CLASS BOOK OF BOTANY

BEING

AN INTRODUCTION

TO THE STUDY OF

THE VEGETABLE KINGDOM.

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TO

HIS GRACE THE DUKE OF ARGYLL,

CHANCELLOR OF THE UNIVERSITY OF ST. ANDREWS,

LORD PRIVY SEAL, ETC. ETC.

A NOBLEMAN

WHO OCCUPIES A DISTINGUISHED PLACE AS

A STATESMAN, A PHILANTHROPIST, A SCHOLAR, AND

A MAN OF SCIENCE,

AND WHO, BY HIS RESEARCHES AND WRITINGS,

HAS ADVANCED OUR KNOWLEDGE OF

THE RELATIVE BEARINGS OF GEOLOGY AND BOTANY,

The following Work

IS (BY PERMISSION) DEDICATED,

WITH EVERY SENTIMENT OF RESPECT AND ESTEEM,

BY

THE AUTHOR.

PREFACE.

The object of the present work is to initiate the student into the study of the Structure, Functions, Classification, and Distribution of Plants. The First Part embraces Vegetable Organography, or a description of the tissues of which plants are composed, and of the various organs which are concerned in the processes of nutrition and reproduction, without an accurate knowledge of which it is impossible to make progress in Botanical science. The Second Part includes Vegetable Physiology, or the consideration of the Functions which plants perform in the living state. The Third Part has reference to the Classification of plants—the essential characters of the Classes and Orders being given, along with the properties of the more important species, especially such as are used in medicine or in the arts. In the Fourth Part, the Distribution of plants is considered in a Geographical point of view; and in the Fifth Part, the subject of Fossil Botany is discussed. Directions in regard to the Examination and Preparation of Plants for the Herbarium, Museum, and Microscope, and an explanation of the common Botanical terms, are added as an Appendix.

As it is of great importance that the tyro in Botany should become acquainted with the appearances of plants and of their organs, wood-cuts have been extensively used as illustrations.

The number of these has caused the work to extend over many more pages than was at first contemplated. The publishers have supplied wood-cuts from Maout's Atlas Élémentaire de Botanique, and from Kitto's Biblical Cyclopædia; other cuts have been derived from original sources, as well as from the works of Jussieu, Mirbel, Payer, St. Hilaire, Henslow, Harvey, Greville, Ralfs, Schleiden, Mohl, Amici, Hofmeister, Henfrey, Unger, Lindley and Hutton, and Blackie's Imperial Dictionary. Full explanations of the cuts are given in the notes, and with them are embodied facts relating to Scripture plants, and to other matters not included in the text. At the end of different sections there is inserted a brief recapitulation or analysis of what has been stated in the previous pages; thus enabling the student to see at a glance the principal points which demand his attention; and in the case of subjects requiring further elucidation, references are made to works and papers which may be consulted. In the Histological department of the work there is a description of the microscope and its uses; and lists are given of preparations which may be easily procured for the purpose of illustration.

The Author has to acknowledge his obligation to Dr. Douglas Maclagan, for his assistance in regard to Medicinal and Poisonous plants; and to Dr. George Wilson, for aiding him in the Chemistry of Vegetation.

In prosecuting the science of Botany, the student must ever bear in mind that it is only by the examination of plants in the garden and in the fields, by careful dissections, and by microscopic investigations of living and dead tissues, that he can acquire a correct knowledge of the subject. No book can make up for the want of this; no descriptions nor illustrations can supply its place. All that the teacher can do by his lectures and text-book is to direct the pupil in his researches, and to refer him to the Book of Nature as the guide in his investigations. The student must not be led away by human authority, however distinguished; his motto must be—

Nullius addictus jurare in verba magistri.

While he avails himself of all the aid supplied by eminent Botanists, he must endeavour by personal observation to ascertain the correctness of their statements. He must carefully avoid hasty generalization, and a blind attachment to theories, however plausible. His foundation of facts must be solid if his inductions are to be correct. It is by a patient and laborious search after truth, by a diligent and enlightened questioning of Nature, and, above all, by a humble dependence upon Him "who is before all things, and by whom all things consist," that the botanical enquirer can expect to arrive at satisfactory results.

Edinburgh, January 1854.

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CORRECTIONS AND ADDITIONS.

Page 58, line 19 from the bottom, *before* Bryony *insert* tendril of.
Page 92, line 19, *for* part *read* fact.
Page 108, between paragraphs 161 and 162, insert—

Trecul says that leaves all originate in a primary cellular mammilla, with or without a basal swelling, according as they are to have sheaths or not ; and that they are developed after 4 principal 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 development may be illustrated in 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 contraction 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 subdivided in the same manner 5 or 6 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 are equally numerous with the preceding ; 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 leaf formation of Trecul. 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 the base ; while those which have the whole petiole early exposed to the air, grow much more towards the upper part of the petiole. (Trecul, Comptes Rendus, 1853.)

Page 137, line 13 from bottom, *for* Potamogetous *read* Potamogetons.

Page 234, in note to Fig. 650, *omit* recurved.

Page 244, line 10, *insert* 3 carpels or 3 separate styles; line 11, 4 carpels or 4 separate styles, &c.

Page 268, line 13 from the bottom, *for* Fig. 782 *put* Fig. 780.

Page 294, Fig. 883. Raspberry is put by mistake for Mulberry. The latter fruit is figured at p. 891, Fig. 1656.

Page 295, before apocarpous fruits, put in a separate line, as a general heading—Monogynœcial fruits, formed by the gynœcium of a single flower.

Page 296, before anthocarpous fruits, put Polygynœcial fruits, formed by the gynœcia of several flowers.

Page 296, line 21, *after* Medlar *insert*—in the latter two of which the carpels are covered by the succulent calyx, but not incorporated with it.

Page 421, line 7, *for* serratula *read* serrulata.

Page 439, for additional heights of Pines see pages 908-910.

Page 447, in note to Fig. 1143, *for* Sapindaceæ *put* Malpighiaceæ.

Page 460, headline, *for* yretaw *read* watery.

Page 500, line 30, *for* May *read* January.

Page 561, in Fig. 1194 the flower should be represented as standing above the water.

Page 563, Fig. 1200 is inverted.

Page 571, line 32, after sporangia insert the following—

Thuret has shown that the antheridia of Fuci contain antherozoids which are the immediate fecundating agents. Several of the Fucaceæ are diœcious. When the plants are placed for some time in a damp atmosphere, the spores and antheridia are pushed out on the surface of the fronds in great numbers. They are then easily collected and deposited in vessels filled with sea-water, or simply in a drop of water on a slip of glass, which is protected from evaporation. When kept in separate vessels, the antheridia emit antherozoids, which move about. This goes on for a day or more, while the archegonial cells are decomposed. But if the antherozoids are brought into contact with archegonial cells, then impregnation is effected; the archegonial cell becomes invested with a very distinct membrane in the course of a day or two, a septum is formed, dividing it into two hemispheres, and an elongation takes place at a point in its circumference. The development of the young plant then proceeds rapidly. The septa become numerous, elongation increases, and in about ten days the cell is converted into an ovoid cellular mass (spore) of a brown colour, supported on a transparent radicle. The radicles turn from the light.

Page 644, line 5 from the bottom, *for* graminifolius *put* pygmæus.

Page 750, line 7 from bottom, after Drymis granatensis, *read* which appears to be the same as D. Winteri.

Page 857, line 1, *for* Baba *read* Buba.

Page 1052, line 17 from the bottom, omit three lines beginning with "there," and ending "opposite to the," and insert the following:—"There are two vascular systems, one forming a series of bundles in the medullary axis of the stem, each of the bundles being placed opposite to the wedges of wood internally; and the other going directly to the leaves, the bundles of vessels being placed opposite to the"

Page 1056, line 33, Peuce Lindleyana should be noticed in the Reign of Gymnosperms, as connected with the Lower Oolite.

PART I.

STRUCTURAL AND MORPHOLOGICAL BOTANY.

CLASS BOOK OF BOTANY.

INTRODUCTORY REMARKS.

1. The objects presented to us in the material world are naturally divided into two evident groups—the inanimate or unorganised, and the animate or organised. The study of the former, or of inert matter, is peculiarly the province of Chemistry and Mineralogy; while the consideration of the latter, or of living bodies, belongs to the sciences of Botany and Zoology. Geology, in place of being denominated a separate science, may be considered the means by which the sciences of Zoology, Botany, and Mineralogy, are grouped together in one harmonious system.

2. The substances of which the earth is composed, and the living beings which cover its surface, are mutually subservient to each other; and the adaptations which are opened up to the student of natural science, are well fitted to call forth his admiration of the wondrous works of God. The soil, the waters, and the atmosphere, furnish materials for the growth of plants; these, in their turn, afford food to animals; and from these, along with the fruits of the earth, man derives his nourishment. The decay of living bodies contributes to the formation of vegetable mould, and increases the fertility of the soil. Thus there is a complete circle of transformation, in which matter constantly changes place, and undergoes modifications fitting it for the various purposes to which it is applied. There is a oneness in creation which calls upon the student of nature to take a comprehensive view of all.

3. The different kingdoms of nature, and the different departments of science, pass into each other by insensible gradations. A labourer in one field of science cannot say to the labourer in another, I have no need of thee. Like the members of the body, they are knit together to form one harmonious whole, and their individual efforts are all directed to the same great end. The student of inanimate creation, when he examines the composition of the mineral matters of the globe, supplies to the student of living nature information on which to found his researches; and the latter, in his turn, furnishes data by which the former determines epochs in the history of the crust of the globe. By the researches of the chemist, much has been done to promote the pro-

gress of animal and vegetable physiology, and the study of the functions of living beings; and to the labours of the zoologist and botanist the science of geology is indebted for its most important advances. It is therefore necessary that the student of natural history should not confine his attention to mere isolated portions of creation, but should study the harmonies of all parts of it.

4. Those departments of science which have reference to living bodies, and which are hence termed Biological, are in an especial manner related to each other. No one can be considered a scientific anatomist or physiologist, who does not include in his researches a consideration of the structure and functions both of animals and plants. He must study the forms which they present, the cells and vessels which enter into the composition of both, their mode of nutrition, the circulation of their fluids, their various secretions, their reproductive functions, the movements they exhibit, the diseases to which they are liable, and the decay and death which they undergo. It is only by such means that a correct knowledge can be acquired of vital phenomena.

5. While the higher classes of animals and plants are widely separated from each other, the lowest members of each kingdom approximate so closely, that it is scarcely possible to form a line of demarcation. Some bodies, which Ehrenberg represents as animals, are now considered as belonging to the vegetable kingdom; and there are still many living beings whose place in the system of nature has not been fully determined. Mere external form is not sufficient to give distinctive characters, for, in this respect, there are remarkable similarities. Movements will not constitute a diagnostic mark, for these occur in both; and some beings low in the scale have the organic forces of plants, with the locomotion of animals. Even chemical analysis fails to aid the naturalist; for cellulose, long considered as of a vegetable nature, has now been found in the tunics of Ascidians, and a substance, isomeric with starch, has been detected by Gottlieb in some animal tissues.

6. All researches into the limits between animals and plants lead, as Schmidt remarks, to the conclusion, "that from man to the primary animal and vegetable cell, there exists no gap in the realisation of a general idea upon which nature, as a whole, is based. There is no abrupt transition from one kingdom to another, but an insensible gradation. The spore or germ of the *Vaucheria clavata*, one of the Algæ or sea-weeds, with its vibrating filaments (Fig. 1), seems to resemble the young Medusa and the embryonic cell of the swimming Ascidia. The tunic of the Ascidia (Fig. 3) has the substance and structure of a plant, and so also, in all probability, has the umbrella of the Medusa (Fig. 7). Thus

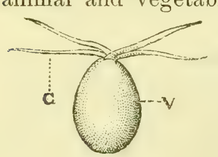


Fig. 1.

Fig. 1. Spore or cellular germ of one of the Algæ (Chætophora); v, vesicle or cell constituting the embryo; c, cilia or moving filaments. From the movements exhibited it has received the name of Zoospore or animal spore.

the embryo-germ of an Alga or sea-weed is identical in elementary composition and form with that of a Medusa or Ascidia; in the former we have the higher stage of development of the plant; in the latter the simpler form of the animal."

7. "Cannot we regard," Schmidt continues, "the Alga as the nurse of its more highly developed embryo? The nurse or the transitionary form of Campanularia exhibits no trace of the phenomena which we necessarily connect with the idea of *animal;* we have here no stomach, no internal cavity for the assimilative process, no spontaneous motion; in short, it is a perfect parent-cell of an Alga. The embryo which, on the bursting of the so-called parent animal, begins to pass through the independent vital cycle, exactly resembles Vaucheria. Like the latter, when the ciliary motion has continued for about two hours, it becomes fixed, and thus attached, is developed into perfect polyps. In the first stage of this process it is a true Alga, in the latter an animal organism. We may regard the Alga as an interrupted formation of the polyp—as a polyp with a simple alternation of generation, whilst Campanularia (Fig. 6) possesses a double one."

8. No chemical or physical difference can therefore be instituted between animals and plants. "Motion is seen in Oscillatoriæ and in the spores of Algæ (Fig. 1), as perfect as in some fixed marine animals. This motion is a necessary fundamental condition of the physical existence of these beings. What the atmosphere is to plants, the ocean is to the adherent marine animals. If the land animals lived in a sea consisting of albumen and hydrate of carbon, they would not require a locomotive apparatus to enable them merely to replenish their formative matter; if the atmosphere contained no carbonic acid, plants would stand in need of locomotion. An internal cavity, for the assimilative process, is to give a great increase of surface to favour the most perfect assimilation. In plants, the whole system of intercellular spaces, and their outlets in stomata or leaf-pores, seems to serve the purpose of an internal cavity. They may be said to combine both the lungs and the intestinal tube. Carbonic acid, the formative material of plants, passes freely through the stomata of the elongated canals of the intercellular spaces, and through the thin-walled cellular extremities of the roots, so as to be taken up into the surrounding cells by diffusion, as formative material; just as albumen and the hydrates of carbon pass through the mouth into the intestinal cavity. As regards respiration, Wöhler has proved that elimination of oxygen takes place in some animals, and it appears that in some fungi carbonic acid is exhaled; and in reference to the substance of the cell-walls, cellulose is found to exist in the cells both of animals and plants. It seems impossible, therefore, in the present state of our knowledge, to give a complete and perfect definition of what is to be considered an animal, in contradistinction to what is to be looked upon as a plant."

9. It is interesting to trace the analogies between the members of the animal and of the vegetable kingdoms, and to observe the wonderful similarity which they exhibit in their various stages of growth and development. The Sertularian polyps (Fig. 2 *a*), with their common stalk bearing numerous individuals (Fig. 2 *b*), each having a certain inherent vital energy, and yet all depending on the general life of the entire compound zoophyte, may be likened to plants producing numerous buds, undergoing certain transformations. A tree may be regarded as a congeries of buds, or separate individuals united on a common stalk. These buds have a certain amount of independent vitality, so that they can be removed and made to grow on other trees by a process of bud-grafting, and yet they are dependent for their continued vigour on the common stem.

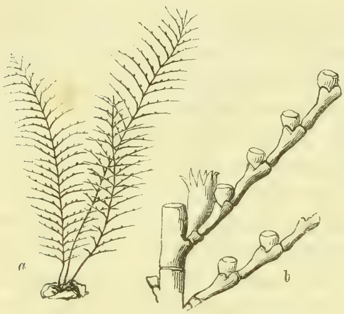


Fig. 2.

10. In some instances, however, leaf-buds are spontaneously detached from plants, as in Bryophyllum calycinum and the bulbiferous lilies, at a certain period of growth, and, on reaching the ground, become at once separate plants. So also, in the case of certain ascidians. Thus in *Clavelina lepadiformis* (Fig. 3) there is a common stalk or

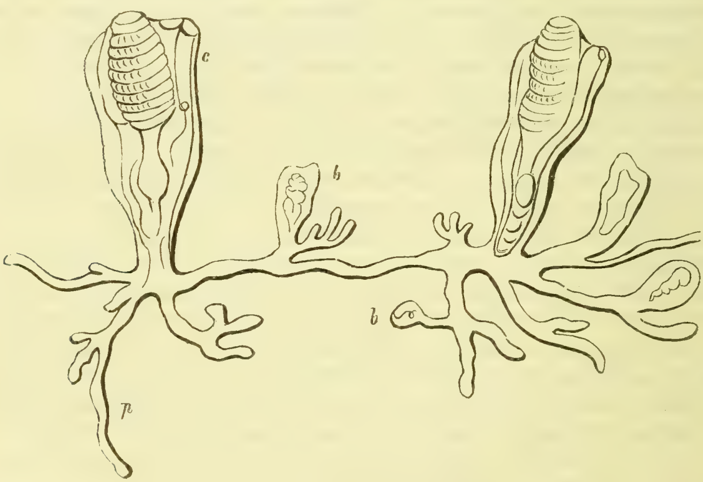


Fig. 3.

Fig. 2. Plumularia pinnata, a compound zoophyte; *a*, natural size of the animal. It may be compared to a tree with numerous living buds; *b*, a portion magnified, showing the separate zoophytes, all of which, except one, have discharged their ova.

Fig. 3. Clavelina lepadiformis, a compound ascidian, with a common stalk like the mycelium or spawn of fungi, and numerous buds *b b b*, in different stages of progress; *c*, the complete animal, capable of living in a detached state.

root-like process, resembling the mycelium or underground stems of mushrooms and other fungi. This stalk gives origin to a series of buds, *b b b*, which are ultimately developed as complete ascidians, *c*. They are then detached as separate individuals.

11. In plants there are two modes in which new individuals are produced, one by the agency of stamens and pistils, or of certain reproductive cells giving rise to seeds or spores containing the embryo plant; the other by the production of leaf-buds, or by the fissiparous division of cells. Animals, in these respects, exhibit resemblances to plants. The most common mode of reproduction in animals is by eggs, equivalent to seeds, depending on the presence of sexes, but the production of buds is by no means rare among some of the lower tribes. Thus, certain medusæ have eggs produced by the agency of testes and ovaries, and at the same time have buds which reproduce the individual. In Figure 4 a representation is given of *Sarsia gemmifera*, a medusa which, besides producing eggs, also exhibits a series of buds attached to a gastric peduncle, *p*. This peduncle, *p*, is highly magnified in Figure 5, and it is seen to end in the mouth at the lower part. Along the sides of the peduncle, buds, *b b*, are developed, and in this state we have a representation of a stalk bearing numerous polyps resembling Campanularia (Fig. 6). These buds, in place of remaining

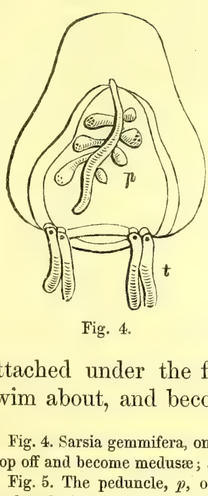


Fig. 4.

Fig. 5.

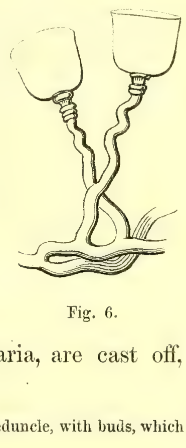


Fig. 6.

attached under the form of polyps, as in Campanularia, are cast off, swim about, and become Medusæ.

Fig. 4. Sarsia gemmifera, one of the naked-eyed medusæ, producing, *p*, a peduncle, with buds, which drop off and become medusæ; *t*, tentacles of the medusa.

Fig. 5. The peduncle, *p*, of Sarsia gemmifera removed, with buds or bulbs, *b b*, which ultimately are detached and become medusæ.

Fig. 6. Campanularia integra magnified. A polyp analagous to that which forms the intermediate state between the egg and the fully developed medusa. The root-like ramifications below resemble the spawn or mycelium of fungi.

12. Analogies may be still farther traced, when we consider the transformations which plants undergo in their various stages of growth, and compare this with the alternations of generation which occur in animals. The seed of a plant, when placed in favourable circumstances, sprouts; a stalk or stem is formed which gives origin to leaf-buds; in due time changes take place, by which flower-buds are formed, and these in their turn form seeds. So it is in the animal kingdom. Polyps and medusæ are, in some instances, different states of the same species. This has been established by the researches of Sars, Dalyell, Steenstrup, and Forbes. The medusa produces eggs which pass through the infusorial state, fix themselves, and become polyps, like Corynæ, Tubulariæ, and Campanulariæ (Fig. 6), and these polyps produce a kind of bud which finally drops off, and becomes a medusa. Thus the egg goes through the intermediate state of a polyp before becoming a medusa. This alternation of generation is similar to the stages of plant-growth, commencing at the seed, and going through the leaf-bud to the flower-bud. Each leaf-bud is an individual as distinct as the polyps in a compound zoophyte. The flower-bud is composed of the same elements as the leaf-bud; but they differ as much as the medusa does from the polyp. The flower-individual arises as a bud from the leaf-individual or the group of leaf-individuals. This is analagous to the buds of Campanularia. The flower-bud, when mature, produces seeds just as the medusa produces eggs. The seed then goes the round of successive or alternating development. "Thus, among plants, leaf-individuals are produced which yield buds becoming flower-individuals, and these, in their turn, produce seeds; in the same way as the animal germ appears as a polyp-bud, and this, on being detached, becomes a medusa, which again produces eggs."

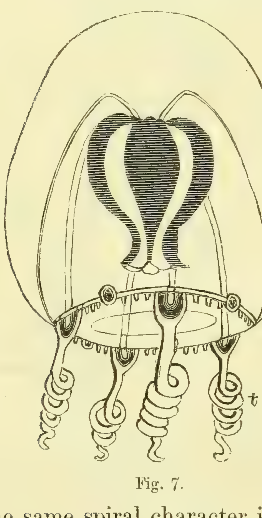


Fig. 7.

