.—Fronds circinate in vernation. Sporangia more or less annulate (*fig.* 805), usually collected in sori on the under surface or at the margins of the fronds (*figs.* 802 and 803), or occasionally arranged in a spiked manner on a simple or branched rachis (*fig.* 804). *Illustrative Genera:*—Polypodium, *Linn.*; Aspidium, *Swartz*; Osmunda, *Linn.*

Sub-order 2. *Danæeæ*, *Danæaceæ*, or *Marattiaceæ*, the Danæa Sub-order.—Fronds circinate in vernation, and all fertile. Sporangia arising from, or imbedded in, the under surface or back of the fronds, more or less united, exannulate. *Illustrative Genera:*—Danæa, *Smith*; Marattia, *Smith.* There are no British plants in this sub-order.

Sub-order 3. *Ophioglosseæ* or *Ophioglossaceæ*, the Adder's-tongue Sub-order.—Fronds not circinate in vernation, barren or fertile. Sporangia arranged in a spike-like form (*fig.* 1117, *a*) on the margins of a contracted frond, distinct, 2-valved (*fig.* 1117, *b*), exannulate. *Illustrative Genera:*—Ophioglossum, *Linn.*; Botrychium, *Swartz.*

Distribution and Numbers.—The plants of this order are more or less distributed over the globe, but they are most abundant in moist temperate regions. In the northern hemisphere they are herbaceous plants, but in the southern hemisphere and in the tropics they are sometimes arborescent, having stems occasionally as much as forty feet in height, and with the general habit of Palms. There are upwards of 2,500 species.

Properties and Uses.—Several species have farinaceous rhizomes, which, when roasted or boiled, are used as articles of food in some parts of the world, but generally only in times of scarcity. The rhizomes of *Pteris esculenta*, *Diplazium esculentum*, *Nephrodium esculentum*, and *Marattia alata*, are those which are thus principally used. The leaves of several species possess slightly bitter, astringent, and aromatic properties, and those of others are mucilaginous. The rhizomes of some are astringent and tonic, and a few possess well-marked anthelmintic properties. The silky hairs found on the rhizomes and lower portions of the caudex of some species have been used for stuffing cushions, &c., and as mechanical styptics.

Acrostichum Huacsaro.—The rhizome of this species constitutes the Middling Calaguala or Little Cord, which is used medicinally in Peru. (See *Polypodium.*)

Adiantum.—The fronds and rhizomes of *A. Capillus-Veneris*, True Maiden-hair, and those of *A. pedatum*, Canadian Maiden-hair, possess mucilaginous, bitter, slightly astringent, and aromatic properties, and have been employed as pectorals in catarrhs. The latter plant is most esteemed. Syrup of Capillaire is properly prepared, by adding to an infusion of Maiden-hair some sugar and orange-flower water; but it is now frequently made by simply adding sugar to orange-flower water. The fronds of *A. melanocaulon* are reputed to have tonic properties; and various qualities have been attributed to other species of *Adiantum.*

Aspidium.—The dried rhizome with the persistent bases of the petioles of *Aspidium Filix-mas* constitute the official Male Fern of the British Pharmacopœia. This has been used from the earliest times as an anthelmintic;

it possesses most activity in a recent state. The rhizome of *Aspidium marginale*, a native of the United States, is said to possess similar properties, and is official as well as the former in the United States Pharmacopœia. The rhizome of *Aspidium athamanticum*, under the names of *Panna* and *Uncomocomo*, is also much esteemed by the Zulus as an anthelmintic. The fronds of *A. fragrans*, possess aromatic and slightly bitter properties, and have been used as a substitute for tea.

Cibotium.—The silky hairs covering the lower portion of the caudex of *C. Barometz* or *Aspidium Barometz*, the Scythian Lamb of old writers, have been imported under the name of *Pakoe Kidang*. This has great reputation in India as a styptic, and has been used for a like purpose (see *Cyathea*) in Holland, Germany, and other countries. It has also been employed for stuffing cushions, &c. It is obtained from Sumatra. Analogous hairs imported from the Sandwich Islands, under the name of *Pulu*, may be employed for similar purposes as the preceding. Pulu is said to be derived from three species of *Cibotium*, viz. *C. glaucum*, *C. Chamissoi*, and *C. Menziesii*; but other species also produce somewhat similar hairs.

Cyathea.—From the caudex of *C. Smithii*, a native of Sumatra, woolly hairs are obtained, which are imported under the name of *Penghawar Djambi*; they are used for similar purposes as *Pakoe Kidang* and *Pulu*.

Ophioglossum vulgatum, the Common Adder's-tongue, has been employed as a vulnerary. In some parts of England it is used in the preparation of a popular ointment.

Osmunda regalis, the Flowering or Royal Fern.—In Westmorland and some parts of Lancashire, this plant is known under the name of 'bog onion.' The rhizomes when beaten, and macerated all night in cold spring water, are much esteemed as an application to bruises, sprains, &c.

Polypodium.—The rhizomes of *P. Calaguala*, Genuine or Slender Calaguala; of *P. crassifolium*, Thick Calaguala or Deer's Tongue; and those of *Acrostichum Huacsaro* (see *Acrostichum*), are used medicinally in Peru, and are said to possess sudorific, diuretic, febrifugal, and anti-venereal properties.—*P. Phymatodes.*—The fronds, under the names of 'Male Fern,' and 'Female Fern,' are employed in Siberia in nephritis, dysuria, and other kidney complaints.

Pteris aquilina, the Common Brake, is reputed to possess anthelmintic properties.

Order 2. EQUISETACEÆ, the Horsetail Order.—Character. *Herbaceous plants* with striated, hollow, jointed, simple or verticillately branched, aerial siliceous erect shoots or stems, arising from slender creeping persistent rhizomes. The *joints* are surrounded by membranous toothed sheaths (*fig.* 13), which are generally regarded as modified leaves. When branched, the branches arise in a whorled manner from the axils of the teeth of the sheaths and correspond in number with them. *Stems* barren or fertile. *Fructification* borne in cone-like or club-shaped masses at the termination of the erect shoots or stems (*fig.* 13). Each mass is composed of peltate scales bearing the *sporangia* or *capsules* on their under surface (*fig.* 810), each of which dehisces internally by a longitudinal fissure. *Spores* surrounded by elastic club-shaped elaters (*figs.* 811 and 812). (See pages 367 and 368 for a more detailed account of the fructification.)

Distribution and Numbers.—These plants are found in marshy or watery places in most parts of the world. There is but one genus (*Equisetum*, Linn.), which includes about 20 species, many of which are indigenous.

Properties and Uses.—Of little importance either in a medicinal or economic point of view. They were formerly regarded as slightly astringent, diuretic, and emmenagogue, but are never employed in medicine at the present day. The rhizomes contain much of starchy matters in the winter months, and might therefore, in case of need, be used as food, like those of some Ferns. Silica is abundant in their epidermal tissues: this is especially the case in *Equisetum hyemale*, Rough Horsetail, which is largely imported from Holland under the name of Dutch Rushes, and employed by cabinet makers, ivory turners, and others, for smoothing the surfaces of their work.

Order 3. LYCOPODIACEÆ, the Club-moss Order.—Character.—*Herbaceous plants*, usually resembling Mosses, or rarely shrubby, with creeping stems (*fig.* 1118) or corms, and forked ramification (*fig.* 12). *Leaves* sessile, small, simple, imbricate

FIG. 1118.

Fig. 1118. *Lycopodium inundatum*, Marsh Club-moss. The stem is creeping, and bears numerous small sessile imbricate leaves.

(*fig.* 1118). *Sporangia* situated in the axis of the leaves, or of spicately or cone-like arranged scales (*fig.* 12), 1—3-celled, compressed, often reniform, 2-valved; and containing numerous spores of one kind only, which are marked at the summit with 3 radiating lines. (See pages 368 and 369.)

Distribution and Numbers.—They are almost universally distributed, occurring in cold, temperate and warm climates. *Illustrative Genera*:—Lycopodium, *Linn.*; Psilotum, *Swartz.* There are about 100 species.

Properties and Uses.—Many species contain an acrid principle. In moderate doses they are frequently emetic and purgative, but in large doses they occasionally produce poisonous effects. Some are reputed to possess aphrodisiac properties. The spores of several are inflammable.

Lycopodium.—*L. clavatum*, the common Club-moss, possesses well-marked emetic and purgative properties, and is also reputed to be diuretic and emmenagogue. The spores have been employed externally for their absorbent qualities, in erysipelas and various cutaneous affections; and when taken internally they are said to be diuretic, sedative, and demulcent. These spores are of a yellow colour, and are sometimes known as *vegetable sulphur*. Besides their use medicinally, as just alluded to, they are occasionally employed in pharmacy for covering pills, the object sought being, to render them tasteless and prevent their adhering together. Lycopodium spores, however, from their inflammable nature, are principally used in the preparation of fireworks, and for the production of artificial lightning at theatres, &c.—*L. Selago* has similar medicinal properties, but it sometimes acts as a narcotico-acrid poison. The spores are of a like inflammable nature to those of *L. clavatum*.—*L. catharticum* is said to be a powerful purgative.

FIG. 1119.

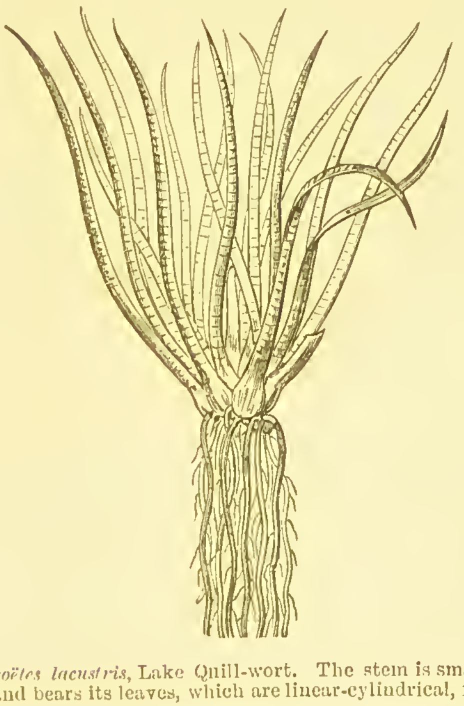


Fig. 1119. *Isoëtes lacustris*, Lake Quill-wort. The stem is small and cormlike, and bears its leaves, which are linear-cylindrical, in tufts.

Sub-class II. *Heterosporia.*

Order 1. SELAGINELLACEÆ, the Selaginella Order.—Character.—*Terrestrial* or *water plants* (*fig.* 1119), with branched slender stems, or the stems are corm-like (*fig.* 1119). *Leaves* sessile, small, and imbricate all round the stem or distichous, or in the plants with corm-like stems tufted, long, and somewhat linear (*fig.* 1119). *Sporangia* of two forms, the larger called the *macrosporangium* or *megasporangium* (*fig.* 816), 2—4-valved, and containing 2—8 large spores (*maerospores* or *megaspores*); and the smaller or *mierosporangium* (*fig.* 815), resembling that of the Lycopodiaceæ, and containing a number of small spores (*mierospores*). (Sec pages 369 and 370.) *The speeies of Isoëtes are sometimes formed into a distinet order—the Isoëtaeeæ (see page* 370). *They are here included in Selaginellaceæ.*

Distribution and Numbers.—They are found in all temperate and warm climates. There are 2 genera, and about ~~100~~ species. *Illustrative Genera:*—Selaginella, *Beauv.*; Isoëtes, *Linn.* 350

Properties and Uses.—Unimportant.

Order 2. MARSILEACEÆ OR RHIZOCARPEÆ, the Pepperwort Order.—Character.—*Aquatic herbs* with small floating or creeping stems (*fig.* 1120), from which arise sessile (*fig.* 1120) or

FIG. 1120.

Fig. 1120. The Creeping Pillwort (*Pilularia globulifera*). The stems are creeping, and bear numerous sessile leaves, which are circinate in vernation. The sporocarps are downy, and placed in the axils of the leaves.

stalked leaves (*fig.* 366). *Leaves* with circinate vernation (*fig.* 1120). *Fructification* at the base of the leaves (*fig.* 1120), and consisting of stalked valvular sporocarps (*figs.* 817, 819, and 820) enclosing antheridia in which a number of small spores (*mierospores*) are contained (*fig.* 818), and sporangia (*fig.* 820, *b*), both of which are either contained in the same cavity (*fig.* 817) or in separate sacs (*fig.* 820). (See pages 370 and 371.)

This order is frequently divided into two orders, namely, Marsileaceæ and Salviniaceæ.

Distribution and Numbers.—They are widely distributed, but are most abundant in temperate regions. *Illustrative Genera:*—Pilularia, *Linn.*; Marsilea, *Linn.* There are about 40 species.

Properties and Uses.—Of little importance. *Marsilea Macropus* is known in Australia as the Nardoo plant. The sporocarps contain starchy matter; these are pounded, and used in the same way as flour.

Class II. Muscineæ.

Order 1. Musci, the Moss Order.—Character.—*Cellular plants* (*figs.* 9, 10, and 824), terrestrial or aquatic, with erect or creeping stems, and usually spirally imbricate leaves (*fig.* 1121). *Reproductive organs* of two kinds, called *antheridia* and *archegonia* (see pages 372–375), which are either placed on the same or on separate plants (*figs.* 9 and 10); hence these plants are *monœcious* or *diœcious*. The *antheridium* (*fig.* 821) is a more

Fig. 1121.

Fig. 1121. A portion of *Andrœa rupestris*, much magnified. The stem is erect, with numerous small imbricate leaves, and a terminal sporangium, which is destitute of a seta. *a.* Sporangium after dehiscence, showing the 4 equal valves of which it is composed connected at the summit by the persistent operculum. The valves are seen to have dehisced vertically. (After Hooker.)

or less rounded, elliptic, or cylindrical sac, containing, when mature, a number of minute cells (*sperm-cells*), each of which encloses a spirally twisted filament (*antherozoid*). The *archegonium* is a flask-shaped body (*fig.* 822), which after fertilisation developes an urn-shaped sporangium (*figs.* 823–825), with usually a central columella (*fig.* 829); the space between which and the walls of the sporangium being occupied by spores, without any elaters among them. The *sporangium* or *capsule* is commonly placed on a stalk (*seta*) (*figs.* 823, *t*, and 824, *p*), or occasionally it is sessile (*fig.* 1121), and at first is covered by a hood (*calyptra*) (*figs.* 824, *c*, and 825, *c*), beneath which is a kind of lid (*operculum*) (*figs.* 826, *o*, and 827). The sporangium usually opens when ripe in a transverse manner from the separation of the operculum (*figs.* 826, *o*, and 827), or sometimes by splitting vertically into four equal valves, which are connected at the summit by the persistent operculum (*fig.* 1121, *a*); or rarely it dehisces irregularly. At the dehiscence of the sporangium, its mouth (*stoma*) is seen to be either surrounded by a peristome, consisting of one (*aploperistomous*) or two rows (*diploperistomous*) of teeth (*fig.* 826, *p*); or the mouth is naked (*gymnostomous*).

Division of the Order and Illustrative Genera.—This order is commonly divided into four sub-orders, which are frequently regarded as separate orders, the principal distinctive characters of which are as follow:—

Sub-order 1. *Sphagnaceæ* or *Sphagneæ.*—Bog-mosses. Sporangium globular, surrounded at the base by the calyptra; the columella does not reach to the apex of the capsule. The only genus is Sphagnum, *Dill.*, which is found on boggy moors and in damp woods.

Sub-order 2. *Andræaceæ* or *Andræeæ.*—Split-mosses.—Sporangium splitting vertically into four valves, but remaining connected at the summit. *Illustrative Genus:*—Andræa, *Ehr.* (*fig.* 1121).

Sub-order 3. *Phascaceæ* or *Phasceæ.*—The sporangium does not burst; the spores escaping by the decay of the wall of the sporangium. *Illustrative Genus:*—Phascum, *Linn.*

Sub order 4. *Bryaceæ* or *Bryeæ.*—Urn-mosses.—Sporangium, which is generally borne upon a seta of considerable length, dehiscing transversely by the separation of the operculum (*figs.* 826 and 827). *Illustrative Genera:*—Funaria, *Hedw.*; Polytrichum, *Linn.*

Distribution and Numbers.—They are generally diffused over the globe, but most abundantly in temperate climates. There are about 1,250 species.

Properties and Uses.—Of little importance either in a medicinal or economic point of view. Some species are reputed to possess astringent and diuretic properties, but none are employed by the medical practitioner in this country. The species of *Sphagnum* furnish food to the reindeer, and even to man in the polar regions.

Order 2. Hepaticaceæ, the Liverwort Order (see pages 375-377).—Character.—*Small cellular plants*, either with a creeping stem bearing minute imbricate leaves (*fig.* 1122) or with a lobed thalloid expansion (*figs.* 830 and 832). *Reproductive organs* of two kinds, called *antheridia* and *archegonia*, which are either on the same plant or on different ones; hence these plants are *monœcious* or *diœcious*. The *antheridia* are small, oval, globular, or flasked-shaped, cellular sacs (*fig.* 831), situated in the axils of leaves, or immersed in the frond, or imbedded in the upper surface of peltate or discoid stalked receptacles (*fig.* 830, *r*). The *archegonia* (*fig.* 833) are usually somewhat flask-shaped bodies, which are imbedded in the fronds, or contained in receptacles (*fig.* 832, *r*) which are elevated on stalks (*fig.* 832, *s*) above the thallus. Each archegonium developes after fertilisation a sporangium, which either bursts by valves (*fig.* 1123) or teeth, or by irregular fissures. The *sporangium* is usually without a columella, and contains spores

FIG. 1122.

FIG. 1123.

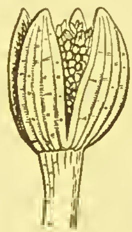


Fig. 1122. *Jungermannia bidentata.* The stem is creeping, and bears numerous small imbricate leaves.—*Fig.* 1123. Sporangium of *Jungermannia hyalina*, dehiscing vertically by 4 valves, and containing spores in its interior.

mixed with elaters (*fig.* 834); or it is furnished with a thread-like columella, and contains spores and no elaters, or the latter are imperfect; or it has neither elaters nor columella.

Division of the Order and Illustrative Genera.—This order may be divided as follows:—

Sub-order 1. *Jungermanniaceæ* or *Jungermannieæ*, Scale-mosses.—Sporangia oval; without a columella; splitting vertically by 4 valves (*fig.* 1123). Spores mixed with elaters. *Illustrative Genera*:—Blasia, *Micheli*; Jungermannia, *Dillen.*

Sub-order 2. *Anthocerotеæ.*—Sporangia pod-shaped; 1—2-valved; with a filiform columella. Spores either mixed with imperfect elaters, or these are absent. *Illustrative Genera*:—Anthoceros, *Micheli*; Monoclea, *Hook.*

Sub-order 3. *Marchantiaceæ* or *Marchantieæ*, Liverworts.—Sporangia without valves; bursting irregularly or by teeth; without a columella. Spores mixed with elaters (*fig.* 834). *Illustrative Genera*:—Fimbriaria, *Nees*; Marchantia, *March.*

Sub-order 4. *Ricciaceæ* or *Riccieæ*, Crystalworts.—Sporangia without valves; bursting irregularly; without a columella.

Spores not mixed with elaters. *Illustrative Genera:*—Riccia, *Mich.*; Sphærocarpus, *Mich.*

These sub-orders are sometimes regarded as distinct orders.

Distribution and Numbers.—These plants are generally distributed over the globe, but they are most abundant in damp shady places in tropical climates. There are about 700 species.

Properties and Uses.—Of no importance, although some have been used in liver complaints, and other species, as *Marchantia hemispherica*, have been employed, in the form of poultices, in dropsy.

Division II. THALLOPHYTA.

Order 1. Fungi, the Mushroom Order.—*Diagnosis.* Plants formed of hyphal tissue, producing their fructification in the air; growing in or upon decaying organic matters (in which case they are termed *saprophytes*), or on living organisms (when they are termed *parasites*), and nourished through their vegetative structure called the *spawn* or *mycelium* (*figs.* 6, *my*, and 839 a, *my*). The Fungi, as here defined—that is, excluding Lichenes, are also destitute of green colouring matter and starch. *Fructification* various. (See pages 378-387, and *figs.* 835—850.)

Division of the Order.—For a notice of the groups into which this order has been divided, see pages 378-387.

Distribution and Numbers.—They abound in all parts of the world except the very coldest, where their spawn would be destroyed. *Illustrative Genera:*—Agaricus, *Linn.*; Saccharomyces, *Meyen*; Botrytis, *Mich.*; Morchella, *Dillen.*; Tuber, *Mich.*; Mucor, *Mich.* The number of species is roughly estimated at over 4,000. There are about 800 British species.

Properties and Uses.—Fungi have very variable properties. Some are medicinal, others edible, and numerous species are more or less poisonous. Many deaths have occurred from poisonous Fungi having been mistaken for edible ones; and, apart from their botanical characters, science as yet affords no certain characteristics by which they may be distinguished. Some general characters, however, will enable us in most cases to do so: these may be tabulated as follows:—

Edible Mushrooms.

1. Grow solitary in dry airy places.
2. Generally white or brownish.
3. Have a compact brittle flesh.
4. When cut do not change colour by exposure to the air.
5. Juice watery.
6. Odour agreeable.
7. Taste not bitter, acrid, salt, or astringent.

Poisonous Mushrooms.

1. Grow in clusters, in woods, and dark damp places.
2. Usually with bright colours.
3. Flesh tough, soft, and watery.
4. Acquire a brown, green, or blue tint, when cut and exposed to the air.
5. Juice often milky.
6. Odour commonly powerful and disagreeable.
7. Have an acrid, astringent, acid, salt, or bitter taste.

All Fungi should be avoided which insects will not toueh, those also which have scales or spots on their surfaee ; and, whatever may be their apparent properties, all those whieh have arrived at their full development, or when they exhibit any signs of ehange, should be used with caution. When there is any doubt as to the qualities of the mushrooms, it is advisable to cut them into slices, and maeerate them in vinegar and water for about an hour, then wash them in boiling water previous to their being cooked. It has been proved that some injurious Fungi lose their poisonous properties when thus treated. It is quite true that, by following strictly the above rules, edible species will not unfrequently be thrown away, but this is of little comparative importance, as by so doing all injurious ones will certainly be rejeeted. Probably the best tests given above are, to avoid those whieh are milky, or which have a biting or acrid taste, or those which have a powerful or disagreeable odour. Colour will frequently fail us, for while some snowy-white Fungi are poisonous, others, which are highly eoloured, as, for instance, *Agaricus cæsareus*, are, according to Berkeley, at onee the most splendid and the best of the eseulent Fungi.

Professor Schiff, of Florence, states that the poisonous mushrooms have a common poison whieh he has termed *muscarine*, and that its effects are counteraeted either by atropine or daturine ; and it is said that Italian apothecaries now keep these alkaloids in the rural districts where the consumption of poisonous Fungi is probable. But no confirmation of these results has as yet been arrived at by other experimenters so far as to prove that muscarine is thus widely distributed, but its presence has been ascertained in *Amanita muscaria*, and it is stated to be antagonistic to atropine. (See *Amanita.*)

The species or varieties of Fungi most commonly consumed in this country are : the Common Mushroom (*Agaricus* (*Psalliota*) *campestris*) and its varieties—those which are eultivated should be preferred; *Agaricus* (*Psalliota*) *arvensis*, *Agaricus* (*Marasmius*) *oreades*, the Champignon, *Morchella esculenta*, the Morel, *Tuber cibarium*, the Truffle, and several speeies of *Boletus*. Of all these the best known in this country is the common Mushroom, whether in its uneultivated or cultivated state ; and as other Fungi are frequently mistaken for this, by which many deaths have occurred, we may give one or two hints in reference to it besides those given previously. Thus its spores are purple ;

the gills are at first delicately pink, and afterwards purple; there is a permanent ring or collar round the stem; and it must *not* be sought in woods. Dr. Badham and others have proved that much valuable food is thrown away in this country by the rejection of edible Fungi. Dr. Badham enumerates no less than thirty species of Fungi which are natives of Britain, and which were eaten by himself and friends; and in the first part of Cooke's 'Handbook of British Fungi,' sixteen species belonging to the genus *Agaricus* alone are stated to be esculent. In France, Russia, Italy, Germany, and other countries, several Fungi are also eaten which are regarded by us as poisonous. It is difficult to account for these conflicting statements, but we believe that the differences thus observed in the effects of Fungi are due to variations of soil and climate, the conditions under which they are grown, the different states, fresh, dried, or preserved, in which they are eaten, manner of cooking, and the peculiar idiosyncrasies of individuals who partake of them. Even the common Mushroom is sometimes poisonous, and in Italy, Hungary, and elsewhere, is generally avoided. We consider, therefore, that, with our present knowledge, it is better to abstain altogether from Fungi when there exists the slightest doubt of their qualities.

From a chemical point of view the Fungi are remarkable for the large proportion of water which enters into their composition, by their containing much nitrogen, and being rich in phosphates.

Medicinally, Fungi have been regarded as aphrodisiac, narcotic, tonic, astringent, emetic, purgative, &c. Ergot of rye (see *Secale cereale*, page 738), which is used medicinally to excite uterine contractions in labour, and for other purposes, is now proved to be the sclerotium of *Claviceps purpurea*, Tulasne. Wheat and a number of other grasses are also frequently ergotised.

Fungi are often very destructive to living plants and animals by growing upon them. Thus, in plants, the diseases known as blight, mildew, rust, smut, vine-mildew, potato disease, ergot, and others, are either caused from, or accelerated by, the agency of Fungi. Many important communications attempting to prove that Fungi are either the cause of, or the means of propagating, various diseases in the human subject, have been also made during the last few years, and it is now certain that Fungi are associated with several cutaneous and other external as well as internal diseases. In some cases of diphtheria reported a few years since in the 'British Medical Journal' by Dr. N. W. Taylor, it is stated that the only apparent source of the disease was the mouldiness of the walls caused by the production of *Coprinus domesticus* and a form of *Aspergillus*. Berkeley also informed Dr. Taylor, that when he was at Lille in 1838, at which time influenza was very fatal, it was supposed to arise from the spores of some species of *Coprinus*. The great success of the antiseptic treatment, first introduced by Sir Joseph Lister, and since carried out by him with such energy, skill, and ability, is also due to its preventing the growths of such Fungi as the *Bacteria* in the discharges of wounds, in which otherwise they would cause putrefaction. The action of Fungi in disease is now under investigation by accurate and discriminating observers, and promises to throw much light on our knowledge of the causes and propagation of various diseases; it is one replete with importance and interest, but which cannot be entertained further in this volume.

In the same way various diseases of animals generally are either caused, or accelerated, by the attacks of Fungi. Thus the disease in the silkworm known under the name of *muscardine* is produced by one or more species of *Botrytis*. Similar diseases also occur in other animals. Caterpillars are frequently attacked by species of *Sphæria* or *Claviceps*, in China, Australia, New Zealand, and elsewhere, and ultimately destroyed. The mucous membrane of birds is also commonly infested with Fungi of various kinds.

In other ways, again, Fungi are often very destructive. Thus the disease called *Dry Rot*, which frequently occurs in wood, is especially caused by dampness, and the subsequent development of the spores of such Fungi as those of *Merulius lacrymans* and *M. vastator*, and *Polyporus destructor*. The different kinds of Moulds which are found on bread, cheese, preserves, fruits, paper, books, and various other substances, are also Fungi of the species Mucor, Botrytis, Aspergillus, Penicillium, Oidium, &c.

An interesting matter connected with the action of Fungi on organic matters is also afforded by the process of fermentation, which is now commonly regarded as being essentially caused by Fungi. Thus, Pasteur has demonstrated that the fermentation of saccharine fluids is due to the development in them of the Yeast plant, and the butyric fermentation to the growth of *Bacteria*.

Agaricus.—Agaricus campestris, the Common Mushroom, and its varieties—*A. arvensis*, *A. oreades* (the Champignon), *A. deliciosus*, *A. cæsareus* and *A. procerus*, &c.—are largely used for food in this and other parts of the world. (See *Properties and Uses of Fungi*, page 757.) The subterranean mycelium of various species of *Agaricus*, as that of *A. oreades*, *A. prunulus*, *A. Orcella*, *A. campestris*, and others, and of allied genera, developes in a radiating manner, and, by the remains acting subsequently as a manure, causes the grass in our meadows, in such places, to grow in a very luxuriant manner in rings, which are commonly called fairy rings.

Amanita (*Agaricus*) *muscaria* is a very poisonous species. It possesses narcotic and intoxicating qualities, and is much used in Kamtschatka and some other parts of the Russian empire as a narcotic and intoxicating agent. This fungus possesses the remarkable property of imparting its intoxicating qualities to the fluid excretions of those who partake of it. When steeped in milk, and other liquids, it acts as a poison to flies; hence its specific name. It contains an uncrystallisable alkaloid named *muscarine*. This closely resembles pilocarpine in its action when administered internally, and it is stated to be antagonistic to atropine; but it is remarkable that when locally applied it dilates the pupil like atropine. (See page 757.)

Bacteria.—The action of these organisms in connexion with disease has been already referred to. (See pages 387 and 759.)

Boletus edulis and several other species are edible.—*B. edulis* is much esteemed in Italy, &c.

Claviceps (*Cordiceps*).—The disease called Ergot, which occurs in the grains of Rye, Wheat, and many other Grasses, is produced by *C. purpurea*. The official Ergot of the British Pharmacopœia is the sclerotium of this fungus, produced between the pales, and replacing the grain of the common Rye (*Secale cereale*). Ergot is largely used in medicine to cause contraction of the uterus in cases of tedious parturition, or to prevent flooding after delivery. It is also employed for other purposes. In overdoses it acts as a poison, and sometimes causes death. Taken for a length of time, as in bread made with diseased Rye, it also acts as a poison.—*C. Robertsii*, *C. sinensis*, *C. entomorrhiza*, and other species, frequently attack caterpillars in a living state, which they destroy as their mycelium developes. The remains of the caterpillar with the developed fungus of *C. sinensis* is a highly esteemed drug in China, where it is much used as a tonic.

Cyttaria Darwinii and *C. Berteroi* are employed for food, the former in Terra del Fuego, and the latter in Chili.

Elaphomyces granulatus and *E. muricatus* are sold in Covent Garden Market under the name of Lycoperdon Nuts. They are supposed to possess aphrodisiac properties, and to promote parturition and the secretion of milk.

Exidia Auricula Judæ, Jew's Ear, is reputed to possess astringent and discutient properties when applied externally in the form of a decoction, or poultice.—*E. hispidula* is used in China as a styptic, and as a food mixed in soups, &c. It is known there under the name of *Moghi*, signifying ears of trees.

Lycoperdon, the Puffballs.—When the *Lycoperdon giganteum* is submitted to combustion, the volatile emanations arising from it possess a narcotic property. It has been employed in this way to stupefy bees when removing honey from the hive, and has been also recommended as an anæsthetic agent instead of ether and chloroform. A similar property is also possessed by some other species.

Merulius lacrymans and *M. vastator* are two of the Fungi which occur in the disease called Dry Rot. (See *Properties and Uses of Fungi*, p. 759.)

Morchella esculenta, the Morel, is a highly esteemed edible fungus, which is principally employed for flavouring. It is commonly imported in a dry state from the Continent.

Mylitta australis is called Native Bread in Australia, where it is largely used as food by the natives. This fungus frequently weighs as much as from one to three pounds. Other species, nearly allied to *Mylitta australis*, are also used in China for food and as medicine.

Oidium.—The Vine Fungus is commonly supposed to be a species of this or a nearly allied genus. It would appear, however, that the so-called fungus, *Oidium*, is a mycelial form of *Erysiphe Tuckeri*.

Pachyma Cocos, Fries, is another fungus, allied to *Mylitta*, which is highly esteemed as a food and medicine by the natives of China, &c., and by the Indians of the United States of North America. It is the Tuckahoe or Indian Bread of the United States. It has been offered in the London markets under the name of China Root. It may readily be distinguished from true China Root by the absence of starch.

Penicillium glaucum, *Mucor Mucedo*, *Aspergillus glaucus*, *Botrytis vulgaris*, and other Fungi, constitute the various kinds of Moulds already noticed. (See *Properties and Uses of Fungi*, p. 759.)

Peronospora (*Phytophthora*) *infestans* is the fungus which causes the potato disease.

Polyporus.—*P. destructor* is one of the Fungi found in the Dry Rot of wood. (See *Merulius.*) Thin slices of *P. igniarius* and *P. fomentarius*, when softened by beating with a mallet, are sometimes employed externally to restrain hæmorrhage. Similarly prepared slices soaked in a solution of nitre, and dried, constitute *Amadou* or *German Tinder*. When impregnated also with gunpowder, they form *Black Amadou*. Amadou has been sometimes used to give support and pressure in certain surgical affections, and as a moxa.—*P. squamosus* and *P. betulinus*, when pressed, sliced, and prepared by rubbing with pumice, &c., are used to make razor strops.—*P. officinalis*, Larch or White Agaric, has been employed externally as an astringent; and internally, to check perspiration, and as an emetic, cathartic, &c. It was formerly employed as an anthelmintic, but its action is frequently violent. Larch Agaric is now imported from the northern part of Russia, where it grows on the stems of *Larix sibirica*.—*P. anthelminticus*, a native of Tavoy in the Tenasserim provinces of Burmah, is known as Shan-mo (Worm Mushroom), being there highly esteemed as an anthelmintic.—*P.* (*Boletus*) *Laricis canadensis*, Canadian Agaric, is reputed to be a valuable remedy in acute rheumatism.—A species of *Polyporus*, believed by Berkeley to be *P. Pini canadensis*, Schweinitz, a native of Canada, is said to be a tonic bitter, and is recommended as an application to wounds.

Puccinia graminis is the fungus which produces the Mildew of Wheat.

Saccharomyces (*Torula*).—The so-called Yeast plant is a mycelial form of *S. cerevisiæ*; and the so-called Vinegar plant is also a more developed form of the mycelium of the same fungus. The ferment obtained in brewing beer is produced by *Saccharomyces cerevisiæ*; it is official in the British Pharmacopœia.

Tuber, the Truffle.—The species of Truffle, several of which occur in Britain, are subterranean. They are highly esteemed as seasoning or flavouring agents. The best are imported from France, Algeria, and Italy; they are commonly preserved in oil. *T. æstivum*, *T. cibarium*, and *T. melanosporum* are the more frequently used species.

Order 2. LICHENES, the Lichen Order.—Character.—*Perennial plants*, composed of hyphal tissue resembling that of Fungi, but its constituent cells are firm and dry, and enclose the cells known as gonidia (*figs.* 853, *gon*, and 855, *gon*), which contain chlorophyll, and are now frequently regarded as minute Algæ, upon which an Ascomycetous Fungus is parasitic. (See page 388.) The whole is arranged so as to form a foliaceous, somewhat woody, scaly, crustaceous, or leprous thallus (*figs.* 851 and 852); living and fructifying in the air, and growing on the bark of trees, or on old palings, walls, &c., or on stones, or on the exposed surface of rocks; usually epiphytic, but sometimes parasitic, and commonly presenting a dry, shrivelled, more or less lifeless appearance. *Reproduction* either vegetative by means of *soredia* (see page 390); or by true *fructification*, consisting of, (1) *apothecia*, which are sessile or stalked, and generally of a rounded (*fig.* 852, *ap*) or linear form (*fig.* 851), and composed of *asci* or *thecæ* (*fig.* 853, *as*), enclosing 4, 8, or 16 spores; (2) of *spermogonia* containing *spermatia* (*figs.* 852, *sp*, and 854, *sp*); and (3) of, very rarely, *pycnidia* enclosing *stylospores*. (For detailed account of the fructification of Lichens, see pages 388–390.)