13. In tracing the arrangement of the parts of plants and animals, we observe other points of resemblance. Dana remarks, the leaf-bud consists of leaves arranged in a spiral order, and in the polyp some species show tentacles and corresponding parts spiral in development. The same spiral character is seen in the flower, although the volutions, from being closer, appear in a circle. In medusæ (Fig. 7), the regular spheroidal form is more perfectly developed than among the polyps; at the same time, the spiral is seen in their tentacles (Fig. 7, *t*). The

Fig. 7. Modeeria formosa, one of the medusæ, showing the general spheroidal form, and the spiral tentacles, *t*.

only part where analogy seems to fail is, that the medusa bud falls off before its full development, while this is not generally the case in plants. This depends on the difference of nutrition in the two kingdoms of nature. Plant-buds, on separation, usually lose their only means of nutriment; although, as already seen, instances occur where certain buds fall off in an early state, and are capable of independent development.

14. While Botany has thus important bearings on Zoology, it has a still more marked relation to Geology. It enables the geologist to draw conclusions as to the succession of the stratified rocks of the globe, and to determine, in some measure, the nature of the surface and of the climate at different epochs of the earth's history. Professor Phillips remarks, "Geology would never perhaps have escaped from the domain of empiricism and conjecture, but for the innumerable testimonies of elapsed periods and perished creations, which the stratified rocks of the globe present in the remains of ancient plants and animals. So many important questions concerning their nature, circumstances of existence, and mode of inhumation in the rocks, have been suggested by these interesting reliquiæ, and the natural sciences have received so powerful an impulse, and have been directed with such great success to the solution of problems concerning the past history of the earth, that we scarcely feel disposed to dissent from the opinion, that without fossil zoology and botany there would have been no true geology."

15. The stratified rocks of the globe present very distinct floras, and in the examination of them the geologist requires to know thoroughly the microscopic structure of plants, and the arrangement of their cells and vessels. Great service has been rendered to Palæontology in this respect by the beautiful sections of fossil wood first executed by Mr. William Nicol of Edinburgh, whose merits have been too much overlooked of late. Besides the elementary tissues of plants, the geologist must attend to the form of their stems, leaves, and fruit, the scars left by the separation of their different parts, and the minute markings observed on the surface. He must also be fully informed as to the physiological constitution of plants, whether terrestrial or aquatic, their mode of growth, the climates in which they grow, and the nature of the soil in which they flourish. In all these points the labours of the botanist have materially aided the researches of the geologist.

16. There are various marked geological epochs characterised by the predominance of certain great classes of plants. Thus, in the Carboniferous and Permian periods, ferns and their allies prevailed, but associated at the same time with plants higher in the scale; in the periods extending upwards to the Cretaceous epoch, the flora is chiefly characterised by the prevalence of Gymnospermous plants or Dicotyledons with naked seeds, such as Coniferæ and Cycadaceæ; and extending from the chalk to the upper members of the tertiary series, the flora has a greater resemblance to that of the present day in the

predominance of Angiospermous Monocotyledons, and Dicotyledons. Although there is thus a gradation of distinct changes in the flora, still, there is no evidence whatever of any progressive development depending on the transformation of one species into another. There are no grounds for tracing back man to the monkey, or for supposing that, by a gradual series of changes, animals and plants have become more and more perfect and complete. All the facts of science lead to the conclusion, that there are distinct species, which vary within certain limits, and even the alternations of generation already referred to, are evidently circumscribed. The doctrine of transmutation of species is disproved by the best physiological reasonings, and its application to geological phenomena is altogether gratuitous and futile. For a refutation of all such speculative doctrines, and an exposure of their dangerous tendency as regards the cause of truth, we refer to Hugh Miller's Footprints of the Creator, Whewell on the Indications of the Creator, and Sedgwick on the Studies of the University of Cambridge.

17. In its relation to Medicine, Botany must be viewed not only as furnishing the medical man with valuable information in regard to the affinities and properties of plants, so as to enable him to substitute one for another, with certainty in circumstances, when the usual remedies are not at hand; but it must be regarded as an important branch of preliminary study training his mind to habits of observation and diagnosis, which are so essential to the successful prosecution of his profession. The physiology of plants, too, enables him to study in a simple form many of those phenomena which are complicated and obscure in the higher order of living bodies. A complete literary and scientific education tends in no small degree to enhance the attainments of the accomplished physician. "It is of importance that a class of men so widely diffused, and mingling so much with society as the members of the medical profession, should be so instructed as to give a tone to conversation, and to promote among those with whom they associate the love and the pursuit of literary and scientific accomplishments."

18. The science of botany includes everything relating to the vegetable kingdom, whether in a living or in a fossil state. Its object is not, as some have supposed, merely to name and arrange the vegetable productions of the globe. It embraces a consideration of the external forms of plants—of their anatomical structure, however minute—of the functions which they perform—of their arrangement and classification—of their distribution over the globe at the present and at former epochs, and of the uses to which they are subservient. It examines the plant in its earliest state of development, when it appears as a simple cell, and follows it through all its stages of progress until it attains maturity. It takes a comprehensive view of all the plants which cover the earth, from the minutest lichen or moss, only visible by the aid of the microscope, to the most gigantic productions of the tropics. It marks the relations which subsist between all members of the vegetable world, and traces

the mode in which the most despised weeds contribute to the growth of the mighty denizens of the forest. It is a science, then, which demands careful and minute investigations—requires great powers of observation and research, and is well fitted to train the mental powers to vigorous and prompt action.

19. Botany may be divided into the following departments:—1. *Structural* Botany, having reference to the anatomical structure of the various parts of plants, including vegetable Histology, or the microscopic examination of tissues: 2. *Morphological* Botany, or the study of the form of plants and their organs; these two departments are often included under the general term of Organography. 3. *Physiological* Botany, by some termed Organology, or the study of the life of the entire plant and its organs, or the consideration of the functions of the living plant. 4. *Taxological* Botany, or the arrangement and classification of plants. 5. *Geographical* Botany, the consideration of the mode in which plants are distributed over the different quarters of the globe. 6. *Palæontological* Botany, the study of the forms and structures of the plants found in a fossil state in the various strata of which the earth is composed.

PART I.

STRUCTURAL AND MORPHOLOGICAL BOTANY.

20. This department includes a consideration of the minute structure of the various parts of plants, and of the forms which they assume. In prosecuting it the student may either consider analytically the anatomy of each part of the plant at the same time that he examines its form, or he may, in the first place, consider those structures, which enter generally into the composition of every part of the plant, and then study synthetically the mode in which they are grouped together in the different organs. The latter is the method which has been usually adopted, and seems, upon the whole, that which is best fitted for the purposes of the student.

CHAPTER I.

VEGETABLE HISTOLOGY, OR THE STUDY OF THE ELEMENTARY STRUCTURE OF PLANTS.

21. The elementary tissues of plants are few and simple. They consist of organs to which the names of *cells* and *vessels* are given. The former are minute bladders or vesicles (Fig. 8), varying in size and

Fig. 8.

form, which, when united together, constitute *Cellular tissue* (Fig. 9); while the latter are closed tubes of an elongated form, frequently tapering to each end (Fig. 10), and, when combined, constituting *Vascular tissue.* The distinction between cells and vessels is founded on their comparative length. Occasionally, however, cells become lengthened, as in the case of some hairs, and the filamentous or thread-

Fig. 8. Two cells or vesicles taken from the Elder (magnified).

like tissue of Fungi (Fig. 11), so as not to differ from vessels as regards length. Such long cells are distinguished chiefly by the thinness and delicateness of their texture.

22. On making a transverse section of a succulent stalk, such as that of Rhubarb, or of a cucumber or melon, we perceive, by the aid of a glass, circumscribed angular meshes and rounded openings; and, in a longitudinal section of the same stalk, similar meshes are also seen with long tubes of various kinds. The angular spaces are cells such as those seen in Figure 12, and the tubes having rounded open-

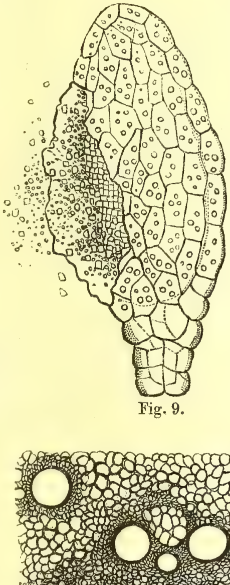


Fig. 9.

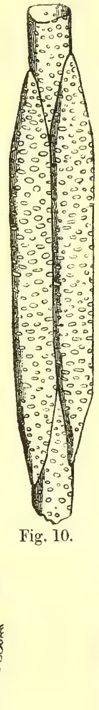


Fig. 10.

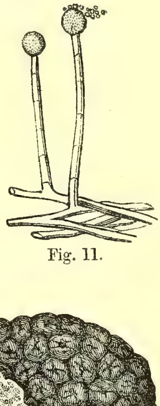


Fig. 11.

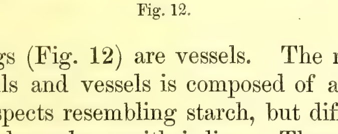


Fig. 12.

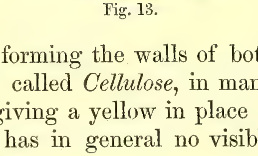


Fig. 13.

ings (Fig. 12) are vessels. The membrane forming the walls of both cells and vessels is composed of a substance called *Cellulose*, in many respects resembling starch, but differing in giving a yellow in place of a blue colour, with iodine. The membrane has in general no visible

Fig. 9. Cellular tissue from Liverwort, a cellular plant (magnified).

Fig. 10. Spindle-shaped vessels, or closed tubes united, and forming vascular tissue (magnified).

Fig. 11. Mould fungus, composed of cells, those at the root being long and tube-like (magnified).

Fig. 12 Section of a bamboo, after a specimen cut by Mr. W. Nicol, showing angular meshes of cells and rounded openings of vessels (magnified).

Fig. 13. Truffle (*Tuber cibarium*) a subterranean fungus, consisting entirely of cellular tissue.

pores or perforations; but fluid matters pass through it easily. Some plants, such as truffles (Fig. 13), mould (Fig. 11), Liverworts (Figs.

Fig. 14.

Fig. 15.

14 and 15), and Lichens, consist of cellular tissue alone, and hence are called Cellular plants; while others, such as ordinary flowering plants, consist of cells and vessels combined (Fig. 12), and receive the name of Vascular plants.

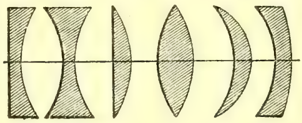
I. ON THE USE OF THE MICROSCOPE IN THE EXAMINATION OF VEGETABLE TISSUES.

23. The study of the minute tissues of plants is denominated Vegetable Histology. In prosecuting it, the student must have recourse to the microscope, an instrument of great value, both to the anatomist and physiologist, and which it seems to be proper, in the first instance, to describe. In carrying on histological examinations, it must be borne in mind that it is not enough to possess a good

Figs. 14 and 15. Liverwort (*Marchantia polymorpha*), a cellular plant, showing its various kinds of fructification, which will be afterwards noticed.

microscope; there must also be the power of using it properly. Constant practice is required in order to be able to do so, and hence the value of a regular course of instruction in histology. In ordinary botanical dissections, it is seldom necessary to use a very high magnifying power; it is chiefly when examining some of the points connected with the formation of the embryo and the motions of fluids that such aid is required.

24. *Lenses.*—The ordinary lenses in use are the *double convex* (Fig. 19), with two convex faces; *plano-convex* (Fig. 18), with one convex and one flat-face; *meniscus* (Fig. 20), with a convex and concave face, and a sharp edge, the concave face having the larger radius; *concavo-convex* (Fig. 21), with a concave and convex face of equal radius, the edge being flat; *plano-concave* (Fig. 16), with a flat and concave face, and *double concave* (Fig. 17), with two concave faces. The first three (Figs. 18, 19, 20) are called sharp-edged or convex lenses, and cause parallel rays to converge, or to come to a focus; the last three (Figs. 16, 17, 21) are called flat-edged or concave lenses, and cause divergence. By a combination of convex and concave lenses, certain advantages are obtained which will be afterwards noticed. The focus of a lens is the point to which the rays converge. The magnifying power of a lens is estimated by its focal length, or the distance of the focus from its centre. The focal distance of the eye varies from 6 to 12 inches, and hence 10 is taken as the mean. This number is a convenient one, for, by adding a cypher to the denominator of the fraction expressing the focal length of a lens, we give its magnifying power. Thus, a lens whose focal length is $\frac{1}{4}$ of an inch, is said to magnify 40 times.



25. *Simple Microscope.*—The most useful instrument for a botanical student is the simple microscope, in which the object is viewed directly through a lens, so arranged as to be capable of being adjusted, by means of a screw, to its exact focal distance, and of being moved over different parts of the object. The single lenses used may be either a double convex or a plano-convex. When higher powers are wanted, a *doublet* may be employed, consisting of two plano-convex lenses of different focal lengths, viz., one to three, placed at a certain distance from each other, with a stop between them to limit the aperture; or a Coddington or periscopic lens, consisting of two hemispherical lenses, cemented together by their plane faces, having a stop between them, or rather having a groove in the whole sphere filled with opaque matter. In the simple microscope, single or combined lenses may be used, varying in focal lengths from $\frac{1}{4}$ to $1\frac{1}{2}$ inch.

26. In ordinary lenses, such as those described, there are sources

Figs. 16-21. Different kinds of lenses—16. Plano-concave. 17. Double concave. 18. Plano-convex. 19. Double convex. 20. Meniscus. 21. Concavo-convex. 18, 19, 20, are sharp-edged lenses, and cause convergence. 16, 17, 21, are flat-edged, and cause divergence.

of confusion both from their form and from the nature of the glass of which they are made. These two causes give rise to what are termed *aberrations* of *sphericity* and *refrangibility*. The former, called also *spherical aberration*, depends on the circumstance of a convex lens, or one with a spherical surface, not bringing all the rays exactly into one focus; while the latter, denominated also *chromatic* (coloured) *aberration*, depends on the different refractions of the rays in passing through glass, which thus causes the objects to be coloured. In the human eye the variable curvature of the lens is with the view of correcting aberration, while its variable density seems to alter the figure of it under pressure. When using low magnifying powers these aberrations do not materially interfere with the accuracy of the observation, and this may be remedied to a certain degree by means of a *diaphragm* or *stop*, which diminishes the aperture, and, consequently, the pencil of light, by stopping the rays passing through the margins of the lens. Although, in such a case, however, the pencil of light may not suffer much distortion, yet it is often too small to shew the markings which we wish to see. There is a want of *definition*, as it is termed, in consequence of the moderate light not bearing dispersion over the magnified picture. In more minute observations, however, especially with the compound microscope, it is essential to have lenses which are free from all sources of confusion, and which combine a large aperture with definition. Hence the value of achromatic lenses (Fig. 22, *a*), composed of a double convex lens of plate or crown-glass, and a plano-concave of flint-glass (Fig. 22, *b*). The combination of these different forms of lenses, constructed of materials having different dispersive powers, is found to remedy the defects attributable to aberration. In the achromatic glass, the two kinds of lenses are accurately fitted together, and united by Canada balsam. In the finest compound microscopes, all the glasses are achromatic, and several are combined in one piece.

b *a*

Fig. 22.

27. *Compound Microscope.*—The compound microscope is constructed on a different principle from the simple one. In using it, the observer does not view the object directly, but a picture or image of the object is formed by one lens or set of lenses, and that image is seen through another lens. The lens next the object is called the *object-glass* or *objective;* that next the observer is the *eye-piece* or *ocular.* The object-glass is generally made of two or three achromatic lenses fixed in a tube, as seen at *o*, in Figure 24, while the eye-piece consists of two plano-convex lenses (Fig. 24, E and C), with their flat-faces next the eye, and separated at half the distance of the sums of their focal lengths, with a diaphragm between them (Fig. 24, B).

28. In Figure 23, a representation is given of one of Smith and Beck's microscopes, for students. A is the brass stand, supported firmly on three feet, and having two upright flat cheeks, to the top of which

Fig. 22. *a*, An achromatic or aplanatic lens, consisting of a double convex lens of plate-glass, and a plano-concave of flint-glass. *b*, Section of the plano-concave lens.

the stage-plate, *d*, is fixed. Into the stage-plate is screwed an upright round tube, to which is attached an open tube, *g*, in which the body of the instrument, *f h*, slides. By moving the body up and down in this tube, the coarse adjustment is effected, and when the instrument is brought near to the object on the stage-plate, *d*, a finer adjustment is made by means of the screw with the milled head, *e*, which either raises or depresses the part by which *g* is attached to the upright tube. The mirror is represented at *b*, supported on trunnions, and capable of motion upwards or downwards, so as to reflect the light on the object placed on the stage-plate; *c* is the diaphragm or stop, or perforated plate attached to the stage, with the view of shutting off the extreme rays of light. The object-glass or objective is placed at the lower end of the instrument, *f*, and the eye-piece or ocular, at the upper part, *h*.

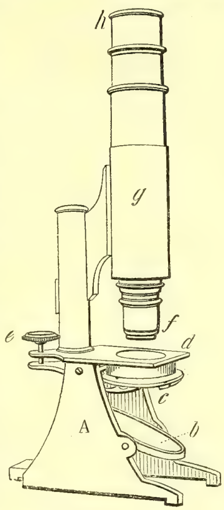


Fig. 23.

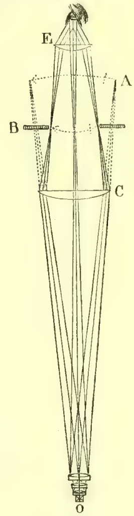


Fig. 24.

29. In Figure 24 a diagram is given to explain the mode in which the compound microscope acts. In this figure, *o* is the object, above which is seen the triple achromatic object-glass or objective, consisting of three achromatic lenses, which are combined in one tube; E C is the eye-piece or ocular, consisting of two plano-convex lenses, one at E, being the eye-glass, and the other at C, the field-glass. Three rays of light are represented as proceeding from the centre of the object, and three from each end of it. These rays have a tendency to proceed so as to form an image of the object at A, but coming in contact with the field-glass C, they are made to converge and meet at B, where the diaphragm is placed to intercept all light except what is necessary for the formation of a perfect image. The image formed at B is viewed as an original object by the observer through the eye-glass E.

30. The magnifying power of the compound microscope depends on the sum of the magnifying powers of the object-glass and the eye-

Fig. 23. Smith and Beck's compound microscope for students. A, brass stand, supported on three feet; *b*, mirror supported on trunnions; *c*, diaphragm; *d*, stage-plate on which the object is placed; *e* screw with milled head for fine adjustment; *g*, brass tube in which the body of the instrument is moved, so as to effect the coarse adjustment; *f*, the object-glass, or objective; *h*, the eye-piece or ocular.

Fig. 24. Diagram to shew the mode in which the compound microscope acts. O, an object, with three rays of light from its centre, and three from each of its ends; E C, eye-piece, consisting of two plano-convex lenses—one at E, the eye-glass, the other at C, the field-glass; B, diaphragm; A, the point where an image would be formed if the rays were not made to converge by the lens C.

piece; and its power may be increased or diminished by a change in either, or both of these glasses. It is better, however, to increase the power by a change of the object-glass than by altering the eye-piece. In the instruments made by Ross, the following are the effects produced by different combinations of eye-pieces A, B, C, and object-glasses of different focal lengths, the magnifying power being estimated in lineal measure, or by diameters, as it is called :—

Eye-Pieces.	Object-Glasses.					
	2 Inches.	1 Inch.	$\frac{1}{2}$ Inch.	$\frac{1}{4}$ Inch.	$\frac{1}{8}$ Inch.	$\frac{1}{12}$ Inch.
A	20	60	100	220	420	750
B	30	80	150	350	670	950
C	40	100	200	470	870	1200

31. In the compound microscope there are mechanical parts which are connected with the general form and appearance, and there are optical parts which determine its value as an instrument for histological researches. In the mechanical arrangements, it is of importance to have steadiness, easy means of adjustment, and facility for making observations; while, as regards the optical parts, a flat field of vision, clearness of definition, and complete achromatism, are of the highest consequence. A magnifying power of 200 or 250 diameters or linear, is sufficient for examining ordinary vegetable structures. The object-glasses may vary from $1\frac{1}{4}$ to $\frac{1}{4}$ of an inch in focal lengths.

32. In measuring minute objects, an instrument called a *Micrometer* is used. The ordinary stage-micrometer consists of a piece of glass ruled at intervals of $\frac{1}{100}$ of a millimetre, or about $\frac{1}{2500}$ of an inch apart. On this the object to be measured is placed, so that both it and the lines may be visible at the same time under the microscope. This, however, cannot always be accomplished easily, more especially under high magnifying powers. The eye-piece micrometer consists of a scale ruled on glass, and inserted in the diaphragm of the ordinary eye-piece of the compound microscope. With this instrument, when using a magnifying power of 500 or 600 diameters, we can estimate spaces of $\frac{1}{5000}$ to $\frac{1}{7500}$ of an inch with tolerable precision. The cobweb screw-micrometer, constructed of fine wires or cobwebs, which are made to separate from each other by means of a delicate screw, is employed for minute observation, but it is very apt to become deranged by the effects of friction causing the screw to wear unequally. In observations of extreme delicacy, Welcker's micrometer has been lately recommended as the best. It surpasses the cobweb screw-micrometer in elegance of principle and in cheapness.*

* A full description of it is given by Dr. Robertson in the Edinburgh Monthly Journal of Medical Science for April 1851.

33. In making drawings of microscopic objects, a *Camera lucida* is useful, in which, by means of a prism and a metallic speculum, the representation of the magnified object is thrown upon paper. In testing the power of an instrument, certain objects are used, in which peculiar markings occur, which can only be properly seen by a fine instrument. Either artificial or natural objects may be chosen as test-objects. The former have been prepared by Robert, a Konigsberg optician, and consist of glass plates, on which are ruled, with a diamond, systems of a hundred lines, which, 10 by 10, approach closer together and are finer, according to a definite standard. With most instruments only the 6th and 7th systems can be distinctly made out to be composed of separate lines. Superior instruments reach the 8th and 9th. No instrument has yet reached the 10th system, with its component lines. The best test-objects are the natural ones, as being regular and uniform in their markings, such as the scales of Podura or Lepisma. The cross striæ of Hipparchia Janira, a very common brown butterfly, can only be seen distinctly by the best instruments.

34. Vegetable structures, when examined by the microscope, may be viewed either by transmitted light, as transparent objects, or by reflected light, as opaque objects. In the former case, they are put on slides of thin plate glass, three inches by one, some water is added, they are then covered with very thin pieces of crown or plate glass, and the light is thrown on them by the mirror below the stage. Examinations of tissues are best made during the day, with the light reflected from a white cloud. When observations are made at night, a sperm-oil lamp is used, and the light is transmitted to the mirror through a plano-convex lens, called a condenser. To correct the unpleasant glare attendant on the reflected light from an ordinary mirror, Mr. Handford makes a mirror of thin concave-glass, three inches in diameter, the back rendered white by plaster of Paris. This is mounted on brass, and fitted over the frame of the ordinary silvered mirror, thus not requiring the latter to be removed. The advantage is, that the whole rays reflected from the surface of plaster of Paris are brought into one focus, together with those reflected from the surface of the glass, and thus an equal and brilliant light is produced. In viewing opaque objects, the light is thrown by the condenser directly on the object, and sometimes a metallic speculum, called a *Lieberkuhn*, is connected with the object-glass, by means of which an additional supply of light is obtained.

35. When mounting or putting up vegetable preparations for permanent use, the objects are preserved either in alcohol or a weak solution of creasote, and the thin glass is cemented over them by black japan varnish. For preserving microscopic objects, as mosses, Dr. C. Müller takes clear talc, splits it into thin layers, and cuts it into oblong pieces of proper size. Then, with a penknife, he splits one of these pieces (from one of the narrow sides) *half-way through*, so that it may be opened to admit the object, and then close by its elasticity, the unsplit end serving as a holder. A drop of water is introduced

into the slit with the object; when laid aside it dries, and may be again rendered fit for use by dipping in water. This does for mosses, but it will not answer for minute structure, which spoils on drying.

36. Schleiden gives the following method of preserving minute structures for the microscope. Upon a glass slide of the common form, two narrow slips of paper are gummed, of a thickness proportioned to the object, and at a distance which is regulated by its size. Between these the object is laid in a drop of solution of chloride of calcium (one dram to half an ounce of water). A thin slip of glass, sufficient to cover the object and paper-slips, is put on; the slips are gummed, and the thin glass applied to its place, where it is retained by the gum drying. The whole may be secured by pasting a long slip of paper over all, with a hole for the object. The advantage of this method is preventing *running in.* Chloride of calcium being deliquescent, never dries up, and, if evaporation takes place, water is easily introduced at the open sides of the thin glass. The points to be attended to are—1, that the paper between the glasses be thick enough to prevent much pressure on the object, and not so thick as to allow it to float about or fall out at the side; 2, that the drop of solution be not too large, but covering the object, and yet not reaching the paper. Glycerine may be used in place of chloride of calcium in cases where the objects are very delicate, or contain chlorophyll or albumen.*

II. CELLS AND CELLULAR TISSUE.

37. Cellular tissue is generally called *Parenchyma*, and it also receives the names of Areolar, Utricular, and Vesicular tissue. It exists more or less in all plants, and abounds in fleshy roots, stems, and leaves, and in succulent fruits. It constitutes the pith and outer bark of trees, and the central part of rushes, of the Papyrus (Figs. 25 and 26) and of the Rice-paper plant. By cultivation, the turnip, carrot, cabbage, and other esculent vegetables, acquire much cellular tissue, and become tender and succulent. The bladders or cells (Fig. 40, p. 21), of which the tissue is composed, vary in size. In a cubic inch of a leaf of the Carnation, there are said to be upwards of three millions of cells. They are frequently seen $\frac{1}{1000}$, $\frac{1}{500}$, and $\frac{1}{300}$ of an inch in diameter. In some of the Cucumber tribe, and in the pith of aquatic plants, large cells, $\frac{1}{50}$ and $\frac{1}{30}$ of an inch in diameter, occur.

* For a complete account of the various kinds of microscopes, and their use in histology, see "Practical Treatise on the Use of the Microscope, by John Quekett;" also Ross's article Microscope in the Penny Cyclopædia; and Schacht, Das Microscop. Berlin, 1851.

38. Cells are either surrounded by a simple thin membrane, or by thickened walls. The thickening of the walls of cells takes place by a deposit of woody matter on the inside, as seen in the microscopic structure of the hard shell of the Coco nut and Piaçaba fruit, in the stone of the peach and cherry, and in the seed of the Ivory and Date palms. Occasionally, rounded portions of the cell-wall are left uncovered by deposits, giving rise to the formation of *Porous*, or *Dotted*, or *Pitted* cells (Figs. 27 and 41); while, at other times, the thickening matter assumes the form of a ring or of a spiral coil, thus constituting *Annular* (Fig. 28) and *Spiral* cells (Fig. 29). In Vaucheria, Chætophora (Fig. 30), and other sea-weeds, peculiar reproductive cells called spores are met with, having thread-like filaments surrounding them, which exhibit a vibratile motion resembling that of the cilia of animal mucous membranes. Some of these ciliated spores are represented in Figures 31, 32, 33, and also in Figure 1, p. 2. In Equisetum or horse-tail (Fig. 34), there are reproductive cells, which are surrounded by two filaments, with thickened clavate or club-shaped extremities (Figs. 35, 36), which are remarkably hygrometric, and exhibit movements when breathed upon. In Figure 35, the filaments are coiled round the cell; in Figure 36, they are expanded.

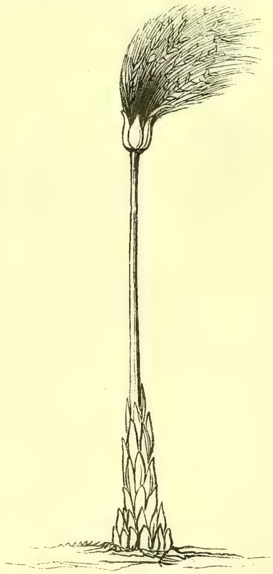


Fig. 25.

39. When formed of cells composed of a homogeneous or uniform membrane, the tissue is called *Membranous* cellular tissue; when of spiral cells it is denominated *Fibrous* cellular tissue, or *Inenchyma* (from a Greek word signifying fibres, with the general termination *enchyma*, applied to tissue). Elongated cells or tubes, with pointed extremities (Fig. 45, p. 23), when united together, form the tissue called *Prosenchyma*. The membranous walls of some elongated cells occasionally unrol in a spiral manner. Quekett has noticed this in hairs taken from the fruit of Cycas revoluta (Fig. 37). Spiral cellular tissue exists in many Orchids (Fig. 38), as Stelis, Oncidium, and Pleurothallis; also in the outer covering of the seed of Collomia linearis, and of the fruit of Salvia verbenaca wild clary. The spiral cells in the last two mentioned cases, when placed in water under the microscope, exhibit interesting movements, owing to the solid spiral fibre rupturing the softened membrane of the cell, and expanding in all directions. In some of these cases, the spiral coils are

Fig. 25. Papyrus antiquorum, found in the Nile. Its stem contains much cellular tissue. In the figure the plant is shewn before flowering, with numerous scales at the base.

of a gelatinous consistence, and lie loose in the cells. In Liverworts (Figs. 14, 15, p. 12) and other cellular plants, spiral fibres, called *Elaters*, are found in spindle-shaped cells (Fig. 39).

40. Cells differ in form according to the mode in which they are aggregated. They are frequently rounded or spherical (Fig. 40);

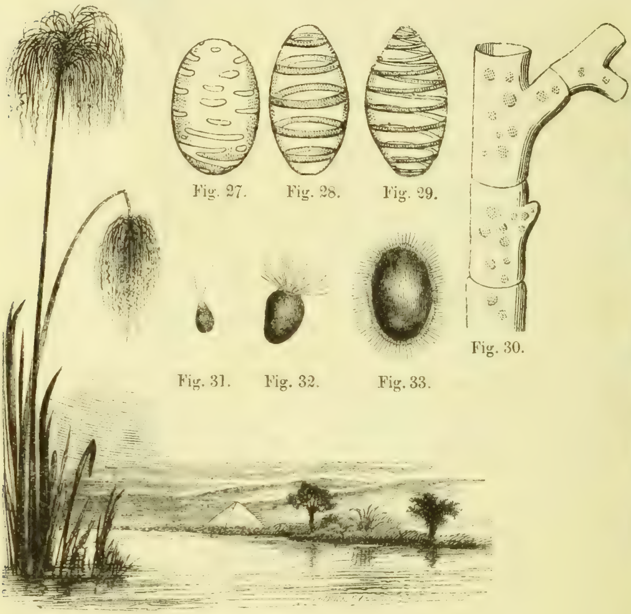


Fig. 27. Fig. 28. Fig. 29. Fig. 30. Fig. 31. Fig. 32. Fig. 33. Fig. 26.


Fig. 34.

at other times they present angular (Fig. 41) or elongated (Fig. 42) forms, such as pentagonal or five-angled, hexagonal or six-angled, prismatic, square, fusiform or spindle-like. When the cells are so placed as to touch each other on every side, the Parenchyma is called *complete*. This is seen in the dodecahedral or twelve-sided, and prismatic Parenchyma of pith, and in the flat tabular Parenchyma of the outer corky bark of trees. When the individual cells touch each

Fig. 26. Papyrus antiquorum, with clusters of flowers hanging down. The plant was used in ancient times to furnish paper. It is the Bulrush of the Bible, and is called in Hebrew Gome.

Fig. 27. Porous or pitted, and reticulated cell from the mistleto.

Fig. 28. Annular or ringed cell from the mistleto. The fibre inside is in the form of a complete ring.

Fig. 29. Spiral cell, or cell with a spiral fibre inside, from an orchid.

Fig. 30. Chætophora, one of the algæ. A cellular plant composed of cylindrical cells, containing granules.

Fig. 31. Small cell or spore, with two vibratile filaments.

Fig. 32. Spore with numerous cilia at one end.

Fig. 33. Spore with numerous cilia surrounding it.

Fig. 34. Equisetum Telmateia, one of the species of horse-tail. It has much silica in its composition, and the fructification, with hygrometric cells, is at the apex.

other only at certain points, the Parenchyma is *incomplete*. This occurs in the case of the spherical and elliptical cells (*merenchyma*) of succulent plants, such as the Cactus (Fig. 43), and in the *stellate* or star-like cells of the rush, Callitriche verna and Bean (Fig. 44). In incomplete Parenchyma spaces are left between the cells, which are

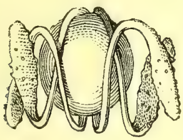


Fig. 35.

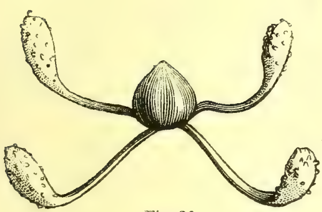
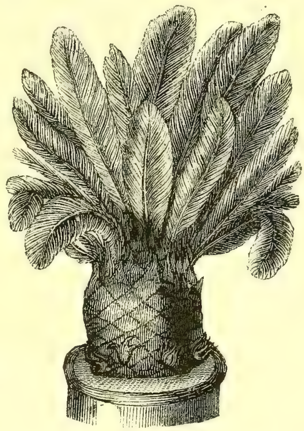


Fig. 36.



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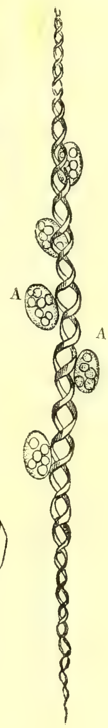

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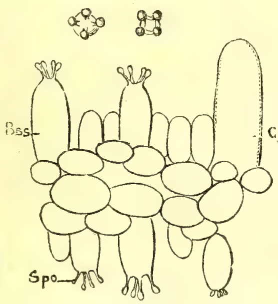

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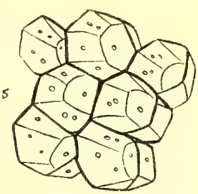

Fig. 41.

Fig. 39.

either large circumscribed cavities called *lacunæ* (Fig. 44), or continuous passages called *intercellular canals*. The spaces between the

Fig. 35. Spore of Equisetum in the moist state, with two filaments coiled round it. Each filament has two club-shaped extremities.

Fig. 36. The same spore or cell in the dry state, with the filaments uncoiled.

Fig. 37. Cycas revoluta (¶ 39), a plant yielding a substance like sago. It has naked seeds.

Fig. 38. An orchid (*Maxillaria*) of warm climates, containing spiral cells in its composition.

Fig. 39. Elaters, or spiral fibres, with spores or reproductive cells A A, from liverwort (*Marchantia*). The fibres are elastic, and serve to scatter the spores.

Fig. 40. Cells of the mushroom, loose and more or less oval or elliptical in form, with cavities between some of them. The letters refer to the different forms of reproductive cells, to be afterwards noticed; and the spores are represented above the figure.

Fig. 41. Hexagonal cellular tissue from pith of Elder. The cells are dodecahedral and dotted.

cells are filled either with fluids of different kinds, or with air. Occasionally the intercellular substance assumes a thickened or corky

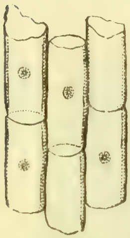

Fig. 42.

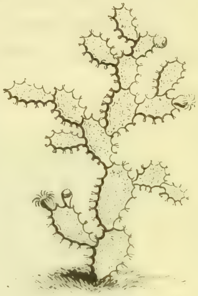

Fig. 43.

Fig. 44.

consistence, and unites the cells firmly; and it appears to be sometimes prolonged over the surface of the plant in the form of a cuticular covering.*

III. VESSELS AND VASCULAR TISSUE.

41. The vessels of plants which collectively form vascular tissue, may be considered as differing from cells chiefly in their length. They are closed tubes tapering to each extremity. Their walls are composed of the chemical matter called cellulose in a membranous form, and they are thickened and altered in various ways by the formation of deposits in their interior.

42. *Woody Tissue.*—This is composed of thickened tubes or elongated cells, with conical extremities overlapping each other, as seen in Figure 45. The tubes are said to be fusiform or spindle-shaped, and the tissue has received the name of *Pleurenchyma*, from a Greek word meaning a rib, on account of the support which it furnishes to the stems and leaves of plants. The woody portion of trees and shrubs, and of all the ordinary flowering plants, consists in part of this tissue. It exists also in the inner bark, and in the veins of the leaves. The materials used for ropes and cordage, linen, certain Indian muslins, mummy cloth, and mats, consist of the woody fibre of plants from which the more delicate tissues have been removed by maceration in

Fig. 42. Elongated cylindrical cells of the lily. Several of them contain a nucleus or cytoblast.
Fig. 43. Opuntia vulgaris, one of the succulent plants belonging to the Cactus tribe.
Fig. 44. Stellate or star-like cells of the Bean, with lacunæ or intercellular spaces.

* Mohl, sur la Connexion des Cellules des Plantes. Ann. des Sc. Nat. 2d ser. viii. 304.

water. Flax or lint is thus procured from the bark of Linum usitatissimum (Fig. 46), hemp from Cannabis sativa (Fig. 47), New Zealand flax from Phormium tenax (Fig. 48), Pita flax called in Sicily Zambarone from Agave Americana, Sun-hemp from Hibiscus cannabinus, and bass or bast from the common Lime or Linden-tree. Fibres are also procured for manufacture from the Pine-apple plant (Ananassa sativa), from Yucca gloriosa (Fig. 49), from Boehmeria nivea, which yields the Chinese grass fibre, from most of the plants belonging to the

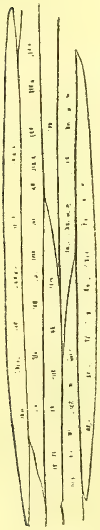

Fig. 45.

Fig. 46.

Fig. 47.

mallow and nettle tribes, and from some of the leguminous plants, such as Crotalaria juncea, which supplies a kind of Bengal hemp.*

43. The tenacity of different kinds of woody fibres, as contrasted with silk, is given in the following table, by De Candolle :—

Silk supported a weight of . . .	34
New Zealand Flax, ...	$23\frac{4}{5}$
Common Hemp, ...	$16\frac{1}{3}$
Common Flax, ...	$11\frac{3}{4}$
Pita Flax, ...	7

44. If the maceration of the fibre is carried to a great extent, a pulp is formed from which paper is manufactured. In ordinary paper the

Fig. 45. Woody tissue or pleurenchyma, consisting of fusiform or spindle-shaped tubes overlapping each other. Sometimes the term prosenchyma is applied.

Fig. 46. Linum usitatissimum, the Flax plant, called in Hebrew, Pishtah, and in Greek, Linon.

Fig. 47. Cannabis sativa, the Hemp plant. Staminiferous or male flower.

* Specimens of these, and of many other kinds of vegetable fibres, are deposited in the Museum of the Edinburgh Botanic Garden. In particular, two beautiful specimens of Chinese grass-cloth, made from Boehmeria nivea, have been presented by Dr. Cleghorn.

vegetable structure is destroyed, but in rice-paper, which is not prepared by maceration, it is preserved. This can be easily seen on examination with the microscope. By a similar mode of examination the texture of articles made from vegetable tissues may be ascertained.

45. Pleurenchyma does not occur in cellular plants, such as Mosses, Lichens (Fig. 50), Liverworts (Figs. 14, 15, p. 12), Seaweeds, Mushrooms and other fungi (Figs. 11 and 13, p. 11). The tissues of these plants speedily disappear under the action of water, and hence, perhaps, the reason of their rarity in a fossil state. In the very young state woody tubes are delicate, and it is only in proportion as they attain maturity that their walls acquire a thick consistence. This depends on the formation of layers of cellulose, which have received the name of lignin or sclerogen. In the sap-wood of ordinary trees the woody tubes are thickened in their walls, but are pervious; while in the heart-wood they are rendered solid by the deposited matter, which is often variously coloured. Some of the fully formed woody tubes, when cut across, exhibit distinct zones or circles of ligneous deposit. The diameter of the woody tubes varies from $\frac{1}{2000}$ to $\frac{1}{200}$ of an inch.

Fig. 48.

Fig. 49.

Fig. 50.

46. *Punctated or Disc-bearing Woody Tissue.*—This kind of woody fibre or pleurenchyma is seen in firs (Fig. 51) and other cone-bearing trees, when a section is made in the direction of the rays running from the centre to the circumference of the stem. It is sometimes called glandular woody tissue. The fibres exhibit under the microscope discs or large circular dots, which are saucer-like spaces or depressions on the walls of the tubes. They are seen in Figure 52. When two woody tubes lie together face to face, the depressions or hollowed-out spaces on each of them are applied like two watch glasses leaving lenticular cavities, which are sometimes filled with air. When viewed

Fig. 48. Phormium tenax, New Zealand Flax plant, which yields very tenacious fibres.
Fig. 49. Yucca gloriosa, Adam's needle, a Liliaceous plant which yields fibres.
Fig. 50. Lichen (*Parmelia*) with rounded spots of fructification containing minute germs.

by transmitted light under the microscope, these appear like circular discs. The dot seen in the centre of the disc depends on a portion of the wall being thinner than the rest. In Figure 53 this structure is seen in a magnified form. The walls of the fibres or tubes are marked

Fig. 51.

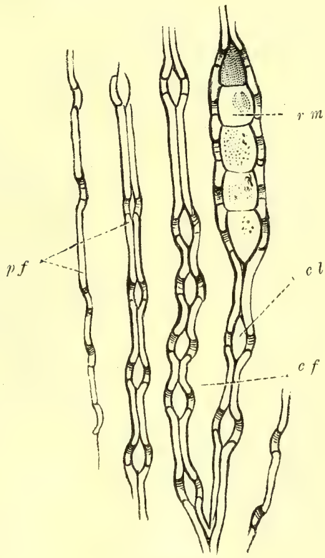

Fig. 53.

Fig. 52.

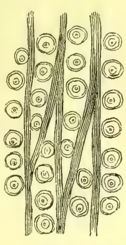

Fig. 54.

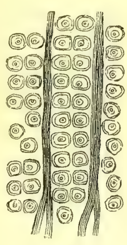

Fig. 55.

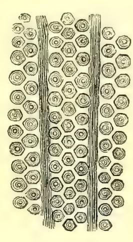

Fig. 57.

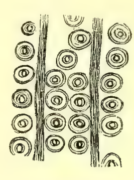

Fig. 56.

p f, the internal cavity of the fibre *c f*, and the lenticular cavities *c l* formed between the two contiguous fibres, *r m* being one of the cellular

Fig. 51. Pinus sylvestris, common Scotch fir. Like other Coniferæ or Cone-bearers, it has punctated woody tissue in its stem and branches, and scarcely any porous vessels.

Fig. 52. Punctated or disc-bearing woody fibre of the fir.

Fig. 53. Vertical section of part of the stem of a fir, to shew the formation of the discs. *p f* marks the walls of the same fibre or woody tube. *c f* is the cavity of a woody tube. *c l* one of the lenticular cavities formed by two contiguous tubes. These cavities appear as discs by transmitted light. *r m* medullary ray, consisting of cellular tissue proceeding from the centre to the circumference.

Fig. 54. Disc-bearing woody tubes of the pine. Single rows of discs on each tube (after Nicol).

Fig. 55. Disc-bearing woody tubes of the pine, with a double row of discs on each fibre (after Nicol).

Fig. 56. Section of vessels of Pinus Strobus, Weymouth pine, showing a double row of discs, each row consisting of discs at the same level, or opposite to each other (after Nicol).