Distribution and Numbers.—Lichens are distributed over all parts of the world. The pulverulent species 'are the first plants that clothe the bare rocks of newly formed islands in the midst of the ocean, foliaceous lichens follow these, and then Mosses and Liverworts.' Lichens also form a considerable proportion of the vegetation of the polar regions and of mountain-tops. *Illustrative Genera:*—Opegrapha, *Pers.*; Verrucaria, *Pers.*; Lecidea, *Ach.*; Cladonia, *Hoffm.*; Peltigera, *Hoffm.*; Usnea, *Hoffm.* There are above 2,500 species.

Properties and Uses.—Several possess nutritive properties from containing amylaceous substances, and such are also emollient and demulcent: others contain bitter principles, which render them tonic and astringent; and many are important as dyeing agents. A few possess aromatic properties. Some Lichens, as species of *Variolaria,* contain a large amount of calcium oxalate. None are known to be poisonous.

Cetraria.—C. islandica, Iceland Moss.—This lichen contains about 70 per cent. of *lichenin* or *lichen starch,* and above 2 per cent. of a crystalline bitter principle termed *cetraric acid* or *cetrarin.* It is official in the British Pharmacopœia, and is employed as a nutritious food, and as a mild mucilaginous tonic in catarrh, consumption, and other affections. When used for food it should be previously deprived of its bitterness: this may be done either by heating it once or twice in water to near the boiling point of Fahrenheit, or, still better, by digesting it in a weak alkaline solution formed by adding half an ounce of carbonate of potassium to about a gallon of cold water, and afterwards washing it with water.

Cladonia or *Cenomyce.—C. rangiferina* is the Reindeer Moss. It is so termed from constituting the food, more especially in the winter months, of the Reindeer.—*Cladonia* (*Scyphophorus*) *pyxidata* is commonly termed Cup-moss; this and other species have been employed as remedies in whooping-cough.

Gyrophora (*Umbilicaria*).—Several species, denominated *tripe de roche,* possess nutritive qualities, and are used as food in the Arctic regions. Franklin and his companions owed their preservation in 1821, in a great measure, to the use of these lichens as food. The *Gyrophoras* also possess slight tonic properties owing to the presence of a bitter principle.—*G. pustulata* is one of the Lichens used in this country by the manufacturers of orchil and cudbear. (See *Roccella* and *Lecanora.*) It may be also made to produce a brown colour.

Lecanora.—L. tartarea was formerly the principal lichen used in the preparation of the dye called Cudbear; but cudbear is now obtained not only from it, but also from a number of other Lichens, as the species of *Roccella,* &c. (See *Roccella* and *Gyrophora*).—*L. Perella* yields a similar dye. Two species of *Lecanora,* namely, *L. esculenta* and *L. affinis,* form important articles of food both to man and animals generally, in Persia, Armenia, Tartary, &c. They appear in some seasons in such enormous quantities, that in certain districts they cover the ground to the depth of several inches, and the natives believe they fall from heaven. *L. esculenta* is also found in Algeria, Asia Minor, &c., and Dr. O'Rorke has endeavoured to prove that this lichen was the *manna of the Hebrews,*—that which fed them with regularity for forty years in the wilderness.

Parmelia.—P. parietina was formerly regarded as a valuable febrifuge, astringent, and tonic. It contains a yellow crystalline colouring matter, called *chrysophanic acid,* which is identical with that obtained from Rhubarb, Goa powder, &c.—*P. perlata* is employed by the manufacturers of orchil and cudbear. (See *Roccella.*) It is also reputed to possess diuretic properties.

Peltigera.—Peltigera (*Peltidea*) *canina* and *P. rufescens* are known in the herb shops of this country under the name of Ground Liverwort. This was at one time official in the London Pharmacopœia, and regarded as a specific in hydrophobia.

Roccella, Orchella Weeds.—*R. tinctoria*, *R. fuciformis*, and *R. hypomecha*, under the common name of Orchella Weed, are the species usually met with in this country. They are imported from various parts of the world, as the Canary and Cape de Verd Islands, the Azores, Angola, Madagascar, Mauritius, Madeira, South America, Cape of Good Hope, &c. In commerce they receive the name of the country from whence they have been derived. Orchella weed is extensively used in the manufacture of the purple and red colours called *orchil* and *cudbear.* In Holland, the blue colour called *litmus* is also prepared from the same Lichens; but the best kind is said to be made from *R. tinctoria.* Other Lichens, as species of *Lecanora*, *Gyrophora*, *Parmelia*, *Variolaria*, &c., are also sometimes employed in Britain and elsewhere for the preparation of orchil, &c. (See these species.) Orchil and cudbear are used for staining and dyeing purple and red colours, and also occasionally as tests for acids and alkalies. Litmus is employed as a test for alkalies, acids, and some salts with a basic reaction. It is official for this purpose in the British Pharmacopœia. A decoction of Orchella weed possesses mucilaginous, emollient, and demulcent properties, and has been used in coughs, catarrhs, &c.

Sticta pulmonaria, Tree Lungwort, Oak-lungs.—This lichen possesses tonic and nutritious properties, somewhat resembling in these respects *Cetraria islandica.* In Siberia it is said to be used instead of hops for imparting bitterness to beer. It is also employed in France, &c., for the production of a brown dye.

Variolaria.—*V. dealbata* and *V. orcina* are used for the preparation of Orchil in France.

Order 3. CHARACEÆ, the Chara Order.—*Diagnosis.*—*Water plants*, with a distinct axis branching in a whorled manner (*fig.*

FIG. 1124.

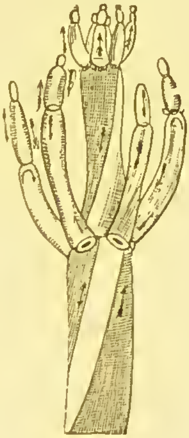


Fig. 1124. A small portion of a species of *Nitella*, magnified. The branches are arranged in a whorled manner. The contents of each cell exhibit a kind of circulation. The direction of this circulation is indicated by the arrows. The circulating matter does not pass from cell to cell, but is confined to that in which it originates.

1124), and either transparent or coated with calcium carbonate. *Reproductive organs* of two kinds arising at the base of the branches (*fig.* 856, *s*, *a*), and either on the same or on different branches of the same plant, or on separate plants. These organs are termed *globules* or *antheridia* (*figs.* 856, *a*, and 858) and *nucules* or *carpogonia* (*figs.* 856, *s*, 859, and 860). (See pages 390-392 for a detailed account of their structure.)

Distribution and Numbers.—These plants occur in stagnant fresh or salt water in all parts of the globe; but they are most abundant in temperate climates. *Illustrative Genera:*—There are two genera, Chara, *Linn.*; and Nitella, *Agh.*; and about 40 species.

Properties and Uses.—These plants during their decay give off a very fœtid odour, which is regarded as most injurious to animal life. They have no known uses.

Order 4. ALGÆ, the Sea-weed Order.—*Diagnosis.*—*Parenchymatous plants*, growing in salt or fresh water, or in moist situations. The thallus is foliaceous and branched (*fig.* 5), or filamentous (*figs.* 861 and 862), or pulverulent. Many Algæ are microscopic, and others are of large size. In colour they are usually greenish, rose-coloured, or brownish. They are reproduced in various ways. (See pages 392–399.)

Division of the Order and Illustrative Genera.—The order is commonly divided into three sub-orders, which are frequently regarded as distinct natural orders; these are known under the names of the *Melanosporeæ*, *Melanospermeæ*, or *Fucoideæ*; *Rhodosporeæ*, *Rhodospermeæ*, or *Florideæ*; and *Chlorosporeæ*, *Chlorospermeæ*, or *Confervoideæ*. To these sub-orders or orders may be added two others, called respectively the *Diatomaceæ* and *Volvocineæ*. Numerous other arrangements of the Algæ have been proposed of late years, but as these must be regarded as transitional, we have retained the above-named sub-orders from their being more generally used in this country in works treating practically of the Algæ; and must refer those desiring detailed information in reference to other arrangements to such works as Sachs' 'Text Book of Botany,' &c, and to speeial treatises on this group of plants. Reference should also be made to pages 392-399 of this Manual for a general notice of their Reproductive Organs. Their distinctive characters may be briefly described as follows:—

Sub-order 1. *Melanosporeæ*, *Melanospermeæ*, *Fucoideæ*, or *Brown-coloured Algæ.*—Multicellular Algæ, growing in salt water, forming a foliaceous or filamentous thallus, and of an olive-green or olive-brown colour. *Illustrative Genera:*—Sargassum, *Rumph.*; Fucus, *Linn.*

Sub-order 2. *Rhodosporeæ*, *Rhodospermeæ*, *Florideæ*, or *Rose-coloured Algæ.*—Marine multicellular Algæ, with a foliaceous or branched filamentous thallus, and of a reddish-purple, rose-coloured, or reddish-brown colour. *Illustrative Genera:*—Corallina, *Tourn.*; Chondrus, *Grev.*; Porphyra, *Agh.*

Sub-order 3. *Chlorosporeæ*, *Chlorospermeæ*, *Confervoideæ*, or *Green-coloured Algæ.*—Unicellular or multicellular Algæ, growing in fresh or salt water, or in moist situations; usually of a bright green colour, or rarely red. *Illustrative Genera*:—Conferva, *Plin.*; Palmella, *Agh.*; Spirogyra, *Link.*

Sub-order 4. *Diatomaceæ.*—The following diagnosis is modified from Henfrey:—Microscopic unicellular plants, occurring isolate or in groups of definite form, usually surrounded by a

FIG. 1125.

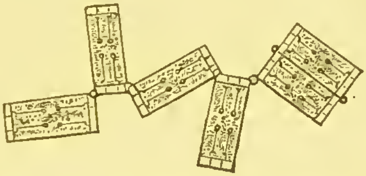


Fig. 1125. A species of Diatomaceous Alga (*Diatoma marinum*) divided into parts by *merismatic* or *fissiparous* cell-division. The parts are seen to be striated.

gelatinous investment, the cells exhibiting more or less regular geometrical outlines and enclosed by a membrane, striated (*fig.* 1125) or granular, either simply tough and continuous (*fig.* 1126), or impregnated with silex and separable into valves (*fig.* 1125). Reproduction by spores formed after conjugation of the cells which have previously lost or thrown off their cellulose walls (*fig.* 1126), or by division (*fig.* 1125). The Diatomaceæ are again divided into two sections or tribes. 1. *Diatomeæ* (*fig.* 1125). Natives of fresh, brackish, or salt water, or of moist ground, of a brownish or olive colour,

FIG. 1126.

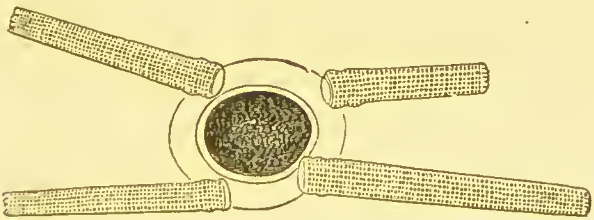


Fig. 1126. Two Desmidiaceous Algæ (*Docidium Ehrenbergii*) after conjugation, with a *resting* or *inactive* spore between them. (After Ralfs.)

valvular, and invested by a siliceous membrane. *Illustrative Genera*:—Diatoma, *DC.*; Navicula, *Bory.* 2. *Desmidieæ* (*fig.* 1126). Found only in fresh water, of a green colour, continuous, containing starch, and not invested by a siliceous membrane. *Illustrative Genera*:—Closterium, *Nitzsch*; Desmidium, *Agh.*

Sub-order 5. *Volvocineæ* (*fig.* 1127). Henfrey diagnoses them as follows :—'Microscopic bodies swimming in fresh water by the aid of cilia arranged in pairs upon the surface of a common semi-gelatinous envelope, the pairs of cilia each belonging to a green corpuscle resembling the zoospore of a confervoid, imbedded in the periphery of the common envelope. Reproduction by the development of each corpuscle into a new colony, the whole being set free by the solution of the parent envelope, or by conversion of the corpuscles into encysted resting-spores like those of Conferveæ ;' or, sexually, by impregnation taking place within the colony from oogonia and antheridia.' *Illustrative Genera:*—Volvox, *Lam.*; Gonium, *Lam.* The members of this group were frequently regarded as Infusorial Animalcules, but in all their essential characters they closely resemble the Confervoideæ ; indeed, they are commonly placed in that sub-order.

FIG. 1127.

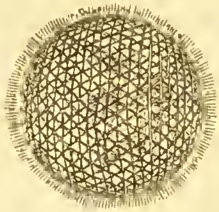


Fig. 1127. The Revolving Volvox (*Volvox globator*). The outer surface is ciliated.

Distribution and Numbers.—Algæ are more or less distributed throughout the globe, growing in salt or fresh water, or in moist situations. Some species are found in the boiling springs of Iceland, &c.; others occur in mineral springs, and some in chemical solutions. The waters of whatever temperature have their own peculiar forms. It is impossible to estimate with any degree of accuracy the number of species of Algæ, but they may be roughly estimated at 2,500.

Properties and Uses.—Several species are employed for food in different parts of the world ; as, *Laminaria saccharina*, *L. digitata*, *L. potatorum*, &c.; *Alaria esculenta*, *Durvillæa utilis*, *Sargassum species*, *Iridæa edulis*, *Chondrus crispus* and *C. mamillosus*, *Gelidium corneum*, &c., *Gigartina speciosa*, *Laurencia papillosa*, &c., *Gracilaria lichenoides* and other *Gracilarias*, *Rhodymenia palmata*, *Porphyra vulgaris*, and *P. laciniata*, *Ulva latissima*, *U. compressa*, &c., *Nostoc edule* and other species, *Hormosiphon arcticus*, and many others The nutritious properties of the above are due to the presence of starch, sugary matter (*mannite*), mucilage, and albumen. M. Payen also discovered a principle in *Gelidium corneum* (*Algue de Java*), and some other Algæ, to which he gave the name of *gelose*. To this substance the nutritious properties of Algæ are likewise, to a great extent, due. According to Payen, 1 part of *gelose* dissolved in 500 parts of boiling water will afford, upon cooling, a colourless, transparent jelly,—thus forming ten times more jelly than a like weight of the best animal gelatine. In order, therefore, to produce a jelly of equal consistency, it would be only necessary to employ the tenth part of what is necessary when isinglass is used. Jellies prepared from species of *Gelidium*, *Laurencia*, &c., are much employed for food in China, Japan, &c. The so-called Japanese isinglass consists of numerous Algæ, but more especially of *Gelidium corneum*, *Gloiopeltis tenax*, and *Endocladia vernicata*. The edible birds' nests, so highly valued for food in China, owe their properties probably in part to certain species of Algæ, but essentially to the secretions of the swallows by which they are constructed.

In medicine the above-mentioned nutritious Algæ may be used for their emollient and demulcent properties. Several species of Algæ, particularly *Fucus vesiculosus*, have been also employed as remedies in goitre and scrofulous diseases. They owe their beneficial effects in such cases, principally, to the presence of a small quantity of iodine. The ashes obtained by burning many species of Algæ in the open air form the substance called *kelp*, which was formerly much used for the preparation of carbonate of sodium, but this is now more cheaply obtained from sea-salt. Iodine is, however, still prepared from kelp.* Some Algæ have been reputed to possess vermifugal properties ; none are known to be poisonous.

Several Algæ are remarkable for imparting colours to water, snow, &c. Thus, *Protococcus atlanticus* gives a red colour to certain parts of the Atlantic ; *P. nivalis* contributes to communicate a red colour to snow ; and *P. viridis*, a green tint ; *Dolichospermum Thompsoni* imparts a green colour to some Irish and Scotch lakes ; the red colour of the Red Sea is also in part attributed to the presence of *Trichodesmium erythræum*, &c. &c. Dr. Robert Brown has also shown that the discoloration of the Arctic Sea is due to Diatomeæ, but principally to *Melosia arctica*, and that these form the brown-staining matter of the 'rotten ice' of northern navigators.

Alaria esculenta, Bladderlocks, Hen-ware, or Honey-ware, contains *mannite*. It is employed for food in Ireland, Scotland, Iceland, and other northern regions. Berkeley says that 'it is the best of all the esculent Algæ when eaten raw.'

Chondrus (*Sphærococcus*).—*C. crispus* is the source of the so-called Carrageen or Irish Moss. It possesses nutritive, emollient, and demulcent properties, and may be employed in the form of a decoction or jelly, in pulmonary complaints and other affections. *Bandoline* or *fixature*, used for stiffening the hair, and other purposes, is commonly prepared from Carrageen. The mucilage of carrageen is likewise much employed in the United States as a size for paper, cotton goods, felt and straw hats, and for thicken-

* See two valuable communications by E. C. Stanford, in the 'Journal of the Society of Arts,' for a detailed account of a new process for preparing iodine from kelp, and for a description of several other important products obtainable from Algæ: and also a 'Report on the Exhibits in the Paris Exhibition of 1878,' by Paul, Holmes, and Passmore, in 'Pharmaceutical Journal,' ser. iii. vol. ix. p. 303.

ing the colours used in calico printing. Carrageen is also used in the United States for fining beer, coffee, &c.—*C. mamillosus* or *Gigartina mamillosa* almost always occurs in the Carrageen Moss of commerce. Its properties are similar.—*G. acicularis* is another species also sometimes found mixed with it.

Durvillæa utilis is used for food by the poorer inhabitants on the western coast of South America.

Fucus.—Several species contain *mannite*, as *F. vesiculosus*, *F. nodosus*, and *F. serratus*. These species are used in the preparation of kelp, and are also collected for manure.—*F. vesiculosus*, Sea Wrack.—This Alga is much used in winter in certain islands of Scotland for feeding horses and cattle. Boiled in water and mixed with a little coarse meal or flour, it has been used in Gothland for feeding hogs, hence the plant is there called *swine-tang*. The expressed juice has been given internally, and frictions of the plant have been employed externally in glandular and scrofulous affections. A kind of wine prepared from this Alga has also been used with success in similar diseases. The substance called Vegetable Ethiops, which has been likewise employed in such cases as the above, is a kind of charcoal produced by the incineration of this Alga in close vessels. The beneficial effects in these instances are principally due to the presence of a small quantity of iodine. This Alga has also, of late years, been in some repute as remedy for obesity, but its value for such a purpose seems to be but trifling. It is the essential constituent in the nostrum termed *Anti-Fat*.

Gelidium corneum, as already noticed, is nutritive. It is the *Algue de Java*, from which M. Payen first obtained *gelose*. (See page 766.) It forms a favourite article of food in Japan, and other countries, and is also used in the manufacture of a kind of glue, and for other purposes.

Gigartina spinosa (*Fucus spinosus*) is the Jelly Plant of Australia. It is employed for food and for making size, cement, &c. (See *Chondrus* and *Gracilaria*.)

Gracilaria (*Plocaria*).—*G. lichenoides* (*Plocaria candida*), and *G. confervoides* are the sources of the so-called Ceylon Moss, which is official in the Pharmacopœia of India. In most commercial specimens, however, the principal constituent is *G. lichenoides*. Ceylon Moss is nutritive, emollient, and demulcent, and may be employed in the form of a decoction or jelly, as food for children and invalids, and also medicinally, in pulmonary complaints, diarrhœa, and other affections. It is sometimes imported under the name of *Agar-agar*, but *Gigartina spinosa* has been also imported under the same name. Both species are largely employed in the East for making nutritious jellies, for stiffening purposes, and for varnishing.—*G. tenax* may be similarly used.—*Gracilaria* (*Plocaria*) *Helminthocorton* is Corsican Moss. (See *Laurencia*.) It has been used principally as a vermifuge, but its properties have been much overrated.—*G. crassa* (Ki-tsai) is cooked with soy or vinegar in China. It is also employed by the Chinese ladies to give a glossiness to their hair.

Halidrys siliquosa contains nearly 6 per cent. of *mannite*.

Hormosiphon arcticus (*Nostoc arcticum*), which is very common in the Arctic regions, according to Berkeley, 'affords a mass of wholesome food, which is far preferable to the Tripe de Roche (see *Gyrophora*, p. 762), as it has none of its bitterness or purgative quality.'

Iridæa edulis, as its name implies, is nutritious, and is sometimes used for food in Scotland, and other parts of the world.

Laminaria.—*L. saccharina* is remarkable for the large quantity of *mannite* it contains, upwards of 12 per cent. Its young parts, mixed with those of *L. digitata*, are eaten in Scotland, &c., under the name of *Tangle*. The latter species also contains much *mannite*. *L. saccharina* is called *Seatape* in China, where it is used for food and other purposes.—*L. potatorum* is likewise employed for food in Australia, and other species possess similar properties.—*L. bulbosa*, *L. digitata*, and *L. saccharina* are used to a very large extent for manure and for the preparation of kelp. The latter is also frequently used as an hygrometer. *L. digitata* also contains much iodine.

Laurencia.—L. pinnatifida is remarkable for possessing pungent properties. It is called Pepper-dulse in Scotland, where it is occasionally eaten. Berkeley says that *L. obtusa* forms the greater part of what is now sold in the shops as Corsican Moss. (See *Gracilaria*).—*L. papillosa* (Tanshwui) is extensively employed in China and Japan in the preparation of a gelatinous substance called *Yang-Tasi.*

Nostoc.—N. edule is eaten in China, &c. Other species are also edible. (See *Hormosiphon arcticus.*)

Porphyra laciniata and *P. vulgaris* are employed in the preparation of a kind of sauce or pickle, which is termed *Sloke*, *Slokan*, or *Laver.*—*P. vulgaris* is eaten in China as a relish to rice. It is termed *Tsz-Tsai* (purple vegetable). It is also used for food by many of the Indians along the Pacific coast, being cooked separately as greens, or with meat.

Rhodymenia palmata is an article of food in Scotland, Ireland, Iceland, &c. It is the *Dulse* of the Scotch, and the *Dillesk* of the Irish.

Sargassum.— S. bacciferum is the Gulf-weed of the Atlantic. This and other species contain iodine, to the presence of which they owe their beneficial effects in goitre, for which purpose stem-like pieces of *S. bacciferum* are much employed in South America under the name of *Goitre-sticks.*

Ulva latissima is employed in the preparation of *Green Laver.* It is very inferior to the laver prepared from species of *Porphyra.* Both these lavers might be beneficial in scrofulous affections, &c., as they contain iodine.

BOOK III.

PHYSIOLOGY OF PLANTS, OR PHYSIOLOGICAL BOTANY.

HAVING now examined the structure, classification, properties and uses of plants, we have still to consider them in a state of life or action, and to explain, as far as science enables us, the laws which regulate their life, growth, and reproduction. The department of Botany which investigates these phenomena is termed Physiology; and the various processes which go on in the plant, and which are the necessary accompaniments of its life, are called its *functions*. The different vital actions are naturally divided into classes, called, respectively, the functions of the organs of nutrition, and the functions of the organs of reproduction; the former being those concerned in preserving the life of the particular plant, and the latter in continuing the species. Physiology includes the study of the life of the whole plant, when it is termed *general*, and that of the particular organs, in which case it is called *special*; and each division may be further divided into Physiological Chemistry, and Physiological Physics.

The present state of our knowledge of many points connected with the physiology of plants is so imperfect that there is some difficulty in arranging a good plan for its study. In examining, therefore, the functions of the different organs, the order of arrangement adopted in treating of their structure and morphology will be followed as far as possible, after which will be added a brief notice of General Physiology, and some observations on Special Phenomena in the life of the whole plant.

CHAPTER 1.

SPECIAL PHYSIOLOGY OF THE ELEMENTARY STRUCTURES, AND OF THE ORGANS OF NUTRITION.

Section. 1. Physiology of the Elementary Structures.

1. Functions of Parenchymatous Cells.—As the simplest forms of Vegetable life, such as the Red Snow Plant (*Protococcus nivalis*) (*fig.* 1), consist of a single cell of a parenchymatous nature, such a cell is necessarily capable of performing all the actions appertaining to plant life. Parenchyma also constitutes the whole structure of Thallophytes, as well as the soft portions of all plants above them ; hence the physiology of parenchymatous cells is of the first importance. The more important vital actions of these cells are : (1) Formation of new cells ; (2) Absorption and transmission of fluids ; (3) Movements in their contents ; and (4) Elaboration of their fluid contents, and production of the various organic compounds of the plant.

(1) *Formation of Cells* (*Cytogenesis*).—All plants, as we have seen (p. 21), in their earliest conditions, are composed of one or more cells, hence all the organs which afterwards make their appearance must be produced by the modification of such cells, or by the formation of new ones.

The subject of *cell-formation* or *cytogenesis* has for many years engaged the attention of able physiologists, and by their united labours we have now arrived at tolerably definite conclusions upon the main points of the inquiry, although some of the subordinate ones are still involved in obscurity.

New cells can only be formed from the thickened semi-fluid matter called *protoplasm* ; hence cells can in no case be formed without the influence of living organisms. The nature of protoplasm has been already fully described. By various observers this formative matter of cells has also been called *organisable matter*, *vegetable mucilage*, *cytoblastema*, &c. The *cell-wall* or membrane of cellulose takes no part in the formation of cells.

Each cell or elementary part consists of two kinds of matter, or of matter in two states : the one termed by some *germinal matter*, which is vitally active ; the other, *formed material*, which is physiologically dead. The protoplasm, primordial utricle, and nucleus of vegetable cells are of the first kind, and the cell-wall—which Dr. Beale has shown to be not a necessary part of the cell—the starch granules, &c., are examples of formed material. This latter may have very various appearances, whilst germinal matter is always the same.

In vegetable tissues the formed material may be thick or thin, but has in every case been produced by germinal matter. Nutrition is effected by the constant passage of nutrient matters from without inwards through the formed material to the germinal matter, whilst the direction of growth is usually from within outwards, the new formed material being generally interior to that of longer existence.

Cells originate in one of two ways: either free in the cavities of older cells, or at least in the protoplasmic fluid elaborated by their agency; or by the division of such cells. The first is called *Free Cell-formation* or *Original Cell-formation*; the second, *Cell-division* or *Cell-multiplication*, which is the usual mode of growth in the nutritive organs of plants.

A. FREE CELL-FORMATION.—We may distinguish two modifications of *free cell-formation.* 1. Free cell-formation from a nucleus or cytoblast; and, 2. Free cell-formation without the previous formation of a nucleus.

a. Free Cell-formation from a nucleus.—This mode was discovered by Schleiden, who at first considered it to be the only process of cell-formation that occurred in plants. Subsequently he modified his views materially, not only as regarded the manner in which it took place, but also as to its universality, and admitted that it was only one principal mode of cell-formation. The manner in which he describes it as taking place is as follows (*figs.* 1128 and 1129):—A portion of the protoplasm collects into a more or less rounded or somewhat oval form, with a defined outer border, thus forming the nucleus of the cell; upon this a layer of protoplasm is deposited, which assumes the form of a membrane, and expands so as to form a vesicle; on the outside of this a cellulose membrane is secreted, and the formation of the cell is completed. The protoplasmic vesicle in this case forms the subsequent lining of the young cell-walls, and constitutes the 'primordial utricle' of Mohl.

b. Free Cell-formation without a previous nucleus.—In the process of free cell-formation, as described above, we have alluded to the production of the nucleus as the first step of the process, and it is regarded to be so in most instances by the greater number of observers. Henfrey, agreeing with Nägeli &c., however, does not consider the nucleus of any physiological import in free cell-formation, which process he thus describes:—'The essential character of free cell-formation lies in the circumstance that the protoplasm which produces the primary cellulose wall of the new cell previously becomes separated from the wall of the parent cell, so that the new cell is free (or loose) in the cavity of the parent cell.' In some cases, it is certain, no nucleus can be detected in a cell previous to the formation of other cells free in its cavity; hence the presence of the nucleus cannot be regarded as essential; but the portion of protoplasm, which in such cases separates from the general mass, must be capable of covering itself with a membrane and forming a cell. This, according to Mohl, frequently occurs in the formation of the spores of the Algæ, &c.

FIG. 1128.

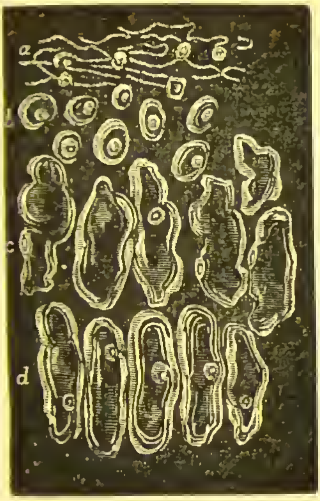


FIG. 1129.

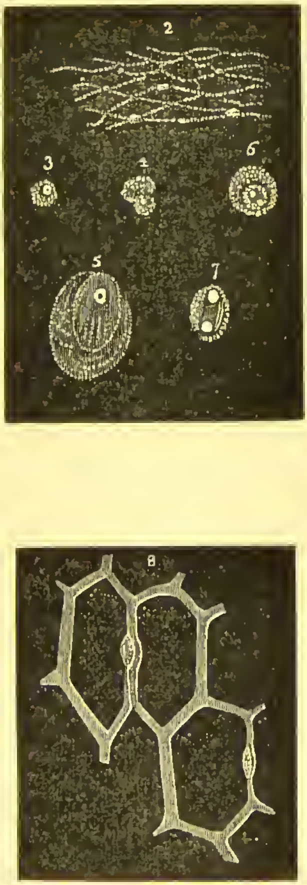


Fig. 1128. Cells from the embryo-sac of *Chamædorea Schiedeana* in the act of formation. *a*. The youngest part, consisting of nuclei and protoplasm. *b*. Newly formed cells. *c*, *d*. Cells still further developed, with nuclei adhering to their sides. (After Schleiden.)——*Fig.* 1129. 2. The part of *fig.* 1128, *a*, more highly magnified. 3. A nucleus still more highly magnified. 4. A nucleus with the cell forming upon it. 5. The same more highly magnified. 6. The same: the nucleus here shows two nucleoli. 7. The nucleus of 6, after the destruction of the cell by pressure. 8. The cells of *fig.* 1128, *d*, in a higher degree of development, the cell-walls having already united. (After Schleiden.)

In Flowering Plants free cell-formation has been generally believed to occur in the embryo-sac, in which part, after impregnation, the germinal vesicles, the antipodal cells, and the cells of the endosperm thus originate. In Flowerless Plants it is the mode by which the spores in the asci of Lichens, Algæ, and Fungi are developed.

In the ordinary course of vegetation, free cell-formation can only take place in the protoplasm contained in the interior of cells forming parts of living tissues.

B. CELL-DIVISION.—This mode of cell-formation has been also called by authors *merismatic* or *fissiparous cell-formation.* Cell-division can only take place in cells in which the contained protoplasm is in an active state, as in the cells of the *meristem*, a name given to that kind of parenchyma the constituent cells of which are capable of multiplying by division (see page 88). It may be treated of under two heads: namely (1) *Cell-division without absorption of the walls of the parent cell*; and (2) *Cell-division with absorption of the walls of the parent cell, and the setting free of the new cells.*

a. Cell-division without absorption of the walls of the parent cell.—This mode of cell-formation was first observed by Mohl, whose opinions were afterwards ably supported by Henfrey and Mitscherlich. According to these physiologists (and their observations have now been confirmed in all essential particulars by subsequent observers), this process is the one by which all the vegetating or growing parts of plants, whether Flowering or Flowerless, are produced and increased;—all increase in the mass of the different organs is therefore due to its agency. The manner in which it takes place is as follows:—the protoplasm of the cell, or, according to Mohl and Henfrey, the primordial utricle, becomes gradually constricted on the sides

FIG. 1130.

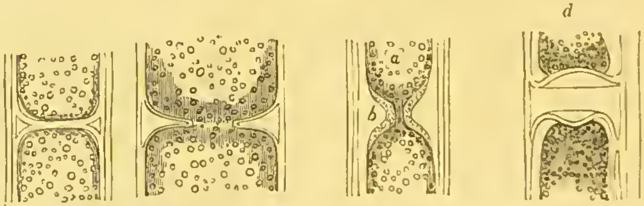


Fig. 1130. *a.* Cell of *Conferva glomerata*, with the cell-contents constricted by the half-completed septum. *b.* A half-completed septum in which a considerable deposition of cellulose has already taken place. *c.* A septum in course of development, after the action of an acid, which has caused contraction both of the primordial utricle (*b*), and the cell-contents (*a*). *d.* Complete septum split into two lamellæ by the action of an acid. (After Mohl and Henfrey.)

so as ultimately to form a sort of hour-glass contraction, and thus to divide the original contents into two distinct portions (*fig.* 1130 *a, b, c, d*). Each portion of the protoplasm or of the primordial utricle then secretes a layer of cellulose over its whole surface; and where this is in contact with the original wall of the primary cell it forms a new layer interior to it; but where away from the wall, at the new septum, a distinct cell-wall, so that the partition is double. The original cell thus becomes divided into two, and forms two cells, each of which may grow and divide in a similar way, and thus by the continued growth and division in like manner, of successive cells, all increase in the mass of the different parts and organs is due. This method of division is now often spoken of as *direct*, in contradistinction to the *indirect* method described further on (see p. 778). (It should be noticed that the primordial utricle of Mohl here referred to differs from that defined at page 26 of this Manual. Thus, according to the views adopted in this volume, the primordial utricle is characterised as the thin layer of protoplasm enclosing the watery cell-sap, and which lines the cell-wall after the cell has grown too large to be filled by protoplasm alone; while Mohl regards it as a more or less thickened layer of protoplasm, having the appearance of a membrane lining the cellulose wall, and enclosing the ordinary protoplasmic contents of the cell.)

Cell-division is best observed in water-plants of a low grade of organisation, and in hairs. In very simple plants also, such as *Palmella*, in which the newly formed cells separate and become independent plants, the process of division is well seen; but in the higher plants, where they remain permanently united to form tissues of greater or less solidity, it is demonstrated with difficulty.

In this mode of cell-formation, it is by no means evident what function the nucleus performs. That *in some cases* it is unimportant is clear, because cell-division, as above described, may take place, as it does in some of the lower orders of plants, without the presence of a nucleus. In the higher orders of plants, however, the original nucleus of the cell appears to undergo subdivision into two halves, as is the case with the other contents, so that a nucleus is thus formed for each new cell into which the parent cell has been divided. But in other cases, separate nuclei are formed for the secondary cells, instead of the original nucleus dividing into two.

FIG. 1131.

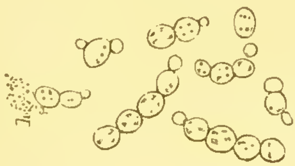


FIG. 1132.