Fig. 57. Section of woody tubes of Araucaria, shewing double and triple rows of discs, which are alternate with each other (after Nicol).

rays proceeding from the centre to the circumference, interposed between the walls of two contiguous fibres. In the case of some fossil woods, pieces of silica like double-convex lenses have been removed from the cavities. The discs are in single, double, or triple rows (Figs. 54–57). When there is more than one row, the individual discs in the rows are either at the same level, that is, opposite to each other (Figs. 55, 56), as in the case of ordinary pines (Fig. 51), or they are at different levels, that is, alternate with each other (Fig. 57, 58), as in Arau-

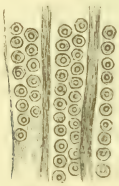

Fig. 58.

Fig. 60.

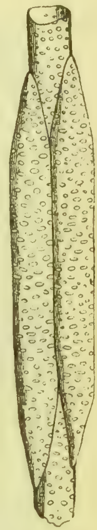

Fig. 61.

Fig. 59.

Fig. 62.

carias and Altingias (Fig. 59). Mr. William Nicol, than whom no one has devoted more attention to the structure of wood, was the first to apply these characters to the determination of fossil woods. Sometimes spiral fibres are seen between the discs. Woody tissue with discs, but without the central dot, occurs in many plants, as in Wintera aromatica (Fig. 60), the plant which yields Winter's bark, Illicium floridanum, and in some other trees.

Fig. 58. Sections of woody tubes of Altingia excelsa, shewing double rows of discs which are alternate, each disc being at a different level from that next to it.

Fig. 59. Altingia excelsa, Norfolk Island pine (after Hugh Miller), from a specimen transplanted during summer into the open ground of the Edinburgh Botanic Garden.

Fig. 60. Wintera aromatica, Winter's bark tree, which exhibits punctated woody tissue.

Fig. 61. Dotted or pitted vessels united, so as to form Bothrenchyma or Taphrenchyma, or, in other words, pitted tissue.

Fig. 62. Dotted or pitted, or porous vessel taken from the melon. It is formed originally of pitted cells united, the divisions being seen externally, and giving the vessel a moniliform or necklace-like appearance.

47. *Dotted or Pitted Vascular Tissue.*—The vessels, or, as they are often called, Ducts, forming this tissue, are usually continuous tubes of a larger size than the other vessels of plants (Fig. 61), and presenting often broad or oblique extremities in place of pointed ones like other vessels. Their dotted or pitted appearance, as seen in Figures 61 and 62, depends on the mode in which the encrusting matter or cellulose is formed inside. In place of being deposited equally over the whole surface of the membrane, as in ordinary woody fibre, it leaves rounded uncovered spots at various intervals, and these, when viewed by transmitted light, appear from their thinness to be perforations or holes. Hence, the name *Porous*, which is often applied to these vessels. In old dotted ducts it is occasionally found, that the thin membrane of the dots or pits has been absorbed, and actual perforations have taken place. Dotted vessels frequently exhibit contractions at intervals, giving rise to a jointed or bead-like appearance. In such cases, as in Figure 62, they are seen to be formed of dotted cells placed end to end, with the partitions between them obliterated, so as to form continuous cylindrical and sometimes branched tubes. In the Elm and Lime the dotted ducts have sometimes spiral fibres ramifying between the dots.* The membranous walls of dotted vessels sometimes unrol in a spiral manner. Dotted ducts are found in large quantity in the wood of trees, and they constitute the large rounded openings which are seen in the transverse section of the stems of oak, poplar, willow, &c. They also abound in the bamboo, (as seen in Figure 12, p. 11, where the porous vessels are distinguished by their large round apertures), and in other plants of rapid growth. The names of *Bothrenchyma* and *Taphrenchyma*, given to this tissue, are derived from Greek words signifying pits.

48. *Spiral vessels* form the tissue called *Trachenchyma*, on account of its resemblance to the tracheæ or air-tubes of animals. They are tubes tapering to each extremity, and having their membranous walls strengthened by the formation of elastic spiral fibres within (Fig. 63). They vary from $\frac{1}{3000}$ to $\frac{1}{300}$ of an inch in diameter. When lying together the vessels overlap each other at their extremities (Fig. 63), and occasionally, by the absorption of the membrane, perforations of their walls take place, so as to establish a communication between two contiguous tubes. The fibres are usually rounded and simple; but sometimes two or more are combined, as seen in one of the vessels in Figure 63, so as to form a flat band. These flat ribbands, consisting of fibres which vary in number from 2 to 25, or more, are

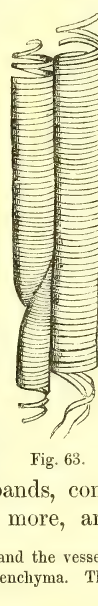

Fig. 63.

Fig. 63. Spiral vessels taken from the melon, shewing the elastic fibres uncoiled, and the vessels overlapping at their pointed extremities. These vessels form the tissue called Trachenchyma. The general name of Angienchyma being given to all kinds of vascular tissue.

* Mohl, sur la Structure des Vaisseaux Ponctués. Linnæa, 1842, p. 1. Ann. des Sciences Nat. 2d ser. t. xviii. p. 321.

met with frequently in the stems of Bananas (Fig. 64) and Plantains, and in the shoots of Asparagus. The spirals in such cases are called compound. The spiral fibres have such tenacity, that when the vessels are ruptured they can be pulled out and separated from the inside of the membrane. This capability of being unrolled characterises the fibre of true spiral vessels. On breaking the young shoots or leaf-stalks of the Geranium, Strawberry, and Rose, or the leaves of the Hyacinth, Amaryllis, and Banana, and pulling the parts gently asunder, the fibres can be easily seen in the form of a fine cobweb. When the aerial stems of the Banana (Fig. 64) and Plantain are cut across, the spiral fibres may be pulled out in large quantity so as to be used for tinder. The fibres of Musa textilis, a kind of Plantain, are used in manufac-

Fig. 65.

Fig. 64.

Fig. 66.

Fig. 67.

ture. The coils or volutions of the fibre are said to be in general left-handed. In the garden lettuce vessels are met with, some having the fibre turning to the left, others to the right. In the scarlet bean the coils of the fibres are left-handed, while the plant itself turns to the right in twining. Spiral vessels are abundant in young plants and shoots, while in the hard stems of trees and shrubs they chiefly surround the pith.

Fig. 64. Aerial stem of Banana (*Musa sapientum*), formed by sheathing leaves. The proper stem is subterranean, and the stem shewn in the figure is a shoot sent up, bearing leaves and fruit, and then decaying, to give place to another shoot. The cluster of fruit is seen at the top. The extremity of the cluster is abortive; the flowers at the base of the stalk bearing fruit. The plant contains numerous spiral vessels, some of them having flat ribbands composed of numerous fibres combined. Such vessels being called Pleiotracheæ.

Fig. 65. Vessel partly spiral and partly annular, taken from the melon plant. In the middle of the vessel a complete fibrous ring is seen, while the fibre at the ends is spiral. The ring is formed by a breaking up of the spiral coil.

Fig. 66. An annular vessel taken from the melon plant. The rings of fibre are complete.

Fig. 67. Vessel partly annular and partly reticulated, taken from the melon plant. Some complete rings are seen, while others are broken up and divided, so as to form dots and reticulations. The dots are in this case opaque, and thus differ from pits in porous vessels.

49. *Modifications of Spiral Vessels.*—The spiral vessel is the type of what is called the *fibro-vascular* tissue, or that tissue which is composed of vessels having membranous walls strengthened by fibres of some sort. In their perfect condition the vessels have a complete spiral or cork-screw-like coil inside, which is elastic, and can be unrolled. In different plants, however, and in different parts of the same plant, the spiral vessel undergoes certain modifications and changes. Sometimes, as in ferns, the spiral fibre becomes united to the membrane, so that it cannot be unrolled. This constitutes what is called the *closed* spiral. At other times the fibre is broken up into rings, reticulations, bars, or dots. These changes take place in the progress of growth, and their various stages may be traced in the vessels of such plants as the garden balsam or melon. In Figures 65, 66, 67, are seen the transformations effected in vessels. Thus, in Figure 65, there is a complete spiral fibre, which in the middle of the vessels is interrupted by the formation of a fibrous ring; in Figure 66, the fibrous rings are uniform throughout, while, in Figure 67, some of the rings are complete, and others are broken up into lines or dots. *Annular* vessels are those in which the fibre is in the form of rings (Fig. 66). These rings in Mammillaria quadrispina, and in some other plants of the Cactus tribe (Fig. 43, p. 22), are very deep, and leave only a small hole in the centre of the vessel. Annular vessels are from $\frac{1}{800}$ to $\frac{1}{400}$ of an inch in diameter. *Reticulated* vessels have interlacing fibres on the membrane, as seen in Figure 67, while in *Scalariform* vessels (Fig. 68), the fibre is so broken up as to appear in the form of bars or lines like the steps of a ladder, whence their name. The entire walls of some scalariform vessels are capable of being unrolled in a spiral manner. In Ferns (Fig. 69), we meet with scalariform vessels which assume a prismatic form. In place of lines, the fibre is in some instances so broken up as to appear in the form of dots or opaque points. The appearance of bars, dots, and reticulations, may sometimes be traced not to a thickening of the membrane by means of fibres, but to an actual thinning of the membrane, such as has been already noticed in the case of dotted ducts.

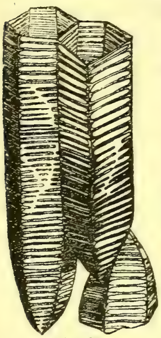

Fig. 68.

50. *Laticiferous Vessels.*—These vessels, as seen in Figures 70, 71, consist of long branching tubes or passages, having a diameter of about $\frac{1}{1400}$ of an inch, forming, by their union, an anastomosis or net-work, like the veins of animals. They receive their name from containing

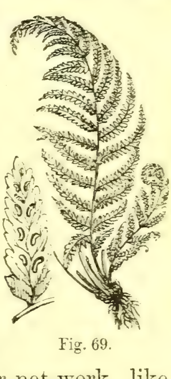

Fig. 69.

Fig. 68. Scalariform or ladder-like vessels of tree ferns. The fibre is in the form of bars or lines; and the vessel is prismatic.

Fig. 69. Athyrium Filix-fœmina, a British fern. Ferns contain scalariform vessels in their composition.

a fluid called *Latex*, of a granular nature, often milky or coloured, and well seen in the India-rubber and Gutta Percha plants, the Mudar plant, the Cow-tree (Fig. 72) Spurges, Dandelion, Lettuce, Chicory, and Celandine. Many of these fluids contain a large quantity of caoutchouc ; some of them are bland and nutritious, as that of the Cow-tree ; others are narcotic and acrid. The Latex exhibits movements which have given origin to the name *Cinenchyma*, or moving tissue, applied to Laticiferous vessels by some authors. The motions have been particularly described by Schultz,* and will be afterwards considered under Physiology. When fully formed, the vessels of latex exhibit in their course contractions and dilatations of an irregular kind. They are considered by some as composed of cells placed end to end, with their partitions more or less completely absorbed ;

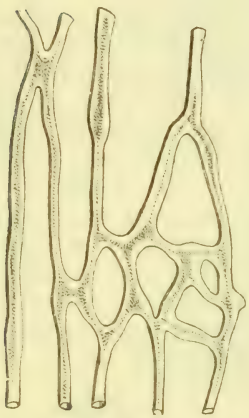

Fig. 70.

Fig. 71.

Fig. 72.

while others consider them as intercellular passages lined with a membrane. These vessels are found especially in the bark and leaves of plants.

Fig. 70. Laticiferous vessels or Cinenchyma from the dandelion. The vessels contain granules.

Fig. 71. Laticiferous vessels, containing orange-coloured granular latex from the Celandine (*Chelidonium majus*).

Fig. 72. Cow-tree of the Caraccas (*Galactodendron utile*). It yields a bland milky fluid which is contained in laticiferous vessels.

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* Schultz's paper is in the 18th vol. of the Nova Acta Academiæ. Cæsar. Leopold.-Carol. Naturæ Curiosorum. See also Ann. des Sc. Nat. 2d ser. t. vii. p. 257.

IV. CONTENTS OF THE VEGETABLE TISSUES.

51. It is not proposed at this place to give a full account of the substances which are found in the tissues of plants, but simply to notice a few of the more evident contents of cells and vessels, or those which the student is likely to observe in his examination of structure. The details as to the organic and inorganic constituents of plants, and the mode in which they contribute to the nutrition of plants, will be given under Physiology. Some substances are found generally in the cells and vessels of all plants, while others are very limited in their distribution. To the former class belong cellulose, lignin, starch, gum, sugar, oils, colouring matter, and certain nitrogenous and saline compounds; to the latter belong alkaloids and certain special secretions.

52. *Cellulose* is an essential part of the structure of cells and vessels. It is in many respects allied to starch, and is changed into starch by the unaided action of heat, or by sulphuric acid, or caustic potash. When iodine is applied to it, it becomes yellow, and if sulphuric acid is added, a blue colour, like that of iodide of starch, is produced.* Cellulose was long considered as peculiar to vegetable tissues, but it has been recently detected by Schmidt,† Löwig, and Kölliker, in the tunics of ascidia and other molluscous animals. The thickening of the cellular membrane is accomplished by the deposition of layers of encrusting matter, to which the name of *Sclerogen* or *Lignin* has been given. This substance may be looked upon as a modification of cellulose. It is frequently seen in the form of distinct concentric layers, which vary in their composition in different circumstances. The hard cells in the stone of the peach, and in the shells of other fruits and seeds, consist of cellulose, with deposits of lignin. So also woody fibre, the encrusting matter of which varies in hardness and colour in different trees and shrubs. The spiral threads, rings, and bars, in the membrane of cells and vessels, consist apparently of two layers, one being cellulose, the other woody matter. Cork is a nitrogenous substance, which, next to cellulose, according to Mitscherlich,‡ is the most important constituent of the cell-wall. It occurs in a marked degree in the outer bark-cells of many trees, and it is also found in other plants, such as in potatoes. In the latter the cork-cells do not contain starch, and they are thus distinguished, as well as by chemical properties, from the cells made up of cellulose. Cellulose, corky substance, and fatty matters, seem to be found in the same cell; and when the

* For a full account of the chemical nature of cellulose and other substances entering into the composition of elementary tissues, see Mulder's Chemistry of Organic Bodies, translated by Fromberg, 347-493. For the nature of the cell-walls, see Mohl on the Structure of the Vegetable Cell, in Taylor's Scientific Memoirs, vol. iv. p. 91. Mohl on Cellulose, Bot. Zeitung, 1847. Ann. des Science Nat. 3 serie, Botanique, tom. viii. p. 240. Also Grundzuge der Anat. de Veg. Zelle, 1851. Schulze states that a mixture of a solution of chloride of zinc and iodide of potassium colours cellulose blue.

† Taylor's Scientific Memoirs, vol. v. p. 1.

‡ See Reports of the Berlin Academy for March 1850, p. 102. Ann. der Chem. und Pharm. tom. lxxv. p. 305.

cellulose has been absorbed, the corky substance alone remains. It forms the outermost part of the cell-wall, and unites the cells together.

53. *Starch* is one of the substances found in great abundance in the cells of plants where it is stored for the purposes of nutrition.* It is not found in animal tissues, although a substance isomeric with it is stated to have been detected in them by Gottlieb. A distinguishing character of starch is the blue colour which it assumes on the addition of iodine. It occurs in fine grains, more or less oval or rounded, which vary in diameter from the 4000th to the 240th of an inch. The individual grains either lie distinct from each other in the cells, as in the potato, wheat, and peas (Fig. 73), or they are aggregated so as to form compound grains, as in West Indian Arrow-root, and Portland Sago procured from Arum maculatum. Grains of starch frequently present at one end a spot called the hilum, which is seen in the grains given in Figure 73. It is a concavity or nucleus over which

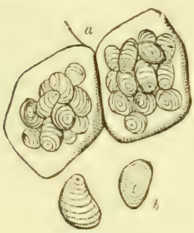

Fig. 73.

Fig. 74.

Fig. 75.

successive layers have been deposited, giving rise to the striated appearance seen in potato starch. Starch is accumulated in the internal, and often in the subterranean parts of plants. It occurs abundantly in fleshy roots, and in stems, as well as in seeds and fruits, and is easily separated by washing. The ordinary cultivated grains yield starch in considerable quantity, so also the Potato, Arrow-root and Cassava plants, the Sago-palms, and Banana fruit (Fig. 74). That procured from the Arrow-root plant (Maranta arundinacea), consists of dull white grains, while that from the potato, and from various species of Canna supplying tous-les-mois, is in the form of large shining particles. Sago and Tapioca are granulated forms of starch, the former being procured from the cells of various species of Sagus and Metroxylon, the latter from the Cassava plant. The existence of starch in the bark and young wood of trees, such as the Birch and Pine, render them useful as articles of food in cold countries. Lichenin is a form of starch existing in the cells of Iceland moss (Fig. 75), and

Fig. 73. *a* Starch cells of the pea, showing grains of starch in the interior. *b* Separate starch grains, with striæ and hilum.

Fig. 74. Cluster of Bananas. The fruit contains much starch.

Fig. 75. Iceland moss (*Cetraria islandica*), a cellular plant, yielding Lichenin, a kind of starch.

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* Starch is composed chemically of Carbon and the elements of water (Hydrogen and Oxygen), its formula being $C^{12} H^{10} O^{10}$. See remarks on starch, by Payen, in Ann. des Sciences Nat. Partie Bot. 1838, p. 5.

other lichens; while Inuline is the starchy matter supplied by the roots of the Dahlia, Dandelion, and Elecampane. By the action of prolonged heat, as well as by the addition of diluted sulphuric acid, and of malt, starch is converted into a soluble gummy substance called dextrin. The same change we shall find occurs during germination or the sprouting of the seed.

54. *Gum* is another substance contained in vegetable tissues. When pure, it is clear, soluble in water, and also in dilute acids, but not soluble in alcohol or ether. It is one of the forms through which vegetable matter passes in being applied to the purposes of plant life. It exists largely in the vegetable juices. From the bark of many trees it is procured in the form of an exudation. Two well marked kinds of gum are met with: Arabine, soluble in cold water, constituting the chief ingredient of gum-arabic, procured from various species of Acacia (Fig. 76); and Cerasine, insoluble in cold water, and readily soluble in boiling water, constituting the gummy secretion obtained from the cherry and plum. A substance, called Bassorin, or vegetable jelly, is found in Tragacanth, the roots of some Orchids (Fig. 77), as well as in Carrageen (Sphærococcus crispus), and other sea-weeds. It is allied to

Fig. 76.

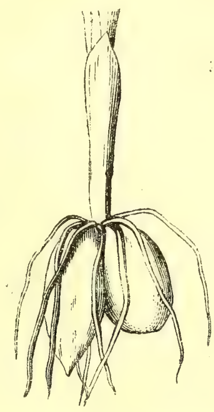

Fig. 77.

Fig. 78.

gum, but differs in swelling up and becoming gelatinous when mixed with water. Another jelly-like substance called Pectic acid exists in the juice of turnip, beet, and carrot, as well as in the apple and pear.

Fig. 76. Acacia Seyal, one of the trees yielding gum-arabic, $C^{12}H^{11}O^{11}$. It is the Shittah tree and Shittim wood of the Bible.—Exod. xxv. 5; xxxv. 7, 24. Isaiah xli. 19.

Fig. 77. Roots of an orchis, which supply bassorin, a kind of gum. The salep of the Turks is procured from them.

Fig. 78. Saccharum officinarum, the sugar-cane, a grass which contains much saccharine matter in its cells and vessels. The sugar it furnishes is called cane sugar, $C^{12}H^{11}O^{11}$. The stalk of the sugar-cane is called a culm.

55. *Sugar* occurs abundantly in the sap of plants. When pure, and in a solid state, this substance is crystalline, and soluble in water. It occurs, however, in an uncrystallisable form. There are two marked varieties of it. Cane sugar, procured from the sugar-cane (Fig. 78), sugar-maple, beet, carrot, and many other plants; and grape-sugar,* occurring in numerous fruits, as grapes, gooseberries, currants, peaches, and apricots. During the sprouting of the seed, starch is converted into grape-sugar, and a similar change is induced by the action of malt, and of any ferment. A sweet substance (not a true-sugar), called Mannite, is procured from the Manna-ash, as well as from various sea-weeds, from species of Eucalyptus, and from the Dandelion.

56. The substances which have been noticed as occurring in the elementary tissues are important as organic products concerned in the growth and nourishment of plants, and they will call for special consideration when we treat of the functions of the living vegetable. Some differences of opinion exist among chemists as to their exact atomic composition; it is sufficient at present to notice that they all consist of a definite proportion of carbon, united to oxygen and hydrogen, the elements of water. They are convertible into each other by the action of heat, and of various chemical re-agents, and by the powers of vegetation. The ultimate composition of several of them is identical, and the difference of their properties, in such instances, seems to depend on differences in the arrangement of their atoms.

57. Another class of substances, found in the tissues of plants, and essential for the process of vegetation, consist of carbon and the elements of water, with the addition of nitrogen or azote. Hence, they are called nitrogenous or azotised. They occur abundantly in the gluten of wheat flour. Schleiden includes them under the general name of vegetable mucus. The chief substances which enter into the composition of this nitrogenous matter are albumen, fibrine, caseine, legumine, and emulsine.

58. *Nuclei.*—The cells of plants, at some period of their existence, usually contain what are denominated nuclei or cytoblasts. The nucleus is a small rounded body resembling a minute cellule, which is either loose or attached to the walls of the cell containing it. It is seen in Figure 42, p. 22. It frequently contains smaller bodies called nucleoli. The nucleus has an important function to perform in cell growth, as will be noticed under cytogenesis or cell-development, and after a certain period it frequently disappears.

59. *Chlorophyll and Colouring Matters.*—Chlorophyll or Phytochlor, is the matter which gives the green colour to plants. It is a coloured fatty or wax-like substance, which may be separated by the action of alcohol and ether. The green colour is associated with globules of various sizes, which are either free or united together. The globules of chlorophyll can be seen under the microscope in any of the green parts of plants. In delicate structures, such as the cellular tissue of

* The formula for Dry Grape-sugar is C^{12} H^{12} O^{12}.

mosses and liverworts, they are easily examined.* The colour is only produced under the action of light; hence chlorophyll exists in the superficial cells of the parenchyma, thus differing from starch, which is produced in the internal and subterranean organs, whence light is excluded. It undergoes changes according to its state of oxidation; hence the tints which the green leaves acquire in autumn. There would appear, therefore, to be a colourless chlorophyll present in plants, which is acted on by light, oxygen, and other agents, so as to give rise to green, yellow, and red tints. Schleiden says, the yellow leaves in autumn contain proportionately more wax than the green leaves of summer, the yellow rind of the ripe fruits more than the green rind of unripe fruits. The tints of flowers depend either on variously-coloured insoluble globules, which are considered to be of a nitrogenous nature, or on soluble substances which have not been fully examined. Colouring matters not green are included under the name of Chromule.

60. *Oily, Fatty, and Resinous Matters.*—These are contained in cells and in special canals and cavities, called receptacles of secretion. The oils are either fixed or volatile; the former being divided into drying, fatty, and solid; while the latter are distinguished according as they consist of carbon and hydrogen alone, or of these elements combined with oxygen or with sulphur. Resinous matter occurs either in the form of fluid balsams, or of the various kinds of solid resin and pitch. In the rind of the orange and lemon, receptacles of oil occur. These are represented in Figure 79, which is a vertical section of part of the rind of the orange, the reservoirs of volatile oil being marked R R R. The cellular tissue of the rind is seen surrounding the oil cavities, and the cells are elongated and condensed, so as to form a compact tissue in the walls. Turpentine canals are met with in the bark of Pines; and Vittæ or oil-canals, in the fruit of umbelliferous plants, such as the Coriander (Fig. 80). In the fleshy covering of the fruit of the Olive (Fig. 81), there are numerous oil-cells. The fruit of the Guinea-palm (Fig. 82), yields a solid oil called Palm oil. The dotted appearance of the leaves of the orange, myrtle, Eucalyptus, and St. John's wort, depends on the presence of numerous cells or cavities containing essential oil.

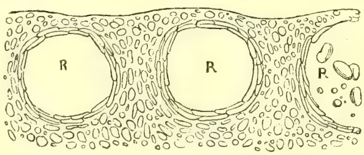

Fig. 79.

Fig. 79. Vertical section of part of the rind of the orange, showing receptacles of volatile oil, R R R surrounded by cells.

* Green vesicles or granules allied to chlorophyll, are found in the parenchyma of the body of Hydra viridis, of many Turbellarias (Hypostomum viride, and Typhloplana viridata), and Infusoria (Euglena viridis, Stentor polymorphus, Bursaria vernalis, Loxodes Bursaria). What has been called the red eye in many infusoria, by Ehrenberg, is considered by Nægeli as an altered state of the chlorophyll, which is converted into a red oil. In many unicellular algæ, as Protococcus nivalis, Pleurococcus miniatus, and Palmella miniata, the chlorophyll disappears completely, and is converted into a red or orange oil. Nægeli, Gattungen einzelliger Algen physiol. und systemat. bearbeit. Zurich, 1849. Also Siebold, Observations sur les plantes et les animaux unicellulaires. Ann. des Sciences Naturelles, 3 serie, Botan. t. xii. p. 138.—For remarks on Chlorophyll, see Mohl's paper 'Sur la Chlorophylle.' Ann. des Sc. Nat. 2d ser. Bot. ix. 150.

61. As allied to these secretions, we may notice *Caoutchouc*, which is found in the milky juice of plants, especially those belonging to the Fig, Spurge, and Dogbane orders. The trees most prolific in this substance are, Siphonia Caoutchouc, Urceola elastica, and Ficus elastica. Of these, the first extends over a vast district in central America; and the caoutchouc obtained from this tree is best adapted for manufactures. Over more than 10,000 square miles in Assam the Ficus elastica is abundant. The Urceola elastica (which produces the Gumtowan of the Malays) abounds in the islands of the Indian Archipelago. It is described as a creeper of so rapid growth, that in five years it extends 200 feet, and is from 20 to 30 inches in girth. This tree can, without being injured, yield, by tapping, from 50 lbs. to 60 lbs. of caoutchouc in one season. A curious contrast is exhibited in the tardy growth of the tree from which gutta percha is obtained, and which requires from 80 to 120 years to attain maturity. Gutta percha is the produce of a sapo-

Fig. 80.

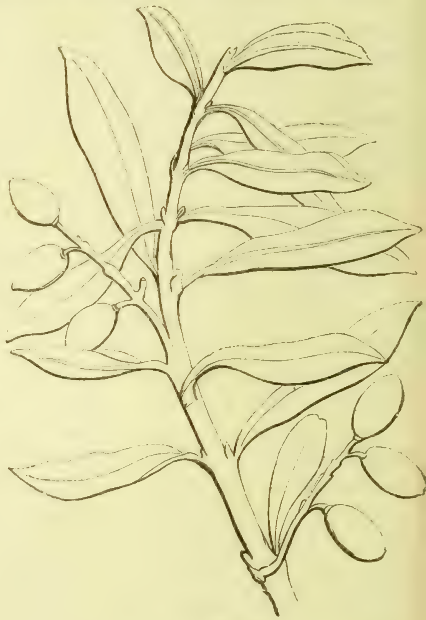

Fig. 81.

taceous plant (Isonandra gutta). *Wax* is also found in the tissues of plants, and it frequently occurs as a secretion on the stems, as in the Wax Palm (Fig. 83), and on the surface of fruits, as in the bloom or glaucous secretion of the plum and the candleberry myrtle.

62. *Air-Cavities.*—Cells and intercellular spaces containing air are found in many aquatic and marsh plants, apparently with the view of

Fig. 80. The Coriander plant (*Coriandrum sativum*), the fruit of which exhibits vittæ, or cavities containing volatile oil. It is the Gad of Scripture (Exod. xvi. 31; Num. xi. 7).

Fig. 81. The Olive tree (*Olea europea*), the fruit of which yields a fixed oil by expression. It is the Zait or Sait of the Scriptures (Gen. viii. 11; 1 Kings vi. 23, &c.)

rendering them buoyant (Fig. 84, V). In some cases they are regular in their formation, being surrounded by cells which are built up on a uniform plan in each species of plant, as in Pondweeds (Fig. 85, *l*). In other instances they are formed by the destruction or absorption of part of the cellular tissue, as in the case of many hollow stems. The air-cells in Limnocharis Plumieri, are beautiful objects under the microscope.

63. *Raphides* or *Crystals*.—Cells and vessels also contain various

Fig. 82.

Fig. 83.

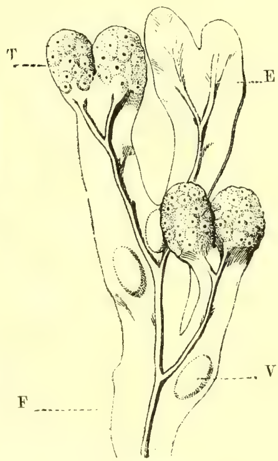

Fig. 84.

mineral and organic acids, combined with alkaline substances. The most important of these acids and alkalis will be noticed when considering the chemistry of vegetation, and the products furnished by different natural orders. At present we shall consider the composition of certain crystalline matters found in cells, to which the name of Raphides has been given. These are present in greater or less quantity in almost all plants. They consist of oxalic, phosphoric, malic, sulphuric, and carbonic acid, in combination with lime, and they exhibit various forms. Crystals of phosphate of lime occur usually in the form of acicular crystals, varying from $\frac{1}{40}$ to $\frac{1}{1000}$ of

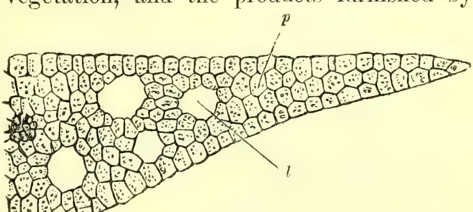

Fig. 85.

Fig. 82. Elais Guineensis, a palm growing in Guinea, the fruit of which yields the solid oil called Palm Oil.

Fig. 83. Ceroxylon Andicola, the Wax Palm of South America. It supplies wax. Its stem is called a caudex.

Fig. 84. Fucus vesiculosus, a common sea-weed, showing vesicles or bladder V, full of air. F, E, the cellular frond; T, the fructification.

Fig. 85. Vertical section of the leaf of Potamogeton or Pondweed, showing air cavities or lacunæ, *l*, and parenchymatous cells, *p*, with granules.

an inch in length (Fig. 86, R); to these the name of needles or raphides was originally given. Cells with clusters of raphides may be seen attached to the divisions between the cells in the Banana. Crystals of oxalate of lime assume an octohedral form,

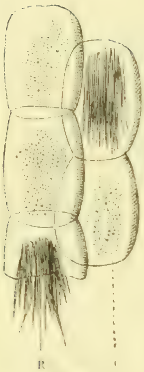

Fig. 86.

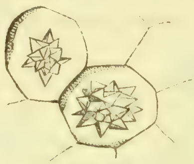

Fig. 87.

Fig. 88.

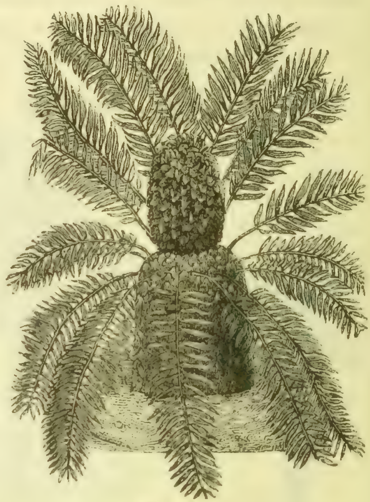

Fig. 89.

and vary from $\frac{1}{50}$ to $\frac{1}{250}$ of an inch in length (Fig. 87). They are abundant in the root of Turkey Rhubarb, to which they impart grittiness, and in the Old-Man-Cactus they constitute 60-80 per cent. of the dried tissue. In other species of Cactus (Fig. 88) they frequently occur. Professor Bailey states, that in a square inch of Locust-bark, about the thickness of writing-paper, more than a million and a half of these crystals are found. A good way of shewing the crystals is to boil in water a piece of Rhubarb root, or a part of the frond of Encephalartos pungens (Fig. 89), till the cohesion of the tissue is destroyed, and then the separated cells will be seen, usually containing each a cluster of raphides, as in Figure 87. The squill bulb (Fig. 90), and the bulb of the onion, exhibit raphidian cells, which are easily separated during the decay of the plants. In a single cell of the Poke (Phytolacca decandra), twenty to

Fig. 90.

Fig. 86. Cells of Rumex, C, containing raphides, R. The cells are called Raphidian. The raphides consist of acicular or needle-like crystals united together.

Fig. 87. Cells of Beet-root, containing conglomerate crystals.

Fig. 88. Melon Cactus, a succulent plant, the cells of which contain numerous crystals or raphides.

Fig. 89. Encephalartos pungens, a Cycadaceous plant, containing starch and raphidian cells.

Fig. 90. Squilla maritima, the Squill plant, the bulb of which exhibits cells containing large crystals.

thirty crystals may be seen. Clustered crystals are also visible in the cells under the epidermis of the Marvel of Peru. Sulphate of lime occurs occasionally in the form of a single or double octohedron, or in a tabular shape. Carbonate of lime crystals, in the form of rhombohedrons, occur in species of Cycas (Fig. 37, p. 21) and Cactus. Some raphidian cells are called biforines by Morren, because, when moistened, they discharge the crystals through openings at each end. It is said that raphides may be produced artificially in the cells of rice-paper by introducing lime into them in solution under the air-pump, and afterwards putting them in a weak solution of oxalic or phosphoric acid.

64. *Siliceous matter* occurs in the walls of cells, and enters into their composition. This is the case with grasses and horsetails (Fig. 34, p. 20), and, in a remarkable degree, with those peculiar organisms supposed by Ehrenberg to be infusoria, but now referred to the vegetable kingdom under the name of Diatomaceæ.

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65. Recapitulation of the Elementary Tissues of Plants:—

1. Cells, Vesicles, or Utricles, consist of minute sacs or bladders of various forms and sizes, having their walls composed of cellulose.
2. Membranous Cells have thin walls, and contain a formative protoplasm in their interior, with nuclei and nucleoli.
3. Thickened Cells, have their walls composed of several uniform layers of ligneous matter, which is often very hard, and fills up their cavities.
4. Dotted or Pitted Cells, have their walls irregularly thickened so as to leave numerous rounded thin portions.
5. Spiral Cells, have a spiral fibre coiled up in the inside of their walls.
6. Cells contain starch, gum, sugar, lignin, oils and resins, nuclei, chlorophyll and other colouring matters, air, raphides or crystals, and nitrogenous substances.
7. Cellular Tissue, composed of various cells united.
    a. Parenchyma, made up of membranous or thickened cells.
    b. Inenchyma, or Fibro-cellular Tissue, made up of spiral cells.
8. Intercellular Spaces and Canals, are cavities between the cells of cellular tissue. They contain fluids and air.
9. Vessels are closed tubes of different lengths, often tapering to each end, and overlying each other, having their walls composed either of membrane alone or of membrane and fibre.
10. Membranous Vessels are thin-walled tubes, having their walls composed of membrane only, as laticiferous vessels.
11. Thickened Vessels are tubes, the walls of which are composed of several layers of ligneous matter, as woody vessels.
12. Dotted or Pitted Vessels, are tubes having their walls unequally thickened, so as to have numerous round thin portions.
13. Fibrous Vessels are tubes having a spiral fibre more less complete coiled up in their interior.
    a. Spiral Vessels, with a complete spiral fibre, usually unrollable.
    b. Annular Vessels, with rings of fibre.
    c. Scalariform Vessels, with bars of fibre.
    d. Reticulated Vessels, with irregular netted fibres.

14. Vascular Tissue, Angienchyma, is composed of various kinds of vessels combined.
    a. Pleurenchyma, woody vascular tissue, either membranous, thickened, or disc-bearing.
    b. Bothrenchyma or Taphrenchyma, tissue composed of dotted or pitted vessels.
    c. Trachenchyma, tissue composed of spiral or annular vessels.
    d. Cinenchyma, tissue composed of anastomosing laticiferous vessels.

66. List of a few of the plants which may be used by the student in his examination of microscopic vegetable tissues. Preparations of most of these are preserved in the Museum of the Edinburgh Botanic Garden :—

1. *Cells and Cellular Tissue.*—Sea-weeds; Rice-paper; independent cells, with nuclei in yeast plant (Torula Cerevisiæ); cells with nuclei and nucleoli in ripe fruit of strawberry, in the onion bulb, and in ovules or very young seeds; cells united in a linear series in common mould, confervæ, and many hairs; branching cells in many hairs, and in some moulds, as Botrytis; cells united in fours in pollen of Acacia, and in some spores of sea-weeds; cells thickened by deposit of lignin in the shell of the Coco nut, and Attalea funifera or Piaçaba palm, in the stone of the peach, cherry, and nut, in the seed of the Ivory Palm and Date, in the gritty matter of the Pear; cells with siliceous covering in Diatomaceæ. Porous cells in Elder pith, in stem of common garden Balsam (Balsamina hortensis), in the outer covering of the seeds of Gourd and Almond, in the wing of the seed of Lophospermum erubescens and Calempelis scaber. Spiral cells in leaves and stems of many orchids, as Oncidium and Pleurothallis ruscifolia, in garden Balsam, in the leaf of Sphagnum, the fructification of Liverworts, the winged seed of Sphenogyne speciosa. Annular cells in Opuntia. Filamentous cells in Mushrooms and Agarics. Hexagonal cells in pith of Elder. Stellate cells in Rush. Ciliated moving cells in Vaucheria, Fuci, and Chara. Professor F. Schulze of Rostock, states, that by means of nitric acid and phosphate of potash, the cells of plants, young or old, hard or soft, may be perfectly isolated from one another, so as to give single cells free and distinct for microscopic examination.
2. *Vessels and Vascular Tissue.*—Woody tissue in the stem of ordinary trees; the fibres may be separated by maceration from the inner bark of the Hemp-plant, Flax-plant, Elder, New Zealand Flax, Mallows, &c. Disc-bearing woody tissue in Scotch Fir, Weymouth Pine, Araucaria, Altingia excelsa, Cycas, Winter's bark tree, Illicium. Dotted Vessels in Stem of Willow, Sugar-cane, Pitcher plant. Spiral Vessels in Oncidium bicolor, Banana and Plantain, most liliaceous plants, (as Hyacinth, Lily, and Crinum) leaf of Geranium and Strawberry, Cabbage, Lettuce, Asparagus shoot; branched spirals in Long-leek and Anagallis. Annular vessels in Opuntia vulgaris, Leek, Equisetum Telmateia. Reticulated vessels in garden Balsam. Scalariform vessels in Tree Ferns, Diplazium seramporense, Asplenium pubescens, Osmunda. Laticiferous vessels in various species of Ficus, as the India-rubber fig (Ficus elastica), Gutta Percha plant (Isonandra Gutta), Euphorbias, Lettuce, Dandelion, Celandine, Goatsbeard.
3. *Contents of Cells.* — Starch-cells in Potato, angular starch granules in Rice, compound starch granules in Arrow-root, peculiar starch grains in the milky juice of Euphorbia. Air cells and lacunæ in the Rush, Sparganium ramosum, Limnocharis Plumieri, and other aquatic plants. Cells with raphides of oxalate of lime in Rhubarb root, cells with acicular crystals in Hyacinth, cells with octohedral and prismatic crystals in Onion and Squill. Oil cells in rind of Orange and Lemon, in leaves of Hypericum, and of the Myrtle order. Chlorophyll cells in Mosses, Vallisneria, Chara; cells with colouring matter in leaf of Rottlera tinctoria, and in petals.

V. INTEGUMENTARY SYSTEM.

67. The general Integumentary covering of plants consists of cells, various, aggregated, and may be considered in connection with the elementary tissues. It has been divided into two parts—the *Proper Epidermis*, and the *Outer Pellicle* or *Cuticle.* The epidermis is formed of one or more layers of colourless thick-walled cells cohering together, so as to constitute a firm membrane, which can be pulled off from the subjacent tissue.* The colour of the epidermis in general depends on that of the parenchymatous cells below, from which it can be separated as a colourless layer. Occasionally, however, the epidermal cells contain colouring matter, as well as waxy, siliceous, and calcareous substances. In the case of Orchids (Fig. 38, p. 21), it is not uncommon to find spiral cells in the epidermis covering their aerial roots. The epidermis covers all parts of plants exposed directly to the air except the stigma, which is formed of loose cells at the upper part of the pistil or central organ of the flower. The epidermis is sometimes much thickened, as in the Oleander and American Aloe, by being composed of numerous layers of cells, while, at other times, it is very thin. A delicate epidermis, called *Epithelium*, lines the internal cavities of certain organs, such as the ovary, containing the young seeds. The boundaries of the epidermal cells frequently assume a waved or sinuous aspect (Fig. 93). The outer cuticle is a thin layer covering the true epidermis, and apparently formed from the cells of the latter. It may be merely a changed condition of the walls of these cells, or a modification of the intercellular substance (¶ 40 and 52) which surrounds the cells. It forms the covering of hairs, as seen in Figure 91, which represents the cuticle of the cabbage with hairs, *h*, and it extends into certain openings in leaves called stomata (Fig. 91, *s*). In plants constantly under water, and in certain of the lower tribes, the cuticle is the only integumentary covering. The outer cuticle is considered by Mitscherlich as a corky substance, which prevents the penetration of moisture. The same substance is considered by him as cementing the cell-walls

Fig. 91.

Fig. 91. Cuticle, or outer integument of the Cabbage (*Brassica oleracea*), showing the covering of the hairs, *h*, and the openings called stomata, *s*.

* For a fuller notice of the Epidermis, see subsequent remarks on the structure of leaves. See also Mohl, Recherches sur la Cuticule des plantes. Ann. des Sc. Nat. 2d Ser. Bot. t. xix. p. 201, and Linnæa for 1842. Carpenter thinks that the term Epidermis as regards plants should be dropped as being inappropriate. He adopts the term Cuticle for the general integument. Physiology, 3d Edit. p. 767.

(¶ 52). Hairs having this corky covering do not absorb fluids easily. Hence the reason why fresh cotton-wool imbibes water with difficulty. If the corky layer be removed by chlorine, or some other oxidizing agents, the wool may be moistened as readily with water as any other substance which consists only of cellulose. Before treatment with chlorine, cotton-wool can hardly be impregnated with mordants; while, after bleaching, the colours are easily imparted.

68. *Epidermal Appendages.*—These consist of openings, to which the name of stomates is given, as well as of hairs, glands, and scales. They are not invariably present in the epidermis of all plants, and some of them, after having been developed, disappear in the progress of plant growth. Their presence and absence, as well as their form and structure, give rise to important botanical characters. The botanical terms used to indicate the nature of the hairs covering plants will be given in the Glossary at the end of the volume.

69. *Stomata* or *Stomates*, called also breathing pores, are orifices between the epidermal cells situated on the leaves and other green parts of plants exposed to the air, and communicating with intercellular spaces. These openings are bounded by two (sometimes three or four) cells (Figs. 92, 93), of a delicate nature, which have the power of opening or closing the orifice. When moist, these cells become swollen, and, while they lengthen, curve outwardly in the middle, so as to leave a free opening; when dry, they are shortened and straightened, and thus their sides are applied to each other, so as to close the orifice. They are not found in underground roots, nor in plants which

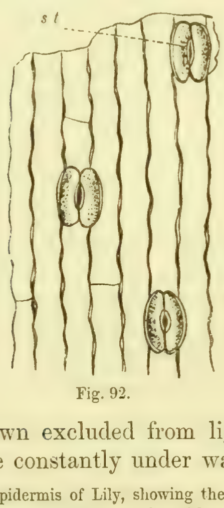

Fig. 92.