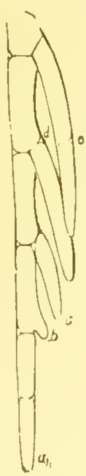


Fig. 1131. Yeast plant in process of development.——*Fig.* 1132. *Conferva glomerata*, showing the progressive stages of gemmation or budding (*b*, *c*, *d*, *e*). *a*. Terminal cell. (After Mohl.)

In some of the lower kinds of plants, a modification of the above described process of cell-division takes place especially as a method of reproduction; this consists in the formation of secondary cells, as little bud-like prominences on the primary cells, either at their extremities, as in the Yeast plant (*fig.*

1131), by which the plant is increased in length; or on the side of the primary cell when branches are produced, as in some Confervæ (*fig.* 1132), in the fibrilliform cells of Fungi and Lichens, and in other cases, probably, much more frequently than is commonly supposed. The mode in which this budding occurs may be thus described. At a certain point the protoplasm or primordial utricle appears to acquire a special development, for it is seen to bulge out, carrying the cellulose wall of the cell before it, by which a little prominence is produced externally (*fig.* 1132, *b*); this continues to elongate until it forms a tubular projection, *c*, on the side of the primary cell. The cavity of this projection is at first continuous with that of the cell from whence it sprung, but after the projection has acquired a certain definite size, its protoplasm becomes constricted at the point of contact with the primary cell, *d*, and ultimately a cellulose partition forms between them, as in the ordinary process of cell-division. This process of cell-division is usually termed *gemmation* or *budding*. In some cases, as in the formation of the fibrilliform cells of Fungi and Lichens, no partitions are formed, but all the branches communicate with each other (*fig.* 48).

b. Cell-division with absorption of the walls of the parent cell, and the setting free of the new cells.—The pollen cells of all

FIG. 1133

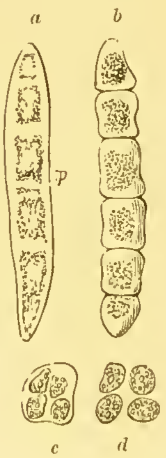


FIG. 1134.

Fig. 1133. *a.* Cylindrical cell from which are formed the parent cells of the spores of *Marchantia polymorpha*. *p.* Protoplasm of the parent cells. *b.* The same cell converted into a string of cells. *c.* One of the parent cells isolated. *d.* The four spores free. (After Henfrey.)——*Fig.* 1134. Formation of zoospores in *Achlya*. A. Zoosporangium, still closed. B. The same burst, with the discharged zoospores. (After Carpenter.)

Flowering Plants, and the spores of the higher Flowerless Plants, are formed by this process, which only occurs in connexion with the organs of reproduction. The manner in which it commonly takes place in the formation of pollen cells has already been described at page 258 of this volume. The manner in which spores are formed in the higher Flowerless Plants is substantially the same in most cases. It sometimes happens, however, that in the development of pollen and spores, the special parent cells are not formed, as has been shown by Schacht in the pollen of *Œnothera* and in the spores of *Anthoceros lævis*; and by Henfrey in the spores of *Marchantia polymorpha* (*fig.* 1133).

In other cases, instead of the development of only four secondary cells in the cavity of the parent, the whole mass of the protoplasm may break up into a great number of small particles, as in the production of the swarm spores of many Algæ and Fungi (*fig.* 1134). In this case the new cells (primordial) are only clothed by a cellulose wall after their separation from the parent- or mother-cell. The formation of the oospheres in *Achlya* (*fig.* 1135), is a modification of this process of division. Some of these modifications of cell-division are closely analogous to the ordinary process of *free cell-formation* to which by many authors they are referred.

FIG. 1135.

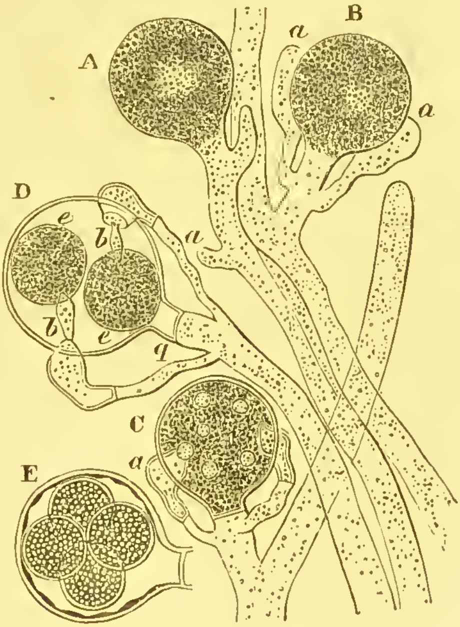


Fig. 1135. Oogonia and antheridia of *Achlya lignicola*, showing cell-division. The letters A to E indicate the course of development. The protoplasm of a cell or branch of a cell collects into a globular form A, B, and by the formation of a septum, D *q*, becomes an independent cell (the oogonium) in which nucleus-like bodies may appear, C. The protoplasm then breaks up into two or more parts, D, *e*, *e* (oospheres), which quickly become spherical, and after fertilisation by the antheridia *a*, *a*, penetrating into the oogonium by their sacs, *b*, *b*, as seen in D, secrete a cell-wall E, and become oospores. (After Sachs.)

c. Rejuvenescence.—Another method of cell-division is that which is termed *rejuvenescence* or *renewal* of a cell, where the whole contents of a cell contracts, some of the cell-sap is expelled, the chlorophyll becomes rearranged, and its whole form alters as it escapes from the cell-wall and eventually forms a fresh cell-wall. This process may be well seen in the swarm-spores of *Œdogonium* (*fig.* 1136).

d. Conjugation.—The production of a *zygospore*, which occurs in the process of conjugation as already noticed in *Spirogyra* (*fig.* 863), is also another method of cell-formation. It occurs frequently in Algæ, and various groups of Fungi.

Indirect Division of the Nuclei of Cells (*Karyokinesis*).—Where this occurs, the nucleus, instead of dividing simply and directly, assumes various figures before dividing.

Fig. 1136.

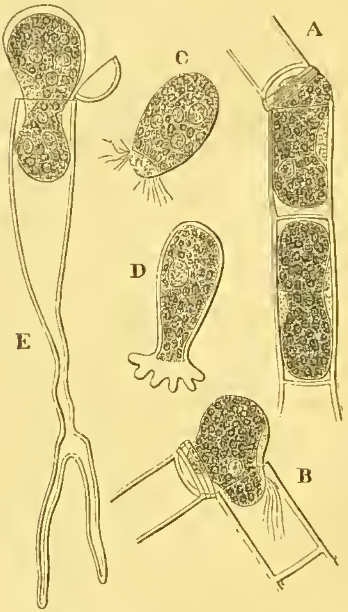


Fig. 1136. A, B. Escape of the swarm-spores of an *Œdogonium*. C. One in free motion. D. The same after it has become fixed, and has formed the attaching disc. E. Escape of the whole protoplasm of a germ-plant of *Œdogonium* in the form of a swarm-spore. (After Pringsheim.)

Strasburger described this method of division of the nucleus in many vegetable cells, and a similar method has since been shown by several observers to occur in animal cells. To this process Flemming has given the name karyokinesis, because a spontaneous movement of the nucleus and its contents is of essential importance.

The first stage in the process is the separation of the fibrils forming the intranuclear network, so that they become more distinct, and make the nucleus appear larger (*fig.* 1137, *a*). The fibrils then become thicker and more separated, thus exaggerating the appearance produced during the first stage. The fibrils next acquire the form of long loops, some of which appear to consist of two threads (Flemming); but whether this is their true character, or they are thick fibrils which have become hollowed out, is uncertain (Klein). In the next step the loops cease to be single and are very long, each thread forming several, and the whole producing a radiating, wreath-like appearance (*fig.* 1137, *b*). The loops then break so that their bends are central, the ends pointing outwards and producing a star-like appearance, the *aster* or *monaster*. The central mass and rays now appear to divide into two parts having different planes one above the other (*fig.* 1137, *c*, *d*), except at the periphery of the loops, where for a time the two stars remain connected, though soon they separate, producing the double star, or *dyaster*, which in many cases is the only form of star that is seen, the monaster apparently not occurring at all. The two stars of the dyaster then recede from each other so that their centres occupy opposite poles of the nucleus (*fig.* 1137, *e*, *f*, *g*); the daughter-stars of the dyaster thus produce a double basket appearance. The fibrils of these baskets next arrange themselves alternately, so that they seem to be transversely striated. A membrane next forms between the two divisions of the former nucleus (*fig.* 1137, *h*), i.e. between the two daughter-baskets whose fibrils now become convoluted, thus producing in the new nuclei an intranuclear network similar to that which existed in the mother-nucleus.

FIG. 1137.

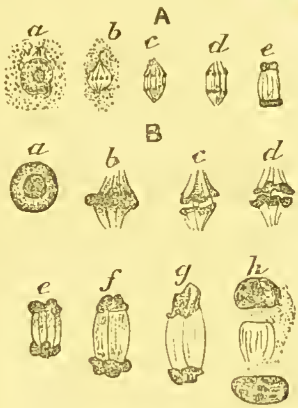


Fig. 1137. Successive phases of karyokinetic division of the nucleus (*a*) in the embryo sac: A, in *Viola palustris*; B, in *Corydalis cava*. (After Strasburger.)

These intracellular and intranuclear networks, as well as the division of the nuclei, are well seen in rapidly forming cells, such as those in the growing points and ovules of plants.

Rapidity of Cell-production.—By the ordinary method of cell-division, cells are in many instances produced with almost inconceivable rapidity. Thus it has been stated that a fungus of the *Puff-ball* genus has been known to grow in a single night, in damp warm weather, from the size of a mere point to that of a large gourd; and it has been calculated, from the average size of its component cells, that such a plant must have contained at least *forty-seven thousand million* cells, so that they must have been developed at the rate of nearly *four thousand millions* per hour, or more than *sixty-six millions* per minute. Another illustration of the rapid production of cells is afforded us in arctic and alpine regions, where it frequently happens that the snow over an extensive area is suddenly reddened by the Red Snow-plant (*fig.* 1). Again, it may readily be ascertained that, in a favourable growing season, many stems will increase three or four inches in length in twenty-four hours; thus the *Agave americana* or *American Aloe*, when flowering in our conservatories, has been known to develop its flower-stalk at the rate of at least a foot a day; and in the warm climates where it is indigenous, as in the Mauritius, it will grow at least two feet in the same period of time. Leaves also, in some cases, develop very rapidly; thus, Mulder states that he has seen the leaf of *Urania speciosa* lengthen at the rate of from one and a half to three and a half lines per hour, and even as much as from four to five inches per day. In all these cases of rapid growth in size, it must be remembered, however, that the increase is due not only to the formation of new cells, but also to the expansion of those previously formed.

In connexion with the rapidity of growth, it may be stated

Fig. 1138.

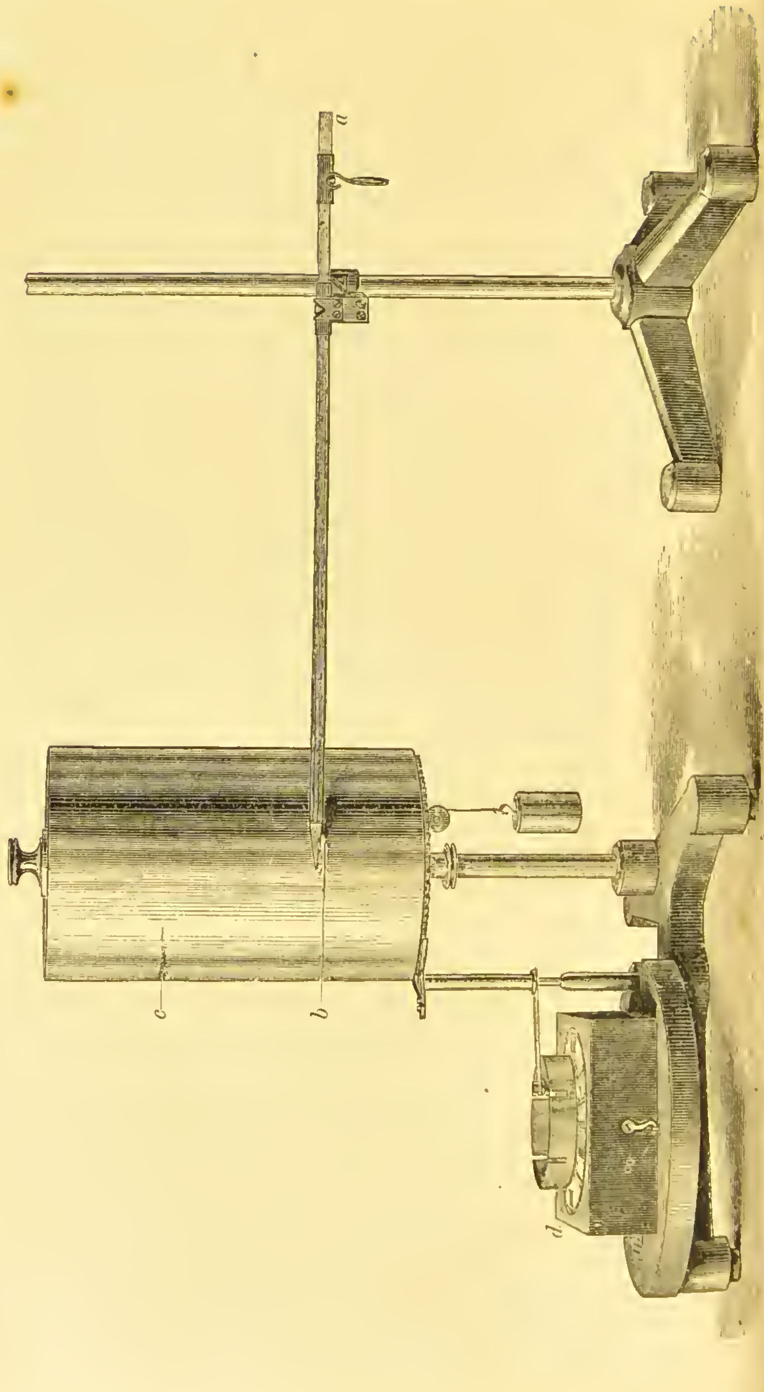


Fig. 1138. Vines' Auxanometer, from a block kindly lent by the Cambridge Scientific Instrument Manufacturing Company.

here that great light retards growth, as shown by the comparative height attained by the Wild Hyacinth according to whether it grows at the edge of, or in the thick part of a wood. Moisture and warmth, on the other hand, encourage growth ; hence, if a greenhouse is allowed to be warmer at night than in the daylight, the plants therein contained become drawn up (leggy, as it is termed) and weak.

For the purpose of measuring accurately the rapidity of growth, some such instrument as that shown in *fig.* 1138, and called an Auxanometer, is employed, where at the end of the long arm of a lever *a*, is a pen *b*, which marks on a revolving drum *c*, covered with smoked paper. To the hook on the short arm of the lever *a*, is attached the one end of a thread, the other end being fastened to the tip of the stem. As the stem grows, the long arm of the lever, which is weighted, falls, and a record traced on the drum *c*, which may travel continuously, or, as in Vines' Auxanometer, make a movement only at certain intervals of time, which are regulated by the clockwork arrangement at *d*.

(2) *Absorption and Transmission of Fluids.*—The cell-wall of all young and vitally active parenchymatous or prosenchymatous cells is capable of readily imbibing fluids, and we find, accordingly, that liquid matters are constantly being absorbed and transmitted through such cells. The power which thus enables cells to absorb and transmit fluids is called *osmose.* This physical force, as will be afterwards shown, is a most important agent in plant-life, for by its agency plants are enabled, not only to absorb crude food by their roots in a fluid state, but also to transfer it upwards, from cell to cell, to the leaves and other external organs, for the purpose of being elaborated by the action of light, heat, and air. It is, moreover, by a somewhat analogous process (*diffusion of gases*) that the cells on or near the surface of plants are enabled to absorb and transmit gaseous matters.

FIG. 1139.

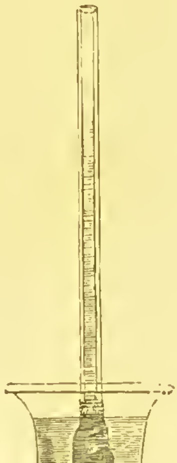


Fig. 1139. Apparatus to show *osmotic action.* It consists of a bladder filled with syrup, to the open end of which a tube is attached, and the whole placed in a vessel containing water.

Osmose may be explained as follows :—Whenever two fluids of different densities are separated by a permeable membrane which is capable of imbibing them, there is always a tendency to equalisation of density between the two, from the formation of a current in both directions, which will be modified by the action of the membrane, as well as by their own rates of diffusion. This osmotic action may be easily observed, by filling a bladder with coloured syrup, attaching to its open end a glass tube, and then immersing it in a vessel containing water (*fig.* 1139). Under such circumstances the volume of the denser fluid in the interior of the bladder becomes increased (as will at once be seen by its rise in the tube), by the more rapid passage through the membrane of the thinner fluid than of the thicker, though at the same time a less portion of the syrup passes out into the water or thinner fluid, as may be proved by the sweet taste and colour which the latter gradually acquires. This double current will continue so long as there is any material difference of density between the two liquids. The stronger in-going current is termed *endosmose*, and the weaker outgoing current *exosmose.* If the position of the liquids be reversed, the currents will be reversed in like manner, the preponderating current, in almost all cases, being that which sets from the thinner to the denser liquid.

Fig. 1140.

Fig. 1140. Apparatus for illustrating the effect of stretching or compressing a turgid cell. (After Sachs.)

The pressure exerted by the water absorbed by endosmose against the walls of a cell, is spoken of as *turgidity* or *turgescence.* In such a cell the pressure exercised against the walls reacts upon the cell contents. If a cell is turgid, but capable of further extension without bursting, the changes which would be produced by stretching or compressing it, or otherwise altering its form, may be easily shown by the use of such a piece of apparatus as that represented in *fig.* 1140, where K is a wide and thick india-rubber tube, to which the glass rod S *g* acts as a stopper at one end, while into the other end is fitted a glass tube drawn out, R *o*. The tube is now filled with water, the upper level of which is at *n*. It will be found that on stretching the tube its calibre is diminished, but its capacity is increased, as shown by the fall of the water below *n*; while compression, bending, or creasing will diminish the calibre, and thus raise the level above *n*.

The absorption and transmission of liquid matters through cells is now very easy to explain, for as the fluid contents of the cells of the roots of plants are denser than the water contained in the media in which they grow, they will continually absorb the latter by endosmose; and as the changes which are going on in the cells by evaporation, assimilation, and other processes on the surface of plants, tend to thicken their contained liquids, there will also be a constant passage of the absorbed fluids from cell to cell towards those parts where such processes are taking place. The laws of ordinary *adhesive* or *capillary attraction* and of the *diffusion of fluids* also regulate the flow of the juices, which in certain cases may be even set in motion by either force. The action, however, of the intervening membrane (cell-wall) in greatly modifying or even overcoming osmotic action, is evidenced by the numerous cases in which neighbouring cells contain different substances without their intermixture. In cellular plants, such as Algæ and Fungi,

FIG. 1141.

FIG. 1142.

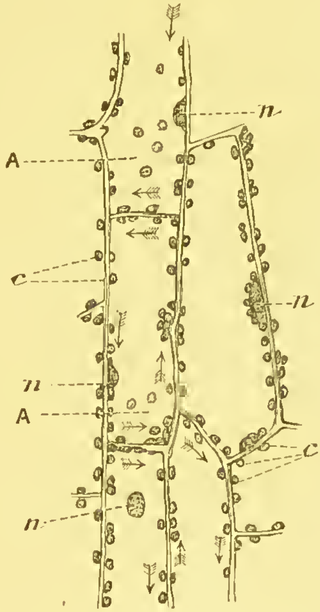


Fig. 1141. Hair on calyx of flower-bud of *Althæa rosea.* The streaming of the protoplasm is indicated by the arrows. (After Sachs.)——*Fig.* 1142. Part of leaf of *Vallisneria spiralis*, showing rotation of the protoplasm. *n*, *n*, *n*, *n*. Nuclei. *c*, *c*. Chlorophyll corpuscles. A, A. Cells in which some chlorophyll corpuscles are passing along the upper wall of the cell. (After J. W. Groves.)

absorption may take place at any part of the thallus; while in vascular plants it occurs principally through the roots, though all the green parts may contribute to it (see page 787), and that, too, probably independently of the presence or absence of stomata.

(3) *Movements in the Contents of Cells.*—In many cells, and probably in all at a particular period of their life, when they are in a vitally active state, a kind of movement of a portion of their contents takes place. This movement is sometimes

erroneously considered as a kind of rotation of the watery cell-sap; but the very complete observations of Mohl have proved that it is due to a circulation of the protoplasm, which is rendered visible by the opaque granular particles which it contains (*fig.* 1142 A, *c*). The protoplasm thus circulating does not pass from one cell to another, but is strictly confined to the cell in which it originates. This kind of movement has been termed *Rotation*, *Gyration*, *Cyclosis*, or *Intracellular Circulation*: it ceases, in the generality of cases, in cells when they have attained a certain size, but in those of many aquatic plants it continues throughout their life.

The appearances presented by these movements vary in different cases. Thus, in the cells of many hairs, as in those of the Common Spiderwort (*Tradescantia virginica*), the Potato (*Solanum tuberosum*) (*fig.* 40), and *Althæa rosea* (*fig.* 1141), the protoplasm becomes hollowed out by a number of vacuoles filled with watery cell-sap, between which threads of protoplasm remain, and the motion is in reticulated currents radiating apparently from, and returning to, the nucleus; to this action the term *circulation* is applied. In the cells of the leaves of the *Vallisneria* (*fig.* 1142) and *Anacharis*, and in those of other parts of the same plants, intracellular movements may be readily observed when they are submitted to a moderate microscopic power; here, however, the protoplasm becomes hollowed out by a single central vacuole filled with watery cell-sap, and passes with its granular contents round the interior of the walls of each cell, retaining its activity permanently; which movement is called *rotation*. In the *Characeæ*, and especially in the *Nitellæ*, which are transparent, the moving protoplasm does not rotate round the walls, nor in reticular currents, but passes obliquely up one side of the cell (*fig.* 1124) until it reaches the extremity, and then flows down in an opposite direction on the other side.

No satisfactory explanation has yet been brought forward to account for this movement, but it is unquestionably connected with the vitality of the cell-contents, and Dr. H. de Vries believes that it is chiefly instrumental in the transport of food material from one part of a plant to another. All agents that actually injure the cell will generally stop it at once, and permanently, though in some plants (as *Nitella*) a large cell may be tied across the middle with the effect of stopping the circulation temporarily; but after a short time it will recommence in each half. The movements of the *ciliated zoospores* of the Algæ (see page 395, and *figs.* 75–77), and those of the *ciliated antherozoids* of Algæ (see page 397, and *fig.* 868), and of the higher Cryptogamia (see page 366, and *fig.* 807), are usually regarded as '*analogous to the rotation of the protoplasm*.'

4. *Elaboration of the Cell-contents.*—All cells exposed to light, heat, and air, which contain protoplasm, have the power of pro-

ducing in their contents the various organic compounds which are concerned in the development of new tissues, and in the formation of others which have been termed secretions. (See *Respiration and Assimilation.*) In old cells the secretions of the plant are also, in part, deposited.

2. FUNCTIONS OF PROSENCHYMATOUS CELLS.—Prosenchymatous cells are especially adapted by their construction and mode of combination into a tissue, for giving strength and support to plants ; and there can be no doubt but that this is one of the offices which they perform. In a young state, also, before their walls are thickened, they appear to be the main agents by which the fluids absorbed by the roots are carried upwards to the leaves and other external organs, to be elaborated by the agency of heat, light, and air. The experiments of Hoffmann, Unger, Knight, Dutrochet, and others, seem to prove this. Thus, Hoffmann, by placing plants in such a position as to cause them to absorb a solution of ferrocyanide of potassium, and then adding a persalt of iron to sections of them, found that the prussian blue which was formed by the reaction of the chemical agents thus applied was principally deposited in the prosenchymatous cells. Unger also came to the same conclusion, by causing plants to absorb a coloured vegetable juice, and tracing its passage. Knight and Dutrochet cut a ring of tissue out of the stem down to the duramen, with the result that the leaves withered, and the tree subsequently died. But other experimenters, such as Link, Rominger, and Herbert Spencer, have arrived at opposite conclusions. (See *Functions of Vessels.*)

3. FUNCTIONS OF VESSELS.—The functions of the spiral, annular, reticulated, pitted, and scalariform vessels have been a subject of much dispute from an early period, and have been repeatedly investigated. Hales, Bischoff, and others came to the conclusion that these vessels were carriers of air, and it is certain that air alone is found in old vessels ; while Dutrochet, Link, Rominger, &c., believed that their essential function was to carry fluids from the root upwards, which views from recent observations appear to be correct. According to Link, when plants are watered for several days with a solution of ferrocyanide of potassium, and afterwards with a solution of persulphate of iron, prussian blue is found in the vessels, and not in the prosenchymatous cells, as the experiments of Hoffmann, alluded to in speaking of the functions of prosenchymatous cells, seem to indicate ; and, more recently, the experiments of Herbert Spencer, conducted with great care, tend to show that in young plants at all events the vessels are the chief sap-carriers whence the fluid exudes into the surrounding prosenchyma. From this it is clear that the constituents of the xylem are sap-carriers.

Functions of Laticiferous Vessels.—The physiological importance of these vessels has given rise to much discussion, and is still involved in obscurity. But it would appear that these vessels, and others which are closely allied to them, as *sieve-tubes* and *vesicular vessels*, act as temporary reservoirs of nutrient fluids, and also as carriers of such fluids to those parts of plants where they are required. (See also page 51.) Schultz called the tissue formed by the ramifications of the laticiferous vessels *cinenchyma*, because he believed that he had discovered in it a peculiar vital movement or circulation of the latex, to which he gave the name of *cyclosis.** Other observers have also described a similar circulation ; but Mohl, Henfrey, &c., altogether deny the existence of such a movement in uninjured tissues.

Dr. A. Fischer states that it is only the young cells of sieve-tubes which can produce albuminous substances, since they possess nuclei which are absent in the mature tubes.

4. Functions of Epidermal Tissue.—The special functions of epidermal tissue are :—to protect the tissues beneath from injury, and from being too rapidly affected by atmospheric changes ; to regulate the transpiration or exhalation of watery vapours ; to absorb and exhale gaseous matters ; and probably, to some extent, to absorb water. The epidermis itself is specially designed to prevent a too ready evaporation of fluid matters from the tissues beneath, and hence we find that it is variously modified to suit the different conditions to which plants are submitted. Thus, in submersed plants and submersed parts of plants, which are always exposed to similar influences as regards moisture, there is no true epidermis ; whilst in aerial plants submitted to ordinary influences in cold and temperate climates, we generally find an epidermis with only one layer of thin-sided cells, and covered by a cuticle of only moderate thickness. Cellulose is rarely, and then only with difficulty, discovered in cuticle, which is a thin structureless membrane extending uninterruptedly over the boundaries of the subjacent epidermal cells. It is coloured yellow by Schulze's fluid, yellow or yellow-brown on the addition of iodine, with or without sulphuric acid ; it is soluble in boiling caustic potash, but insoluble in concentrated sulphuric acid. In other aerial plants, however, growing in the same latitudes, such as the Box, &c., and generally also in those of a succulent nature where there is but a moderate exhalation, we find the upper walls of the epidermal cells especially thickened, or protected by a dense layer of cuticle ; whilst in aerial plants growing in very dry or hot regions, as the Oleander (*fig.* 125), we have frequently an epidermis of two, three, or more layers of thick-sided cells, and other special contrivances to prevent a too ready exhalation of fluid. For instance, De Bary states that wax may be deposited in the cuticle, and that on heating to about 100° C., it

* The term 'cyclosis' has also been applied to the movement of protoplasm in cells. (See p. 784.)

separates out in the form of drops. This wax may be associated with resin, and assists in preventing the aerial parts of plants from becoming moistened by water. Such plants as these are best fitted for growth in houses, where the air is usually very dry. While the epidermis may thus be shown to have for its object the restraining of a too abundant exhalation, the *stomata* and water-pores are especially designed to facilitate and regulate the passage of fluid matters, and in proportion to their number, therefore, upon the different organs and parts of plants, *cæteris paribus*, so will be the exhalation from them. (See also page 63.) Stomata, as already noticed (page 62), are sometimes found at the bottom of depressions on the under surface of leaves (*fig.* 124), and occasionally projecting above the general level, but usually they are placed nearly or quite on a level with the epidermal cells. The exact manner in which the stomata act is not readily explained, but it may be always noticed that when plants are freely supplied with moisture, the stomata have their bordering *guard-cells* distended with fluid, elongated, and curved, so that the orifices between them are open; whilst in those cases where there is a deficiency of fluid the bordering cells contract, straighten on their inner surfaces, and thus close the orifices. Under the former condition of stomata, there is a ready communication between the external air and the internal tissues, and hence a free exhalation takes place; while in the latter state, the exhalation is more or less prevented. As a rule, stomata are open during the day when circumstances are favourable, and closed at night when the plant is asleep.

It is also through the cells of the epidermis, and more especially through the stomata, that certain gaseous matters are absorbed from, and exhaled into, the atmosphere, in the processes of Respiration and Assimilation. (See page 799.)

It has long been a disputed question whether the epidermal tissue and its appendages have the power of absorbing liquids, such as water. Some authors, as Unger and Duchartre, not only deny the possession of such a power, but also that of taking up watery vapour; and Prillieux has repeated their experiments with the same results and conclusions. Some researches of Henslow seem, however, to prove that leaves can absorb moisture. (See page 799.) Indeed, it is very difficult to account for the immediate recovery of drooping plants in a greenhouse when water is sprinkled upon the floors, or the revival in nature of vegetation when a mist follows a long succession of dry weather, except on the supposition that watery vapour is taken up by the epidermal tissue and its appendages, unless the presence of moisture acts only in the way of checking transpiration. Epiphytical species seem also to obtain nourishment from the atmosphere by absorption through the epidermis. Whether water itself is absorbed by the epidermal tissue and its appendages is doubtful, though from the experiments of Detmer it seems to be possible under certain circumstances. Various experimenters have endeavoured to show that they have this power. The researches of Garreau led him to the following conclusions :—1. That the epidermis possessed an evident endosmotic property, the intensity of which was in proportion to the age of the tissues which it invested; thus it was greatest when they were young, gradually diminished as they approached maturity, and was altogether lost when they became old. 2. The absorbing power of the epidermis was greater in proportion to the absence of waxy or fatty matters. 3. The epidermis covering the upper surface of the ribs, and especially of that of the petiole where it joins the stem, is that part of the leaf surface which presents the most marked power of absorption. 4. In certain instances in which the epidermis is absorbent, the cuticle presents impediments to absorption. 5. Simple washing with distilled water, and more especially with soap and water, augments the absorptive power. 6. When the epidermal tissues of leaves have lost their power of absorbing water, they can still absorb carbon dioxide. Further, the behaviour of Carnivorous

FIG. 1143.

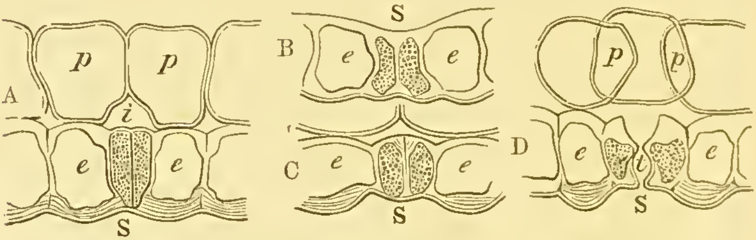


Fig. 1143. *p, p*. Parenchyma of the leaf. *e, e*. Epidermis cells. S. Stoma. *i*. Air cavity. In these figures the development of the stoma of *Hyacinthus orientalis* is represented from the first division of the mother-cell in A into two daughter-cells, to the complete separation shown in D. (After Sachs.)

Plants, as *Drosera*, *Utricularia*, &c., seem distinctly to prove the truth of the power of epidermal tissues to absorb nutrient materials in solution.

Origin and Development of Stomata.—A stoma is formed by the division of an epidermal cell (the mother-cell) by a partition which extends across and divides the two daughter- or sister-cells (*fig.* 1143); this partition then becomes thickened, especially at the angles where it joins the wall of the parent-cell. After a time the thickened partition becomes laminated, when a cleft appears in it, narrower in the middle, wider without and within, which unites the intercellular space (*fig.* 1143, D, S, *t*) with the external air. Before the parent-cell divides, a cuticularisation of its surface takes place, the cuticle extending over the apposed surfaces of the sister-cells, and the adjoining cells of the epidermis. Even when the division is complete, a portion (if the leaf is examined in a superficial position) still remains as a simple lamella. These two sister- or daughter-cells are called guard-cells, and further differ from the rest of the epidermis in containing chlorophyll and starch.

A special form of stomata called water-pores is found at the termination of the veins of some leaves (*Tropæolum* &c.) which differ from other stomata in being non-contractile, and in some cases the guard-cells become entirely absorbed, leaving open spaces.

5. FUNCTIONS OF THE APPENDAGES OF THE EPIDERMIS.—*Hairs* and their modifications appear to be designed to protect the epidermis and parts beneath from injury due to cold and other external influences, hence we find young buds (see page 105), &c., frequently coated with hairs, also in many flowers to prevent injurious insects carrying away pollen. Hairs also appear in certain instances, at least to some extent, to absorb fluid matters from the atmosphere, whilst in other cases they serve to assist the epidermis in restraining exhalation ; and we find, accordingly, that plants which are densely coated with them are well adapted to grow in dry situations, and to sustain without injury a season of drought.

Glands are those organs which in themselves secrete some peculiar matter. (See page 68.) These secretions are either permanently stored up in them, or excreted.

6. FUNCTIONS OF THE INTERCELLULAR SYSTEM.—The *intercellular canals*, except at those times in which the tissues of the plant are gorged with sap, as in the spring of the year, are filled with air, and the especial function which they perform is to allow a communication between the external air and the contents of the internal tissues by virtue of the laws regulating the diffusion of gases. They likewise facilitate exhalation of liquid matters by their connexion with the stomata. The *intercellular spaces* are also, in most cases, filled with air, though certain recent observers have described protoplasm as occupying some of them, and as communicating with the protoplasm of the cells ; while the *air-cells* and *air-cavities*, as their names imply, are in like manner filled with aeriform matters, and in water-plants are especially designed to diminish the specific gravity of the parts in which they are found, and thus to enable them to float readily, or to be suspended in the water. The *receptacles of secretion*, as their name implies, contain the peculiar secretions of certain plants, and are closely allied in their nature to glands. (See page 72.)

Section 2. Physiology of the Organs of Nutrition.

1. Of the Root or Descending Axis.—The offices performed by the root are :—1. To fix the plant firmly in the earth or to the substance upon which it grows, or, in some aquatic plants, to float or suspend it in the water. 2. To absorb liquid food. 3. According to some authors, to excrete into the soil certain matters which are injurious, or at least not necessary for the healthy development of the plant, though in the earth they may assist subsequent nutrition by dissolving substances which could not otherwise pass into the plant. 4. To act as a reservoir of nutriment.

The office which the root performs, of fixing plants in those situations where food can be obtained, is evident, and needs no further remarks. It is also essential to the proper performance of its absorptive powers.

Absorption by the Root.—The function which the root performs of absorbing nutriment for the uses of the plant, from the materials in or upon which it grows, is not possessed by its whole surface, but is almost exclusively confined to the cells and root hairs (*figs.* 128 and 248) of the newly developed portions and young parts adjacent to them ; and even these parts can only absorb when they are in the closest contact with the particles of soil by the root-hairs. Hence, in the process of transplanting, it is necessary to preserve the young growing roots as far as possible, otherwise the plants thus operated upon will languish or die, according to the amount of injury they have sustained. The injury done to plants in transplanting is also to a great extent influenced by atmospheric circumstances, and conditions of the soil at the time in which such an operation is performed ; thus, under the favourable circumstances of a warm soil and moist atmosphere, the destruction of a large portion of the young extremities of the root will do but little injury, as the plant will then speedily form new absorbent extremities ; but if the conditions of the earth and soil be the reverse, then a large destruction of the young extremities of the roots will cause the plant to die before new absorbent extremities can be formed. Special attention should be paid to the above facts when transplanting is performed in the growing season ; but it is far better, when possible, to transplant late in the summer or in the autumn when the growing season is drawing to a close, or in the spring before it has recommenced, as at such periods little or no absorption takes place and the plants have accordingly time to recover themselves before they are required to perform any active functions. (See page 819.)

This absorption of food by the youngest rootlets is due to osmose taking place between the contents of their cells and the fluids of the surrounding soil. But it should be noticed that, as already mentioned (page 126), the cells at the extreme apex of the rootlets forming the cap are not adapted for absorption.

Roots absorb more water than the plant requires, and this excess of fluid exerts a pressure up the stem called *Root-pressure*, which may be measured by cutting off the upper part of the stem of a growing plant and attaching a manometer to the cut end. (See page 822.)

Roots, as will be shown (page 792), only grow in length by additions near to their extremities, and as it is at these parts that absorption of food almost entirely takes place, they are always placed in the most favourable circumstances for obtaining it, because in their growth they are constantly entering new soil, and hence, as one portion of that soil has its nutritious matters extracted, another is entered which is in an unexhausted state. It has also been shown, by direct experiment, that when the roots meet with a store of nourishment in the soil, a greatly increased development of rootlets takes place for its absorption.

Roots can only absorb substances in a liquid state, therefore the different inorganic substances which are derived from the soil, and which form an essential part of the food of plants, must be previously dissolved in water. If the roots of a freely growing plant be placed in water in which charcoal in the most minute state of division has been put, as that substance is insoluble in the fluid, it will remain on the surface of the roots, and the water alone will pass into them.

Selection of Food by Roots.—Various experiments have been devised to ascertain whether the plant possesses any power of selecting food by its roots. Saussure proved, that when the roots of plants were put into mixed solutions of various salts, some were taken up more freely than others. He also found that dead or diseased roots absorbed differently to those in a living and healthy condition. The experiments of Daubeny, Trinchinetti, and others, lead essentially to the same conclusions. Again, though the seeds of the common bean and wheat be sown in the same soil, and exposed, as far as possible, to the same influences in their after-growth and development, yet chemical analysis shows that the wheat stalk contains a much larger proportion of silica (which it must have obtained from the soil) than that of the bean.

The experiments of Bouchardat, Vogel, and others, appear, on the contrary, to indicate that roots absorb all substances presented to them indifferently, and in equal proportions. But the simple fact, as just mentioned, which is easily proved by chemical analysis—that the ashes of different plants grown in the same soil, contain different substances or in different proportions—seems to prove incontestably that roots have a power of selecting their food. In using the term *selecting*, we do not, however, intend to imply that roots have any inherent vital power of selection resembling animal volition, but only to express the result produced by virtue of the mutual actions of the root and the substances which surround it in the soil. This power or property of selection is without doubt due to some at present but little understood molecular relation which exists between the membranes of the cells of different plants and the substances which are taken up or rejected by them, different roots possessing different osmotic action for the same substances. It follows also, from the recognition of this action as the cause of the absorpt on of fluid matters by the plant, that poisonous substances may be taken up when in solution by the roots, provided their tissues are not injured by them in their passage; and we find, accordingly, that when such substances are found in the soil, a corresponding effect is produced upon plants by their absorption.

Excretion by Roots.—Roots seem to have no power of getting rid of excrementitious matters like that possessed by animals; but that they do throw off into the soil a portion of their contents by a process of exosmose, which appears to be an almost necessary result and accompaniment of the endosmose by which absorption takes place, is possible. Carbon dioxide, and possibly other acid substances, are parted with by roots in this way; and thus assist subsequent absorption by dissolving substances which could not otherwise pass into the plant. This is proved by Sachs' experiment of letting roots grow over a slab of polished marble, which was eroded wherever the roots came in contact with it.

Fig. 1144.

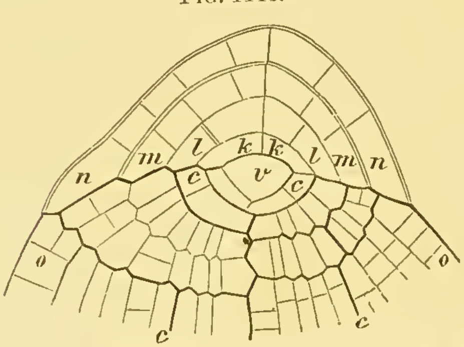


Fig. 1144. Longitudinal section through root of *Pteris hastata*, showing apical region. *v.* Apical cell, from which are developed the tissue of the substance of the root, *o*, *c*, and the root-cap or pileorhiza, *k*, *l*, *m*, *n*. (See page 125.) (After Sachs.)

Storing of Nutriment by Roots.—Roots are frequently enlarged by becoming reservoirs of nutriment in the form of starchy, gummy, and similar matters for the future support of the plant. The tubercules of the Dahlia (*fig.* 263) and Orchis (*figs.* 261 and 262); and the roots of the Turnip (*fig.* 269), Carrot (*fig.* 267), and other biennials, are familiar illustrations.

Development of Roots.—The growing part of the root is called the *growing point* (*punctum vegetationis*). It is commonly spoken of as the apex of the root, but is not really so, since it is covered with a cap of cells, the *pileorhiza*. (See pages 125 and 126.)

The cells composing it consist of *primary meristem*;* they are thin-walled, filled with protoplasm, and are capable of division. Here, as in stems, and unlike leaves, the last formed part is towards the apex; hence the growth in length is indefinite, the difference between the *growing part* or so-called *apical cell* in roots (*fig.* 1144, *v*) and stems being that, in the former case, it or they (for there is (*fig.* 1145, *a*) usually a group of apical cells) are covered by a cap of cells formed from the distal or

FIG. 1145.

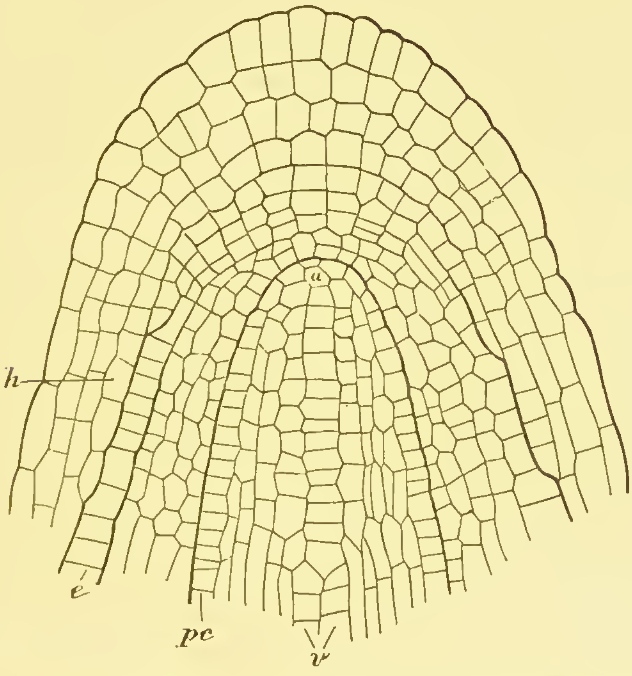


Fig. 1145. *Polygonum Fagopyrum.* Root apex, median longitudinal section. *pc.* Pericambium, outside boundary of the plerome. *v.* Rudiment of a vessel. *e.* Dermatogen. Between *pc* and *e*, periblem. *h.* Root-cap or pileorhiza. *a.* Apical cells. After De Bary.

apex end of the so-called apical cell (*figs.* 1144, *k*, *l*, *m*, *n*, and 1145, *h*); whereas in stems there is no such cap. (See page 795, and *figs.* 1146 and 1147.)

2. OF THE STEM OR CAULOME.—The offices performed by the stem and its ramifications are :—1. To form a support for the leaves and other appendages of the axis which have but a

* This name is given to that kind of meristem which forms the whole tissue of very young organs or parts of organs, in order to distinguish it from another kind of meristem, which is termed *secondary meristem* (as the cambium cells), which occurs in organs along with *permanent tissue*, or that tissue in which the cells are no longer capable of division, but have assumed their definite form.

temporary existence, and thus enable them to be freely exposed to the influences of light and air, which are essential for the proper performance of their functions and development. 2. To convey air and fluid matters upwards, outwards, downwards, and inwards, to the organs of respiration, assimilation, transpiration, development, and secretion. And 3. To act as a reservoir for the so-called secretions of the plant.

A. *Special Functions of the Different Parts of the Stem.—a. The Medulla or Pith.*—Various functions have at different times been ascribed to the pith. In the very young plant, and in all cases when newly formed, the cells of the pith are filled with a greenish fluid containing nutrient substances in a state of solution; but as the pith increases in age it loses its colour, becomes dry, and is generally more or less destroyed. The pith, therefore, would appear to serve the temporary purpose of nourishing the parts which surround it when they are in a young state; and in some cases it seems also to act as a reservoir of the secretions of the plant.

b. *The Wood or Xylem.*—The wood, when in a young and pervious condition (*alburnum*), is the main agent by which the crude sap is conveyed upwards to the external organs to be aerated and elaborated; but whether the passage is primarily by the vessels or the prosenchymatous cells is disputed. (See page 785.) As the wood increases in age, and becomes heartwood or duramen, the tissues of which it is composed become thickened and altered in various ways, by which they are more or less hardened and solidified, and in this manner the stem acquires strength and firmness, but the tissues are no longer physiologically active, and are in fact useless as carriers of sap.

Formation of Wood.—On the outside of the young wood, but organically connected with it and with the liber or bast of Dicotyledons, is the vitally active layer of cells (*secondary meristem*) called the cambium layer, from which are annually formed new layers of wood (*xylem*) and inner bark (*phloëm*). The cells of the cambium layer are filled in the spring, and at other seasons when growth takes place, with elaborated sap, or that sap which contains all the materials necessary for the development of new structures. Great differences of opinion exist amongst botanists as to the exact manner in which wood is formed, but they are nearly all agreed that the materials from which it is formed are elaborated in the leaves, that without leaves there can be no additions to it, and that in proportion to their amount so will be the thickness of the wood. It is necessary, therefore, that the process of pruning timber trees should be carefully conducted, and that when planted they should be placed at proper intervals, in order that they may be freely exposed to those influences which are favourable for the development of their foliage.

Herbert Spencer believes that intermittent mechanical strains, such as those produced by the wind, are the sole cause of the formation of wood, which is developed to resist the strains. His experiments were anticipated by Knight so far back as 1803; but his results must be taken with modification. It is probably true that such a conservative formation of wood does occur to meet unusual strains; but the want of correspondence in nature between great exposure to such strains and large deposit of wood, and the numerous examples of great wood-formation in ligneous twiners and nailed-up trees, must prevent us from considering it an all-sufficient explanation. In the cases where no strains can have occurred, 'the natural selection of variations can have only operated' to form wood, according to Spencer.

c. *The Medullary Rays.*—The functions which these rays perform is, probably, to assist the diffusion of a portion of the elaborated sap from the bark and cambium layer through the wood, in which certain of the secretions it contains are ultimately deposited.

d. *The Bark.*—The bark acts as a protection to the young and tender parts within it. The inner part is generally believed to convey the elaborated sap from the leaves downwards, in order that new tissues may be developed, and the different secretions deposited in the wood and in its own substance. The bark frequently contains very active medicinal substances, and others which are useful in the arts, &c.

B. *Development of the Stem (Caulome).*—The stem is developed from the apex or growing point (*punctum vegetationis*), where is situated the apical cell or apical groups of cells. In most of the Cryptogamia growth is effected by the division of a single *apical cell* (*fig.* 1146, *t*), which is generally large, and divides into two daughter-cells, one of which becomes the new apical cell, while the other, the *segment cell*, by further division, forms the permanent tissue. In the stems of the higher plants, instead of a *single* apical cell, there are generally several such cells (*fig.* 1147 *s*, *s*), which differ from the like cells of roots in having no special cap, and from leaves in the fact that the cells last formed are at the apex. (See *Development of Roots*, page 792; and *of the Leaves*, page 811.)

FIG. 1146.

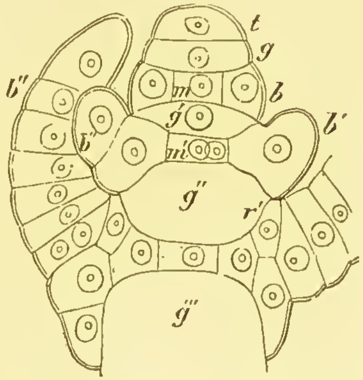


Fig. 1146. Longitudinal section through the apical region of three primary shoots of *Chara fragilis*. *t*. Apical cell, in which segments are formed by septa, each segment being further divided by a curved septum into a lower cell not further divisible, which develops into an internode, *g*, *g'*, *g''*, *g'''*, and an upper cell which produces a node, *m*, *m'*, and the leaves, *b*, *b'*, *b''*, *b''*, which also undergo segmentation. (After Sachs.)

3. Of the Leaves or Phyllomes.—The essential functions of the leaves are :—(1) The exhalation of the superfluous fluid of the crude sap in the form of watery vapour ; (2) the absorption of fluid matter ; (3) the absorption and exhalation of gases ; and (4) the formation of the organic compounds which are concerned in the development of new tissues, and in the formation of the various secretions of plants. These functions they are enabled to perform through the influence of heat, air, and light, to which agents, by their position on the ascending axis of the plant, and by their own structure, they are necessarily, under ordinary circumstances, freely exposed.

(1) *Exhalation of Watery Vapour by the Leaves.*—The im-

Fig. 1147.

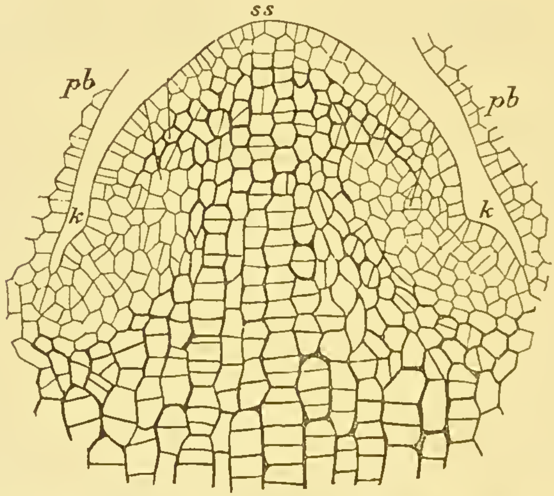


Fig. 1147. *Phaseolus multiflorus.* Longitudinal section through the apical region of the stem of an embryo. *ss.* Apex. *pb, pb.* Parts of the two first leaves. *k, k.* Commencement of their axillary buds. (After Sachs.)

mediate object and effect of this process, which is commonly termed transpiration, is, the thickening of the crude sap, and the consequent increase of solid contents in any particular portion of it. This transpiration of watery vapour, as already noticed (see page 787), takes place almost entirely through the stomata, and hence as a general rule the quantity transpired will be in proportion to their number. The presence or absence of a true epidermis, and the various modifications to which this is liable, have also, as already noticed (page 786), an important influence upon the transpiration of fluid matters.

From some interesting experiments of M. Garreau on transpiration of leaves, he was led to draw the following conclusions:—
1. The quantity of water exhaled by the upper and under surfaces

of the leaves is usually as 1 to 2, 1 to 3, or even 1 to 5, or more. The quantity has no relation to the position of the surfaces, for the leaves, when reversed, gave the same results as when in their natural position. 2. There is a correspondence between the quantity of water exhaled and the number of the stomata. 3. The transpiration of fluid takes place in greater quantity on the parts of the epidermis where there is least waxy or fatty matter, as along the line of the ribs.

This transpiration of fluid is influenced to a great extent by the varying conditions of the atmosphere as to moisture and dryness ; thus, if two plants of the same nature are submitted to similar conditions, except that one is placed in a dry atmosphere, and the other in a moist, the former will give off more fluid than the latter, though, according to M'Nab, a plant exposed to the sun will transpire most in a moist atmosphere ; while in the shade, an atmosphere loaded with vapour causes transpiration to cease. The great agent, however, which influences transpiration is light. According to De Candolle, light is the only agent which is capable of promoting and modifying transpiration. He says, 'If we take three plants in leaf, of the same species, of the same size, and of the same degree of vigour, and place them, after weighing them carefully, in close vessels, —one in total darkness, the other in the diffused light of day, and the third in the sunshine—and prevent absorption by the roots, we shall find that the plant exposed to the sun has lost a great quantity of water, that in common daylight a less amount, and that which was in total darkness almost nothing.' The experiments of Henslow, Daubeny, and others, also demonstrate, in a most conclusive manner, the great influence of light upon transpiration. Daubeny, moreover, found that the different rays of the solar spectrum had a varying influence, the illuminating rays having more effect than the heating rays. Transpiration has been studied by M. Weisner in three ways:—(1) By comparing that of green with that of bleached plants ; (2) by exposing plants to the solar spectrum ; (3) by placing them behind solutions of chlorophyll. The result of these experiments has been that the action of light on transpiration is greatly increased by the presence of chlorophyll ; that they are not the most luminous rays, but those which correspond to the absorption band of the chlorophyllian spectrum, which excite transpiration ; and finally, that the rays which passed through the chlorophyll solution exerted but little effect on transpiration.

Transpiration in some cases seems to depend but little upon whether the stomata are open or closed, though it is generally greater on the under surface of leaves—i.e. where the stomata are chiefly found. In summer transpiration is more active than absorption, while in spring the reverse condition obtains.

The quantity of fluid thus exhaled or transpired by the leaves has been the subject of various experiments, The most complete observations upon this point were made by Hales so long ago as 1724. He found that a common Sunflower 3½ feet high, weighing 3 pounds, and with a surface estimated at 5,616 square inches, exhaled, on an average, about twenty ounces of fluid in the course of the day; a Cabbage plant, with a surface of 2,736 square inches, about nineteen ounces per day; a Vine with a surface of 1,820 square inches, from five to six ounces; and a Lemon tree, exposing a surface of 2,557 square inches, six ounces on an average in a day. Hence if such a large amount of fluid be thus given off by single plants, what an almost incalculable quantity must be exhaled by the whole vegetation of the globe! It can therefore be readily understood that the air of a thickly wooded district will be always in a damp condition, while that of one with scanty vegetation will be comparatively free from humidity: and hence it will be seen that a country, to be perfectly healthy, should have the proportion of plants to a particular area carefully considered; for while, on the one hand, too many plants are generally prejudicial to health by the dampness they produce; on the other, a deficiency, or want of them will produce an equally injurious dryness. The same circumstances have an important bearing upon the fertility or otherwise of the soil, and in this way have an indirect influence upon the health of the inhabitants. Thus, it is a well-known fact, that as vapour is constantly given off by plants, rain is more abundant in those regions which are well covered with forests, than in those which are comparatively free from them. It is found, accordingly, that a great change may be produced in the climate of a country by clearing it too much of plants; for while an excessive amount of vegetation is injurious to their healthy growth, if there be a great deficiency, it will become entirely barren from extreme dryness. By inattention to these simple but most important facts, which clearly indicate that open land and that furnished with plants should be properly proportioned the one to the other, many regions of the globe which were formerly remarkable for their fertility are now barren wastes; and, in like manner, many districts, formerly noted for their salubrity, have become almost, or quite, uninhabitable.

The fluid which thus passes off by the leaves of plants is almost pure water. This transpiration of watery vapour must not be confounded with the excretion of water containing various saline and organic matters dissolved in it, which takes place in certain plants, either from the general surface of their leaves or from special glands. In the peculiarly formed leaves of *Dischidia*, *Nepenthes* (*fig.* 390), *Sarracenia* (*fig.* 391), and *Heliamphora* (*fig.* 392), watery excretions of this nature always exist. From the extremities or margins of the leaves of various Marantaceæ, Musaceæ, Aroidaceæ, Graminaceæ, and other plants, water is also constantly excreted in drops, at certain periods of vegetation, through the water-pores there situated. But the most remarkable plant of this kind is the *Caladium distillatorium*, from which half a pint of fluid has been noticed to drop away during a single night, from orifices (water-pores) placed at the extremities of the leaves, and communicating freely with internal passages. In those Mosses which have no trace of vascular bundles, Oltmanns points out that the rise of water does not take place within the stem, but by capillarity externally, and that in these plants transpiration does not take place.

(2) *Absorption of Fluids by Leaves.*—Hales, Bonnet, and others, inferred that leaves were capable of absorbing moisture, though De Candolle and others subsequently asserted positively that such was not the case, and that leaves remained fresh for some time when exposed to the influence of moisture, solely because transpiration was hindered or arrested. The more recent researches of Henslow, however, as already noticed (page 787), seem to prove conclusively that both leaves and green internodes are capable of absorbing a large amount of moisture, and that probably the quantity absorbed is independent of the presence or absence of stomata. The experiments of Darwin and others with Carnivorous Plants seem to prove this also.

(3) *Absorption and Exhalation of Gases by Leaves.*—We have already noticed (page 790) the property possessed by the roots of absorbing liquid food from the medium in which they grow, and also their power of excretion (page 792). Whilst plants are thus intimately connected by their roots with the soil or medium in which they are placed, thoy have also important relations with the atmosphere by their leaves and other external organs, which are constantly absorbing from, or exhaling into it, certain gases. The atmosphere, it should be remembered, is brought into communication with the interior of the leaves by the stomata ; it indeed fills the whole intercellular structure of these organs much in the same way as the air fills the lungs of a mammal, or the lungs, bones, &c. of a bird, to which in function they bear some sort of resemblance. The gases which are thus absorbed and exhaled by the leaves and other green organs and parts of plants have been proved, by a vast number and variety of experiments, to be essentially carbon dioxide and oxygen. The experiments of Boussingault would also indicate that, in some cases at least, carbon oxide is evolved with the free oxygen. Draper, Mulder, Cloez, Gratiolet, and others, likewise believe that leaves and other parts exhale nitrogen when exposed to sunlight. Plants, under certain circumstances, may also absorb nitrogen from the air, though it does not then serve for nutrition ; but the investigations of Lawes, Gilbert, Daubeny, and Pugh tend, on the contrary, to negative this statement. Sir J. B. Lawes has recently confirmed his old opinion that the source of nitrogen is the soil, of carbon dioxide the air.

The amount of nitrogen found in plants is greater, however, than can be accounted for by the quantity of nitrogen supplied to the soil by rain, and is doubtless partly due to the absorption of ammonia from the soil, as also, probably, partly by the leaves, according to Sachs and Meyer, whose observations have been confirmed by Schlösing.

The absorption and exhalation of carbon dioxide and oxygen by the leaves vary according to the circumstances in which they are placed. Thus, when the green leaves of a healthy plant are exposed to sunlight, all experiments show that carbon dioxide is absorbed from the atmosphere and decomposed, leaving its carbon, which is the result of the decomposition, behind, and evolving its oxygen. It is in this way that by far the largest proportion of carbon, which, as will be presently shown, forms so large a part of plants, is taken up by them.

The evolution of oxygen by the green leaves and also by other green organs may be readily observed taking place in the form of bubbles, when a submersed aquatic plant or some freshly gathered leaves are placed in water exposed to the direct rays of the sun. No such evolution of oxygen takes place unless the water contains carbon dioxide, and not, therefore, in pure freshly distilled water, or in that which has been recently boiled. It has been found, also, that there is a constant relation between the amount of carbon dioxide absorbed and the oxygen exhaled. These experiments prove therefore, not only the exhalation of oxygen by the leaves, but also that part of it must be derived from the decomposition of the absorbed carbon dioxide. These changes do not take place in the deep-seated tissues of the plant, nor in the epidermal cells, but in those only immediately beneath the latter. This decomposition of carbon dioxide is effected by the influence of chlorophyll ; for when leaves are not green, as is the case in many parasitic plants and in those which are more or less blanched, they, like the other parts of a plant in a similar condition, are incapable of assimilating, and must therefore procure their nutriment from already assimilated materials.

This absorption of carbon dioxide with fixation of carbon and evolution of oxygen is in direct proportion to the intensity of the light to which the plants are exposed ; but the experiments of Draper, Hunt, and others, show that the different rays of the spectrum have a varying influence in promoting such a decomposition. The results obtained by Draper by exposing the green parts of plants to the different rays of the spectrum were, that no oxygen was set free by them when they were in the violet and indigo rays ; ·00 to ·33 only when in the extreme red ; 1 in the blue ; 4·10 in the green and blue ; 43·75 in the yellow and green ; and 24·75 in the red and orange. Hence he concluded, that the illuminating or yellow rays have the greatest effect in promoting decomposition of carbon dioxide, those nearest them much less so, and the heating and chemical rays none at all. The experiments of Cloez and Gratiolet lead substantially to the same conclusions. That is to say, that the rays which photographically are most active are almost or wholly inert in the decomposition of carbon dioxide and the elimination of oxygen, while the so-called non-actinic rays are the most active. Some heat is necessary for this decomposition, and within certain limits it is found that a slight increase of heat will compensate for a corresponding diminution of active light rays. (See also *The Effect of the Electric Light on the Growth of Plants*, &c., page 858.)

Whilst the absorption of carbon dioxide and evolution of oxygen are thus taking place by day, it is supposed by most observers, that in the absence of light a contrary action occurs —oxygen being then absorbed, and carbon dioxide exhaled. At the same time, all who hold this opinion admit, that the amount of oxygen gas thus absorbed by night is very much less than that given off by day. Thus, the experiments of Saussure and Daubeny prove, that if plants be enclosed in jars containing ordinary atmospheric air, and be supplied under such circumstances with carbon dioxide, the quantity of oxygen gas in the contained air becomes increased.

Some authors, such as Burnett, Carpenter, and Garreau, maintain that carbon dioxide is given off by the leaves in varying quantities, both by day and night; whilst others again, such as Pepys, Cloez, and Gratiolet, deny that leaves, at any time when in a healthy state, give off carbon dioxide.

Those, again, who hold the opinion that leaves when exposed to solar light give off oxygen, in consequence of the absorption and decomposition of carbon dioxide, and that a contrary change takes place by night, maintain different views upon the nature of these changes. Some of them regard the evolution of oxygen by day as a true *vegetable respiration*, and hence look upon vegetable respiration as producing results upon the atmosphere we breathe diametrically opposite to those of animal respiration. Others, such as Mohl and Henfrey, say that here we have two distinct functions going on,—*one*, taking place by day, and consisting in the consumption of carbon dioxide, with fixation of carbon and evolution of oxygen; and *another*, only occurring by night, in the leaves and other green parts, but also by night and day in those not green, and which consist in the absorption of oxygen and evolution of carbon dioxide. The former function they regard as a process of *assimilation*, and the latter as *respiration*. Broughton has more recently demonstrated a constant evolution of carbon dioxide from nearly all parts of growing plants, and considers that this gas, though partly due to previous oxidation, is mainly separated from the proximate principles during chemical changes.

Those who maintain Burnett's views regard the constant exhalation of carbon dioxide by day and night, as constituting vegetable respiration ; and the exhalation of oxygen by day, as connected with assimilation ; while the supporters of Pepys' views regard the exhalation of oxygen gas as vegetable respiration. Pepys says that oxygen is given off by the leaves both by night and day, but in a greatly accelerated degree during the day ; by most observers, however, no evolution of oxygen has been traced at night.

It will be seen from the above abstract of the opinions of different physiologists, that various ideas have been entertained by them as to the action of the leaves and other green organs under different degrees of light ; and also upon the character of such changes. Generally, it may be stated,—that all agree as to the evolution of oxygen by the leaves and other green parts of plants under the influence of solar light with the fixation of carbon, i.e. the deoxidation of assimilable materials, to which process the term *assimilation* is applied in this volume in accordance with the views now commonly entertained by botanists ; while that of *respiration* is here used to denote the absorption of oxygen and evolution of carbon dioxide, which takes place both by night and day, but is most evident by night, because the large quantity of oxygen given off during the day in the process of assimilation obscures the former change. In certain plants the sun's light appears to be stored up in some unknown way for future use, so that we find some aquatic plants after exposure to its influence disengage bubbles of oxygen in the dark.

Whatever views we may entertain, all admit that this evolution of oxygen gas by day has a most important influence in Nature. This will be at once evident when it is remembered that it is the only known process by which oxygen gas,—so essential to our existence, and which is constantly being removed from the atmosphere we breathe, by the respiration of man and other animals, by the process of combustion, by oxidation of mineral matter, and by other processes that are constantly going on upon the globe,—is restored to it in a free condition. Thus we see that, 'the two great organised kingdoms of nature are made to co-operate in the execution of the same design ; each ministering to the other, and preserving that due balance in the constitution of the atmosphere which adapts it to the welfare and activity of every order of beings, and which would soon be destroyed were the operations of either of them to be suspended. It is impossible to contemplate so special an adjustment of opposite effects without admiring this beautiful dispensation of Providence, extending over so vast a scale of being, and demonstrating the unity of plan upon which the whole system of organised creation has been devised.'

In a like manner, plants purify the water in which they grow, and render it habitable by certain animals. We all know by early experience, that if fish or other aquatic animals be placed in water in which no plants are grown, they will soon perish. This is partly because, as there is then nothing present in the water to destroy the noxious matters which are given off by the animals in their respiration and other processes, they are destroyed by their own action upon the medium in which they are placed. In nature, we always find plants existing with animal life in the water, so that the injurious influence communicated by the latter to that medium is counteracted by the assimilation of the former: this compensating influence of plants and animals is beautifully illustrated in our aquaria. We are taught by these facts that it is absolutely necessary, if we desire to maintain a large town in a healthy state, to set apart large areas and plant them freely.

How far our views regarding the purifying influence of plants may require modification by the discovery by Boussingault of the evolution of a certain proportion of such a poisonous gas as carbon oxide, together with oxygen, it is at present impossible to say ; but the subject is one of the very greatest importance, and cannot but repay further careful investigation. Boussingault has even thrown out a suggestion, that in some cases, so far from plants purifying the air, they may, on the contrary, cause the atmosphere of marshy districts, where they are in excess, to be unhealthy. It is also probable that *one cause* of the unhealthiness of densely wooded districts may be due to the evolution of carbon oxide. With reference to the above conclusions of Boussingault, it may be remarked, that his experiments were solely made by putting plants or the green parts of plants in water previously impregnated with carbon dioxide. The conditions, therefore, under which carbon oxide was formed were not altogether natural ones ; and hence it is desirable that future experimenters should test plants growing in the air as well as in water, and in every respect in as nearly as possible their ordinary states of existence.

There exists a widely spread notion, that plants, when grown in rooms where there is but little ventilation, and hence, especially in our sleeping apartments, have an injurious influence upon the contained air. This idea has arisen from a knowledge of the fact that plants, as already noticed, when not exposed to solar light, have a contrary effect upon the atmosphere to that which they have when submitted to its influence ; that is to say, that they then absorb oxygen and give off carbon dioxide, instead of absorbing carbon dioxide and giving off oxygen. But the amount of carbon dioxide which is then given off by plants is so extremely small, that it can have no sensible effect upon the atmosphere in which they are placed. It might be readily shown that it would require some thousands of plants, in this way, to vitiate the air of a room to anything like the extent of that of a single animal, and that, therefore, the idea of a few plants rendering the air of close rooms unwholesome by their action, is altogether erroneous. It is certain, however, that, under such circumstances, the odours of plants may affect injuriously, to some extent at least, individuals of delicate organisation or peculiar idiosyncrasies.

(4) *Formation of Organic Compounds by Leaves.*—By the alterations produced in the watery contents of the green leaves, &c., by exposure to light, heat, and air, the matters which they contain are left in a very active chemical condition or in a state prone to change, and therefore freely combine together. By this means the different organic compounds are produced which are concerned in the development of new tissues; and in the formation of others, such as resinous matters, various acids, numerous alkaloids, colouring matters, &c., which, so far as we know at present, perform no further active part in the plant, and are accordingly removed from the young and vitally active parts, and either stored up in the older tissues as *secretions*, or removed altogether from the plant as *excretions.* (See page 792.) The production of these organic substances takes place by *assimilation*, and *metastasis.* (See page 823.) We see, therefore, that without leaves or other analogous green organs no growth to any extent could take place, or any peculiar secretions be formed; but it must be also recollected that without the exposure of even the leaves to light, no proper assimilation of the various matters taken up by the plant can be effected; for instance, if a plant be put into the dark, it becomes blanched (*etiolated*), in consequence of the non-development of chlorophyll, and, moreover, no woody matter is then formed (page 794), and but few of its peculiar secretions. The experiments of Pringsheim tend to show that the earliest nutritive product produced by the influence of light, heat, and air is formed in the interior of the chlorophyll grains. This principle he has termed *hypochlorin*, and by its oxidation he believes that all nutritive bodies, such as starch, glucose, and oil, are formed. It is also supposed by Pringsheim that the function of the green colouring matter is to act as a screen, and to reject the rays of the spectrum favouring oxidation, and to allow those only to pass which aid nutrition. It is possible, however, that the hypochlorin is simply the result of the action of the hydrochloric acid used in the experiment upon the chlorophyll.

The effect of the absence of light upon plants is well shown when a potato tuber sprouts in the dark, in which case the whole of the tissues formed are seen to become etiolated, and ultimately to die; or when potatoes are reared with a diminished supply of light, as in an orchard, or under trees, when the tubers are found to be watery in consequence of the small quantity of starch then produced. Another illustration of the effect produced by the absence of light is afforded in growing certain vegetables for the table, such as Sea-kale, Celery, &c. In these instances when the plants are grown freely exposed to light, as in their natural conditions, they form abundance of woody matter, which renders them tough or stringy; and also peculiar secretions, which are either unpleasant to the taste or absolutely injurious. But the formation of these secretions, and also of the woody matter, is interfered with when the access of light is more or less prevented, and the plants then become useful vegetables.