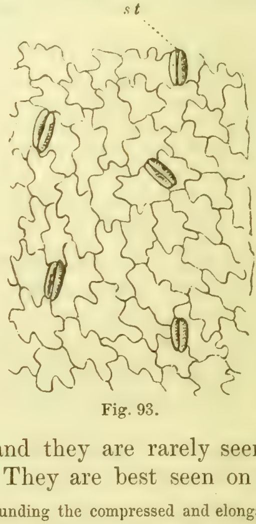

Fig. 93.

have grown excluded from light; and they are rarely seen in those which are constantly under water. They are best seen on the under

Fig. 92. Epidermis of Lily, showing the lines bounding the compressed and elongated cells, and stomata, *s t*, composed of two cells, with an opening or slit between them. Some granular matter is seen in the stomatic cells.

Fig. 93. Epidermis of the garden Balsam, Balsamina hortensis, showing wavy lines bounding the flattened cells, and stomata, *s t*, of an elliptical form.

surface of leaves, and will be again noticed when treating of these organs. When the epidermis becomes hard and glazed, stomata sometimes disappear, and are altered in their appearance. Their form is usually oval or elliptical (Figs. 91, *s*, 92, 93, *st*), but in some instances they are spherical or quadrangular. They are either scattered singly at regular or irregular intervals over the epidermis, or they are arranged in clusters. Their number varies from 200 to 160,000 or more in a square inch of surface. In the leaves of the white lily there are 60,000 in a square inch on the under surface, and about 3000 on the upper; on the leaves of the cherry laurel there are 90,000 on the lower surface, and none on the upper.

70. *Hairs* are prolongations of the epidermal cells. They consist either of single cells, more or less elongated, (Fig. 91, p. 40, and Fig.

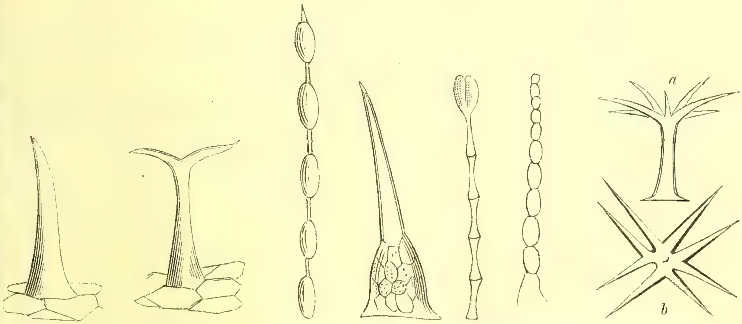

Fig. 94. Fig. 98. Fig. 96. Fig. 97. Fig. 100. Fig. 95. Fig. 99.

94), or of several cells placed in a linear series, like beads, as in Figures 95, 96, or united both longitudinally and laterally, as in Figure 97, where the lower part of the hair consists of numerous cells. In Figure 98, the hair divides at the apex into two, in a forked manner. In Figure 99, *a*, it splits into several cellular projections, which, in the lower figure, *b*, are represented spreading out in a star-like or stellate manner. A forked hair (Fig. 98) sometimes has the divisions hooked (uncinate), or presenting a barbed (glochidiate) appearance. In Figure

Fig. 94. Hair of common Cabbage; it is composed of a single elongated conical cell. Such a hair is called simple and unicellular.

Fig. 95. Hair of Virginian spiderwort (*Tradescantia virginica*), composed of numerous cells united in a linear series. It is called a partitioned hair.

Fig. 96. Hair of Marvel of Peru (*Mirabilis Jalapa*). It is moniliform or necklace-like, being composed of separate cells with contractions.

Fig. 97. Sting (stimulus) of Nettle (*Urtica dioica*); its base is formed by numerous cells containing irritating fluid; from these arise a simple unicellular conical hair, which serves as a duct for conveying the fluid.

Fig. 98. Forked or bifurcated unicellular hair of Draba or Whitlow-grass, one of the cruciferous plants.

Fig. 99. Unicellular hair *a*, of Alyssum, dividing into rays at the apex. The stellate or starlike arrangement is represented in the lower figure *b*.

Fig. 100. Glandular multicellular, or many-celled hair of Frogsmouth (*Antirrhinum majus*). It is a partitioned capitate hair. The glands in Fig. 100 and 103, are at the apex of the hair, while in Fig. 97 they are at the base.

100 is seen a capitate hair having a rounded top. Hairs are sometimes attached to seeds, as in the Cotton plant (Fig. 101), for the purpose of scattering them. The cotton hairs consist of elongated cells, the walls of which in drying collapse in the centre, so as to present a twisted appearance. Various parts of plants are transformed into hairs. Thus, in Rhus Cotinus or the Wig-tree (Fig. 102), the flower-stalks are changed into hairs, and in the common Dandelion and other composite plants, (Fig. 105), the outer covering of the flower, called the calyx, assumes a hairy or pappose aspect. Hairs which have secreting cells at their apex, as in the Chinese Primrose, and in

Fig. 101.

Fig. 102.

Fig. 103.

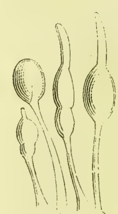

Fig. 104.

Sage (Fig. 103), and in Frogsmouth (Figs. 100 and 104), are called glandular. The cells of the hairs occasionally secrete colouring matter, more especially when they arise from parts of the flower, as in the Iris and Virginian Spiderwort. When the cells of hairs are hardened by deposits, as in the Rose (Fig. 106) and Bramble, they are called Prickles (aculei). Bristles (setæ) are rigid hairs usually formed of a single cell; while stings (stimuli), as in the common Nettle (Figs. 97 and 107) and Chili Nettle, are stiff hairs arising from a series of cells which secrete an irritating fluid. The scales produced on the

Fig. 101. Gossypium herbaceum, the Cotton plant. The hairs surrounding the seeds constitute cotton. The hairs, when the seed is ripe, exhibit a peculiar twisted appearance under the microscope. The Cotton plant is said to be indicated by the word Karpas, translated in Esther i. 6, green.

Fig. 102. Flowering branch of Rhus Cotinus, a kind of Sumach. One of the branches is seen bearing the fruit. The others produce hairs, and are sterile. The tree is called arbre à perruque, or the Wig-tree, on this account.

Fig. 103. Glandular unicellular hair of Salvia. The hair is called capitate, from its rounded head.

Fig. 104. Glandular unicellular hairs of Frogsmouth (*Antirrhinum majus*).

Fig. 107.

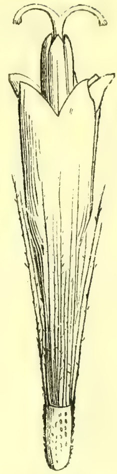

Fig. 105.

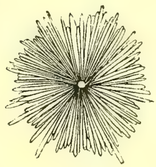

Fig. 108.

Fig. 106.

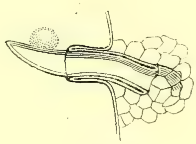

Fig. 109.

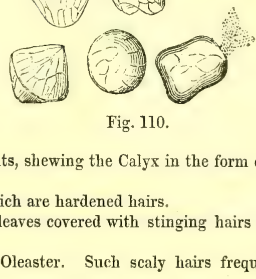

Fig. 110.

Fig. 105. Flower of Senecio, one of the composite plants, shewing the Calyx in the form of hairs or pappus.

Fig. 106. Rose branch, shewing aculei or prickles, which are hardened hairs.

Fig. 107. Urtica urens, a species of nettle, with its leaves covered with stinging hairs like those represented in Figure 97.

Fig. 108. Radiating hair or scale in Elæagnus, the Oleaster. Such scaly hairs frequently give out waxy and other secretions.

Fig. 109. Collecting hair on the pistil or central organ of the flower of Campanula or Harebell. The upper part of the hair which bears a pollen-grain, is partially drawn within the lower portion.

Fig. 110. Superficial glands of the Hop, containing a resinous secretion, called Lupulin.

leaves of Oleaster (Fig. 108), and of some Begonias, the scurf on those of Bromelias, the chaff (ramentum) covering the fronds of Ferns, are all modifications of epidermal cellular tissue. On the central part of the flower of the hare-bells peculiar hairs are seen, the upper part of which is retracted within the lower (Fig. 109) at a certain period of growth. These hairs are called collecting hairs, inasmuch as they collect the powder which falls from the stamens. In the germs of some sea-weeds vibratile hairs called cilia (Fig. 1, p. 2, and Figs. 31, 32, and 33, p. 20) are seen.

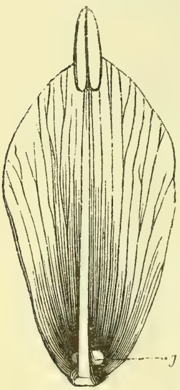

Fig. 111.

71. *Glands* are epidermal cells containing various fluid and solid secretions. They are either applied closely to the surface (sessile), as in the Ice-plant, where they appear as elevations of the epidermis, containing a transparent fluid like ice, or in the Hop (Fig. 110), where they appear as resinous scales of different shapes; or they are raised on stalks (stipitate) of different lengths, and then may be called glandular hairs, as in the Sundew. The bases of undeveloped hairs sometimes assume the appearance of glands. The secretions of glands are of an oily, waxy, resinous, gummy, saccharine, saline, acid, or irritant nature. The honey-like matter of the flower is secreted by glands. In Figure 111 is represented one of the leaves of the flower of the Crown-imperial, showing the depression, *g*, at its base, in which the honey is secreted; a similar pit is seen in the common Buttercup. The cells at the base of the Nettle hair (Fig. 97) contain an irritant secretion, those at the apex of the Sundew hairs contain viscid matter. The glands on the flower-stalk of Dittany and Rose secrete oil, while those of the Chick-pea have an acid fluid in their interior. Mr. Weddell states that on the inner surface of the base of the stipules of Cinchona and allied genera, there are numerous small sessile glands which secrete a gummy fluid. In Cinchonas the secretion is transparent and fluid, while in several other genera it is solid and opaque, and seems to glue the stipules to the bud which they embrace; this is particularly the case in Pimentelia glomerata. In Rondeletia the secretion is soft, like wax, and of a beautiful green colour. The inhabitants of Peru give it the name of Aceite-Maria; they collect it carefully, and use it as an external application in various diseases. The stipular glands have an oval or lanceolate form, and are somewhat pointed. These glands can be detected in fresh specimens of Cinchona Calisaya, Burchellia capensis, Cephaelis Ipecacuanha, Coffea arabica, Ixora javanica, Mussænda frondosa, Rondeletia speciosa, Pavetta indica, Luculia gratissima and Pinceana, Pentas carnea, Gardenia Stanleyana, and other species.

Fig. 111. One of the petals or leaves of the flower of Fritillaria imperialis, Crown Imperial, shewing a pit or depression *g* at the base containing a honey-like secretion. This gland is sometimes called a nectary. A stamen is attached to the petal.

72. List of a few plants which may be employed in examining the Integumentary System :—

Epidermis of leaves, as Hyacinth; epidermal cells of the flowers of Pelargonium, of the Apple, and Foxglove; siliceous cuticle of Equisetum, Bamboo, stalks of Wheat, and other grasses; hairs of Cotton; articulated hairs on leaves of Goldfussia and Alstroemeria ovata; moniliform hairs in flowers of Virginian Spiderwort; stellate hairs on leaves of Deutzia scabra, Rottlera tinctoria, and in air cavities of Nuphar lutea, or yellow Water lily; peltate hairs on leaves of Malpighia urens; forked hairs on leaves of Alyssum; glandular hairs on the leaves of the Nettle, Chinese primrose, and Drosera or Sun-dew; spiral hairs, or, in other words, spiral cells, on the outer covering of the seeds of Collomia, Cobæa, and many Polemoniaceous plants, also of Acanthodium spicatum, and on the fruit of Salvia; glands, with oil, in Sweet-briar; scaly glands, which may be called a modification of hairs, on the leaves of Elæagnus and some Begonias; elliptical stomata on the leaves of liliaceous plants, as the Hyacinth and Lily; square stomata on Agave leaf; hair-like stomata on leaf of Oleander; clustered stomata in some Begonias; and siliceous pectinate stomata in Equisetum. For a full account of the Chemico-Histological constitution of the Cuticle, of the Epidermis, and of the various appendages of the Integumentary System, see Mulder's Chemistry of Organic Bodies, translated by Fromberg. For Epidermal Structure, see Brongniart, sur la Structure de l'Epiderme des Vegetaux. Ann. des Sciences Nat. 2d Ser. part. Botan. tom. i. p. 65.

CHAPTER II.

NUTRITIVE ORGANS OF PLANTS.

73. Having now considered the elementary tissues of plants, their composition, and contents, we proceed to view them in combination, as forming various compound organs. These are naturally divided into the organs destined for the nourishment or nutrition of the plant, and those concerned in reproduction, or in the formation of the new plant. Viewed as individual beings, plants present various aspects. Some, like the red-snow plant (Protococcus nivalis) and Oscillatoria, are composed of single isolated cells, which are capable of performing the functions both of nutrition and reproduction. Others, as Fungi (Fig. 11, p. 11) and sea-weeds (Fig. 30, p. 20, and Fig. 84, p. 37), are composed of numerous cells, united either in a linear series or as a flattened expansion, some of which are appropriated to the nutritive, and others to the reproductive functions. These plants are denominated *Cellular*. The higher classes of plants have cells and vessels combined, presenting more complicated organs of nutrition and reproduction, and they are denominated *Vascular*.

74. In the lower classes of plants there are no evident flowers—their organs of reproduction are obscure, and hence they are called *Flowerless* and *Cryptogamic*, while the higher classes have conspicuous flowers, and evident organs of reproduction, and hence are called *Flowering* and *Phanerogamous* or *Phænogamous*. In both classes the young plant, or embryo, in its earliest state, is cellular. This state is retained by the embryo or spore (Fig. 1, p. 2) of the former; while in the latter it assumes a high degree of development in the seed, and at maturity exhibits the parts which are to form the root, stem, and leaves, associated with certain temporary leafy appendages, or lobes, called cotyledons (Fig. 112).

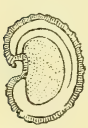
Fig. 112.

75. When the spore of Cryptogamic plants is sown in the soil, it gives off root-like processes, and either sends upwards a conspicuous stem with leaves, or produces a peculiar flattened expansion, called a *frond* or *thallus* (Figs. 14, 15, p. 12), bearing organs destined for forming spores. In Phanerogamous plants, on the other hand, when the seed

Fig. 112. Seed of Lychnis or Campion cut vertically, shewing the embryo plant coiled up in the interior. The narrow line, at the upper extremity of the embryo, points out the division of the two cotyledons. The other extremity is the radicular portion of the axis whence the root arises.

is planted, the young root of the embryo, proceeding from one end of the primary axis, descends, while the stem ascends, bearing leaves and conspicuous flowers. This process is represented in Figure 113,

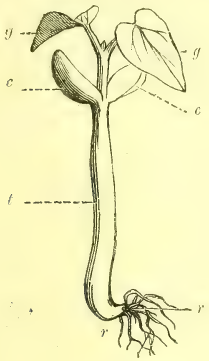

Fig. 113.

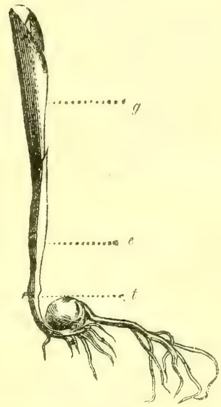

Fig. 114.

where r is the young root coming off from the radicular end of the axis; t is the stalk supporting the cotyledons $c\ c$; and $g\ g$ are the first leaves of the plant. The same process is seen in Figure 114, where the roots are seen proceeding from the lower part of the axis t; a single cotyledon is seen at c; and the young stem is marked g.

76. When we take a comprehensive view of the Vegetable Kingdom, we find that all the organs of plants are formed upon one harmonious plan. All are produced from cells, which are modified and aggregated in various ways, and are fitted for the special functions performed by the different parts of plants. The organs called Root, Stem, and Leaves, with their modifications, are those destined for nutrition or vegetation; while certain cellular bodies in Cryptogamic plants, and the Flowers in Phanerogamous plants, are the organs of reproduction.

I. THE ROOT OR THE DESCENDING PORTION OF THE AXIS.

77. The root (Fig. 113, r), generally speaking, is that part of the plant which descends into the soil, avoiding the light. It is the first organ developed from the axis of the embryo. The por-

Fig. 113. Haricot or French bean, a Dicotyledonous plant, germinating. r, the roots coming off from the radicular end of the axis; t, the stalk bearing the cotyledons $c\ c$; the young stem and leaves $g\ g$.

Fig. 114. Grain of Maize or Indian Corn, a Monocotyledonous plant, germinating. Roots come off from lower end of t, the axis; c, the single cotyledon; g, the young stalk and leaves.

tion of the axis from which it arises is called radicular. In Figure 115, the embryo of a pea exhibits, at *r*, the portion of the axis from which the young root proceeds. This portion is called the *Radicle;*

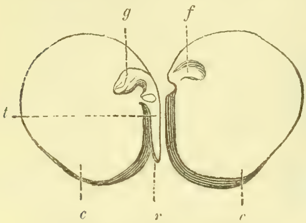

Fig. 115.

while the part, *t*, is connected with the ascending axis bearing the cotyledons, *c c*, and the young stalk, *g*, which lies in a depression, *f*, of the cotyledons. The root consists at first entirely of cellular tissue; and, in cellular plants, this continues to be the case throughout life. In vascular plants it is strengthened by the addition of woody fibres and vessels, and presents the same internal structure as is seen in the stem. It may be considered a downward prolongation of the stem.

78. The extremities of the roots are composed of loose cells, which appear to be the terminal tissue of the radicle, carried forward by the elongating root. These cells have been called *spongioles*, or *spongelets*, but they ought not to be reckoned special organs. They do not consist of the newly-formed tissues, but they are in reality an annual mass of older cells, pushed forward by the root as it is developed, and when they decay, they are replaced by the layer beneath. Thus, according to Schleiden, the point of the root consists of older and denser tissue than that immediately behind it. In the structure of the root we do not meet with true spirals. The epidermal covering does not present stomata; but hairs, usually formed of a single elongated cell, are produced, often in great abundance, which appear to serve the purpose of absorption. Figure 116 represents the magnified extremity of a young root of Orchis; *c c* being the cellular tissue, passing into fusiform dotted cells and vessels, *f p;* the cellular extremity of the root, called the spongiole, being marked *s p*. The extremities of some roots, as those of Duckweed and Pistia, are covered by a little cap-like process, or calyptra, which consists of a cellular layer, separating from the external parenchyma, but still retaining its connection with the point of the root, which perishes if the covering is removed. In Figure 117, there are seen two plants of Lemna minor, or lesser Duckweed, with their roots enclosed in a cellular sheath,

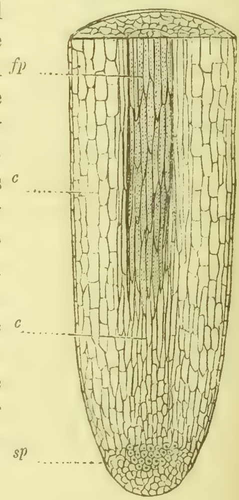

Fig. 116.

Fig. 115. The Dicotyledonous embryo of the pea laid open, magnified. *c c*, the two fleshy cotyledons, or seed-lobes, which remain under ground when the plant sprouts; *r*, the radicular extremity of the axis whence the root arises; *t*, the axis bearing the young stalk and leaves, *g*, which lie in a depression of the cotyledons, *f*.

Fig. 116. Vertical section of an Orchis root, highly magnified. The cells, *c c*, gradually pass into dotted cells and vessels, *f p;* the extremity of the root, called a spongiole, *s p*.

or pileorhiza.* Hairs are found on the roots of many plants, as on the roots of Orchids, on the aerial roots of Ivy, on grasses, as Piptatherum multiflorum and common maize, on the British species of Drosera, where the simple roots, which contain abundant starch granules, and perform the office of the thickened roots of some Orchids, are constantly submerged, and are coated with cellular filamentous processes. It is probable, Berkeley says, that the presence of hairs on roots is a very frequent phenomenon, though only recently observed. The hairs on roots seem to be without partitions. Some have a simple internal cell-wall, others have a spiral structure developed either through the whole or a portion of the thread.

79. The young roots of Cryptogamic plants, which have no cotyledons, or seed-lobes, arise from every part of the surface of the cellular

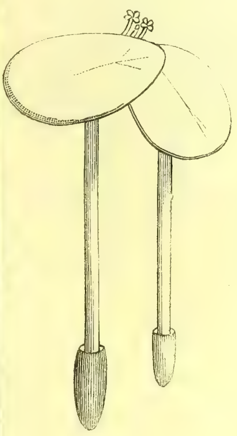

Fig. 117.

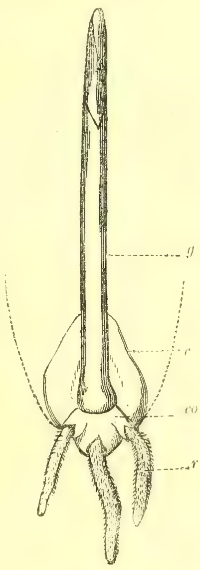

Fig. 118.

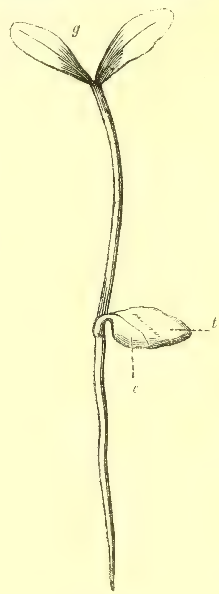

Fig. 119.

axis or spore (Fig. 1, p. 2), and they are called by Richard *Heterorhizal.* In Phanerogamous plants, having one seed-lobe, or cotyledon, and hence called Monocotyledonous (Fig. 118, *c*), the young roots arising from the radicular portion of the axis separate into numerous fibres (Fig. 118, *r*), which, in piercing the axis, are covered with a

Fig. 117. Magnified representation of two plants of Lemna minor, or Lesser Duckweed—the green mantle of the pools—shewing the extremities of the roots covered by a cellular sheath.