How such a vast variety of compound substances can be formed in such simply organised bodies as plants, is at present almost unknown. It is to the labours of the physiological chemist that we must look for the elucidation of this important matter; but as it is not our purpose to allude to the various theories that have been entertained upon their formation and nature, we must refer the student to chemical works for full details upon this subject. It is, however, certain that the elimination of oxygen and carbon dioxide, already described, are results of these chemical processes. The food of plants is highly oxygenated as compared with the important proximate principles formed within their leaf-cells, and hence a disengagement of oxygen must occur during their formation.

(5) *Effects of Gases generally upon Leaves.*—In the last section we have seen that those ordinary normal constituents of atmospheric air, namely, oxygen, nitrogen, carbon dioxide, and ammonia, in certain proportions, are especially necessary for the due elaboration of the various organic compounds of plants, and we have also shown that they are absorbed by the leaves or roots, or by both. It is by leaves especially, or perhaps entirely (see page 815), that carbon, which is so essential to plants, and which enters so largely into the composition of their various products and secretions, is absorbed. But it must be understood, at the same time, that plants will not live in an atmosphere composed simply of either carbon dioxide, oxygen, or nitrogen; but that for their proper development these gases must be mixed in suitable proportions, for if either of them be in great excess, the plants will either languish or perish, according to circumstances. Plants will, however, flourish in an atmosphere containing a moderate addition of carbon dioxide, even more vigorously than in ordinary atmospheric air; but if the amount be considerably increased, they will perish. This injurious effect of carbon dioxide, when in excessive amount, would seem to be owing to a directly poisonous influence. When plants are placed in pure nitrogen or oxygen, or under any other circumstances where they cannot obtain a suitable supply of carbon dioxide, they soon decay.

Whilst the above gases in suitable proportions are necessary to the due performance of the proper functions of plants, all other gases when mixed in the air in which they are placed, appear to act more or less injuriously upon them. This is more particularly the case with sulphurous acid and hydrochloric acid gases, even in small quantities ; but an atmosphere containing much ammonia, common coal gas, cyanogen, &c., also acts prejudicially.

The action of sulphurous and hydrochloric acid gases upon plants appears to resemble that of irritants upon animals ; thus they first exert a local action upon the extremities of the leaves, and this influence is soon communicated to the deeper tissues, and if the plants be not removed into a purer air, they will perish ; but when such gases are not in great quantities, if the plants are speedily removed from their influence, they usually revive, the parts attacked being alone permanently injured.

While the gases thus mentioned act as irritant poisons upon plants, sulphuretted hydrogen, carbon oxide, common coal gas, cyanogen, and others, seem to exert an influence upon them like that produced by narcotic poisons upon animals, for by their action a general injurious influence is produced on their vitality, and a drooping of the leaves, &c., takes place ; and, morever, when such is the case, no after removal into a purer air will cause them to revive.

As the above gases are constantly present in the air of large towns, and more especially in those where chemical processes on a large scale are going on, we have at once an explanation of the reason why plants submitted to such influences will not thrive. The air of an ordinary sitting room, and especially one where gas is burned, is also rendered more or less unsuitable to the healthy growth of plants, in consequence of the production of injurious gases as well as from the dryness of the atmosphere.

Wardian Cases.—In order to protect plants from the injurious influences thus exerted upon them by the soot and impure air of large towns, the late N. B. Ward introduced the plan of growing them under closed glass cases which has been found to succeed so admirably. These cases consist essentially of a box or trough in which a suitable soil is placed ; in this the plants are put, and the whole is then covered by a closely fitting glass case. It is necessary, at first, to water the plants freely. When plants are grown under such circumstances, upon exposure to light and air, transpiration takes place from their leaves, as under ordinary conditions of growth ; the fluid thus transpired is, however, here condensed upon the surface of the glass case which encloses the plants, and ultimately returned to the soil. It is thus brought into contact again with the roots of the plants, to be again absorbed and exhaled by them ; and these changes are continually repeated, so that the plants are always freely exposed to moisture, and do not require a further supply of water for a considerable period. Those plants, especially, which succeed best in a damp atmosphere, as is commonly the case with Ferns, do exceedingly well in such cases. The important influence which is exerted by the invention is, the protection of the contained plants from immediate contact with air impregnated with soot and other injurious substances; for in consequence of the glass cover fitting closely to the trough in which the plants are placed, the external air in its passage has to pass through the very narrow crevices beneath the cover, and in so doing becomes filtered, as it were, in a great measure from its impurities, before it is brought into contact with them.

Besides the use of these cases in growing plants luxuriantly in those places where, under ordinary circumstances, they would perish, or at all events grow but languidly, they have a still more important application, for they have now been most successfully employed in transporting plants from one country to another which under ordinary circumstances would have died in their transit, and whose seeds could not have been transported without losing their vitality. The action of the Wardian cases in this mode of transporting plants is twofold: in the first place, the plants are protected from the influence of salt breezes, which are in most instances very injurious to them; and, secondly, the atmosphere of such cases remains in a quiet state, and they are therefore also protected from rapid changes of temperature.

(6) *Colour of Leaves.*—The green colour of leaves is due to chlorophyll contained in the cells situated beneath the epidermis. Chlorophyll bodies may be formed in the dark, but remain yellow, only becoming green under the influence of light, and hence the leaves and other parts of plants grown in darkness are blanched or etiolated (page 804). To this rule there are some notable exceptions—viz., the germinating seeds of many Coniferæ and the fronds of Ferns, which will become green even in total darkness, provided that the temperature is sufficiently high. If plants with green leaves be withdrawn from the action of light and be placed in the dark, these leaves soon fall; and if others are produced, they have a whitish or yellowish colour. Again, if plants which have been grown in the dark be removed to the light, the leaves upon them soon lose their whitish hue and become green. The rapidity with which leaves become green, and the intensity of their colour, will be in proportion to the amount of light and heat (25°-30° C. being about the maximum) to which they have been exposed. It has also been shown that iron is necessary for the production of chlorophyll. (See also *The Effect of the Electric Light on the Growth of Plants*, &c., page 858.)

The different rays of the spectrum have a varying influence in promoting the formation of chlorophyll Some difference of opinion exists as to those rays which are most active in this respect, but the majority of experimenters agree that the illuminating or yellow rays—namely, those which, as we have already seen (page 800), have the greatest effect in promoting the decomposition of carbon dioxide—are those also which are the most active in the production of chlorophyll.

M. Frémy has investigated the nature of chlorophyll, and ascertained that it is composed of two colouring principles,—one a yellow, which he has termed *phylloxanthin* or *xanthophyll*; and the other a blue, which he has called *phyllocyanin* or *cyanophyll.* Both these principles have been isolated by M. Frémy, who has also endeavoured to show that the yellow colour of etiolated and very young leaves is due to the presence of a body which he has termed *phylloxanthéin*, and which is coloured blue by the vapour of acids. The same principle results from the

FIG. 1148.

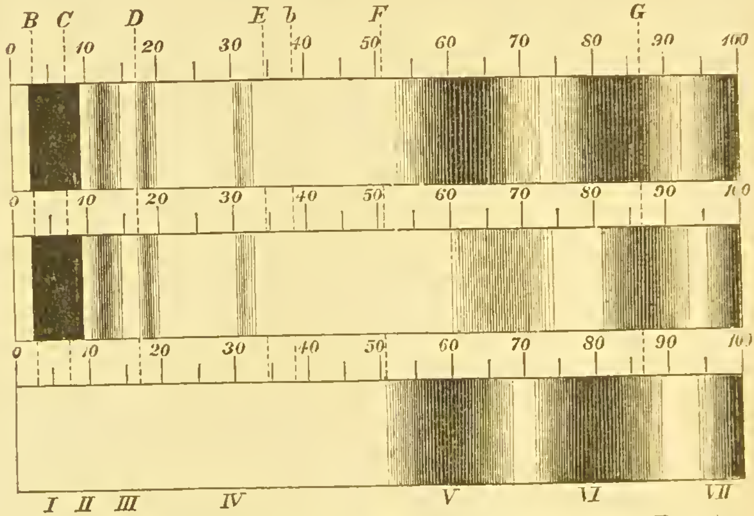


Fig. 1148. Absorption spectra of chlorophyll and xanthophyll. (After Kraus.) The upper spectrum is given by an alcoholic extract of leaves, the middle one by dissolving chlorophyll in benzol, and the lowest by xanthophyll. The bands in the least refrangible portion B–E are figured as obtained with a concentrated solution; those in the most refrangible part of the spectrum F–G are given as obtained with a weak solution. The letters B–G indicate the principal rays, the numbers I–VII the absorption bands of chlorophyll from red to violet, and the figures 0–100 divide the length of the spectrum into 100 equal parts. (After Sachs.)

decoloration of phyllocyanin; hence it would seem that phyllocyanin is not an immediate principle, but that it is formed by the alteration of phylloxanthéin. The experiments of M. Filhol do not, however, altogether correspond with those of M. Frémy, whilst the more recent spectroscopic investigations of Professor Stokes and H. L. Smith tend to show that chlorophyll is more complex than M. Frémy imagined.

Chlorophyll is stated by Sorby to exist in a blue and also in a yellow state, giving different effects with the spectroscope, and Kraus finds that by shaking up an alcoholic solution of chlorophyll with benzol, two clearly separated strata are formed, a lower alcoholic one of a yellow colour, and an upper one of benzol with a blue-green colour (see *fig.* 1148). *Chlorofucin* is another colouring matter, which, like the two preceding, is fluorescent, and has a yellow-green colour. These three are soluble in alcohol, but not at all in water, and not always in bisulphide of carbon. Sorby also describes other colouring matters which are soluble in bisulphide of carbon, and give different results to the foregoing with the spectroscope.

The autumnal tints of leaves, which are generally some shades of yellow, brown, or red, are commonly regarded as due to varying degrees of oxidation of the chlorophyll which their cells contain, to which change Henfrey applied the term 'decay of chlorophyll.' The experiments of M. Frémy show that the yellow leaves of autumn contain no phyllocyanin, and hence that their colour is entirely due to the phylloxanthin, either in its original condition or in an altered state. Strong light may produce a fading of leaves and other green parts, which change appears to be due to an alteration in the position of the grains of chlorophyll in the cells, and is termed *epistrophe* or *apostrophe* as the case may be.

When leaves are of some other colour than green, the different colours are produced either by an alteration of the chlorophyll or of one of the principles of which it is formed, or in consequence of the presence of some other colouring agent.

Variegation in leaves must be regarded as a diseased condition of the cells of which they are composed; it is commonly produced by hybridisation, grafting, differences of climate, soil, and other influences. The variegated tints are due either to the presence of air in some of the cells, or more commonly to an alteration of the chlorophyll of certain cells, or one of the substances of which chlorophyll is composed. (See also *Colour of Flowers*, page 828.) To all these solid bodies contained in the cells and connected with its coloration or starch production, Schimper applies the general term of *plastids*. Schimper uses prefixes to the different plastids thus:—Starch-forming corpuscles and colourless plastids which do not form starch he terms *leukoplastids*; chlorophyll granules *chloroplastids*, and other colouring granules *chromoplastids*. From the observations of Schimper it seems that all these plastids have a common origin: viz. that they are the result of the division of leukoplastids, and never originate, as was formerly believed, by free cell-formation. Some plastids have an active life, assimilating, forming starch or pigments, increasing by division, &c.; others having temporarily or permanently little or no vital functions, as is the case with many leukoplastids. Further, these passive plastids are frequently crystalline in form; the active plastids, especially in the higher plants, being usually round. The passive crystalline forms are doubly refractive. The crystalline forms may become spherical, and conversely, those which are spherical and active may become crystalline. From leukoplastids may be produced either *chloro-* or *chromo-plastids*, and the latter may also be formed from chloroplastids. Meyer and Schmidt confirm these views in a remarkable manner, while Schmidt further suggests that there is some definite and close relationship between these plastids and nuclei.

(7) *Defoliation, or the Fall of the Leaf.*—Leaves are essentially temporary organs; for after a certain period, which varies in different plants, they either gradually wither upon the stem, as is usual in Monocotyledons and Cormophytes (see page 190), and also in some Dicotyledons (page 189); or they separate from the stem by means of an articulation when they have performed their active functions, or even sometimes when quite green. In the former case, as we have seen, the leaves are described as non-articulated; in the latter, as articulated. In the trees of this and other temperate climates the leaves commonly fall off the same year in which they are developed, that is, before the winter months; and in those of warm and tropical regions the fall of the leaf often takes place at the dry season. But the leaves of some other plants, such as Firs, Boxes, Hollies, frequently remain for two or more years. In the former case they are said to be annual or deciduous, and in the latter persistent or evergreen. The fall of the leaf is commonly termed *defoliation*.

The cause or causes which lead to the *death* of the leaf are by no means well understood. The opinion commonly entertained is this: the membrane constituting the walls of their cells gradually becomes so incrusted by the deposit of earthy and other matters which are left behind by the fluid substances which are contained in or transmitted through them, that ultimately the tissues of the leaf become choked up and are no longer able to perform their proper functions, and the leaf then begins to dry up. After its death the leaf may either fall, or remain attached to the stem, as already observed.

The *fall* of the leaf does not, then, depend upon the death of the organ; it may occur before death, or may not take place at all. When it happens, it is dependent on an organic separation or articulation, which Asa Gray thus describes:—'The formation of the articulation is a vital process, a kind of disintegration of a transverse layer of cells, which cuts off the petiole by a regular line, in a perfectly uniform manner in each species, leaving a clean scar (*fig.* 207, *b*, *b*) at the insertion. The solution of continuity begins at the epidermis, where a faint line marks the position of the future joint while the leaf is still young and vigorous; later, the line of demarcation becomes well marked, internally as well as externally; the disintegrating process advances from without inwards until it reaches the woody bundles; and the side next the stem, which is to form the surface of the scar, has a layer of cells condensed into what appears like a prolongation of the epidermis, so that when the leaf separates,' as Inman says, 'the tree does not suffer from the effect of an open wound.' Gray then, quoting Inman, adds :—'The provision for the separation being onee complete, it requires little to effect it ; a desiccation of one side of the leaf-stalk, by causing an effort of torsion, will readily break through the small remains of the fibro-vascular bundles ; or the increased size of the coming leaf-bud will snap them ; or, if these eauses are not in operation, a gust of wind, a heavy shower, or even the simple weight of the lamina, will be enough to disrupt the small connexions and send the suicidal member to the grave. Such is the history of the fall of the leaf.'

(8) *Development of Leaves.*—Leaves and all their homologous forms, such as the parts of flowers, &c. are developed laterally just below the apex of the stem by cell-division either of a group of cells as in the Phanerogams, or of a single eell as in the Vascular Cryptogams. A conical papilla, or (in sheathing leaves) an annular eollar, is then the result of a deflection to one side of a group of these divided cells. Leaves are formed acropetally or indefini ely, the youngest always being the highest, according to the laws of Phyllotaxy. 'The papillæ from which the leaves originate are at first wholly cellular, consisting of periblem or proto-meristem, covered by a layer of dermatogen cells ; after a time elongated cells are formed in the centre ; and these are followed by spiral vessels, formed in a direction from the base upwards.' The first formed part of the leaf generally corresponds with its apex or with the summit of the common petiole—i.e. the apex of a leaf is generally its *oldest* instead of its youngest part as is the case with the stems where the apex is the growing point. (See page 795.) In leaves the apical growth soon ceases, though interstitial growth continues.

The following is an abstract of Trécul's conelusions :—

'All leaves originate in a primary cellular mamilla, with or without a basal swelling, according as they are to have sheaths or not ; they are developed after four prineipal types : (1) the *centrifugal* formation, from below upwards ; (2) the *centripetal* formation, from above downwards ; (3) the *mixed* formation ; and (4) the *parallel* formation. The *centrifugal* or *basifugal* development may be illustrated by the leaf of the Lime-tree, which begins as a simple tumour at the apex of the stem. This tumour lengthens and enlarges, leaving at its base a eontraction which represents the petiole. The blade, at first entire, is soon divided from side to side by a sinus. The lower lobe is the first secondary vein. The upper lobe is divided in the same manner five or six times, forming as many secondary veins. Sinuosities then appear in the lower lobe, indicating the ramifications of the lower vein ; and, finally, fresh toothings appear corresponding with more minute ramifications. Thus the various veins in the leaf of the Lime-tree are developed like the shoots of the tree that bears them, and the toothing does not arise from cells specially adapted for that purpose on the edge of the leaf, as Mercklin has supposed. The hairs on the under surface of the leaf are also formed from below upwards.

'Leaves developed *centripetally* (called also the basilar or basipetal mode of leaf formation) are more numerous than the preceding, and this method may be well studied in the formation of the leaves of the Hyacinth; of this sort are the leaves of *Sanguisorba officinalis*, *Rosa arvensis*, *Cephalaria procera*, &c. In them the terminal leaflet is first produced, and the others appear in successive pairs downwards from apex to base. The stipules are produced before the lower leaflets. All digitate leaves, and those with radiating venation, belong to the centripetal mode of formation as regards their digitate venation.

'In some plants, as *Acer*, the two preceding modes of development are combined. This is called *mixed formation*. In *Acer platanoides* the lobes and the midribs of the radiating lobes form from above downwards, the lower lobes being produced last, but the secondary venations and toothings are developed like those of the Lime-tree. In Monocotyledons we meet with the *parallel* (included by some writers with the basilar) *leaf formation* of Trécul. All the veins are formed in a parallel manner, the sheath appearing first. The leaf lengthens especially by the base of the blade, or that of the petiole when present.

'Leaves furnished with sheaths, or having their lower portions protected by other organs, grow most by their base; while those which have the whole petiole early exposed to the air grow much more towards the upper part of the petiole.'

CHAPTER 2.

GENERAL PHYSIOLOGY, OR LIFE OF THE WHOLE PLANT.

Having now briefly treated of the special functions of the elementary structures and of the organs of nutrition, as such structures are alone intimately concerned in maintaining the life of the plant and its various organs, we proceed to give a sketch of general physiology, or the whole plant in a state of life or action. In doing so, we shall first notice the substances required as food by plants and their sources; then proceed to consider the function of *absorption*, or that process by which food is taken up dissolved in water; and lastly, show how this fluid food is distributed through the plant, and altered in the leaves, so as to be adapted for the development of new tissues, and the formation of other organic compounds, which are commonly termed secretions.

Section 1. Food of Plants and its Sources.

The various substances required as food can be only ascertained by determining the elementary composition of the parts and products of plants; for as plants have no power of forming these elements for themselves, they must have derived them from external sources.

As plants are incapable of locomotion, being fixed to the soil or to the substance upon which they grow, or floating or suspended in water, they must obtain their food from the media by which they are surrounded, that is, as a general rule, from the soil, or from the air, or from both; but no plants can take up their food except in the state of gas or vapour, or in a fluid state. In by far the majority of cases plants take up their food, both from the air by their leaves in a gaseous or vaporous state, and from the earth dissolved in water by their roots. But plants which are termed Epiphytes or Air Plants, as many Orchids (*fig.* 256), derive their food entirely from the air by which they are surrounded (see page 131); while Parasites (*figs.* 257 and 258) and Saprophytes essentially differ from both Epiphytes and ordinary plants in the fact that their food, instead of being derived entirely from inorganic materials, which are afterwards assimilated in their tissues, is obtained entirely or partially from the plants upon which they grow, that is, in an already assimilated condition, or, as in Saprophytes, from organic matter in a state of decay (see page 133).

The materials of which plants are composed, and which, as stated above, are either derived from the air, or the earth, or more commonly from both, and which consequently constitute their food, form respectively their *organic* and *inorganic* compounds; and in all plants there is also a varying proportion of water. The process of burning enables us conveniently to distinguish, to a great extent at least, the comparative proportion of these organic and inorganic compounds, and acquaints us with one of their distinctive peculiarities. Thus, if we take a piece of wood, or a leaf, or any other part of a plant, and burn it as perfectly as we are able, we find that the greater portion disappears in the form of gas and vapour, but a small portion of the original substance remains in the form of ash or incombustible material. The former or combustible portion is made up of *organic compounds* or *volatile constituents*, that is to say, of combinations of carbon with other elements, and the latter portion of *inorganic compounds*. The relative proportion of the organic and inorganic constituents varies in different plants; but, as a general rule, the former constitute from 92 to 99 parts, while the latter form from 1 to about 8 parts in every 100.

1. *The Organic or Volatile Constituents, and their Sources.*—The organic constituents of plants are, Carbon, Oxygen, Hydrogen, Nitrogen, and Sulphur. The first three alone form the cellulose of which the cell-walls are composed (see pages 4 and 23); while the protoplasmic contents of the cell are formed of compounds of these three elements with the two other organic constituents, namely, nitrogen and sulphur (see page 26). Phosphorus is also regarded as a necessary constituent of these nitrogenous cell-contents (page 26); but it belongs to the inorganic constituents.

These organic constituents are required alike by every species of plant, hence the great bulk of all plants is composed of the same elements, although the proportion of these varies to some extent in the different species, and even in different parts of the same plant. The following table, by Johnston, indicates approximately the relative proportion of the organic and inorganic constituents of some of our vegetable food substances in 1,000 parts, and of the different elements of which the former are composed. These substances were first dried at a temperature of 230° Fahr.:—

	Wheat.	Oats.	Peas.	Hay.	Turnips.	Potatoes.
Carbon	455	507	465	458	429	441
Hydrogen . . .	57	64	61	50	56	58
Oxygen . . .	430	367	401	387	422	439
Nitrogen . . .	35	22	42	15	17	12
Ash	23	40	31	90	76	50

We must now make a few remarks on each of the organic constituents, the sources from which they are derived, and the state in which they are taken up by plants.

Carbon is the most abundant organic constituent, forming as it does from 40 to 60 per cent. of the weight of the entire dried substance of different species of plants. That plants thus contain a large proportion of carbon may be conveniently proved by taking a piece of wood, the weight of which has been ascertained, and converting it into charcoal, which is impure carbon containing in its substance also a small quantity of the inorganic constituents or ash. The charcoal thus produced is of the same form as the piece of wood from which it was obtained, and when weighed it will be found to have constituted a large proportion of its original substance. As carbon is a solid substance and insoluble in water, it cannot be taken up in its simple state, for plants, as already noticed, can only take up their food as gas or vapour, or dissolved in water. In the state of combination, however, with oxygen, it forms carbon dioxide, which is always present in the atmosphere and the soil. Carbon dioxide is also soluble to some extent in water. Hence we have no difficulty in ascertaining the source of carbon and the condition and mode in which it is absorbed by the plant; thus it is taken up essentially combined with oxygen in the form of carbon dioxide, from the air directly in a gaseous state by the leaves, and, according to some, to a small extent from the earth, dissolved in water, by the roots. Sachs, however, states: 'The fact is unquestionable that most plants which contain chlorophyll obtain the entire quantity of their carbon by the decomposition of atmospheric carbon dioxide, and require for their nutrition no other compound of carbon from without. But there are also plants which possess no chlorophyll, and in which, therefore, the means of decomposing carbon dioxide is wanting; these must absorb the carbon necessary for their constitution in the form of other compounds. . . . Even the food of Fungi which are parasitic in and on animals is derived from the products of assimilation of plants containing chlorophyll, inasmuch as the whole animal kingdom is dependent on them for its nutrition.'

Oxygen is, next to carbon, the most abundant organic constituent of plants; and when we consider to what an enormous extent it exists in nature, constituting as it does about 21 per cent. by volume of the atmosphere we breathe, eight-ninths by weight of the water we drink, and at least one-half of the solid materials around us and of the bodies of all living animals, we see that there are abundant materials from which plants can obtain this necessary portion of their food. The whole of the oxygen required by plants, except the small quantity which is necessary in the process of respiration (page 802) appears to be taken up either combined with hydrogen in the form of water, with carbon as carbon dioxide, or in the form of oxygen salts. Some of the oxygen is therefore obtained by the roots from the soil, and some from the air by the leaves.

Hydrogen, the third organic constituent of plants, as just noticed, forms one-ninth by weight of water, and it is in this form that plants obtain nearly the whole of the hydrogen they require as food. It does not exist in a free state in the atmosphere nor in the soil, and hence cannot be obtained by plants in a simple state. But in combination with nitrogen it forms ammonia, which always exists to some extent in the atmosphere and in the excretions of animals; and is also always produced during the decomposition of animal matter. Ammonia exists in a gaseous state in the atmosphere, and being freely soluble in water, the rain as it passes through the air dissolves it, and carries it down to the roots, by which organs it is taken up. The roots in like manner absorb the ammonia dissolved in water which is contained in the soil. While the larger proportion of hydrogen, therefore, is taken up combined with oxygen as water, a small portion is acquired with nitrogen in the form of ammonia.

Nitrogen, the fourth and last organic constituent of plants, constitutes about 79 per cent. of the volume of the atmosphere, and is an important ingredient in animal tissues. It also exists in combination with oxygen as nitric acid in rain water, and in the soil as a constituent of the various nitrates and animal products there found. Whether nitrogen can be taken up by plants in a free state is at present very doubtful (see page 799), though most probably it cannot; for if all other necessary food materials be supplied to plants, but all sources of ammonia, or compounds of nitric acid, rendered inaccessible, the albuminoids and nitrogenous substances generally do not increase, although the plants may be freely exposed to the nitrogen-containing atmosphere, hence it is quite clear that the principal form in which it is absorbed is as ammonia.

Sulphur, the only other organic constituent, and which, as we have noticed (page 26), is always combined with nitrogen and phosphorus in the protoplasmic cell-contents, is absorbed in a state of combination from the soil dissolved in water by the roots.

In reviewing the sources of, and modes in which, the different organic or volatile constituents of plants are derived and taken up, we see that the sources are the earth and the air, more particularly the latter; and that they are principally absorbed in the forms of carbon dioxide and water, the latter of which is not only food in itself, as it is composed of oxygen and hydrogen, two of the essential organic constituents of plants, but it is also an important vehicle by which other food is conveyed to them.

2. *The Inorganic Constituents or Ash, and their Sources.*—The amount of inorganic matter found in plants, as already observed (page 313), is very much less than that of the organic. The inorganic matters are all derived from the earth in a state of solution in water, and hence we see again how important a proper supply of water is to plants. While the organic constituents are the same for all plants, *the inorganic constituents vary very much in the different kinds of plants.*

The inorganic constituents differ from the organic also, in the following particulars:—1st, they are incombustible, and hence remain as ash, when the organic constituents are dissipated by burning; and, 2nd, they are not liable to putrefaction, as is the case with them, under the influence of warmth and moisture.

The inorganic constituents of plants are as follows:—Phosphorus, Chlorine, Bromine, Iodine, Fluorine, Silicon, Potassium, Sodium, Calcium, Strontium, Magnesium, Aluminium, Manganesium, Iron, Zinc, Titanium, Lithium, Cæsium, Rubidium, Arsenic, Copper, Lead, Cobalt, Nickel, and Barium. Some of these appear to be almost universally distributed in varying proportions, but others are only occasionally met with. The more important are Phosphorus, Chlorine, Potassium, Calcium, Magnesium, and Iron, which appear to be absolutely necessary for the nutrition of plants. The various inorganic constituents are not taken up in their simple states, but as soluble oxides, chlorides, bromides, fluorides, sulphates, phosphates, silicates, &c.

Although the amount of inorganic matter in plants is very much smaller than that of the organic, still this portion, however small, is necessary to the life and vigorous development of most plants, and probably of all; although in certain Moulds no inorganic constituents have been detected.

The inorganic constituents of plants are of great importance in an agricultural point of view, and in growing plants for use in medicine, &c., as it is to their presence or absence, their relative quantities, and the solubility or insolubility of their compounds, in a particular soil, that it owes its fertility or otherwise, and its adaptability of growing with success one or another kind of plant.

Rotation of Crops.—The principle of the rotation of crops in agriculture is founded upon the fact of different plants requiring different inorganic compounds for their successful cultivation; and hence a particular soil which is rich in materials necessary for some plants, may be wanting or deficient in those required by others. Thus, Wheat or any cereal crop requires more especially for its proper growth a full supply of silica and phosphates; hence it will only flourish in a soil containing the necessary amount of such substances. As growth proceeds, these constituents are absorbed in a state of solution by the roots, and are applied to the requirements of the plants. When the grain is ripe, it is removed as well as the straw, and the silica and phosphates obtained from the soil will thus be also removed with them; the result of this is necessarily, except in fertile virgin soil, that these ingredients will not be then contained in the soil in sufficient quantities to support immediately the growth of the same species of plants. But by growing in a soil thus exhausted by Wheat, another crop of a different kind, such as Clover, Peas or Beans, which requires either altogether different substances, or a different amount, or other combinations of the same substances, or whose roots penetrate to a greater or less depth, we may obtain a profitable crop: while at the same time certain chemical changes will go on in the soil, and other ingredients be taken up from the atmosphere, and in other ways, by which the land will be again adapted for the growth of Wheat.

The consideration of the above facts shows how important it is for the agriculturist to have some acquaintance with vegetable physiology and chemistry. He should know the composition of the various soils, and the plants which he cultivates, as well as the nature of the compounds required by them, and the modes in which they are taken up, and thus be able to adapt particular plants to the soils proper for them. If such soils do not contain the substances necessary for their life and vigour, he must supply them in the form of manures. The applications of chemistry and vegetable physiology to agriculture are thus seen to be most important, and the great practical improvements which have of late years taken place are mainly due to the increased interest taken in such matters, and the many admirable researches to which it has led. But however interesting in an agricultural point of view these applications may be, our necessary limits will not allow us to dwell upon them further.

Section 2. Life of the whole Plant, or the Plant in Action.

The various substances required by plants as food having now been considered, we have in the next place briefly to show how that food is taken up by them, distributed through their tissues, and altered and adapted for their requirements. The consideration of these matters involves a notice of the functions of vegetation. The more important facts connected with these functions have, however, already been referred to in treating of the Special Physiology of the Elementary Tissues, and of the Root, Stem, and Leaves; so that it now only remains for us in this place to give a general recapitulation of the functions of the plant, and to consider them as working together for the common benefit of the whole organism. It will be convenient to treat of these under the two heads of (1) Absorption; and (2) Distribution of Fluid Matters through the Plant, and their Alteration in the Leaves.

1. *Absorption.*—The root, as already noticed, is the main organ by which food is taken up dissolved in water, for the uses of the plant. No matter can be absorbed in an undissolved condition; and this absorptive power is owing to the superior density of the contents of the cells of the young extremities of the roots over the fluid matters surrounding them in the soil, leading to the production of osmotic action through the cell-walls (see page 781 and *fig.* 1139).

That the roots do thus absorb fluid matters may be proved by a very simple experiment. Thus, if we take two glasses of the same capacity, and pour water into them until it is at the same level in each, and then put the roots of a vigorous growing plant in the one, and expose both in other respects to the same influences of light, heat, and air, it will be noticed that the water will gradually disappear from the glasses, but from that in which the roots are placed far more rapidly than from the other without them, and the more rapid removal in the former case must therefore be owing to its absorption by the roots. In this way we can also estimate, in some degree at least, the amount absorbed, which will be found to be very considerable; commonly, in a few days, far exceeding in weight that of the plants which are experimented upon. This absorption of liquid by the roots is in many cases altogether independent of leaf-action, for, if the rootlets be healthy and the tissues above them filled with fluid, it will always occur; and the great force of the action in stumps cut off a little above the ground is well seen in such experiments as those of Hales (see page 822) and Hofmeister. But nevertheless, as a general rule, the amount of fluid absorbed by the roots is directly dependent upon the activity with which the other processes of vegetation are carried on, and more especially by the quantity of fluid matters transpired by the leaves; indeed, under ordinary conditions, absorption is directly proportioned to transpiration in a healthy plant, for as fluid is given off by the leaves, it is absorbed by the roots to make up for the deficiency thus produced, and therefore all stimulants to transpiration are at the same time exciters of absorption. (See page 821). When absorption and transpiration differ greatly in amount, the plants in which such a want of correspondence takes place become unhealthy; thus when transpiration is checked from deficiency of light, as when plants are grown in dark places, the fluids in them become excessive in amount; whilst if the atmosphere be too dry, as is the case when plants are grown in the sitting-rooms of our dwelling-houses, transpiration is greater than absorption, and hence they require to be frequently supplied with water.

The mutual dependence of absorption upon transpiration should also be borne in mind in the process of transplanting trees. Transpiration is greatest at those seasons of the year when plants are most abundantly covered with leaves, and when solar light is most intense; we ought not, therefore to transplant at such periods, because, as it is almost impossible to do so without some injury to the extremities of the roots, the amount of fluid absorbed may be insufficient to compensate for the loss by transpiration, and hence the plants will languish, or die, according to circumstances. By transplanting in autumn or spring, we do not expose the plants to such unfavourable conditions, as the light is then less intense, and there are no leaves from which transpiration essentially takes place. (For further particulars on Absorption, see *Absorption by the Root*, page 790.)

FIG. 1149.

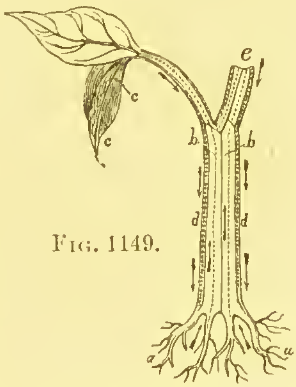


Fig. 1149. Diagrammatic vertical section of the stem of a Dicotyledon showing the distribution of the sap. The direction is indicated by the arrows. *a, a.* Roots, by which the fluid matters are absorbed. *b, b.* The tissues by which they ascend to the leaves. *c, c.* *d, d.* Outer portions of stem and inner bark where the descent takes place. *e.* Vertical section of a branch.

2. *Distribution of Fluid Matters through the Plant, and their Alteration in the Leaves.*—The fluid matter thus absorbed by the roots (the *sap*, as it is called) is carried upwards by their tissues (*fig.* 1149) to the stem, and through its young portions to the

leaves, &c. (as indicated by the arrows in the figure), to be aerated and elaborated. After this it is returned to the stem; and descends probably by the inner bark and cambium layer of Dicotyledons towards the roots from which it started (page 825); and by means of the medullary rays and the general permeability of the tissues of which plants are composed, it is also distributed to the different parts where new tissues are being formed, and where the secretions are to be deposited. This general distribution of the fluid matters through the plant is commonly termed the *Circulation of the Sap.* The fluid as it ascends is called the *Ascending* or *Crude Sap*; and as it descends, the *Descending* or *Elaborated Sap.* Although the term Circulation is thus commonly applied to this movement of the sap, it must be borne in mind, that the process bears no analogy to the circulation of the blood in animals; for plants have no heart or any organ of an analogous nature to propel their fluid matters, nor any system of vessels in which a flow thus produced takes place. As Professor Johnson has well put it, 'nutrient substances in the plant are not absolutely confined to any path, and may move in any direction. The fact that they chiefly follow certain channels, and move in this or that direction, is plainly dependent upon the structure and arrangement of the tissues, on the sources of nutriment, and on the seat of growth or other action.'

A. *Ascent of the Sap.*—The sap in its ascent to the leaves passes principally through the young wood-cells and vessels (page 785), and therefore in Dicotyledons, when they are of any age, through the outer portion of the wood or *alburnum.* In such plants, also, we have but one main stream of ascending sap. In the stems of Monocotyledons and of Cormophytes the ascent also takes place through the unincrusted cells and vessels of the fibro-vascular bundles; and hence in such plants, and more especially in Monocotyledons, we have a number of more or less distinct ascending streams. In the lower Cryptogams or Thallophytes, which have no stems, there is no regular course of the sap, but the fluids may be noticed flowing in all directions through their cells, and to be more especially evident in those parts which are of a lax nature.

The *cause* of the ascent of the sap is, as Herbert Spencer has well expressed it, a disturbance of equilibrium creating a demand for liquid. This is produced mainly by the transpiration going on in the leaves, but also by abstraction of the sap by the growing tissues and by extravasation from the vessels by pressure. The circulation is helped by osmotic and capillary action, probably by the movements of protoplasm in the cells (see page 783), and also, when it occurs, by any swaying motion of the branches causing intermittent pressure on the vessels. In the winter no transpiration takes place, and the wood of the stem and roots is filled with watery matters holding starch and other insoluble substances in suspension. The fluids of the plant are therefore in a nearly quiescent state, as there are no changes then taking place to produce their distribution. When the increased heat and light of spring commence, the insoluble starch, &c., become converted into soluble dextrin and sugar, development and transpiration immediately follow, and a consequent ascent of the sap. This flow continues throughout the summer months, when the causes favourable to it are in full activity; but towards the autumn, as heat and light diminish again, the force of the ascent also diminishes, and the flow of sap is again suspended in the winter months from the reasons above alluded to.

The force with which the sap ascends is probably greatest in the summer months, when heat and light are most intense, and when vegetation is consequently most active; and least in the winter. At first sight it would appear, that the most rapid flow of the sap was in the spring months, at which period alone plants will give off much fluid, or bleed as it is commonly termed, when their stems are wounded. At this period gallons of fluid will come, in some cases, in a few hours, from a wounded tree before the leaves have expanded; and the fact that the leaves have not expanded is the explanation of the matter. For at this season of the year, before the leaves are fully developed, the reserve materials of the tree are largely stored up in the root, and from chemical changes there actively going on, the fluids in that part become very dense, and the consequence is that an excessive osmotic action takes place. There is far more fluid absorbed from the earth than the plant can use, and root-pressure then takes place, and this pressure forces the fluid up the stem. (See page 791.) This is the explanation of what is called bleeding. But this bleeding arises from the vessels as well as the prosenchymatous cells being then filled with sap, so that the whole plant is, as it were, gorged with it: much of the sap which at that period flows is indeed little more than water rapidly pumped up from the soil to supply the drain of fluid. The process does not take place at any other time of the year, for as soon as the leaves are in full activity, or the flowers, if they be developed before the leaves, the fluid which is absorbed by the roots is naturally carried up the plant, and becomes transpired, and thus carried off. It by no means follows, therefore, that when the plant is most gorged with fluid matters, and bleeds, the force of the circulation is most active; but rather that it is greatest when the stem is least gorged with sap, as in the summer months, when vegetation is in full vigour, and the sap consumed as fast as it can be transferred upwards through the stem.

In a healthy plant in a perfectly normal state, the amount of fluid absorbed by the roots, the force with which it ascends to the stem, and the amount transpired by the leaves, are directly proportionate to one another.

The force of the ascent of the sap was measured by Hales in the stem of the Vine by an apparatus, a modified and improved form of which is represented in *fig.* 1150, where is shown a vine stock, to the transverse section of which is attached a glass tube *R*, and the tube *r* fixed into it by the cork *k*. *R* is completely filled with water, the upper cork *k'* then fixed firmly into it, and mercury poured into the tube *r*, so as to stand from the first higher at *q'* than at *q*. The bent tube being filled with mercury to the level *q'* at the commencement of the experiment, the force of the sap was readily calculated by the fall of the mercury in one leg of the tube *q*, and its corresponding rise above *q'* in the other leg. In this way he found, that in one experiment the force of the ascent was sufficient to support a column of mercury 32½ inches in height. He also calculated from his experiments on the Vine, that the force with which it rises in this plant is nearly five times greater than that of the blood in the crural artery of a horse, and seven times greater than that of the blood in the same artery of a dog. In some experiments of Brucke on the force of the ascent of the sap in the spring in the Vine, he found that it was equal to the support of a column of mercury 17½ inches high. Hales' experiment is, however, a measure of the force of absorption by the root (*root-pressure*), rather than of ascent of the sap (see pages 791 and 821).

Fig. 1150.

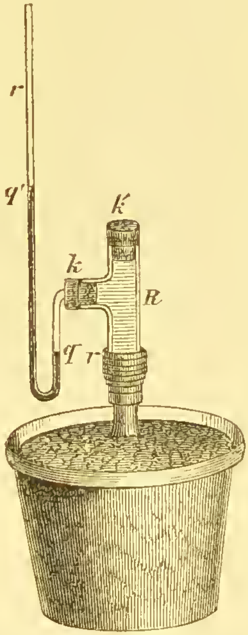


Fig. 1150. Apparatus for the estimation of root-pressure. (After Sachs.)

As the fluid rises in the stem it is of a watery nature, and contains dissolved in it the various inorganic matters in the same state nearly in which they were absorbed by the roots. It also contains some organic substances which it has dissolved in its course upwards. Thus an analysis by Attfield of the spring sap from a 'bleeding' white birch tree, showed that it 'consisted of 99 parts of pure water with 1 part of dissolved solid matter; eleven-twelfths of the latter being sugar. But although the sap in its passage upwards thus becomes more and more altered from the state in which it was absorbed by the roots, when it reaches the leaves it is still quite unfitted for the requirements of the plant, and is hence called Crude Sap. It undergoes certain changes in the leaves and other green parts, by which it becomes altered in several particulars, and is then adapted for the uses of the plant. In this state it is termed Elaborated Sap.

B. *Changes of the Crude Sap in the Leaves.*—The changes which the crude sap undergoes in the leaves and other green parts by the action of light and air have been already alluded to in treating of the Functions of Leaves ; it will be here, therefore, only necessary to state in what those changes essentially consist. They are :—1st. The transpiration of the superfluous fluid of the crude sap in the form of watery vapour, by which it becomes thickened. 2nd. The taking up from the air of oxygen and giving off of carbon dioxide, small quantities of water being probably formed at the same time, to which the term *Respiration* is now applied. The oxygen thus taken up in respiration is necessary to the vitality of the protoplasm, as also for the oxidation of nutrient matters during the process of metastasis, &c. Respiration is most evident during the night, for the large quantity of oxygen given off during the day in the process of assimilation completely obscures the former change. 3rd. The absorption and decomposition of carbon dioxide, by which carbon, that most important constituent of plants—is added to the crude sap, whilst oxygen is evolved, carbohydrates being at the same time produced. To this the term *Assimilation* is commonly applied. The carbohydrates so formed may be starch, fat, or cane sugar (*sucrose*), but more especially starch. A further process is found to take place in some of the assimilated substances ; thus they may change their position, passing from the cells in which they were formed to others, generally also undergoing at the same time a change in their chemical composition ; which combined changes are termed *metabolism* or *metastasis*. The differences between *assimilation* and *metabolism* may be seen in the Potato, where by the former process starch is formed in the chlorophyll-bearing leaves, which in its turn is converted into a glucoside in the stem and branches, and back again into starch in the tubers by metastasis. The crude sap being thus altered, then contains in itself the various nitrogenous and non-nitrogenous matters which are required for the development of new tissues, and the formation of other organic products, which are commonly called secretions. It is then termed Elaborated Sap.

Those organic matters which are necessary for development or growth are termed *constructive materials*, whereas those which are formed by metabolism or metastasis and which are not constructive—may be divided into two groups—

1. *Degradation products*, such as wood and cork, which can never be reconverted into constructive materials, though of the greatest use to the plant in giving mechanical support ; protecting the internal living tissues from frost, enabling plants to withstand the scorching heat of the sun, and in other ways. Many gums, as tragacanth, gum arabic, and others ; and gum resins, as myrrh and bdellium ; are also formed from the cell-walls, &c., of different plants, and are, therefore, other examples of such products.

2. *Secondary products of metastasis*, some of which, as sweet secretions, &c., are necessary for the perpetuation of the species, by attracting some insects, guarding against the visits of others which would be injurious, and so furthering fertilisation; while some—as ethereal oils, resins, colouring matters, and many acids and alkaloids—appear to be of no further use to the plant.

The important influences which these changes in the leaves have in promoting the purity of the atmosphere we breathe (page 802), the healthiness or otherwise of a particular country (page 798), and the fertility or barrenness of a soil (page 798), have likewise been already noticed. We have also seen that, in order that these changes may be properly performed, the leaves must be freely exposed to light; and from this dependence of assimilation on light, it follows, as we have noticed (page 804) that when the secretions of particular plants, which are otherwise agreeable, are injurious, or of unpleasant flavour, they can, by growing them in darkness or in diminished light, be made fit for the table, as is the case with Celery, Sea Kale, Lettuce, Endive, and others. For the same reason the plants of warm and tropical regions, where the light is much more intense than it is in this country or in other cold and temperate regions, are commonly remarkable for the powerful nature of their secretions, as is well illustrated by the stronger odours of their flowers, and the richer flavours of their fruits. (See also *Electricity of Plants*, page 858.)

Again, as the formation of secretions depends upon the intensity of light, it frequently happens that when a plant of a warm or tropical region which naturally produces a secretion which may be of great value as a medicinal agent, or useful in the arts, is transported to this or any other climate in which the intensity of the light is much less than it is in its native country, the secretion is not formed at all, or in diminished quantity. Even if such plants be placed in our hot-houses, where they may be submitted to the same degree of heat which they obtain naturally in their native countries, their secretions are either not formed at all, or in diminished amount, because light is the main agent concerned in their formation, and we cannot increase the intensity of light as we can that of heat, by artificial means. Another cause which commonly interferes with the formation of the secretions of plants of warmer regions when grown in our hot-houses is the want of a proper and incessant supply of fresh air to facilitate transpiration, &c.

The above facts are of great interest, as they have an important bearing upon the growth of plants and fruits for the table, as well as in a medicinal and economic point of view. At present, however, much remains to be discovered, before we can be said to have anything like a satisfactory explanation of the causes which influence the formation of the secretions of plants; for it is found that the same species of plants when grown in different parts of Great Britain, where the climatal differences are not strikingly at variance, or even at the distance of a few miles, or in some cases a few yards, frequently vary much as regards the nature of their peculiar secretions. A striking illustration of this fact is mentioned by Sir Robert Christison, who found that some Umbelliferous plants, as *Cicuta virosa*, and *Œnanthe crocata*, which are poisonous in most districts of England, are innocuous when grown near Edinburgh. The causes of such differences are at present obscure, but the varying conditions of soil and moisture under which plants are developed have doubtless an important influence upon their secretions. From a pharmaceutical point of view, so far as the active properties of the various medicinal preparations obtained from plants are concerned, this modification in their secretions by such causes is of much interest, and would amply repay investigation; for it cannot be doubted but that each plant will only form its proper secretions when grown under those circumstances which are natural to it, and that consequently any change from those conditions will modify in a corresponding degree the properties of the plant. Probably here we have an explanation, to some extent at least, of the cause of the varying strength of the medicinal preparations obtained from the same species of plants when grown in different parts of this country, or in different soils, &c.

C. *Descent of the Sap.*—After the crude sap has been transformed in the manner already described, it passes from the leaves to the stem, probably to the inner bark, and cambium-layer of Dicotyledons; and apparently to the parenchymatous tissues generally of the stems of Monocotyledons and Cormophytes. It then descends in the stems of the several kinds of plants as far as the root, and in its course affords materials for the development of new tissues and the production of flowers and fruit; and at the same time undergoes further changes owing to metabolism, and deposits its various secretions, &c. (page 823). Hoffmann in his experiments upon Ferns, however, could not find any path by which the elaborated juices descended in the stem.

That the elaborated sap in Dicotyledons descends through the inner bark and cambium-layer is commonly believed, and several facts seem to support this belief. Thus, the formation of wood is obviously from above downwards, for when a ligature is tied tightly round the bark of a Dicotyledonous stem, or more especially if a ring of bark be removed, no new wood is produced below the ligature or ring, while there will be an increased development above it, or roots will be produced there. Again, it is well known, that by removing a ring of bark from a fruit tree, a larger quantity of fruit may be temporarily obtained from that tree, owing to the greater amount of nutritive matter which then becomes available for the use of the reproductive organs (see page 847). Another circumstance which appears to show the line of descent of the nutritive matter, is the fact, that if the cortical parts of the stems of a Potato plant be peeled off, the formation of tubers is prevented. It appears that the descending sap supplies the material for the formation of new wood in the fibro-vascular layers. The course of the sap is also lateral, for in the autumn starch grains are found in the medullary rays between the wedges of developed wood ; and where growth is going on, even an upward direction may be assumed. Herbert Spencer, however, argues that the retrograde motion of the sap is through the same channels—chiefly, as he believes, the vessels of the newest wood—by which it passed up. He considers that this descent takes place in response to a demand for liquid by the stem and roots when transpiration from the leaves is at a standstill, as at night. As far as the leaf-petioles are concerned, the back current must be along much the same tissues as the upward flow ; but probably the liber-cells of the petiole are the main channel, and these are directly continuous with the inner bark of the stem.

Spencer has also described and figured (Linn. Soc. Transactions, xxv.) cellular masses which he finds at the termination of the vascular system in the lower layer of parenchyma in many leaves, and which he considers to be undoubtedly absorbent organs by which the elaborated sap is abstracted from the leaves ; his conclusions, however, require confirmation.

The opinions of observers vary much as to the offices of the different parts of plants ; for instance, Mulder considers that all nitrogenous matters are not only absorbed by the roots, but also assimilated by them at once, while carbon is fixed by the green parts ; so that a constant interchange must take place between the leaves and roots. Other authors, again, believe that the leaves form all the organic substances. While Sachs says : 'By the parenchyma of the fundamental tissue, which always has an acid reaction, are conveyed the carbo-hydrates and oils ; by the soft bast the mucilaginous albuminoids, which have an alkaline reaction.'

CHAPTER 3.

PHYSIOLOGY OF THE ORGANS OF REPRODUCTION.

Having now alluded to the special functions of the elementary structures, and of the organs of nutrition, and also to the general physiology or life of the whole plant, we proceed in the next place to treat of the functions of the Organs of Reproduction.

1. Functions of Bracts and Floral Envelopes.—One of the principal offices performed by these organs is, to protect the

young and tender parts placed within them from injury. When green, as is commonly the case with the bracts and sepals, their colour is due to the presence of chlorophyll in their component cells, and they then perform the same functions as ordinary leaves. But when of other colours than green, as is usual with the petals, and occasionally with the bracts and sepals, they appear to have, in conjunction with the thalamus, a special function to perform; which consists in the production of a saccharine substance from the amylaceous matter stored up in them. This saccharine matter is designed more especially for the nourishment of the essential organs of reproduction. That such is the function of these parts seems to be proved by the varying composition of the thalamus at different periods of the flowering stage. Thus, at the period of the opening of the flower, the thalamus is dry and its cells are filled with amylaceous matters; as flowering proceeds, these matters become converted into saccharine substances; and, finally, after flowering, the thalamus dries up. In fact a similar change takes place in the process of flowering to that which occurs in germination, where the amylaceous matters are in like manner converted into those of a saccharine nature. When the saccharine matter is in excess, during the process of flowering, it is found upon the parts in a liquid state, and may be removed without the flower suffering, indeed one of its chief uses seems to be that of determining the direction of the entrance of insects into flowers which receive entomophilous fertilisation.

During this conversion of amylaceous into saccharine matters, oxygen is absorbed in great quantities from the atmosphere, and carbon dioxide given off in a corresponding degree. Hence, the action of the parts of the flower which are of other colours than green upon the surrounding air under the influence of solar light, differs from that of the leaves and other green organs. The absorption of oxygen takes place in a still greater degree in the essential organs of reproduction; hence, such an effect is more evident in hermaphrodite flowers, than in those in which the stamens and carpels have been more or less changed into petals —that is, when the flowers have become partially or wholly double. It has been proved, also, that staminate flowers absorb more oxygen than pistillate ones.

The combination which under the above circumstances takes place between the carbon of the flower and the oxygen of the air, is also attended by an evolution of heat, which indeed is always the case where active chemical combination is going on. This evolution of heat in the majority of flowers is not observable, because it is immediately carried off by the surrounding air; but in those plants where many flowers are crowded together, and more especially when they are surrounded by such a leafy structure as a spathe, which confines the evolved heat, it may be readily noticed. The flowers of the male cone of *Cycas circi-*

nalis, those of the *Victoria regia*, of several Cacti, and of many Aroidaceæ, present us with the most marked illustrations of this evolution of heat. (*See also Development of Heat by Plants*, page 855.)

That the heat thus evolved is dependent upon the combination of the oxygen of the air with the carbon of the flower was conclusively proved by the experiments of Vrolik and De Vries; for they showed that the evolution of heat by the spadix of an Arum was much greater when it was placed in oxygen gas than in ordinary atmospheric air, and that when introduced into carbon dioxide or nitrogen gases it ceased altogether.

Colour of Flowers.—All the colours of flowers otherwise than green depend on colouring matter dissolved in the watery cell-sap, and chromo-plastids, the nature of which was very imperfectly known until the recent observations of Schimper, Meyer, and Schmidt (see page 809), though spectroscopic analysis had done something towards grouping them into series. The changes in colour which many corollas undergo are supposed to depend on the oxidation of these bodies. Most of the Boraginaceæ pass from pink to blue, from their first expansion, till they are fully open; the garden Convolvulus changes from pink to a fine purple in the same period. Cultivation will effect great changes in this respect, but there is a limit to its influence. The Dahlia and Tulip are naturally yellow, and under cultivation may be made to assume all shades of red, orange, and white, but no tint of blue; Pelargoniums and the Hydrangea will take on various shades of blue, purple, red, and white, but never a yellow. These facts led De Candolle to divide flowers in this aspect into two series—a *xanthic* which has yellow for its base, and a *cyanic* which has blue—either of which can be made red or white, but will not assume the basic colour of the other. There seem to be a few exceptions to this rule; e.g. *Myosotis versicolor* changes from yellow in the bud to blue in the open corolla, and the Hyacinth is not unfrequently a pale yellow.

Development of the Floral Envelopes.—The manner in which the floral envelopes are developed may be shortly summed up as follows:—

They are subject to the same laws of development as the usual foliage leaves, and make their first appearance as little cellular processes, which grow by additions to their bases or points of attachment to the axis.

The calyx is commonly developed before the corolla.

When a calyx is polysepalous, or a corolla polypetalous, the component sepals or petals make their first appearance in the form of little distinct papillæ or tumours, the number of which corresponds to the separate parts of the future calyx or corolla.

When a calyx is gamosepalous, or a corolla gamopetalous, the first appearance of these organs is in the form of a little ring, which ultimately becomes the tube of the calyx or corolla, as the case may be. When these present lobes or teeth, as they more commonly do, they arise as little projections on the top of the ring, the number of which corresponds to the future divisions of the calyx or corolla.

All irregular calyces or corollas are regular at their first formation, the cellular papillæ from which they arise being all equal in size; hence all irregularity is produced by unequal subsequent growth.

2. Functions of the Essential Organs of Reproduction. *Sexuality of Plants.*—Though vaguely suspected by the ancients, the true sexuality of plants was not definitively ascertained till 1676, in which year Sir T. Millington, of Oxford, determined the real nature of the stamens. The andrœcium of flowering plants, as has been already repeatedly stated, constitutes the male apparatus, and the gynœcium the female. That the influence of the pollen is necessary to the formation of perfect seed is positively established.

While the presence of distinct sexes may thus be shown in flowering plants, both of which are necessary for the formation of perfect seed, by far the greater number of flowerless plants, in like manner, as we have seen, possess certain organs the functions of which are undoubtedly sexual. It is quite true that the existence of sexuality has not been absolutely demonstrated in all the Cryptogamia; but as it is known to exist in the greater number, we may fairly conclude from analogy that it is present in all.

We have already, as fully as our space will permit, described the structure of the reproductive organs of both the Phanerogamia and the Cryptogamia; we now proceed to give a general summary of the more important conclusions which have been arrived at as regards the process of reproduction in the several divisions of plants, and in doing so we shall commence with the Cryptogamia.

1. Reproduction of the Cryptogamia.—In describing the structure of the reproductive organs of these plants (see pages 363-399), we treated of them in two divisions, called, respectively, Cormophytes and Thallophytes, each of which was again subdivided into several natural orders. We shall follow the same arrangement in describing their modes of reproduction, except that we shall here commence with the Thallophytes, and proceed upwards to those plants of a more complicated nature, instead of alluding to them, as we then did, in the inverse order.

A. *Reproduction of Thallophytes.*—The sexual method of reproduction (*gamogenesis*) of all Thallophytes has not been absolutely proved, but only concluded from analogy, though the asexual or vegetative mode (*agamogenesis*) obtains in all. Sexes have been clearly shown to exist in certain Algæ, Fungi, and Lichens; and generally in Characeæ. Oërsted, indeed, has described the impregnation of oögonia on the mycelium of *Agaricus*; but other observers have failed to verify his assertions, and it is most probable that the reproduction of *Agaricus* is asexual. The process of reproduction in the Fungi and Lichens has already been sufficiently noticed (see pages 378–390); but the Algæ and Characeæ require further explanation.

(1) *Reproduction of Algæ.*—The reproduction of Algæ takes place in the following ways: namely, by *division* (page 765 and *fig.* 1125), *free cell-formation* (page 773), *conjugation*, and by the direct *impregnation of naked spores or germ corpuscles by ciliated antherozoids.* Each process is also liable to modifications.

a. Conjugation.—This process occurs in the Algæ, as Diatoms, Desmids, Spirogyra, &c. (See pages 394 and 765, *figs.* 862, 863, and 1126.) It consists in the union of the contents of two independent unicellular organisms (*fig.* 1126), or of the cells of two filaments (*fig.* 863), and the formation of a germinating spore by their mutual action. No difference can be detected in the structure of the conjugating cells, although in many, if not all cases, it is believed that there is some unobserved difference constituting the one as the male, the other as the female element.

Two methods of conjugation may be noticed among the Algæ. In the first mode, as seen in Desmidieæ, &c. (*fig.* 1126), two individuals, each of which is composed of a single cell, approach each other, the external cellulose membranes bounding their respective cells then burst at their point of contact, and the contents of the two issue from the orifices thus produced, intermingle in the intervening space, and form ultimately, by their mutual action, a rounded body, called a *zygospore*, *resting*, or *inactive* spore, which ultimately germinates. The contents of the spore are green and granular at first, but ultimately become brown, yellow or reddish. These resting spores are furnished with a coat of cellulose which in some cases divides into two layers, the *exospore* and *endospore*; they are sometimes called sporangia, because they ultimately produce two or more germs in their interior, and are not therefore simple spores.

In the other mode of conjugation, which occurs in *Zygnema* and *Spirogyra* (*figs.* 862 and 863), the cells of two filaments develop on their adjoining sides a small tubular process; these ultimately meet and adhere, and the intervening septum existing at the point of contact becoming absorbed, the two cells freely communicate. The contents of the cells then contract into a mass, and ultimately combine together, either by the passage of the contents of one cell into the other, or by the mixture of the contents of the two cells in the tubular process between them. Under either circumstance, the mixture of the contents of the two cells results in the formation of a *zygospore* or *resting spore*, which ultimately germinates and becomes an individual resembling its parents.

b. Impregnation of naked spores or germ-corpuscles by ciliated antherozoids.—There appear to be two forms of this fecundation: thus, in certain Algæ, as *Vaucheria*, the fecundation takes place before the spore has separated from its parent (see page 395, *fig.* 864), and in others, after both the spore and ciliated antherozoids have been discharged, as in *Fucus*. (See page 397, *figs.* 866–868.)

(2) *Reproduction of Characeæ.*—In these plants we have two kinds of reproductive organs, called, respectively, the *globule* or *antheridium* (*figs.* 856, *a*, and 858), and the *nucule* or *carpogonium* (*figs.* 856, *s*, 859, and 860) : the former is regarded as the *male*, and the latter as the *female*. Fertilisation takes place by the passage of the spiral antherozoids of the globule (*fig.* 857) down the canal which extends from the apex of the nucule (*figs.* 859, *a*, and 860) to the central cell of the same structure, which then becomes fertilised. No free spore is, however, produced, but the nucule drops off, and after a certain period germinates, though the sexual leaf-forming plant is not directly developed, but is preceded by a *pro-embryo* (*fig.* 1151), which has, however, only a limited growth, and from it are produced at one part the rhizoids *w*, and further on, as a sort of lateral branch, the *Chara* or *Nitella* proper.

FIG. 1151.

Fig. 1151. Pro-embryo of *Chara fragilis*. *sp*. Germinating spore. *i*, *d*, *q*, *pl*. The pro-embryo. At *d* are the rhizoids, *w*. *w'*. Primary root. *g*. First leaves of the second generation, or *Chara* proper. (After Pringsheim.)

B. *Reproduction of Cormophytes.* Of the sexual nature of the plants in most orders of this sub-division of the Cryptogamia there can be no doubt. The sexual organs in all are also of an analogous character, and are of two kinds, one termed an *antheridium*, which contains spirally wound ciliated antherozoids, and is regarded as the male organ ; and the other, called an *archegonium* or *pistillidium*, containing an embryonal cell or germ-cell, which is the female organ. Fertilisation is effected by the contact of an antherozoid with an embryonal cell or germ-cell. We have already described the structure of the reproductive organs of Cormophytes (pages 364–377), both before and after fertilisation ; it will be only necessary, therefore, in the present place, to say a few words upon the mode in which fertilisation is supposed to take place in the different orders included in this division of the Cryptogamia, which are here, however, arranged in the inverse order to that in which they were formerly described.

(1) *Hepaticaceæ or Liverworts.*—The two reproductive organs of this order closely resemble those of the Mosses. They are termed *antheridia* (*fig.* 831) and *archegonia* or *pistillidia* (*fig.* 833), the former representing the male sex, and the latter the female. When the antheridium bursts (*fig.* 831), it discharges a number of small cells, which also burst, and each emits a very small 2-ciliated spiral antherozoid. These antherozoids pass down the canal of the archegonium (*fig.* 833) to the germ or embryonal cell which is situated at its bottom, which thus becomes fertilised. This cell after fertilisation undergoes various important changes, as already noticed (see page 377), and ultimately becomes a sporangium, enclosing spores and elaters (*fig.* 834), which latter, *c*, are elongated, spirally-thickened cells, whose office is to assist in disseminating the spores when the valves of the sporangia open. When these spores germinate, they generally produce a sort of confervoid structure (*protonema*), which in its after development resembles the like structure of Mosses. (See below.)

Fig. 1152.

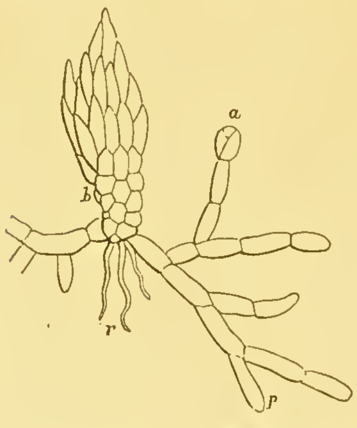


Fig. 1152. *Protonema* of a Moss (*Funaria hygrometrica*). *p*. Confervoid protonema. *a*. Bud. *b*. Young leafy stem. *r*. Rootlets.

(2) *Musci or Mosses.*—The reproductive organs of this order consist of *antheridia* (*fig.* 821) and *archegonia* (*fig.* 822), which closely resemble the same structures in the Hepaticaceæ. Fertilisation takes place in a similar manner (see above), and the changes which take place after fertilisation in the embryonal cell which ultimately forms a sporangium containing spores, but not elaters, have been already described. (See page 373.)

In germination, the spores at first form a green cellular branched filamentous mass, somewhat resembling a Conferva, which is termed the *protonema* (see page 375). Upon the threads of this structure (*fig.* 1152), buds (*a*) are ultimately produced, which grow up into leafy stems (*b*), upon which the archegonia and antheridia are afterwards developed.

(3) *Marsileaceæ, Rhizocarpeæ, or Pepperworts.*—The two re-

productive organs of this order are generally distinguished as *microsporangia* (*figs.* 818 and 820, *a*), and *macrosporangia* or *megasporangia* (*fig.* 820, *b*). These two structures are either contained in separate sacs, as in *Salvinia* (*fig.* 820), or in the same, as in *Marsilea* (*fig.* 817). The microsporangia or antheridia contain a number of small cells, called generally *microspores* or *small spores* (*fig.* 818), which ultimately produce antherozoids remarkable for their length and delicacy (*fig.* 1153). The macrosporangia (*fig.* 820, *b*) contain commonly but one spore, called an *ovulary spore*, *large spore*, *macrospore*, or *megaspore*. In their organs of fructification the plants of this order closely resemble the Selaginellaceæ. Like the Selaginellaceæ, the large spores also produce a small prothallium confluent with them (*fig.* 1154), in which subsequently only a single archegonium generally, as in *Pilularia* and *Marsilea*, appears (*fig.* 1154, *a*), although in *Salvinia* several archegonia are formed. Fertili-

FIG. 1153.

FIG. 1154.

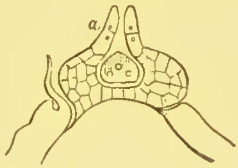


Fig. 1153. *Small spore* or *microspore*, of Pill-wort (*Pilularia globulifera*), bursting and discharging small cells enclosing antherozoids. Some of the latter may be observed to have escaped by the rupture of the small cells in which they were contained.——*Fig.* 1154. Vertical section of the prothallium of the above, which is formed, as in the Selaginellaceæ, in the interior of the *large spore* or *macrospore*. Only one archegonium, *a*, is here produced in the centre. The archegonium consists of an intercellular canal, leading into a sac below, in which may be seen a solitary *germ* or *embryonal cell*.

sation takes place by the contact of the antherozoids with the germ-cell of the archegonium, which immediately developes, and forms a pseudo-embryo bearing a great apparent similarity to the embryo of a monocotyledon, from which a leafy stem bearing fructification is ultimately produced.

(4) *Selaginellaceæ* or *Selaginellas.*—The two reproductive organs of this order are usually termed *macrosporangia* or *megasporangia* (*figs.* 813 and 816), which represent the female; and *microsporangia* or *antheridia* (*figs.* 814 and 815), which are regarded as male organs. The contents of the microsporangia are called *small spores* or *microspores*, which break up into two sets of cells—one of which remains inactive, and probably represents an abortive prothallium; while the other developes the antherozoids (*fig.* 1155, *c*). In the macrosporangia are formed *large spores*, *macrospores*, or *megaspores* (*fig.* 816).

It is not till some months after being sown that the spores commence to germinate, nor are the antherozoids produced till a nearly equal period has elapsed. In germination, the spore (*macrospore*) produces a very small prothallium (*fig.* 1156, *p*), on which archegonia (*fig.* 1157, *a*) are subsequently developed. Each archegonium (*fig.* 1157, *a*) consists of an intercellular canal leading into a sac below, which contains a single germ or embryonal cell. In the microspores one cell only constitutes the prothallium; all the others are mother-cells, which by dividing several times produce antherozoids. Fertilisation takes place by the ciliated antherozoids contained in the microspores (*fig.* 1155, *c*) passing down the canal of the archegonium and coming into contact with the germ-cell. This cell then grows by cell-

FIG. 1155.

FIG. 1156.

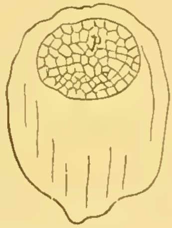


FIG. 1157.

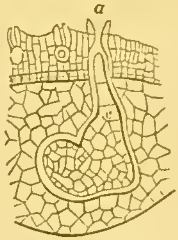


Fig. 1155. *Small spore*, or *microspore*, of a species of *Selaginella*, bursting and discharging small sperm-cells, *c*, in which antherozoids are contained.——*Fig.* 1156. *Large spore*, *macrospore*, or *megaspore*, of a species of *Selaginella*. The outer coat of the spore has been removed to show the entire inner coat, with the young prothallium, *p*, at the upper end.——*Fig.* 1157. Vertical section of a portion of the prothallium of the above in a more advanced state, showing the archegonia. *a*. Archegonium, in which the pseudo-embryo. *e*, has been developed from the germ-cell it contained, by contact with the antherozoids. This embryo, by the growth of the suspensor, is forced downwards and imbedded in the upper part of the cellular mass of the spore-sac.

division and forms a *pseudo-embryo* (*fig.* 1157, *e*), and ultimately produces a new leafy sporangiferous stem.

(5) *Lycopodiaceæ* or *Club-Mosses* probably have only *one kind of spore* (*microspore*), from which is produced a prothallium bearing antheridia and archegonia: the germ cell of the latter being fertilised by the antherozoids which escape from the mature antheridia, and producing in turn an adult plant. Very little, however, is known for certain about the life-history of the Lycopodiaceæ (see page 368).

(6) *Equisetaceæ* or *Horsetails*. And

(7) *Filices or Ferns.*—The mode of reproduction of the plants of these two orders is essentially the same, and we shall accordingly allude to them together. As already fully described (see pages 365–368), their leafy structures bear sporangia or capsules in which the spores are enclosed (*figs.* 802–805, and 810–812). There is but *one kind of spore*.

In germination, which has also been noticed (pages 366 and 368), these spores ultimately form a thin, flat, green parenchymatous expansion or prothallium (*figs.* 806 and 1158, *p*, *p*), which somewhat resembles the permanent thallus of the Hepaticaceæ (*figs.* 830 and 832). Upon the under surface of this structure we have soon formed, in most of the Filices, both *antheridia* and *archegonia*; but in some, as well as usually in the Equisetaceæ, the antheridia and archegonia have only been found on separate prothallia, and hence the latter plants are diœcious. The antheridia (*fig.* 807) contain a number of minute cells called *sperm-cells* (*sc*), each of which contains a spirally wound ciliated antherozoid (*sp*). The *archegonium* (*fig.* 808) is a little cellular papilla, having a central canal, which when mature is open. At the bottom of the canal is a cell called the *embryo-sac*, in which a *germ* or *embryo-cell* is developed. This so-called embryo-cell is, however, simply a *germinal corpuscle* till after fertilisation; that is, a free primordial cell, or mass of protoplasm without an external wall of cellulose.

FIG. 1158.

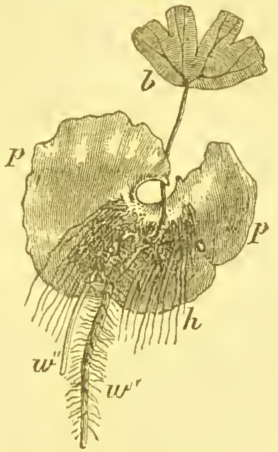


Fig 1158. *Adiantum Capillus-Veneris.* The prothallium, *p*, *p*, seen from below, with young Fern (*sporophore*) attached to it. *b*. Its first leaf. *w'*, *w''*. Its first and second roots. *h*. Root hairs of the prothallium (× about 30). (After Sachs.)