Fig. 118. Grain of Oats sprouting. The roots, *r*, passing through sheaths, *co*, the single cotyledon, *c*, and the young stalk and leaves, *g*. Richard calls it Endorhizal.

Fig. 119. Seed of Orange, a Dicotyledon, sprouting, shewing the root descending and tapering. *c*, the cotyledons in the seed, *t*; the young leaves, *g*. The plant is called Exorhizal by Richard.

* See Trecul on Roots, in Annales des Sciences Nat., 3d ser. tom. v. p. 340.

sheath, called a coleorhiza (Fig. 118, *co*). These roots have been called *Endorhizal.* Schleiden considers them as being adventitious. In Phanerogamous plants, having two seed-lobes, or cotyledons, and hence called Dicotyledonous, the young root elongates directly from the extremity of the radicle (Fig. 119), and afterwards divides. It is called *Exorhizal.* These divisions of Richard are not adopted by Schleiden.

80. Roots have no proper leaf-buds; but in certain circumstances they are capable of producing them. Roots occasionally arise from different parts of the stem. Thus, when a cutting of willow is placed in moist earth, or branches are bent so as to be inserted into the ground, roots are given off, in the form of cellular prolongations, from the surface, or from small lenticular points (Fig. 120, *l*), to which the name of lenticels has been given by some.* Such roots are *adventi-*

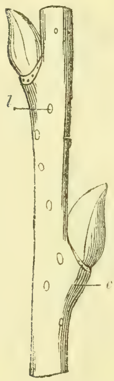

Fig. 120.

Fig. 121.

tious, *secondary*, or *abnormal.* The term *Aerial*, is given to roots which arise from the stem and branches of plants, and which, during the whole or part of their growth, are suspended in the air. Remarkable instances of these aerial roots are seen in the Banyan tree (Fig. 121), and in various other species of fig; in the Screw pine (Fig. 122, and Fig. 167, p. 70), in the Mangrove (Fig. 123), and in the Tree-fern (Fig. 165, p. 70). The extremities of these roots, when in the air, are sometimes covered, as in the Screw pine, with a peculiar cap-like covering. These abnormal roots ultimately reach the soil, and become subterranean, serving to support and prop up the trees to which they are attached.

81. In Epiphytes, or plants growing in the air, attached to the

Fig. 120. Branch of Willow shewing lenticels, *l*, and buds. The scars of the old buds are marked *c*.

Fig. 121. Ficus Indica, the Banyan tree, sending out numerous adventitious roots, which reach the soil, and prop the branches. The famous Nerbuddah Banyan is said to have 300 large, and 3000 small aerial roots, and to be capable of sheltering 3000 men.

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* Mohl, sur les Lenticelles. Ann. des Sciences Nat. 2d ser. x. 33. Unger, sur les Lenticelles. Ann. des Sciences Nat. 2d ser. x. 46.

trunks of trees, such as Orchids (Fig. 38, p. 21), the aerial roots produced do not reach the soil. They continue always aerial and greenish,

Fig. 122.

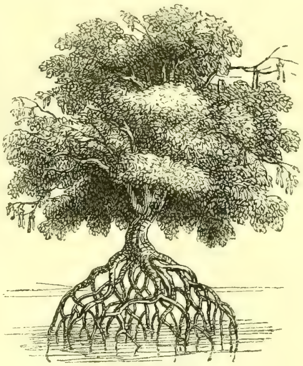


Fig. 123.

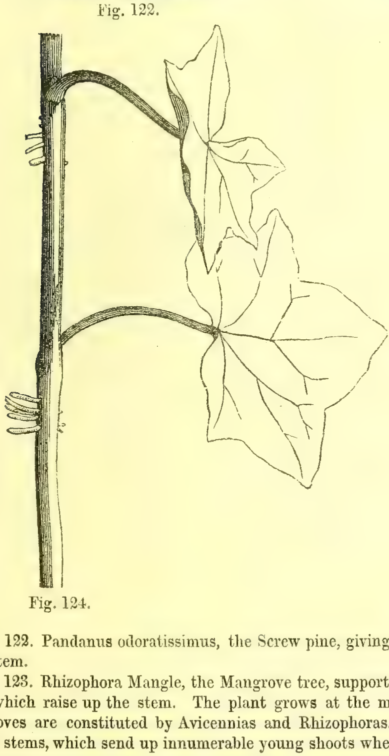


Fig. 124.

Fig. 125

Fig. 122. Pandanus odoratissimus, the Screw pine, giving off numerous aerial roots near the base of its stem.

Fig. 123. Rhizophora Mangle, the Mangrove tree, supported, as it were, upon piles by its numerous roots, which raise up the stem. The plant grows at the muddy mouths of rivers in warm climates. Mangroves are constituted by Avicennias and Rhizophoras. Avicennias have asparagus-like underground stems, which send up innumerable young shoots whenever the main stem is disturbed. Rhizophoras send out aerial roots which preserve the trees from falling after the terrestrial roots have lifted them high above the original level of the ground.

Fig. 124. Climbing branch of Hedera Helix, the Ivy, shewing the root-like processes by which it supports itself. These are not true roots. De Candolle calls them *crampons*.

Fig. 125. Viscum album, the Mistleto, a parasitic plant, deriving nourishment from the plants to which it is attached.

and they possess stomata. Delicate hairs are often seen on these Epiphytal roots, as well as a peculiar investment over their true epidermis.

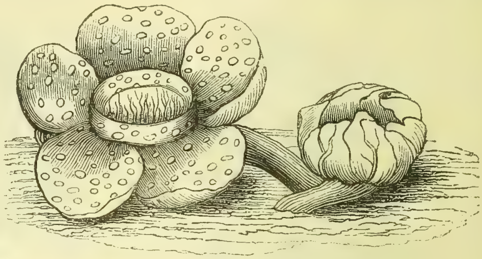


Fig. 127.

Fig. 126.

Fig. 128.

The aerial roots of the Ivy (Fig. 124), and those of Trumpet creepers, are not the proper roots of the plants, but simply processes intended for mechanical support.

Fig. 126. Orobanche Eryngii, a kind of Broom-rape, parasitic on the roots of the Eryngo. *a*, the flowering stem; *b*, the lower part of the stem, with the root, from the point of which fibrils proceed, uniting it to other plants.

Fig. 127. Rafflesia Arnoldi, a parasitic plant of Sumatra. The flower is three feet in diameter. It grows attached to the stem of a climbing Cissus.

Fig. 128. Cuscuta or Dodder, a parasite which first grows in the usual way, from seed, with its roots in the ground, but ultimately twines round other plants, and becomes attached to them by means of the rounded suckers represented on the slender branch, *a*, in the figure.

82. Parasitic plants, as the Mistleto (Fig. 125), Broom rape (Fig. 126), and Rafflesia (Fig. 127), send root-like processes into the substance of the plant whence they derive nourishment. In the Dodder (Fig. 128), the bark over the root swells into a kind of sucker (haustorium), which is applied flat upon the other plant, and ultimately

Fig. 129.

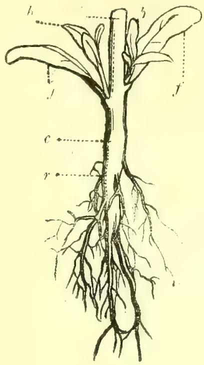


Fig. 130.

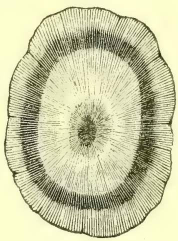


Fig. 131.

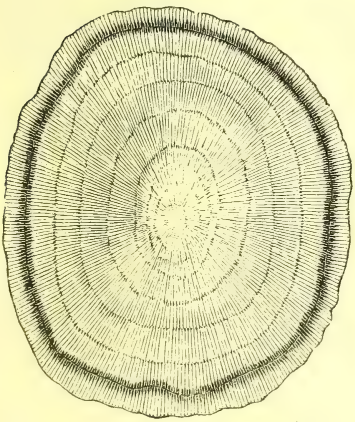


Fig. 132.

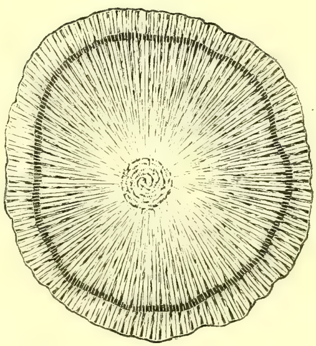


Fig. 133.

becomes concave, so as to attach the plant by a vacuum. From the bottom of the sucker the root protrudes which penetrates the supporting body. In the case of parasitic Fungi, such as mould (Fig. 11, p.

Fig. 129. Fibrous root of a grass. Numerous fibrils coming off from one point.

Fig. 130. Lower part of the stem and root of Matthiola or Stock. *r*, the tap-root, giving off slender branches; *c*, the point of union between root and stem *t*; *f f*, the leaves; *b b*, buds.

Figs. 131, 132, 133. Root of Cocculus palmatus, the Calumba, shewing concentric woody circles and rays running from the centre to the circumference.

11), there are cellular filaments which spread among the tissues of plants, and which may be looked upon as equivalent to roots and stems united. They form the spawn or mycelium of these plants, and in some cases cause rapid destruction of the tissues of plants, as in the disease called Dry-rot.

83. Roots vary in their duration. In plants which grow up, flower, and die in one year, they are annual. In such cases they are usually composed of slender fibrils, which are deciduous, like leaves. These roots, consisting of numerous fibrils, springing from one point, are called *fibrous* (Fig. 129). They are seen in many annual grasses. Plants which spring from seed one year, and flower the second season, and then die, have *biennial* roots; while those which continue to live and flower for many years, have *perennial* roots. In the last

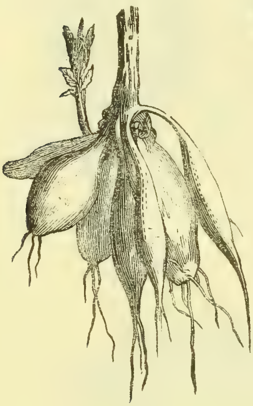


Fig. 135.

Fig. 134.

Fig. 136.

two cases the roots are often of a fleshy or woody consistence (Fig. 130).

84. Perennial woody roots, when cut transversely, as in Figures 131, 132, 133, exhibit a structure similar to that seen in stems. Thus, in these figures there are observed rays going from the centre to the circumference, with a kind of bark outside, and in Figure 132 there are concentric woody circles. Fleshy roots contain much starch, sugar, and gelatinous matter in their structure. They either descend singly, in an elongated tapering form, without branching, giving rise to various forms of *tap-root*—conical in the carrot, fusiform or spindle-shaped in the radish (Fig. 134), or napiform in the turnip—or they branch off in a fibrous-like manner, giving rise to *fasciculated* roots, as in Ranunculus and Dahlia (Fig. 135), and *tuberculate* or *tuberous* roots, as

Fig. 134. Fusiform or spindle-shaped root of Raphanus sativus, the Radish.

Fig. 135. Fleshy or fasciculated roots of the Dahlia.

Fig. 136. Orchis, shewing tubercules or tuberous roots, which contain a gummy matter called Bassorin.

in Orchis (Fig. 77, p. 33, and Fig. 136). In Ipecacuan (Figs. 137, 138,) there is a peculiar *annulated* root, shewing contractions at short intervals, while in Spiræa Filipendula (Fig. 139), the root becomes *nodose*, presenting irregular swellings on its fibrils. Occasionally a tap-root is suddenly arrested in its growth, or, in place of tapering to a point, ends abruptly. This is seen in the Bitten-rooted Scabious, the root of which is called premorse. In some cultivated plants, as turnip, the central root is sometimes injured, so as to end abruptly, and it then divides into numerous branches, resembling a fasciculated root. This gives rise to the disease called Anbury or fingers and toes, which is very injurious to the crop. Its cause is now under investigation by Dr. Anderson. The mode in which the fibres of roots are produced and developed, thus gives origin to different forms of Rhizotaxis, or root-arrangement.

Fig. 137.

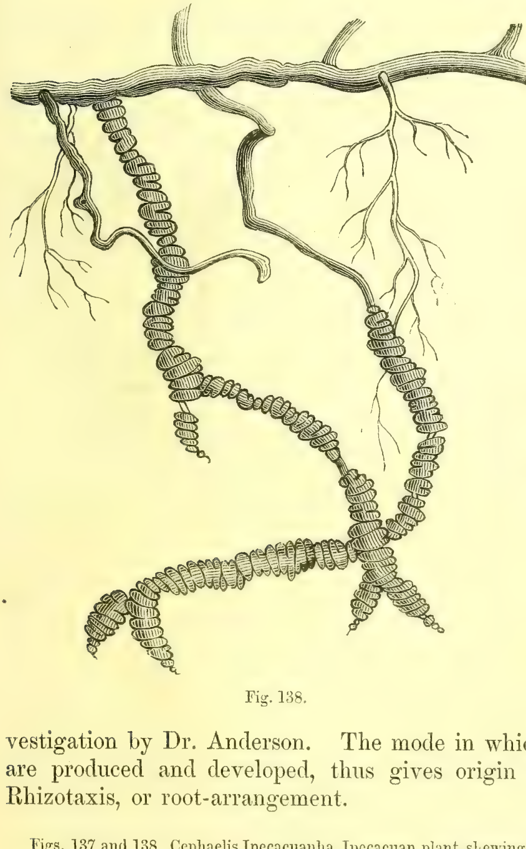


Fig. 138.

Fig. 139.

Figs. 137 and 138. Cephaelis Ipecacuanha, Ipecacuan plant, shewing moniliform or annulated roots.
Fig. 139. Nodulose roots of Spiræa Filipendula.

II. THE STEM OR THE ASCENDING PORTION OF THE AXIS.

1. VARIOUS FORMS OF STEMS AND BRANCHES.

85. The stem is the ascending portion of the axis which is developed in an opposite direction from the root (Fig. 115, *g*, p. 50.) It differs from the latter in usually seeking light and air, in bearing leaf-buds, which are produced at regular intervals, and in growing throughout its whole extent. In flowering plants conspicuous stems are met with, which differ in their texture, some being *herbaceous*, and dying down annually to the ground, others being *woody* and permanent, as in trees and shrubs. When stems are weak and trail on the ground, they are called *prostrate* or *procumbent* (Fig. 140); when such stems rise towards their extremity they are *decumbent*, and when they rise obliquely from near the base they are *ascending.* Some stems are so slender that they require the aid of other plants for their support. They are either *climbing* and *scandent* plants, such as the Passion-flower, which clings to other plants by tendrils, or the Ivy (Fig. 124, p. 53), which adheres to rocks and walls by its root-like processes; or they are *twining*, when the whole stem coils round other plants in a spiral manner, the coils being either from right to left, *i. e.*, to a person supposed to be in the centre of the coil, and the stem twining across his chest from his right to his left, as in Convolvulus, Calystegia (Fig. 141), Phaseolus vulgaris, and Dodder; or from left to right, as in the Hop (Fig. 142) and Tamus; or from right to left, and left to right alternately, as in the Bryony. Dutrochet points out, that there is a revolving movement in the summit of stems, a spiral rolling of the stems round their supports, a torsion of the stems on themselves, and a spiral arrangement of leaves—all these being in each plant in the same direction. These phenomena, he says, are owing to an internal vital force, which causes a revolution round the central axis of the stem.

86. Names are given to plants according to the nature and duration of their stems. *Herbs*, or herbaceous plants, have stems which die down annually. In some of them the whole plant perishes after flowering; in others, the lower part of the stem forming the *crown of the root* remains, bearing buds, from which the stem arises next season. In what are called *biennial* herbs, the whole plant perishes after two years, while in *perennial* herbs the crown is capable of producing stems for many years, or new annual products are repeatedly added many times, if not indefinitely, to the old stems. The short permanent stem of herbaceous plants is covered partially or completely by the soil, so as to protect the buds.

87. Plants producing permanent woody stems are called *trees* and

shrubs. The latter are less than five times the height of a man, and produce branches from or near the ground; while the former have

Fig. 140.

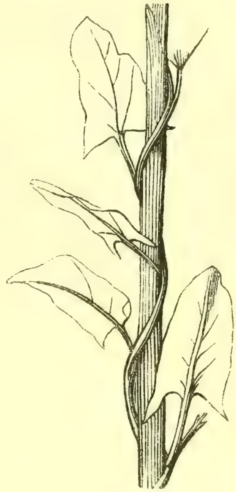


Fig. 141.

Fig. 142.

conspicuous trunks, which attain at least five times the height of a man. Shrubby plants of small stature are called under-shrubs or

Fig. 140. Convolvulus arvensis, common bindweed, with a prostrate or procumbent stem.

Fig. 141. Twining or volubile stem of Calystegia sepium, great bindweed. It turns from right to left of a person supposed to be standing in the axis of the plant.

Fig. 142. Twining stem of Humulus Lupulus, the Hop. It turns from right to left of a person supposed to be standing in the axis of the plant.

bushes. The limits between these different kinds of stem are not always well defined; and there are some plants occupying an intermediate position between shrubs and trees, to which the name of arborescent shrubs is occasionally given. The usual name given to the herbaceous stem is *Caulis;* in grasses the stalk is called a *Culm* (Fig. 78, p. 33); while in Palms (Fig. 83, p. 37), and Tree Ferns (Fig. 165, p. 70), the stem is denominated *Caudex* and *Stipe.*

88. Stems assume anomalous forms. In the Tortoise, or Elephant's-foot plant, the stem forms a large irregular thick mass, with a rough and tuberculated exterior. In the Melon-Cactus (Fig. 88, p. 38), it is globular, in other species of Cactus (Fig. 43, p. 22), it is jointed, columnar, or angular; while in the many Orchids (Fig. 143), it

Fig. 143.

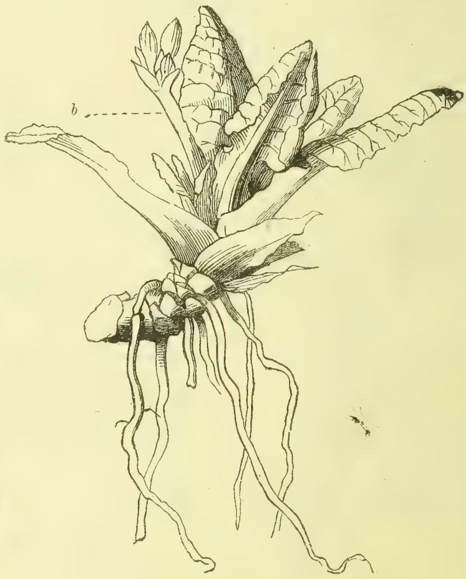


Fig. 144.

assumes an oval or rounded form, and is called a *Pseudo-bulb.* The stem is so short in some plants, as the Primrose, Cowslip (Fig. 144), Gentian, and Dandelion, that they are called *stemless* or *acaulescent.* A similar term is given in ordinary language to plants whose stems are buried in the soil, such as Cyclamen or Sow-bread.

89. The stem, although it has a tendency to rise upwards when first developed, in many instances becomes prostrate, and either lies along the ground, partially covered by the soil, or runs completely

Fig. 143. An Epiphytic Orchid (*Maxillaria*), producing thickened stems, called Pseudo-bulbs, as seen at the lower part of the figure. These Orchids are attached to stems of trees, and send out aerial roots.

Fig. 144. Cowslip (*Primula veris*), having the stem short and thick, and partially under ground. The leaves are called radical, because they arise from the crown of the root. Roots are seen coming off from the thickened stem. The flowering stalk in the state of bud, is seen at *b.*

underneath its surface, giving off roots from one side, and buds from the other. Some stems are therefore subterranean, and are distinguished from roots by the provision made for regular leaf-buds.

90. The points where leaves or leaf-buds are produced, are called *nodes*. In certain jointed stems or branches, as the Bamboo, these are well marked; but in stems which are not articulated, the nodes are often distinguished chiefly by the leaves which they bear, or by the scars left after their fall. The intervals between the nodes are denominated *internodes*, and they are of different lengths, according to the distance at which the leaves are placed from each other.

91. The stem may be considered as formed of a series of leaves, at first closely aggregated on a shortened axis, and afterwards separated by more or less evident intervals. As the leaves decay and fall off, the stem becomes more conspicuous and uninterrupted. Buds may be regarded as shortened leaf-bearing axes, capable of elongation, so as to form stems and branches, with nodes and internodes. Some buds are terminal (Fig. 145, *a*), or are produced at the extremity of the primary axis, just as the first bud in the Embryo-plant. These buds in their after-growth continue to add to the length of the stem. Other buds are lateral (Fig. 146, *b*), or are produced on the sides of the axis. These are concerned in the production of branches.

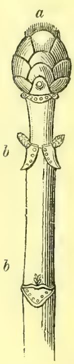


Fig. 145.

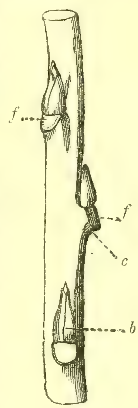


Fig. 146.

92. In trees which do not ramify, as most palms, there are no lateral buds. In plants which have permanent stems, and in which the leaves are deciduous, provision is made for subsequent growth, by the production of buds which lie dormant during the winter, or the season of repose, and are ready to burst forth when the spring or the rainy season returns. The buds are situated at the angles where the leaves join the stem, as in Figures 145 and 146, where *b b b* indicate the scars of fallen leaves, in the *axil* of which, or, in other words, at the angles formed between them and the stem, buds are produced. In cold and temperate climates these buds are protected by a coarse external scaly covering (Fig. 145, *a*), and sometimes also by a waxy, glutinous, or resinous matter, as is well seen in the Horse-chesnut.