When mature, the upper part of the antheridium separates from the lower, something like the lid of a box; the sperm-cells then escape, become ruptured, and emit their contained antherozoids. These antherozoids make their way down the canal of the archegonium to the embryo-sac, by which the contained germinal corpuscle is fertilised. This germ-cell then developes a pseudo-embryo, which soon possesses rudimentary leaves and roots (*fig.* 1158), and ultimately produces a plant with fronds bearing sporangia, which resembles the parent from which the spore was originally obtained. The Ferns and Horsetails are thus seen to exhibit two stages of existence: in the first, the spores produce a thalloid expansion; and in the second, by means of antheridia and archegonia upon the under surface of this prothallium, there is ultimately produced a new plant, resembling in every respect the one from which the spore was originally derived. Hence Ferns and Horsetails exhibit what has been termed *alternation of generations*.

Two remarkable conditions have been found to obtain in certain Ferns with regard to their method of reproduction. Thus in *Pteris cretica*, although antherozoids are developed, no archegonia have been discovered, nevertheless the ordinary Fern plant is developed from the prothallium by a sort of budding. To this peculiarity Farlow applies the term *apogamy*; and quite recently Druery describes what he calls *apospory* in *Athyrium Filix-fœmina*, var. *clarissima*, where the sporangia do not follow their usual course of development by producing spores, but, assuming a more vegetative character, develop more or less well-defined prothallia, which ultimately bear archegonia and antheridia. In *Polystichum angulare*, var. *pulcherrima*, apospory is even more marked, as the prothallium seems to develop in a vegetative manner from the spore-bearing plant, without even being associated locally with the sporangia. Druery's observations have been confirmed by F. O. Bower.

2. Reproduction of the Phanerogamia.—In all the plants belonging to this division of the Vegetable Kingdom the *male apparatus* is represented by one (*fig.* 512) or more (*fig.* 26) stamens, each of which essentially consists of an anther enclosing *pollen* (*fig.* 27, *p*); and the *female*, by one (*fig.* 583) or (*fig.* 31) more carpels, in (*fig.* 33) or upon (*fig.* 730) which one or more ovules are formed. When the ovules are contained in an ovary (*fig.* 33), the plants to which they belong are called *angiospermous*; but when they are only placed upon metamorphosed leaves or open carpels, i.e. are naked (*fig.* 730), the plants are said to be *gymnospermous*. In the plants of both these divisions of the Vegetable Kingdom the ovules by the action of the pollen are developed into perfect seeds whilst connected with their parent, the distinguishing character of a seed being the presence of a rudimentary plant called the embryo. The modes in which reproduction takes place, and the after development of the embryo, differ in several important particulars in the Gymnospermia and Angiospermia; hence it is necessary to describe them separately.

A. *Reproduction of the Gymnospermia.*—We have already given a general description of the pollen and ovules of the Phanerogamia, but as these structures present certain differences in the Gymnospermia, it will be necessary for us to allude to such peculiarities before describing the actual process of reproduction.

The *pollen* of the Angiospermia generally consists, as we have seen (pages 260–263), of a cell containing a matter called the *fovilla*, and having a wall which is usually composed of two coats, the outer being termed the *extine*, which possesses one or more pores (*fig.* 570) or slits (*figs.* 568 and 569), or both; and the inner, called the *intine*, which is destitute of any pores or slits, and consequently forms a completely closed membrane. Each pollen-grain of the Angiospermia is thus generally regarded as a single cell; but as it contains two or more nuclei round which the protoplasm is grouped, there is some doubt as to whether it should be described as consisting of a single cell. In the Gymnospermia, on the contrary, the pollen-grains are certainly not simple cells, but they contain other small cells, each with a nucleus and distinct cell-wall, from one of which the pollen-tube is developed, and which adhere to the inside of the internal membrane close to the point where the external membrane presents a slit (*fig.* 1159).

The ovules of the Gymnospermia, excluding those of the Gnetaceæ, which require further investigation, consist of a nucellus or macrosporangium (*fig.* 1160, *a*), enclosed by a single coat, and with a large micropyle, *m*. Before the contact of the pollen with the micropyle, the primary embryo-sac, *b*, is developed in the nucellus. This embryo-sac is at first very small (*fig.* 1160, *b*), but gradually enlarges (*fig.* 1161, *a*), and after a long period

FIG. 1159.

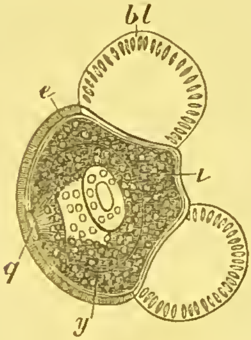


FIG. 1160.

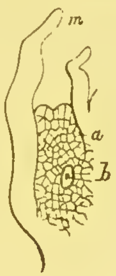


FIG. 1161.

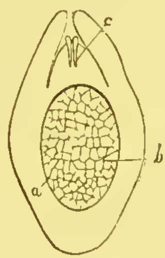


Fig. 1159. Pollen of Spruce Fir. *bl*. Vesicular protrusions of the extine, *e*. *i*. The intine, through a rent in which passes the pollen-tube which is developed from *y*, the larger of the two or more cells produced by the division of the central cell. *q*. The smaller cell according to Schacht, but merely a slit according to Strasburger. (After Schacht.)——*Fig.* 1160. Vertical section of the young unimpregnated ovule of a species of *Pinus*. *a*. Nucellus containing a small primary embryo-sac, *b*. *m*. Micropyle, which is here very large.——*Fig.* 1161. Vertical section of an older ovule of the same. *a*. Enlarged primary embryo-sac filled with secondary endosperm cells, *b*, within the embryo-sac. *c*. Two pollen-tubes penetrating the apex of the nucellus.

becomes filled with delicate cells by free cell-formation, according to the older views, though Strasburger now considers that free cell-formation never occurs in embryo-sacs, but that the appearance of cells and nuclei is due to the division of previously existing nuclei. These cells are called endosperm cells; they disappear very soon, and are replaced later on by a fresh development (*fig.* 1161, *b*). The following account of the subsequent development of the ovule, and the mode by which it is fertilised, is taken from Henfrey, and is founded upon Hofmeister's investigations.

'In the upper part of the mass of the last-formed endosperm (*fig.* 1161, *b*), from five to eight cells are found to expand more than the rest, forming *secondary embryo-sacs* or *corpuscula*. These are not formed in the superficial cells of *b*, but from cells of the second layer, so that each is separated from the membrane of the primary embryo-sac by one cell (*fig.* 1162, A). These *corpuscula*, as they were called by Robert Brown, their discoverer, are very much like the archegonia in the internal prothallial structure of *Selaginella*. After a time the secondary embryo-sacs divide into an upper or *neck-cell*, and a lower or central cell containing the *oosphere*. The neck-cell speedily divides and subdivides, to form the rosette which surmounts the central cell. In the upper part of this latter is then formed,

FIG. 1162.

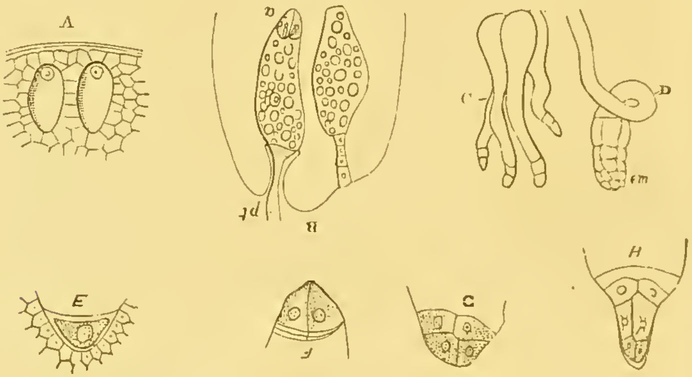


Fig. 1162. Development of the embryo in a species of *Pinus*. (After Henfrey.) A. Upper part of the embryo-sac, with two secondary embryo-sacs, corpuscula, or archegonia. B. The same, more advanced. *pt.* Pollen-tube in the canal leading down to the corpuscula. *a.* Germinal corpuscles at the base of the secondary embryo-sac. E, F, G. Successive stages of development of germinal corpuscles, *a* in B. C. Four cellular filaments or *suspensors*, which are developed from the germinal corpuscles after impregnation; at H, is shown an earlier stage. D. One of these suspensors, with the embryo (*em*) at its apex.

from subdivision of the nucleus, a very delicate cell, which is called the *canal-cell*. The mature corpuscle therefore consists of a large central cell surmounted by a rosette of small cells placed immediately beneath the wall of the primary embryo-sac, or separated from it by a funnel-shaped space.'

The process of fertilisation takes place as follows: 'After the contact of the pollen with the micropyle of the ovule, the pollen-tube, after remaining passive for a variable space of time, takes an active growth, traverses the endosperm, and arrives at the embryo-sac by the time the corpuscles are developed. It penetrates the wall of the embryo-sac, enters into and dilates the funnel-shaped space just mentioned, passes down between the cells of the rosette, pushing them on one side (Taxaceæ, Cupresseæ), or causing their absorption and disappearance (Abieteæ) as well as that of the *canal-cell*, and finally penetrates into the cavity of the canal-cell. The changes which take place in this latter are, according to Strasburger, these :—disappearance of the original nucleus, and formation of four to eight new nuclei by condensation of the protoplasm and subsequent secretion of a cellulose wall around them. In this way four to eight new cells are formed by division of the central cell after fertilisation ; these new cells divide so as to form cellular filaments, which break out through the bottom of the endosperm into the substance of the nucleus (*fig.* 1162, C). At the ends of these filaments cell-division again occurs (*fig.* 1162, D) ; and from the apex of one of these *suspensors* or *pro-embryos* is developed by repeated cell-division in various directions, the embryo (D, *em*). At one stage (in *Thuja*) a single apical cell, the terminal one of a group of five, from which ultimately all the tissues of the embryo are formed, recalls the single apical cell of the Cryptogamia, but it is soon lost by subdivision. As there are several corpuscles, and each produces four suspensors, a large number of rudimentary embryos are developed ; but usually only one of all these rudiments is perfected.

'That embryo which is fully developed gradually increases in size, and most of the structures above described disappear, so that the ripe seed exhibits a single embryo embedded in a mass of endosperm, the latter originating apparently from the nucleus of the ovule. The radicle is covered by a *pileorhiza*, which is ultimately blended with the substance of the endosperm.'

B. *Reproduction of the Angiospermia.*—The structure of the pollen-cells of the Angiospermia has been already described (see *Pollen*, and page 836), and need not be further alluded to in this place.

FIG. 1163.

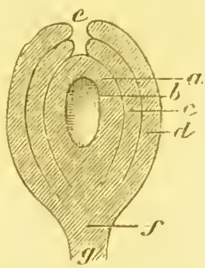


Fig. 1163. Vertical section of an ovule (diagrammatic). *a*. Nucellus. *b*. Embryo-sac. *c*. Inner coat. *d*. Outer coat. *e*. Micropyle. *f*. Chalaza. *g*. Funiculus.

The ovule has also been particularly noticed, and we shall now only recapitulate its component parts at the time when the pollen is discharged from the anthers—that is, just before impregnation takes place. It then consists of a cellular nucellus, containing one large cell, the embryo-sac, which is the mother-cell of the oosphere (*figs.* 1163, *b*, and 1164, *n*), enclosed generally in two coats—an outer or *primine* (*fig.* 1163, *d*), and an inner or *secundine*, *c*. But sometimes there is but one coat (*fig.* 740, *s*), and in rare cases the nucellus is naked or devoid of any coat (*fig.* 738).

These coats completely invest the nucellus except at the apex, where a small opening or canal is left, termed the micropyle (*figs.* 1163, *e*, and 1164, *m*), that portion of it which passes through the primine being sometimes spoken of as the *exostome*, and the part going through the secundine as the *endostome*. In the interior of the nucellus, but of various sizes in proportion to it, the embryo-sac (*figs.* 1163, *b*, and 1164, *s*) is seen. The sac is, however, liable to many modifications; thus, in some cases, as in the Orchidaceæ, the embryo-sac completely obliterates the cells of the nucellus by its development, so that the ovule consists simply of it and its two proper coats. In the

FIG. 1164.

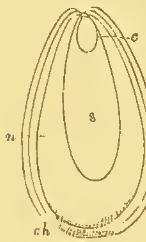


FIG. 1165.

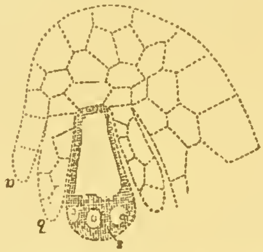


FIG. 1166.

Fig. 1164. Vertical section of the orthotropous ovule of a species of *Polygonum*. *ch.* Chalaza. *n.* Nucellus invested by two coats. *m.* Micropyle. *s.* Embryo-sac. *c.* Germinal vesicle or corpuscle.——*Fig.* 1165. The ovule, some time before fertilisation. *a.* The outer coat. *b.* The inner coat. *s.* The embryo-sac, with three nuclei at the upper end.——*Fig.* 1166. The internal parts of the ovule a short time before fertilisation. *a.* Inner coat of the ovule. *s.* Embryo-sac. *b.* Germinal vesicles. *c.* One of the antipodal cells. (After Hofmeister.)

Leguminosæ, the embryo-sac increases still further, and causes the absorption of the secundine or inner coat of the ovule also, so that it is then simply invested by one coat; while in other plants, as in the Santalaceæ, the sac elongates so much at the apex as to project out of the micropyle. The embryo-sac contains at first a more or less abundant quantity of protoplasm; in this afterwards appear nuclei (*fig.* 1165, *s*), which, surrounded by masses of naked protoplasm, form a corresponding number of cells (usually three) which are commonly termed *germinal vesicles* (*fig.* 1166, *b*). The vesicles are situated at or near the summit of the embryo-sac, one of them being the *oosphere* (*fig.* 1167, *c*), which after fertilisation is sometimes called the *oosperm*, and ultimately becomes the embryo. The two remaining cells after disappearing reappear, and are called *synergidæ* (*fig.* 1167, *s, s*). At the base of the embryo-sac, as already described (page 328), there are also, before fertilisation, two or more nucleated primordial cells, termed *antipodal cells* (*fig.* 1166, *c*).

FIG. 1167.

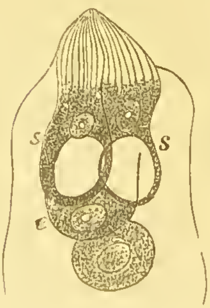


Fig. 1167. *Polygonum divaricatum.* Mature germinal apparatus in apex of embryo-sac, with two synergidæ, *s,s*, and the oosphere, *c*.

Such is the general structure of the ovule before it is fertilised, upon which so much difference of opinion, until the last few years, existed among physiologists. Thus Schleiden, Schacht, and others contended that no germinal vesicle existed in the sac until after the contact of the pollen-tube with it in the ordinary process of impregnation; in fact, they believed that the germinal vesicle was itself formed from the end of the pollen-tube, which, according to their observations, penetrated the wall of the sac, and by subsequent development produced the embryo. This view was, however, at once combated by many accurate observers, who all agreed in describing the presence of one or more germinal vesicles or corpuscles in the sac before impregnation; and subsequently, Schleiden himself, who originated this view of the origin of the embryo, was convinced of his error by Raddlkofer, one of his own pupils.

When the pollen in the process of *pollination* (page 20) falls upon the stigma (*fig.* 1169, *b*, *a*) (the tissue of which at this period, as well as that forming the conducting tissue of the style and neighbouring parts, secretes a peculiar viscid fluid as de-

FIG. 1168.

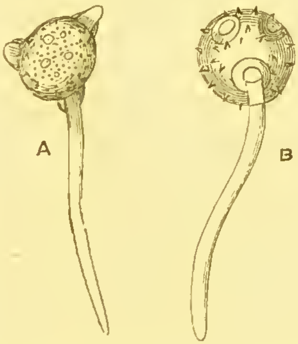


FIG. 1169.

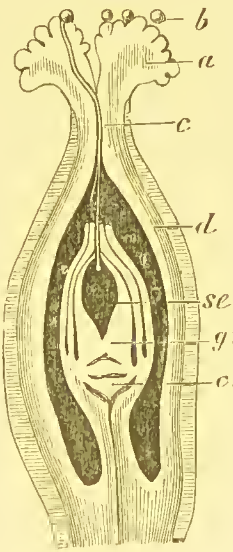


Fig. 1168. A. Pollen-cell of *Dipsacus Fullonum.* B. Pollen-cell of *Cucurbita.* Each pollen-cell is putting out a single pollen-tube. (After Thomé.)——*Fig.* 1169. Longitudinal vertical section through the uniovular ovary of *Polygonum Convolvulus.* *a.* Stigma. *b.* Pollen-cells. *c.* Pollen-tube. *d.* Wall of ovary. *gm.* Erect orthotropous ovule. *se.* Its embryo-sac. *ch.* Chalaza.—N.B. Two of the pollen-tubes have penetrated the conducting tissue of the style, one of which has entered the micropyle of the ovule, the other not. (After Thomé.)

scribed at page 271), its intine, carrying with it the fovilla, protrudes through one or more of the pores or slits of the extine (*fig.* 576) in the form of a delicate tube, which penetrates through the cells of the stigma, by the viscid secretion of which it is nourished. In most plants but one pollen-tube is emitted by each pollen-cell (*figs.* 1168, A and B, and 1169, *c*), but the number varies, and, according to some observers, is sometimes twenty or more. The pollen-tube continues to elongate by growth at its apex, and passes down through the conducting tissue of the style (*figs.* 577, *tp*, and 1169, *c*) when this exists, or directly into the ovary when the style is absent. This growth of the pollen-tube is occasioned by the nourishing influence of the viscid secretion which it meets with in its passage through the stigma and conducting tissue of the style.

These tubes vary in length, but are frequently many inches, and are extremely thin. They are commonly unicellular, and have therefore but one cavity ; but, according to Martin Duncan, in *Tigridia*, and all other monocotyledons with long styles which he examined, they are composed of several elongated cells, and hence have as many cavities as cells (see page 264). The time required for the development of these tubes also varies in different pollen-cells ; thus, sometimes they are developed almost immediately the pollen comes into contact with the stigma ; while in other cases many hours are required for the purpose. The pollen-tubes also occupy a varying time in traversing the canal of the style—that is, from a few hours to some weeks or even months. When the pollen-tubes have penetrated the stigmatic tissue, the secretion of the latter ceases, and the stigma dries up. The upper part of the pollen-tubes also withers above, as growth takes place below.

The pollen-tubes having reached the ovary are distributed to the placenta or placentas, and then come ultimately in contact with the ovule or ovules. One (or sometimes two) of these pollen-tubes enters into the micropyle of each of the ovules (*figs.* 1169, *c*, 1170, *t*, and 1171, *t*), and thus reaches the nucellus and embryo-sac. When it arrives at the latter it is generally somewhat enlarged (*fig.* 1171, *t*), and adheres firmly to it at or near its apex. The embryo-sac is frequently introverted to a slight extent at the point of contact with the pollen-tube (*figs.* 1170 and 1171), and it is stated by Hofmeister to perforate it in *Canna* ; but if such a perforation occurs in this case, it is altogether an exception to what is generally observed. As soon as the contact of the pollen-tube with the embryo-sac is effected, a kind of osmotic action between the contents of the two takes place, the result of which is the development of one (or rarely two, as in *Orchis* and *Citrus*) or more of the germinal vesicles into embryos.

The germinal vesicle (*oosphere*), in its development into an embryo, becomes surrounded by a membrane, and is then the *oosperm.* This generally divides at first in a transverse manner into two cells (*fig.* 1171, *e*) ; and then by further division forms the *pro-embryo* or *suspensor* (*fig.* 1170, *s*). The apical cell assumes commonly a somewhat globular form (*fig.* 1170, *r*), and ultimately by cell-division forms the embryo, whether mono- or dicotyledonous. The suspensor is not present in all cases; while in others, where it is found, it varies in length. It is evidently not essential in all instances, as it always shrivels up during the development of the apical cell into the embryo. The latter, therefore, is the true rudimentary embryo. Other variations occur in the mode in which the germinal vesicle (*oosphere*) is developed into an embryo, but the above is a general sketch of the subject, and all that our space will allow us to give.

The changes which take place in the ovule during the development of the embryo, and the subsequent growth of the latter, have been already generally alluded to when treating of the seed.

Darwin, Sprengel, Hermann Müller, Fritz Müller, and others, have shown that, in numerous plants, *crossing* is neces-

FIG. 1170.

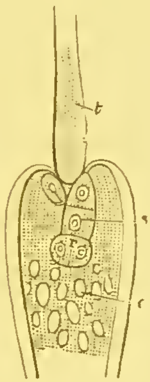


FIG. 1171.

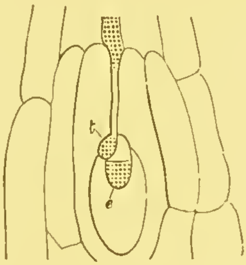


Fig. 1170. Vertical section of an ovule of a species of *Œnothera*. *t*. Enlarged end of the pollen-tube containing fovilla, which has entered the micropyle, and is seen pressing inwards the apex of the embryo-sac. *s*, *r*. Impregnated germinal vesicle, which already begins to exhibit two parts: one, the upper, forming a suspensor, *s*; and another, below, *r*, a globular body, which ultimately becomes the embryo. *e*. Endosperm cells.—*Fig.* 1171. Section of an ovule of a species of *Orchis*. *t*. Enlarged end of the pollen-tube containing fovilla, which has passed through the micropyle, and is closely applied to the embryo-sac, the upper side of which it has pushed inwards. *e*. Germinal vesicle in the interior of the embryo-sac in an impregnated state, and dividing into two portions, the lower of which is the rudimentary embryo, and the upper forms a suspensor.

sary for a completely fertile union of the sexes; that is, that the ovules of one flower must be fertilised by pollen from another of the same species. This may be effected in many ways; e.g. by the wind, when plants are spoken of as being *anemophilous*; or frequently by the unconscious agency of insects, when they are said to be *entomophilous*, as in the Orchidaceæ, where the various modifications of structure to ensure *cross-fertilisation* by this latter means are strikingly beautiful. The observations of Darwin, Müller, and others have shown that *self-fertilisation* is probably exceptional in plants; certainly occasional crossing seems to be necessary. The term *protandrous* is applied to those plants in which the pollen is ripe and extruded before the stigma of the same flower is mature; while those plants in which the stigma is mature before the pollen are said to be *protogynous*; either protandrous or protogynous plants being spoken of as *dichogamous*. It appears that entomophilous plants, by being protandrous or protogynous, or by the peculiar mechanism of their flowers, are generally incapable of self-fertilisation, though some may become self-fertilised in the absence of insect visitors, and these are not infrequently protogynous, so as to facilitate cross-fertilisation if an opportunity should occur. Apparently the form, colour, markings, odour, and nectaries of flowers exist in special positions to determine not only the visits of insects, but also the direction of their entrance so as to ensure cross-fertilisation, just as form, the presence of hairs, or disagreeable odours, or other secretions, impede or wholly prevent the visits of injurious insects. The form and characters of the pollen-cells themselves seem to have a direct connexion with the method of fertilisation, those of anemophilous flowers being generally smooth and dust-like, whereas those of entomophilous flowers are often very irregular and sticky. Anemophilous plants too have not infrequently a much larger quantity of pollen than those which are entomophilous.

Dimorphic or *heterostyled* species are those which possess two forms of both sorts of sexual organs, as species of *Primula*, *Oxalis*, and *Pulmonaria*, which have both long and short stamens, and long and short styles. The long stamens are associated with the short styles, and *vice versâ*, in the flowers; and Darwin has proved, by experiment, that, for the complete fertilisation of either kind of pistil, it is necessary that pollen from the stamens of corresponding length, and therefore from a different flower, be employed. *Lythrum Salicaria* is trimorphic—i.e. has styles and stamens of three different lengths—and similar laws have been observed to prevail in its fertilisation. *Legitimate* fertilisation is the impregnation of the style of one flower by the pollen from a stamen of equal length with itself, but belonging to another flower; while the fertilisation of a pistil by pollen from a stamen of different length is termed *illegitimate*. Some plants have inconspicuous self-fertilising flowers, which are said to be *cleistogamic*. Such flowers occur in large numbers on the common Violets (*Viola odorata* and *V. canina*), in addition to the more showy ones which are entomophilous. Similar flowers are found also on *Lamium amplexicaule*, *Oxalis Acetosella*, &c.

Hybridisation, Hybridation, or the Production of Hybrids in Plants.—If the pollen of one species be applied to the stigma of another species of the same genus, should impregnation take place, the seeds thus produced will give rise to offspring intermediate in their characters between the two parents. Such plants are called *hybrids* or *mules*. The true hybrids, which are thus produced between species of the same genus, must not be confounded with simple *cross-breeds*, which result from the crossing of two varieties of the same species: these may be termed *sub-hybrids*.

As a general rule, true hybrids can only be produced between nearly allied species, although a few exceptions occur, where hybrids have been formed between allied genera; these are called *bigeners*. The latter, however, are not so permanent as the former, for in almost all cases they are short-lived.

Hybrids always possess some of the characters of both parents, but they generally bear more resemblance to one than the other. Sometimes the influence of the male parent is most evident, and at other times that of the female, but no law can at present be laid down with regard to the kind of influence exerted by the two parents respectively in determining the characters of the hybrid. In very rare cases it has been noticed that different shoots of the same hybrid plant have exhibited different characters, some bearing flowers and leaves like their male parent, others like the female, and some having the characters of both. In such cases, therefore, the hybrid characters are more or less separated in the different shoots, which present respectively the characters of one or the other of their parents. An example of these facts may be seen in *Cytisus Adami*, produced by the true hybridation of *Cytisus Laburnum* and *Cytisus purpureus*.

Hybrids rarely produce fertile seeds for many generations, and hence cannot be generally perpetuated with any certainty by them; but if they are of a woody nature, they may be readily propagated by budding, grafting, and other analogous processes. (See page 107.) Hybrids are fertile with the pollen of one of their parents; the offspring in such a case resembles closely the parent from which the pollen was obtained. By the successive impregnation of hybrids through three, four, or more generations with the pollen of either of their parents, they revert to their original male or female type; thus, when the hybrid is successively impregnated by the pollen of its male parent, it reverts to the male type; and when with that of the female, to the female type. The influence of the latter is, however, more gradual.

Hybrids somewhat rarely occur in wild plants. This arises chiefly from the following causes: thus, in the first place, the stigma is more likely to be impregnated with the pollen from stamens immediately surrounding it, or from those in other flowers on the same plant, than by that of other and more distant plants; and, secondly, the stigma has a sort of *electric affinity* or *natural preference* for the pollen of its own species. Indeed, Gaertner found that if the natural pollen and that of another species be applied to the same stigma at the same time, the latter remained inert, and the former alone fecundated the ovules, or was *prepotent* over the other; and, moreover, that when the natural was applied a short period subsequently to the foreign pollen, the seeds thus produced were never hybrids. Hybrids appear to be produced more frequently in wild plants when the sexes are in separate flowers, and more especially when such flowers are on different plants.

Hybrids are frequently produced artificially by gardeners applying the pollen of one species to the stigma of another, and in this way important and favourable changes are often effected in the characters of our flowers, fruits, and vegetables. But varieties thus produced are not commonly true hybrids, but simple cross-breeds.

The investigations of late years would appear to show that a similar law as regards hybridisation occurs in the Cryptogamia as in the Phanerogamia. Thus, Thuret has succeeded in fertilising the spores of *Fucus vesiculosus* with the antherozoids of *Fucus serratus*, an allied species ; but he failed in his attempts to fertilise the spores of one genus of the Melanosporeous Algæ by the antherozoids of another. Other evidence has also been adduced as to the hybridisation of the Cryptogamia, and there can be little doubt that hybrid Ferns are sometimes produced when a number of species are cultivated together, for it has been noticed that, under such circumstances, plants make their appearance which present characters of an intermediate nature between two known species.

3. Of the Fruit.—When fertilisation has been effected (see page 295), important changes take place in the pistil and other organs of the flower, the result of which is the formation of the fruit. The calyx and corolla generally fall off, or if persistent, they form no portion of the fruit except when the calyx is adherent, as in the Apple (*fig.* 722), and Quince (*fig.* 473), when it necessarily constitutes a part of the pericarp. The style and stigma also become dry, and either fall off, as in the majority of cases, or are persistent, as in the Poppy and Anemone (*fig.* 700). But the principal alterations take place in the wall of the ovary, which usually becomes more or less swollen, and soon undergoes important chemical changes, and forms the pericarp, either by itself (a *true fruit*), or combined with the adherent calyx or other parts of the flower, &c. (a *spurious fruit*), (see page 296). Some pericarps, as already noticed (page 298), are fully developed without the fertilisation of the ovules, as those of many cultivated varieties of Oranges, Grapes, Bananas, &c. The fruits thus formed, although frequently more valuable than others for food, are, of course, useless for reproduction.

The fruit in its growth attracts the food necessary for that purpose from surrounding parts, hence, the fruiting of plants requires for its successful accomplishment an accumulation of nutrient matter, and is, therefore, necessarily an exhaustive process. That the reproductive processes, and especially the ripening or maturation of the fruit, tend to exhaust the individual, is proved in various ways. Thus plants which fruit the same year in which they are developed afterwards perish, from the exhaustion of nutrient matter thus occasioned; and that such is the reason is proved by the fact, that we can make annuals biennial, or even perennial, by plucking off the flower-buds as they are successively developed. Some plants which only flower once require many years to accumulate sufficient nourishment to support the processes of reproduction. Such are the American Aloe (*Agave americana*) and the Talipot Palm (*Corypha umbraculifera*), both of which live many years before flowering, after which they die. A bad fruit year is also generally succeeded by a good one, and *vice versâ*, because in the former case an additional supply of nutrient matter is stored up for the fruiting season, and in the latter there is a diminished amount. Again, if a branch of an unproductive tree have a ring of bark removed so as to prevent the downward flow of the elaborated sap, its accumulation above will cause the plant to bear much fruit. Pruning depends for its success upon similar principles. In order to obtain good fruit it is also necessary not to allow too many fruits to come to perfection on the same plant. Other matters connected with this exhaustion by fruiting have been already alluded to, in speaking of Annual, Biennial, and Perennial Roots, at page 133.

The changes produced upon the atmosphere in the ripening of the fruit, depend upon the nature of the pericarp. Thus, when the pericarp preserves its green state, as also always when first formed, it has an action similar to that of the leaves; but when of other colours than green, and more especially when succulent, it evolves carbon dioxide at all times, instead of oxygen.

Chemical Constitution of Fruits.—The chemical constitution of fruits varies according to their nature and age. When the pericarp is of a dry nature, it commonly assumes a whitish or brownish colour, and its cells become thickened with hardened matters, and their cellulose walls converted into *lignin*. Under such circumstances, no further changes take place in its chemical constitution, and its vital activity ceases. But when the pericarp becomes succulent whilst ripening, it assumes various tints; transpiration goes on from its outer cells, the contents of which thus become dense, and absorb the watery matters from those within them; these in like manner react upon the contents of those within them, and so there is a constant passage of fluid matters from the surrounding parts by osmotic action into the pericarp; in this way, therefore, it continues to enlarge, until it has arrived at maturity, when transpiration nearly ceases from the deposition of waxy matter in or upon the epidermal cells, and the stalk by which it is attached to the plant becomes dried up. When first formed such pericarps have a like composition with leaves, and but little or no taste. After a time they acquire an acid flavour from the formation of vegetable acids, and salts with an acid reaction. The nature of these acids and salts varies in different fruits; thus the Grape contains tartaric acid chiefly and acid tartrate of potassium; the Apple, malic acid; and the Lemon, citric acid. As the pericarp ripens, saccharine matter is formed, and the quantity of free acids diminishes, partly from their conversion into other matters, and partly from their combination with alkalies. In order that these changes may be properly effected, it is necessary that the fruit be exposed to the sun and air, for if grown in the dark it will continue acid; and it will be much less sweet even when developed in diffused daylight, than when freely exposed to the sun. As fruits ripen they evolve carbon dioxide, as already noticed, give off watery fluids, and a sensible elevation of temperature may be noted.

The origin of the sugar of fruits, and even its nature, is not satisfactorily determined. According to most observers, ripe fruits contain grape sugar (*glucose*), but M. Buignet states that the sugar which is primarily formed in acid fruits is *sucrose* or *cane sugar*, and that during the process of ripening this sugar is gradually changed into *fruit sugar* (*glucose* and *lævulose*), but very often there remains in the ripe fruit a mixture of these two sugars. The origin of the sugar is variously attributed to the transformation of the acids, cellulose, lignin, starch, dextrin, gum, and other matters of a like nature. According to M. Buignet's investigations, the cause of the change of the primarily formed cane sugar into fruit sugar is not the acids of the fruits, but appears to depend upon the influence of a nitrogenous body playing the part of a glucosic ferment, analogous to that which M. Berthelot has extracted from yeast. M. Buignet adds, that 'the abundance in which starch is found distributed through the Vegetable Kingdom leads to the supposition that it is the true source of the saccharine matter in fruits. Its presence cannot, however, be detected in green fruits, either by the microscope or by iodine, excepting in green bananas, which contain a notable quantity of starch.' M. Buignet also notices that green fruits contain an astringent principle resembling tannin, which is capable of being converted into a sugar identical with the sugar from starch (*maltose*), under the influence of dilute acids and a proper temperature. The proportion of this tannin diminishes in fruits in the same ratio that the proportion of sugar increases.

The pericarp of some fruits has developed in it during the process of ripening, fixed and essential oils, as well as other substances of an aromatic nature. According to Frémy, the inner walls of the cells of succulent fruits in an unripe state consist of a substance called *pectose*, which is insoluble in water, alcohol, or ether. This body has not been isolated, but is converted in ripe fruits by the agency of acids into *pectine*, which is soluble in water. Pectine is afterwards transformed into *pectosic* and then into *pectic acid* through the agency of a peculiar ferment called *pectose*. Frémy has also noticed, that at the period of ripening the thickness of the cell-walls diminishes rapidly; hence it would appear that these transformations of the pectic compounds play an important part in the changes which are taking place during the ripening of the fruit.

The changes which take place in the composition of fruits during ripening are well exhibited in the following table founded upon Bérard's observations:—

Names of Fruits.	Water.		Sugar.		Ligneous Matter.	
	Unripe.	Ripe.	Unripe.	Ripe.	Unripe.	Ripe.
Apricots	89·39	74·87	A trace when young, and then 6·64	16·48	3·61	1·86
					With the seeds:—	
Red Currants	86·41	81·10	0·52	6·24	8·45	8·01
Duke Cherries	88·28	74·85	1·12	18·12	2·44	1·12
Greengage Plums	74·87	71·10	17·71	24·81	1·26	1·11
Melting Peaches	90·31	80·24	0·63	11·61	3·01	1·21
Jargonelle Pears	86·28	83·88	6·45	11·52	3·80	2·19

Ripening of Fruits.—The time when a fruit is considered ripe varies in different cases. When the pericarp is of a dry nature, the fruit is looked upon as ripe just before it dehisces; but when the pericarp is of a pulpy nature and edible, we commonly regard it as mature when most agreeable for food. Hence the Apple is considered to be ripe in a state in which the Medlar would be regarded as unripe.

When succulent fruits are ripe, they undergo another change, a species of oxidation, which produces a decay, or *bletting* of their tissues, as it has been called by Lindley. This bletting, according to Bérard, is especially evident in the fruits of the Pomeæ and Ebenaceæ, and it would appear that the more austere the fruit is, the more it is capable of bletting regularly. Bletting appears to be peculiar to such fruits, and may be regarded as a state intermediate between maturity and decay. A Jargonelle Pear, in passing from ripeness to bletting, according to Bérard, loses a great deal of water (83·88, which it contains when ripe, being reduced to 62·73); much sugar (11·52, being reduced to 8·77); and a little lignin (2·19, being reduced to 1·85); but it acquires, at the same time, rather more malic acid, gum, and albuminous matters.

The time required by different plants for ripening their fruits varies much, but almost all fruits come to maturity in a few months. Some, as those of Grasses generally, take but a few days; while others, as certain of the Coniferæ, &c., require more than twelve months.

4. Of the Seed.—The structure and general characters of the seed, as well as the origin and progressive development of its parts, have been already fully alluded to in a former section of this work (pages 333-348).

Our limited space prevents us from alluding to the multitude of ways and contrivances by which the natural dissemination of seeds is effected, and to the number of seeds produced by plants. Suffice it to say that, in all cases, a great many more seeds are matured than are required for the propagation of the species; and thus the extinction of the species in consequence of their decay, and their use for food by animals, &c., is provided against.

Vitality of Seeds.—Seeds vary very much as to the time during which they will preserve their power of germinating. This vitality is frequently lost long before they lose their value for food. Some seeds of an oily or mucilaginous nature, or which contain much tannic acid, speedily lose their vitality, and decay; this is the case, for instance, with Nuts and Acorns, and hence, when seeds of this nature are required for propagation, they must be sown immediately or within a short time of their arriving at maturity, or special means must be adopted for their preservation. Other seeds, such as those of a farinaceous nature, as Wheat and Cereal grains generally, or those with hard and bony integuments, as many of the Leguminosæ, frequently retain their vitality for years.

From the experiments of De Candolle, those of a Committee of the British Association, and of others, it would appear generally, that the seeds of the Leguminosæ and Malvaceæ preserve their vitality longest, while those of Compositæ, Cruciferæ, and Graminaceæ soon lose their germinating power. But some exceptions to the above statement occur in these orders.

Under particular circumstances it seems certain that seeds have preserved their vitality for a long period. Some of the cases brought forward as illustrations of this capability of seeds are, however, not supported by careful observations, as, for instance, that of the vitality of Wheat taken from Egyptian mummies. There are no well-authenticated instances of Wheat taken from mummies, which have been untampered with, germinating; indeed, all experiments (Dietrich, Lardet, Haberlandt), tend to show that Wheat loses its power of germination in from three to seven years. But other well-authenticated instances of seeds having preserved their vitality for a lengthened period are on record. Thus, on the authority of Dr. Trimen, it was stated in the third edition of this Manual that some seeds of *Nelumbium* in the herbarium (now in the British Museum) of Sir Hans Sloane, who died in 1753, germinated in 1866; these must, therefore, have been considerably over a century old. Mr. Kemp, in the 'Annals and Magazine of Natural History,' has likewise narrated a still more remarkable case. This gentleman received some seeds which were found upwards of twenty-five feet below the surface of the earth, in the lowest layers of a sand-pit in process of excavation. Upon being sown, about one-tenth germinated and produced plants of *Polygonum Convolvulus*, *Rumex Acetosella*, and a variety of *Atriplex patula*. All these seeds are of a mealy or farinaceous nature. Mr. Kemp concluded from various circumstances, that they were deposited at a period when the valley of the Tweed was occupied by a lake; if this be the case, they must have retained their vitality during many centuries at least, as it is certain that in the time of the Romans no lake existed there. It has also long been noticed that when a new soil is turned up, plants previously unknown in the locality appear, which is a proof that the seeds of such plants must have lain dormant for frequently a very lengthened period.

Preservation and Transportation of Seeds.—As many persons frequently wish to send seeds to a distance, a few words on the best means of preserving them for that purpose will be acceptable to our readers. Thus when seeds are enclosed in hard or dry pericarps, they should be preserved and transported in them. This is the case with those of many Leguminous and Coniferous plants. When the pericarps are soft or liable to decay, the seeds should be removed from them. In all cases, seeds when required for preservation should be gathered when quite ripe, as at that period their proximate principles are in a more stable condition than when unripe, when they are very liable to change. Seeds should be also preserved quite dry. Seeds of a farinaceous nature, if ripe and dry, will retain their vitality for a long period, and such may be readily transported to a distance. For the latter purpose they should be placed in perfectly dry papers in a dry coarse bag, which should be afterwards suspended from a nail or otherwise in the cabin of a ship, in which position they are maintained at a moderate temperature and exposed to free ventilation. Such seeds require no further care. But seeds of an oily or mucilaginous nature, or that contain much astringent matter, require, as a further protection, to be excluded from the air. For this purpose they are best packed in stout boxes lined with tin, and filled with dry sand or charcoal powder. The sand or charcoal powder and the seeds should be placed alternately in layers, and the whole firmly pressed together. Such seeds, however, even when thus protected, frequently lose their vitality. A coating of wax has in some cases been found to preserve effectually the vitality of seeds. Probably seeds which are difficult of preservation might be transported in hermetically sealed bottles containing carbon dioxide. Wardian cases are also an important means for transporting seeds (see page 806), and should be resorted to, when possible, in all doubtful cases.

GERMINATION.—By germination we mean that power or act by which the latent vitality of the embryo is brought into activity, and it becomes an independent plant capable of supporting itself. The germination of Cryptogams has already been sufficiently alluded to when treating of the Root, at page 135, and in the sections devoted to the Reproductive Organs, and Reproduction of the Cryptogamia. Our further remarks will apply therefore solely to the Phanerogamia.

Length of Time required for Germination.—The time required for germination varies much according to the nature of the seeds and the conditions under which they are placed. Generally speaking, seeds germinate most rapidly directly after being gathered. If preserved till they are quite dry, the process of germination in some cases is months in being effected, while in some seeds their capability of germination is entirely destroyed. The seeds of the garden Cress will frequently germinate in twenty-four hours, but the majority of seeds do not germinate for from six to twenty days, and some require months or even years. Germination is generally prolonged when the embryo is invested by hardened integuments or albumen, and it is usually most rapid in exalbuminous seeds, more especially if such seeds have thin soft integuments. Heat is the agent which most accelerates germination.

Conditions requisite for Germination.—A certain amount of heat and moisture, and a free communication with atmospheric air, are in all cases necessary to the process of germination. Electricity is also considered by some observers to promote it, but its influence in the process is by no means proved, and if exerted it is apparently of but little importance. Light has no influence on germination in most cases, according to Hoffmann's experiments. (See also *The Effect of the Electric Light on the Growth of Plants*, page 858.)

Moisture is required to soften the parts of the seed and to take up all soluble matters; the cells of which seeds are composed are in this way enabled to expand, and the embryo to burst through the integuments, but excess of water is often injurious.

Heat is necessary to excite the dormant vitality of the embryo, but the amount required varies very much in different seeds, and probably each species has its own proper range in this respect. As a general rule, from 50° to 80° Fahr. may be regarded as most favourable to germination in temperate climates, but some seeds will germinate at a temperature of 35° Fahr.; and those of many tropical plants require a temperature of from 90° to 120° Fahr., or sometimes higher, for germination.

Air, or at least oxygen gas, is required to combine with the superfluous carbon of the seed, which is thus evolved as carbon dioxide, with a sensible increase of temperature (page 856), as is well seen in the malting of Barley. The necessity of a proper supply of oxygen is proved by the fact, that seeds will not germinate when buried too deeply in the soil, or when the soil is impervious to air. This explains how seeds may lie dormant at great depths in the soil, and only germinate when the soil is brought to the surface; and hence we see the necessity of admitting air to seeds, as in the ordinary operations of agriculture.

Process of Germination.—When the above requisites are supplied in proper proportions to suit the requirements of different seeds, germination takes place; but should any be wanting or in too great amount, the process is more or less impeded, or altogether arrested. The most favourable seasons for germination are spring and summer; and seeds sprout most readily in loose pulverised and properly drained soil, at a moderate depth, for, under such circumstances, air, moisture, and warmth have free access. Seeds thus placed absorb moisture, soften and swell, and certain chemical changes go on at the same time in the substance of the albumen, or, when this is absent, in the cells of the cotyledonary portion, by which a proper supply of nourishment is provided for the embryo. These chemical changes chiefly consist in the conversion of starch and other analogous substances, which are insoluble and therefore not in a suitable state for absorption, into soluble matters such as dextrin and grape sugar. The immediate cause of this transformation of starch is due to a nitrogenous substance called *diastase*, which is developed, during germination, from an alteration of a portion of the nitrogenous contents of the seed. During these chemical actions heat is evolved, as in the *malting* of Barley (see p. 856), and carbon dioxide given off from the combination of the superfluous carbon in the starch and albuminoids with the oxygen of the air. The nutriment being thus made available for use, it is absorbed dissolved in water by the embryo, which is in this manner nourished, increases in size, and ultimately bursts through the integuments of the seed. Its lower extremity or radicle (*fig.* 16, *r*), or one or more branches from it (*fig.* 765, *r*), is commonly protruded first from its proximity to the micropyle, which is the weakest point in the integuments, and by taking a direction downwards becomes fixed in the soil, whilst soon after the opposite extremity elongates upwards (*fig.* 16, *t*), and is terminated above by the plumule, which is the first terminal bud or growing apex of the stem. At the same time the cotyledonary portion is either left under ground or is carried upwards to the surface. The embryo during this development continues to be nourished from the matters contained either in the albumen or cotyledonary portion, and ultimately by continuing to absorb nutriment it is enabled to develop its first leaves (*primordial*) (*fig.* 18, *d*, *d*,) and root, *r*. The young plant is now placed in a position to acquire the necessary nourishment for its further support and growth from the media by which it is surrounded, and is thereby rendered independent of the other parts of the seed; the cotyledonary portion accordingly perishes, and the act of germination is complete.

Direction of Plumule and Radicle.—The cause which leads to the development of the axis of the embryo in two opposite directions has not yet been satisfactorily demonstrated, although much has been written on the subject. By some it has been referred to the action of darkness and moisture on the root, and that of light and dryness on the stem. By others it has been attributed to gravitation and the state of the tissues; and others, again, have regarded osmotic action as the cause. All these explanations are unsatisfactory, and need not be further alluded to. Darkness has been shown to have no influence on the direction of the root, which is probably determined by the greater amount of moisture usually met with in the soil, and by gravitation or geotropism (see page 862). In *Trapa natans* the radicle is directed upwards towards the surface of the water in which the plant grows.

Differences between the Germination of Dicotyledonous and Monocotyledonous Seeds.—There are certain differences between the germination of Monocotyledonous and Dicotyledonous embryos, which have already been alluded to briefly (see page 134), but which require some further notice.

1. *Monocotyledonous Germination.*—The seeds of Monocotyledons, in by far the majority of instances, contain albumen. This, as the embryo developes, is usually entirely absorbed; but sometimes, as in the seed of *Phytelephas*, the contents of the constituent cells are removed, and the walls left as a kind of skeleton.

The single cotyledon of Monocotyledonous seeds, when they contain albumen, always remains entirely (*fig.* 765, *c*), or partially within the integuments, during germination. In the latter case, the intra-seminal portion of the cotyledon corresponds to the limb of the cotyledonary leaf, and the portion which elongates beyond the integuments (extra-seminal) represents the petiolar portion. The latter part varies much in length, and is commonly terminated by a sheath, which encloses the young axis with the plumule. In the Palms this petiolar portion is often several inches in length. At other times there is no evident petiolar part, but the sheathing portion enveloping the axis remains sessile on the outside of the seed, and elongates in a tangential direction to it, as in the Oat (*fig.* 765), where the cotyledon, *c*, remains within the seed, and the plumule, *g*, rises upwards from its axil into the air.

In some few Monocotyledonous orders, such as Naiadaceæ, Alismaceæ, &c., where the seeds are exalbuminous, the cotyledon is commonly freed from the integuments, and raised upwards with the plumule.

As already noticed (page 134), in the germination of Monocotyledonous embryos, e.g. the Grasses, the radicle is not itself, except in rare cases, continued downwards so as to form the root, but it gives off one or more branches of nearly equal size, which separately pierce its extremity, and become the rootlets (*fig.* 251, *r*). Each of these rootlets, at the point where it pierces the radicular extremity, is surrounded by a cellular sheath termed the *root-sheath* or *coleorhiza* (*fig.* 251, *co*). This mode of germination is commonly termed *endorhizal*; but it is not, as already stated, universal in Monocotyledons.

2. *Dicotyledonous Germination.*—The seeds of Dicotyledons are either albuminous or exalbuminous, and their germination in such respects, as a general rule, presents no peculiarity worth notice. The two cotyledons either remain within the integuments of the seed in the form of fleshy lobes, as in the Horse-chestnut and Oak, in which case they are said to be *hypogeal* (from two Greek words signifying under the earth); or, as is more commonly the case, they burst through the coats, and rise out of the ground in the form of green leaves (*fig.* 18, *c*, *c*), in which case they are *epigeal* (from two Greek words signifying upon or above the earth). In the course of development the cotyledons commonly separate, and the plumule comes out from between them (*fig.* 16, *n*). In those cases where they remain within the integuments, they sometimes become more or less united, so that the embryo resembles that of a Monocotyledon; but a Dicotyledonous embryo may be always distinguished from a Monocotyledonous one by its plumule coming out from between the bases of the cotyledons, and not passing through a sheath.

The radicle of a Dicotyledonous embryo (see page 125) is itself prolonged downwards by cell-multiplication just within its apex (*fig.* 248, *a*), to form the root. An embryo which germinates in this way is termed *exorhizal* (page 134).

As a general rule, seeds do not germinate until they are separated from their parents; but in some cases, and more especially when invested by pulp, as in the Gourds, Melon, Cucumber, Papaw, &c., they do so before they are detached. In the above plants such a mode of germination is altogether exceptional; but in the plants of the order Rhizophoraceæ, as the Mangrove (*fig.* 255), the seeds commonly germinate in the pericarp before being separated from the tree, in which case the radicle is protruded through the integuments of the seed and pericarp, and becomes suspended in the air, where it elongates.

CHAPTER 4.

SPECIAL PHENOMENA IN THE LIFE OF THE PLANT.

1. Development of Heat by Plants.—As the various parts of living plants are the seat of active chemical and other changes during their development, and in the performance of their

several functions, we might conclude that their temperature would rarely or ever, under natural circumstances, correspond with that of the atmosphere around them.

We have already noticed, that during the germination of seeds a considerable development of heat takes place (page 851). This is more especially evident when a number of seeds germinate together, as in the process of malting. The development of heat in flowering has also been alluded to (page 827). The rise of temperature which thus occurs in the processes of germination and flowering is due, without doubt, essentially to the production of carbon dioxide. To estimate the degree of heat developed during germination and in flowering, Sachs devised the apparatus (*fig.* 1172), where the flask *f* contains a strong solution of potash or soda, *l*, which absorbs the carbon dioxide set free. In the neck of the flask is placed a funnel, *r*, with a small filter perforated by a needle. Into this are placed soaked seeds or freshly cut flower-buds in the act of opening, and a bell-glass, *g*, used to cover the whole. Through the opening of the bell-glass, which is plugged with cotton wool, *w*, is passed a thermometer, *t*, whose bulb is so placed as to be surrounded on all sides by the seeds or flower-buds.

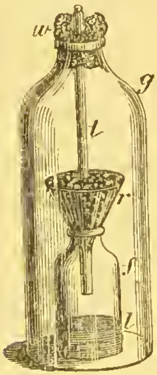


Fig. 1172. Apparatus for estimating the rise of temperature during the germination of seeds and the opeuing of flower buds. (After Sachs.)

We have still to inquire, whether the ordinary vital actions which are going on in plants are calculated to raise or diminish their temperature. The experiments of Hunter, Schoepf, Bierkander, Maurice, Pictet, and more especially of Schübeler, lead to the conclusion that the trees of our climate with thick trunks exhibit a variable internal temperature, being higher in the winter and at sunrise than the surrounding atmosphere—that is, at periods of great cold, or of moderate temperature; and lower in the summer or at mid-day—that is, at periods of great heat. In no observed cases were such trees noticed to possess exactly the temperature of the atmosphere around them. The experiments of Réaumur on trees with slender trunks exposed directly to the sun's rays showed a considerable increase of temperature in them over the external air. These experiments of Réaumur are, however, by no means satisfactory.

The temperature of trees under the above conditions depends upon various causes, such as the sun's rays, the amount of evaporation, chemical changes which take place during assimilation, &c., the conducting powers of the wood, and particularly upon the temperature of the soil in which the plants are grown. In the active periods of the growth of plants, when evaporation is constantly going on, and the fixation of carbon taking place, both of which processes are accompanied by a diminution of heat, it is evident that such changes must have some effect in modifying the temperature; and hence if, at such periods, their temperature be above that of the surrounding air, that it is due to external influences, such as the sun's rays, and the temperature of the soil, &c. This probably explains, to some extent at least, why the temperature of thick trees exposed to great heat is lower than that of the surrounding air, for at such a period vegetation is in a very active condition, evaporation and assimilation being then in full play. Again, when the temperature of the air is low, as in winter or during the night, little or no evaporation or assimilation takes place, and hence we find that the temperature is then higher than that of the external air.

The conclusions in the last paragraph do not, however, altogether agree with the published result of experiments made by Dutrochet; for he found, by operating with Becquerel's thermo-electric needle, that when plants were placed in a moist atmosphere so as to restrain evaporation, a slight increase of temperature took place, thus seeming to prove that the chemical changes taking place in plants produced a rise rather than a diminution of temperature. Probably this slight increase of heat under such circumstances is due to the oxidation or combustion of a portion of the carbon of the plant. But Dutrochet found that when evaporation was allowed, the proper vital or specific heat of plants was slightly below that of the atmosphere. He also noticed that the heat of plants varied during the course of twenty-four hours,—the hour of maximum temperature varying from ten in the morning to three in the afternoon, the minimum occurring at midnight. The variation in such cases was, however, extremely small, being only from about one-tenth to a little over one-half a degree of Fahrenheit. This specific heat of plants could only be observed in green and soft structures, those which were hard or woody (i.e. those which were composed mainly of dead tissues) not possessing any specific heat, because in such parts little or no metabolic changes were going on.

The above is but a brief summary of the conclusions which have been at present arrived at with regard to the development of heat by plants, and these are by no means of a conclusive nature. Much further investigation is required upon this matter.

In connexion with the subject of heat developed by plants may be mentioned the researches of Boussingault, Alphonse de Candolle, &c., as to the temperatures required by different plants to stimulate them into vegetative or reproductive activity. That a certain sum of heat is required for the proper development of a plant has long been known; also that the life-history of some plants (as Wheat) will be completed in a shorter time in hot than in more temperate climates.

2. LUMINOSITY OF PLANTS.—Very little is positively known respecting the development of light by plants. But it seems tolerably well ascertained, on the authority of Humboldt, Nees von Esenbeck, Unger, Drummond, and others, that the thallomes of some living Fungi are luminous in the dark. This luminosity has been noticed in several species of *Agaricus* and the so-called *Rhizomorpha* ; but Brefeld says that only the young hyphæ are luminous in the latter. According to Prescott, the mycelium of the common Truffle is also luminous in the dark.

The statement that certain Mosses, as *Schistostega osmundacea* and *Mnium punctatum* are phosphorescent, appears to have been founded on imperfect observation.

With regard to the development of light by the higher classes of plants, we have at present no very satisfactory observations to depend upon. It has been repeatedly stated, that many orange and red-coloured flowers, such as those of the Nasturtium, Sunflower, Marigolds, Orange Lilies, Red Poppies, &c., give out, on the evening of a hot day in summer, peculiar flashes of light. This peculiar luminosity of orange and red flowers is now commonly regarded as an optical illusion, and the fact of such luminosity having been only noticed in flowers with such bright and gaudy tints, appears strongly to favour such a conclusion.

The rhizomes of certain Indian grasses have been reported to be luminous in the dark during the rainy season ; and Mornay and Martius have observed, that the milky juices of some plants were luminous when exuding from wounds made in them. Martius also states, that the milky juice of *Euphorbia phosphorea* is luminous after removal from the plant, when it is heated.

3. ELECTRICITY OF PLANTS.—Disturbances of electrical equilibrium are undoubtedly connected with the various chemical and mechanical changes which take place in plants. By the medium of a galvanometer, Ranke, Velten, Burdon Sanderson, and others, have demonstrated that there exists in plants an electric current from the transverse to the longitudinal section of a vegetable fibre, similar, but in the contrary direction to that shown by Du Bois Reymond to exist in the muscles, &c., of animals. It is also found that the internal tissue of land plants is always electro-negative to the cuticularised surface.

The Effect of the Electric Light on the Growth of Plants and Production of Chlorophyll.—Some experiments made by the late Sir Wm. Siemens seem to prove that the electric light aids the growth of plants, produces chlorophyll, increases the brilliancy of flowers, and promotes the ripening of fruits. By sowing seeds of rapidly growing plants and exposing them to the same conditions with the exception of light, he found that those grown in the dark were etiolated and soon withered ; those exposed to daylight with a fair share of sunlight were vigorous, and of a good green colour ; but those exposed to the electric light for six hours per day only, being in darkness the other eighteen hours, were vigorous though less green ; while those exposed to daylight and electric light successively, were the most vigorous, and the green of their leaves of a darker hue. This shows that plants may for a time grow continuously without rest, i.e. without sleep ; but for what length of time this endurance would continue further experiments are required to prove. The electric light seems therefore to affect plants in a similar manner to the continuous summer sun in northern latitudes, where Dr. Schübeler found that the arctic sun caused plants to produce more brilliant flowers and richer and larger fruit than if the same plants had been grown with an alternation of light and darkness.

4. Movements of Plants.—Three kinds of movements have been described in plants :—1. Motions of entire plants, such as those which occur in the Oscillatorieæ, Diatomeæ, and some other forms of the lower Algæ ; and of parts, e.g. the antherozoids, connected with the reproductive processes in some of the lower kinds of plants. The movements thus possessed by some of the lower Algæ is a marked deviation from what ordinarily occurs in plants. 2. Movements produced in parts of plants which are dead, or which, at least, have lost their active vitality. Such movements may be noticed in almost all the great divisions of plants, and are more or less connected with some reproductive function. We include here the bursting of anthers in the Phanerogams, and that of spore-cases in the Cryptogams the dehiscence of fruits, the separation of the component carpels from one another in the Euphorbiaceæ and Geraniaceæ, and many other phenomena of a like nature. 3. Movements which occur in the living parts of plants when in an active state of growth, &c.

The *first two classes of movements* have been already alluded to in various parts of this work. The movements of the first class appear to depend upon a rotation of the protoplasmic cell-contents, the cause of which is at present unexplained ; or to the presence of cilia upon their surfaces. Movements of the second kind are entirely mechanical, and produced by the varying conditions of the different tissues as to elasticity and power of imbibing moisture.

The *third kind of movements* must be more particularly noticed. They only occur during active vegetation. The directions taken by organs properly come under this head. But this matter, so far as the plumule and radicle are concerned, has been already noticed (page 854). With regard to the stem the extensive researches of Darwin on Twining Plants and Tendrils are full of interest. The ends of such structures have the power of spontaneously revolving ; and this they constantly do, usually from right to left, once in about two hours ; to this action Sachs has applied the term of *revolving nutation*, which Darwin has simplified into that of *circumnutation*. So soon as the organ meets with a support its motion is arrested, and it becomes spirally twined round by the arrest of the movement of successive portions. Tendrils contract spirally soon after they have laid hold of a support, and so draw up the stem to which they are attached. The remaining movements belonging to this class have been divided by Schleiden in the following manner :—

1. Movements which evidently depend on external influences. These are divided into two :—

   a. Periodical. *b.* Not periodical.

2. Movements independent, at least to some extent, of external influences, which are also divided into two :—

   a. Periodical. *b.* Not periodical.

FIG. 1173.

Fig. 1173. *Nicotiana glauca.* A. Shoots with leaves expanded during the day. B. The same asleep at night, pointing vertically upwards. (After Darwin.)

(1) MOVEMENTS DEPENDING ON EXTERNAL INFLUENCES.—*a. Periodical.*—Under this head we include such movements as those of certain leaves and the petals of flowers, which occur at particular hours, the organs remaining in the new position thus taken up until the return of a particular period, when they

resume as nearly as possible their original position. In leaves, these periodical movements consist in the closing up of such organs towards the evening and their expansion in the morning. In the petals of flowers great differences occur in opening or closing at particular hours of the day ; and, by observing these changes in a variety of flowers, Linnæus and others have drawn up what has been termed a floral clock. This periodical closing up of leaves and flowers has been called the sleep of plants. The compound leaves of certain Leguminosæ and Oxalidaceæ are marked illustrations of these periodical movements, which are probably all indirectly dependent upon the varying con-

FIG. 1174.

Fig. 1174. *Desmodium gyrans.* A. Stem with leaves during the day. B. A similar stem with leaves asleep at night, pointing downwards. (After Darwin.)

ditions of light to which the parts of the plant in which they occur are exposed. All these movements Darwin considers to be due to modified circumnutation. This author says : 'In *Lupinus* the leaflets move either upwards or downwards ; and in some species (for instance, *L. luteus*), those on one side of the star-shaped leaf move up, and those on the opposite side move down ; the intermediate ones rotating on their axes ; and by these varied movements the whole leaf forms at night a vertical star, instead of a horizontal one as during day. Some leaves and leaflets, besides moving either upwards or downwards, become more or less folded at night, as in *Bauhinia* and in some species of *Oxalis*. The positions, indeed, which leaves occupy when asleep are almost infinitely diversified : they may either point vertically upwards (*fig.* 1173, B) or downwards (*fig.* 1174, B) ; or, in the case of leaflets, towards the apex or towards the base of the leaf, or in any intermediate position. . . .

'The nyctitropic movements of leaves, leaflets and petioles are effected in two different ways—firstly, by alternately increased growth on their opposite sides, preceded by an increased turgescence of their cells (see page 782 and *fig.* 1140) ; and secondly, by means of a *pulvinus* or aggregate of small cells, generally destitute of chlorophyll, which become alternately more turgescent on nearly opposite sides, and this turgescence is not followed by growth except during the early age of the plant.'

b. Not periodical.—Such movements are exhibited in a number of plants both in the leaves and in their reproductive organs. In the leaves they are well seen in certain species of *Oxalis* and *Mimosa* (*fig.* 373), in *Dionæa muscipula* (*fig.* 375), &c. In the reproductive organs they may be noticed in the curving inwards or outwards of the stamens of certain plants, such as those of *Berberis vulgaris* and other species, *Parietaria judiaca*, *Helianthemum vulgare* and other Cistaceæ ; also in the stigmas of the Lobeliaceæ, and in the style of *Goldfussia anisophylla*, &c. All the above movements are produced by external agency, such as the action of insects, the agitation caused by the wind, &c. Other movements which fairly come under this heading, and which, like the nyctitropic movements, are by Darwin regarded as being due to modified circumnutation, are *positive* and *negative heliotropism*, *positive* and *negative geotropism*, &c.

Positive heliotropism is the growing towards the source of light. It has been long known that plants grown in comparative darkness increase in length more rapidly than those exposed to a stronger light—i.e. that light appears to have a retarding influence on growth—therefore, where a plant or part of a plant exhibits positive heliotropism, it is found that the part away from the light has attained a greater length than that towards it.

Some few vegetable organs, as the stem of Ivy, and many roots, exhibit *negative heliotropism*, where, as they grow away from the light, the parts next the source of illumination grew most.

Positive geotropism or *gravitation* is the term applied to the force which influences the direction of growth of most roots, especially of primary roots, which usually point directly downwards to the centre of the earth.

Negative geotropism, on the other hand, signifies the direction taken by most stems, trees, &c., being exactly opposite to that sought by the roots—i.e. upwards, or away from the centre of the earth.

As the terms *positive* and *negative heliotropism* and of *posi-*

tive and *negative geotropism* are frequently used carelessly, the qualifying expressions *positive* and *negative* being frequently omitted. Darwin adopts the term *heliotropism* in the sense of bending *towards* the light; *apheliotropism* for the contrary direction, i.e. away from the source of illumination; and, in the same manner, *geotropism* to imply towards the earth, and *apogeotropism* for bending in opposition to gravity, or from the centre of the earth.

In addition to the foregoing terms, *diaheliotropism* is sometimes used to express a position more or less transverse to the light which induced it; and *diageotropism* to a similar position with regard to the radius of the earth.

Irritability.—It has been already stated that some movements of plants are dependent upon the agency of insects. But though it has long been known that insects thus induce movements in certain plants, such as *Drosera*, *Dionæa*, *Nepenthes*, &c., it is only by the observations of Darwin, Müller, Hooker, Vines, Riess, Wills, and many others, that we have learnt that the insects, which by these movements are caught, serve for nutrition, being dissolved and absorbed. It has been also demonstrated that this solution of nitrogenous matters is due to the presence of a kind of ferment which closely resembles that of the peptic glands of animals. It has likewise been proved that this ferment is only efficient when associated with an acid; and hence this solution is a true digestive process like that of animals. During the solution and absorption of these nitrogenous matters the protoplasm retracts from the walls of the cells in the form of a ball. In *fig.* 1175 is shown a leaf of *Drosera* (Sundew) where some of the glands have bent over and caught an insect. Such plants are now commonly termed *carnivorous*.

FIG. 1175.

Fig. 1175. Leaf of *Drosera*, showing a Fly caught by the incurved glands. (After J. W. Groves.)

Another remarkable instance of a carnivorous plant is the *Utricularia*, upon the leaves of which little pouches or air-sacs (*fig.* 1176), are developed. These sacs have a somewhat elaborate mechanism, with a valve which closes directly an animal has entered, thus keeping it a prisoner (*fig.* 1177). It has been known for a long time to be capable of entrapping small invertebrates, but recently it has been found to catch young fish in the same manner.

To plants which are thus stimulated to movement by chemical or mechanical means, the term *irritable* is applied ; thus

FIG. 1176.

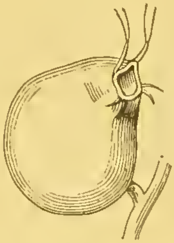


FIG. 1177.

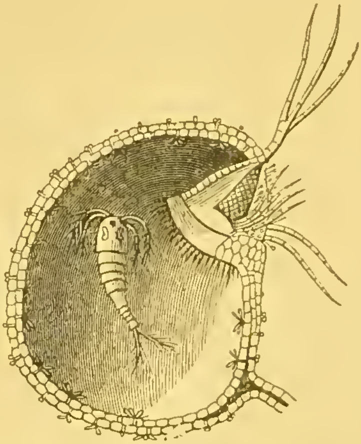


Fig. 1176. A sac of *Utricularia*, showing the external opening. ——*Fig.* 1177. A vertical section of the same, showing the valve past which an entomostracous crustacean has entered, but cannot escape.

it is by reason of their irritability that the leaves and stems of the Sensitive plants (*fig.* 373) droop on contact with any foreign body.

(2) MOVEMENTS INDEPENDENT, AT LEAST TO SOME EXTENT, OF EXTERNAL INFLUENCES.—*a. Periodical.*—These movements are seen in some of the leaflets of certain tropical species of *Desmodium*, and more especially in those of *Desmodium gyrans* (*fig.* 1178). The leaf in this plant is compound, and bears three leaflets; the terminal one, *a*, being much larger than the two lateral ones, *b*, *b*. There are also two other rudimentary leaflets, marked *c*, near the large terminal one. This large terminal leaflet, *a*, when exposed to the influence of a bright light, becomes more or less horizontal, but it falls downwards on the approach of evening (*fig.* 1178, *a*). This movement is clearly analogous to the sleep of plants, and, therefore, comes under the head of movements depending on external influences, as previously described (page 861). But the lateral leaflets, *b*, *b*, exhibit a constant movement during the heat of the day, advancing by their margins towards the large terminal leaflet, and then retreating towards the base of the common petiole. This movement takes place first on one side and then on the other, so that the point of each leaflet describes a circle. The

movements resemble those of the arms of the old semaphore telegraphs, and hence this plant has been termed the Telegraph plant. They go on to a less extent even in the dark, and are most evident when the plants are in a vigorous state of growth, and when exposed to a high temperature. No satisfactory explanation has yet been given of the direct cause of this movement. Similar movements have been observed in the radicle of many plants.

b. Not periodical.—These movements occur in the reproductive organs of a large number of the Phanerogamia. The

FIG. 1178.

Fig. 1178. A portion of a branch, with a leaf of *Desmodium gyrans*. The leaf, which is compound, consists of a large terminal leaflet, *a*, and two smaller lateral ones, *b*, *b*. There are also two other rudimentary leaflets, marked *c*, near the terminal leaflet.

stamens sometimes curve inwards separately towards the stigma, as in *Ruta graveolens* (*fig.* 611) and *Parnassia palustris*; or in pairs, as in *Saxifraga tridactylites*. They afterwards commonly return as nearly as possible to their former position. In *Passiflora*, *Nigella sativa*, certain Onagraceæ and Cactaceæ, &c., the styles move to the stamens; while in other Onagraceæ and certain Malvaceæ, &c., both styles and stamens move towards each other. In each of the above the arrangement is one adapted to prevent self-fertilisation, as it is protandrous and entomophilous (see page 843).

5. ODOURS OF PLANTS.—These are very various in kind, many being highly agreeable, others excessively offensive, while others again, though pleasant in small quantity, become disagreeable in larger amount. The source of the particular odour is often a volatile oil or other product contained in the glands or receptacles of secretion of the plant; but in some cases no

such origin is found, and the source of the odour is unknown, whilst its nature defies analysis. It is generally considered that smell is due to the giving off of minute particles into the air; Morren, however, from observations on the flowers of Orchids, was led to the inference that in some cases it depended on a physiological cause. He observed that the aromatic odour of *Maxillaria*, which continued to be exhaled so long as the flowers were unfertilised, was lost a little while after pollen was applied to the stigma.

Though chiefly developed under the influence of solar light, there are not a few plant-odours which are given off in the evening or at night. Several Orchids, *Cestrum nocturnum*, *Hesperis tristis*, *Lychnis vespertina*, and *Cereus grandiflorus* are examples. In the last-named plant, the odour is given out in intermittent puffs.

There seems to be a connexion between the colour and odour of flowers; thus it has been observed that white flowers are very frequently fragrant, whilst brown and orange ones have often a fœtid smell—the so-called Carrion-flowers (*Stapeliæ*), certain Aroids, some Balanophoraceæ, and the *Rafflesiæ* being examples. The flowers of Monocotyledons are more often odorous than those of Dicotyledons.

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TO

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*** The technical terms mentioned below are explained at the pages referred to, and thus the Index may be also used as a Glossary.

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