93. Buds, in place of producing branches, are, in some instances, abortive, or remain latent, ready to be developed when any injury has been inflicted on the terminal buds or branches. Occasionally, after a

Fig. 145. Stem ending in a terminal bud, *a*, covered with protecting scales, which have a spiral arrangement, and are thrown off when the proper leaves are developed. This terminal bud continues the stem in an upward direction. Lateral buds are seen at *b b*, which are produced in the axil of leaves which have fallen, leaving scars or cicatriculæ. The points in these scars mark the bundles of vessels which proceeded to the leaves.

Fig. 146. Branch of Glycine, shewing lateral buds, *b*, produced in the axils of leaves, *c*, or at the points where the leaves join the axis. The leaves have fallen, and left cicatrices or scars. In the scars the fibrous bundles of vessels, *f f*, are seen.

partial development as branches, buds are arrested and form knots or nodules. The embryo-buds or nodules of the Beech, Cedar, and

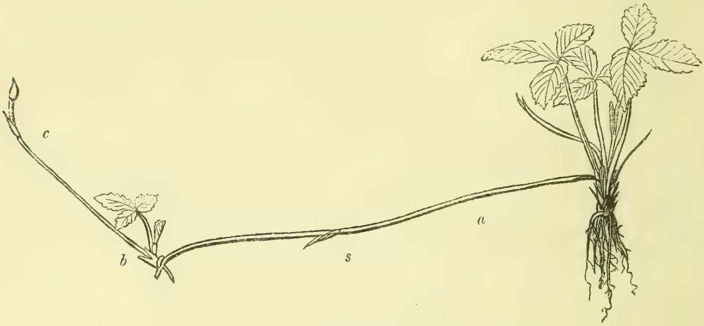


Fig. 147.

Fig. 148.

Fig. 149.

Olive, are apparently of this nature.* Sometimes several buds unite together in the axil of a leaf, and form a peculiar flattened branch.

Fig. 147. Runner, *a*, or flagellum of strawberry (*Fragaria vesca*). The runner is a slender branch, bearing at intervals leaf-buds, *b*, which form separate plants, and which are capable of forming other runners, *c*. The scales, *s*, on the runner, *a*, are small leaves capable of giving off branches.

Fig. 148. Branch of the Sloe (*Prunus spinosa*), producing spines or thorns, which are abortive branches, as shewn by their bearing leaves.

Fig. 149. Ononis spinosa, a spiny or spinescent plant. Leaves are produced on one of the spines or thorns. Some consider it as the Kotz or Koz of the Scripture, which is translated thorns (Gen. iii. 18; Hosea x. 8). The plant is called Spiny rest-harr w, and is said to be common in Palestine, as well as in many parts of Europe.

* Nodules, as they occur in the Cedar of Lebanon, have been shewn to be of the nature of buds; so also in the Olive, where, under the name of Uovoli, they are used for propagating the plant. Lindley says, that specimens he has received of these peculiar knots from Prince of Wales Island, fully confirm the view of their being capable of forming branches. Bird's-eye maple is said to be the timber cut from maple trees affected with these excrescences. The Bruscum of the Romans, so much prized by their cabinet-makers, was the wood of the common maple, twisted into irregular forms, in consequence of the presence of such excrescences.

94. Branches are sometimes long and slender, and run along the ground, producing roots and leaves at their extremity or apex. This is seen in the *runner* (flagellum) of the Strawberry (Fig. 147, *a*). In the Houseleek (Sempervivum) there is a similar prostrate branch of a shorter and thicker nature, producing a bud at its extremity capable of independent existence. It receives the name of *offset* (propagulum). A *stolon* differs from these in being a branch which curves towards the ground, and, when reaching a moist spot, takes root and forms an upright stem, and ultimately a separate plant. It is a sort of natural layering, and the plant producing such branches is called *stoloniferous*.

95. Spines or thorns are usually abortive branches ending in sharp points. This is shown by their producing leaves occasionally

Fig. 150.

Fig. 151.

(Figs. 148, 149), and by their being frequently changed into ordinary branches during cultivation. Plants bearing thorns (modifications of branches or leaves) are denominated spiny, spinose, or *spinescent*. Such plants may be illustrated by the species of Zizyphus, which abound in the warm, dry, and uncultivated parts of the East, and which, while they choke vegetation, present great obstacles to travellers. In Figures 150 and 151 are represented two species, Zizyphus Spina

Fig. 150. Zizyphus Spina Christi, a thorny tree of Palestine, which by some is considered to be the Akantha of the New Testament, mentioned in Matthew vii. 16; xiii. 7, 22; xxvii. 29, and in the parallel passages of Mark and Luke, as well as in John xix. 2, 5.

Fig. 151. Zizyphus Paliurus, or Paliurus aculeatus, another thorny plant of Palestine, supposed to be the Hebrew Shamir, translated briars in Isaiah v. 6; vii. 23, 24, 25; ix. 18; x. 17; xxvii. 4; xxxii. 13.

Christi and Zizyphus Paliurus, which are interesting as connected with Scripture history. *Tendrils* (cirrhi) are frequently an altered state of leaf-buds or branches, as in the Passion-flower and the Vine (Fig. 152), enabling the plants to climb. In the Vine, as represented in Figure 153, the tendrils, *v v v*, are considered by some as the terminations of separate axes. The lowest leaf in the figure is connected with the first axis, which ends in a spiral tendril, *v ;* and between this tendril and the leaf a bud is given off, forming a second axis, which ends in the second tendril, *v ;* between which and this second axis another bud is given off, forming a third axis, ending in a third tendril, *v*, and so on. The different axes are in this case called *cirrhose.*

Fig. 152.

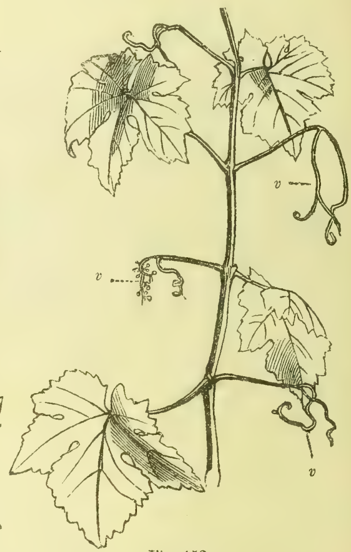


Fig. 153.

96. *Subterranean stems* and *branches* are sometimes short and thick, at other times they are elongated. Some are completely under ground, while others are only partially so; some increase by lateral, others by terminal buds. Many of them are in ordinary language called roots, from which, however, they are distinguished by the power of forming regular buds, or by having rudimentary leaves or scales on their surface. Many of them contain much nourishing matter, which is stored up for the future growth of the plant.

97. *Rhizome*, or root-stock, is the name given to certain root-like forms of creeping stems, which are more or less completely subter-

Fig. 152. The Vine (*Vitis vinifera*), the Gephen of the Old Testament, shewing the leaves with radiating venation, the clusters of flowers, and the tendril or cirrhus coiled up in a spiral form.

Fig. 153. Part of the stem of the Vine, shewing the formation of tendrils, each of which are considered as terminating axes. Between each leaf and tendril a bud is given off which forms an axis ending in a tendril, *v*. The axes are all cirrhose.

ranean. They are seen in Iris (Fig. 154), in Ginger (Fig. 155), and Convallaria (Fig. 156). Such stems exhibit on their upper surface the marks or scars of leaves, and it is to the scale-like appearance of these markings that the plant called Solomon's seal (Fig. 156), owes its name. Of a similar nature is the *Soboles*, or creeping stem of Carices (Fig. 157), Papyrus (Fig. 26, p. 20), and other grass-like plants, which spread through the sand and loose mud in such a way as to bind the particles together.

98. In the Banana (Fig. 64, p. 28), there is an underground stem which sends up shoots or branches of a herbaceous nature to bear the flowers and the fruit. In Asparagus the shoot developed from the subterranean stem is called a *Turio;* it is the part used as an article

Fig. 155.

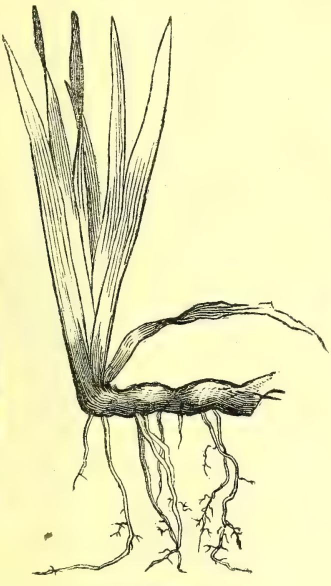


Fig. 154.

Fig. 156.

of diet; at first it is covered with scales, but it afterwards gives off branches, which bear leaves, flowers, and fruit. In the Rose and Mint a subterranean branch arises from the stem, which runs horizontally to a certain extent, and ultimately sends up an aerial stem, which becomes an independent plant. Such branches are denominated *Suckers*, and the plants are called *Surculose.* The gardener divides the connection

Fig. 154. Rhizome, or partially subterranean stem of Iris, giving off ensiform or sword-like leaves at one part, and roots from the lower surface.

Fig. 155. Rhizome, or thickened creeping stem of Ginger (*Zingiber officinale*), producing flowering stems and roots. This rhizome or root-stock is the part used economically and medicinally.

Fig. 156. Rhizome, root-stock, or partially subterranean creeping stem of Solomon's-seal (*Polygonatum multiflorum*). The scars left on the stem by the fall of the buds, give rise to the English name of the plant.

between the sucker and the parent stem, in order to propagate these plants.

99. The *Tuber* is a subterranean branch, which is arrested in its growth, and becomes remarkably thickened, in place of being elongated. It is seen in the potato and Jerusalem Artichoke; and the *eyes* produced in these instances are true leaf-buds. When the older parts die away, these tubers are found to belong to *one* axis with the new structures, which are subsequently formed. In the Arum (Fig. 158), Colchicum (Fig. 159), and Crocus (Figs. 160, 161), the tubers are perfected after the other parts, which belong to the same axis with themselves, so that they and the new structures belong to two axes, or at least to two different processes or shoots of the same axis. Such tubers are called *Corms.* They have a central axis, which is sometimes covered by thin scales, and they may be looked

Fig. 157.

upon as shortened axes with scaly leaves, or as subterranean buds. Corms may be regarded as dilated stems intervening between the first buds and the roots. They occur in monocotyledonous plants. Corms give off buds in the form of young corms. In the Crocus (Fig. 161), these are produced successively near the apex of the old corms, which are gradually absorbed. Thus, in Figure 161, No. 1 indicates the original corm now decayed; 2, the corm or bud produced from it; and, 3, the young bud produced from No. 2, and connected with the flowering stem of the year. In Gladiolus, the new corms are so superimposed

Fig. 157. Carex arenaria, sand carex, shewing a creeping subterranean stem, soboles. The bud marked 1 remains subterranean during the first year. It sends off a creeping branch or stem ending the second year in another bud, 2, which developes leaves and roots. In the same way this produces a stem ending in the bud 3, producing leaves, flowers, and roots. In its turn, 3 gives off a stem ending in a bud, 4. This Carex is one of those which binds the loose sands of the sea-shore together.

upon each other, that they gradually rise above ground. In Colchicum (Fig. 159,) the new corm, *b*, is produced alternately at either side of the old one, *a*, which shrivels. Sometimes three generations may be seen at the same time—the old corm, the new corm, and the bud of next year.

100. The *Bulb* is also a short subterranean axis, which is covered

Fig. 158.

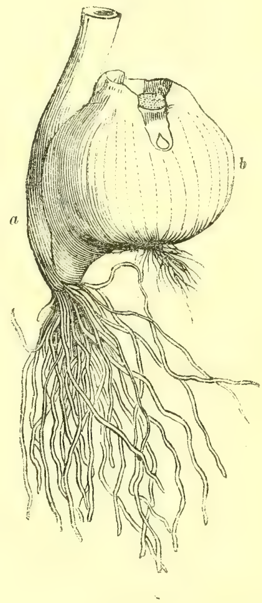


Fig. 159.

with fleshy scales containing succulent cells. It is a bud produced under ground, the centre corresponding to the axis, which is clothed with scales, and which sends flowering stems upwards, and roots downwards. In the Lily (Fig. 162), the thick and narrow scales

Fig. 158. Corm, or underground stem of Cuckow-pint (*Arum maculatum*), a Monocotyledonous plant. The Corm produces leaf-buds at one part, and roots at another. It contains much starch, which, when washed, yields Portland Sago.

Fig. 159. Corms of Meadow-saffron (*Colchicum autumnale*); *a*, old corm shrivelling; *b*, young corm produced laterally from the old one. Leaf-buds are produced at the upper part; roots below.

are arranged separately in rows, and the bulb is called *scaly;* while

Fig. 160.

Fig. 162.

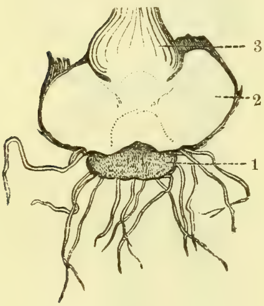


Fig. 161.

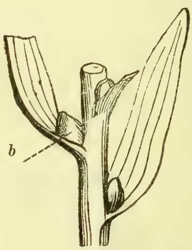


Fig. 163.

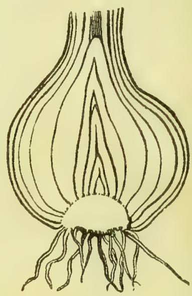


Fig. 164.

in the Leek (Fig. 164), the scales are broad, and enclose each other

Fig. 160. The flower of the Saffron-plant (*Crocus sativus*), the corms of which are seen in Fig. 161. The plant is the Karcom of the Bible, mentioned in Cant. iv. 14; and is the Krokos of the Septuagint.

Fig. 161. Corm of the Saffron (*Crocus sativus*), shewing the mode in which new corms are produced above the old. It may be looked upon as a rhizome, increasing vertically in place of horizontally. No. 1 indicates the old corm now shrivelled; 2, the corm produced at the apex of it, in the form of a bud; 3, the young bud producing a flowering stem.

Fig. 162. Bulb, or underground bud of the Lily, consisting of numerous fleshy scales arising from a common shortened axis, *a*, and covering a growing point, *b*. From the axis roots are given off below. It is denominated a Scaly, or naked bulb, and the axis is in the form of a fleshy plateau or disc, which gives origin to roots and scales; *c*, lateral buds or cloves, arising from the axil of scales; *b*, flowering stem proceeding upwards, covered at first by the scales.

Fig. 163. Stem of bulbiferous Lily (*Lilium bulbiferum*), shewing bulbels or bulblets, *b*, produced in the axils of the leaves. These bulblets are buds easily detached, and capable of forming independent plants.

Fig. 164. Tunicated bulb of Leek (*Allium Porrum*), cut perpendicularly, shewing the plateau or disc at the base whence roots proceed on one side, and scales with the growing point on the other. The outside scales are thin, while the internal ones are fleshy,

in a concentric manner, the outer ones being thin and membranous, and the bulb is *tunicated.* The scales are equivalent to leaves, and they produce buds in the form of cloves or young bulbs at the part where they join the axis. At the base of the bulbs there is a flattened rounded portion (Fig. 162, *a*), which produces roots from one side, and scales and leaves from the other. The central bud produces the flowering stem. The lateral buds or cloves sometimes remain attached to the axis, and produce flowering stems, so that the same bulb continues to flower for many years, as in the Hyacinth and Tulip; at other times the young bulbs are detached, and form separate plants. In the case of some plants, as Lilium bulbiferum (Fig. 163), bulbs are also produced on the stem, in the form of bulbels or bulblets, *b*, which are scaly buds, capable of being detached, and of forming independent plants.

101. Irmisch* considers bulbs and tubers, not independently, either as roots or buds on stems, but as bulbous and tuberous plants, and describes them as a special mode of persistence in plants. He divides them into three kinds: 1. A transformed thickened part, being the altered axial or stem-structure. This is called an axial or stem-tuber, as in the Potato, Arum, Colchicum, and Crocus. 2. Transformations of the root, called radical tubers, as in Orchis. 3. Transformation of leaves, or parts of leaves. These are called bulbs or leaf-tubers, as in the Onion, Lily, and Tulip.

2. INTERNAL STRUCTURE OF THE STEM IN GENERAL.

102. The forms of the stem having been considered, we now proceed to examine its anatomical structure. This structure consists of the elementary tissues combined and arranged in various ways. In some plants the part which serves the purpose of a stem, is composed entirely of cells arranged in the form of very narrow filaments, which are simple or branched, as in some fungi (Fig. 11, p. 11) and confervæ (Fig. 30, p. 20), or which form an expanded surface, called a Thallus or frond (Figs. 14 and 15, p. 12, and Fig. 50, p. 24). Such cellular plants have received the name of *Thallogens* or *Thallophytes;* while those producing stems composed both of vessels and cells, are sometimes called *Cormogens* or *Cormophytes.* In ordinary conspicuous stems, both cellular and vascular tissue are present. The latter is developed in a vertical manner, and is called the vertical or longitudinal system, while the former increases in every direction, and is called the horizontal system.

103. The arrangement and development of these two systems give rise to three marked forms of stems:—1. *Acrogenous*, in which the bundles of vessels are simultaneously developed, and the additions to the stem take place at the summit, by the union of the bases of the

* Irmisch (Th.) Zur Morphologie der Monokotylischen Knollen-und-Zwiebelgewächse. Berlin, 8vo, 1850. See also translation in Botanical Gazette for 1851.

leaves. Plants having this kind of stem are called *Acrogens*, or summit-growers. Tree ferns (Fig. 165) furnish an example. 2. *Endogenous*, in which the bundles of vessels are definite, and are deposited

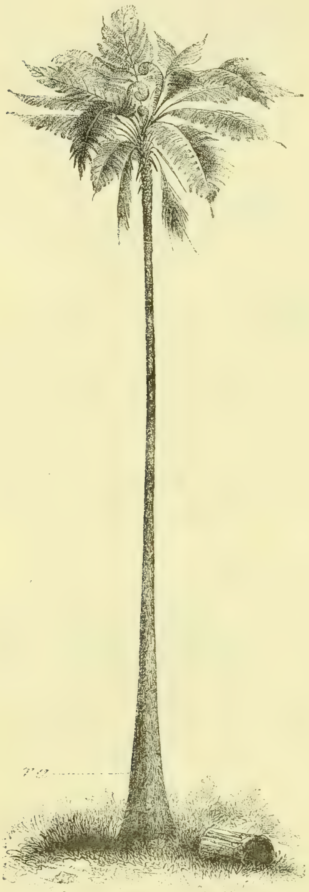


Fig. 165.

Fig. 166. Fig. 167.

towards the centre, which becomes filled up with them in the progress of growth, so that the diameter of the stem increases in a great mea-

Fig. 165. East Indian Tree Fern (*Alsophila perrotetiana*). It has an acrogenous stem, and its embryo is acotyledonous. The stem or stipe is unbranched. Towards the base, *r a*, there is an obvious enlargement caused by a number of adventitious or aerial roots which cover the stem, and are applied closely to it.

Fig. 166. Coco-nut Palm (*Cocos nucifera*). It has an endogenous stem, and its embryo is monocotyledonous. The stem is unbranched, and bears a cluster of leaves and fruit at the summit.

Fig. 167. Screw-pine (*Pandanus odoratissimus*). It has an endogenous stem, and its embryo is monocotyledonous. The stem is branched, and bears numerous clusters of leaves, which are arranged in a remarkable spiral or cork-screw like manner. From the lower part of the stem numerous aerial roots arise.

sure by the new matter pushing out that previously formed. Such plants are called *Endogens*, or Inside-growers. Palms (Fig. 166) and

Fig. 168.

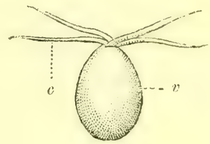


Fig. 169.

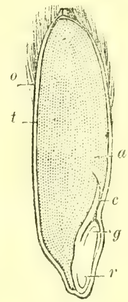


Fig. 170.

Screw-pines (Fig. 167) supply examples. 3. *Exogenous*, in which the bundles of vessels are produced indefinitely in an outward direction, and the stem increases in diameter by the annual formation of a new layer of woody matter formed on the outside of the preceding layers. Such plants are called *Exogens*, or Outside-growers. Ordinary trees, such as the Scotch Fir (Fig. 51, p. 25), and the Oriental Plane tree (Fig. 168), furnish instances.

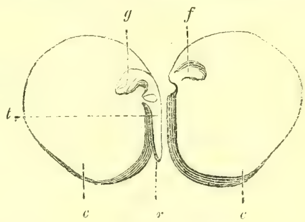


Fig. 171.

104. While the structure of the stem supplies obvious characters, it will be found that other distinguishing marks separate these three great classes of plants even in their earliest state. Thus, Acrogens have a cellular Embryo (Fig. 169), which

Fig. 168. The Plane-tree of the East (*Platanus orientalis*). It has an exogenous stem, and its embryo is dicotyledonous. The stem is branched. The tree seems to be the Armon of the Bible, and is mentioned under the name of Chesnut-tree in Gen. xxx. 37; Ezek. xxxi. 8.

Fig. 169. Spore, *v*, or cellular embryo of an acrogenous plant, with vibratile cilia, *c*. The embryo is acotyledonous, *i. e.*, has no seed-leaves or cotyledons.

Fig. 170. A vertical section of grain of oats, shewing the embryo plant at the lower part, consisting of *r*, the part whence the roots proceed; *g*, the young stem, and *c*, the single cotyledon. The plant is monocotyledonous. It has an endogenous stem. The covering of the grain is marked *o*, that of the seed *t*, and *a* is the nourishing matter called albumen. In Figure 114, p. 49, the single cotyledon, *c*, of maize, is represented when the embryo is sprouting.

Fig. 171. Embryo of the Pea, shewing the point whence the young root arises, *r*; the young stem or plumule, *g*; the stalk, *t*, connected with the cotyledons, *c c*, which are separated and laid open; *f*, the depression in which the plumule lay. The plant is dicotyledonous, and its stem is exogenous. In Figure 113, p. 49, the cotyledons, *c c*, of the haricot, are represented appearing above ground at the time when the embryo is sprouting.

has no cotyledons or seed-lobes—that is to say, has no leafy appendages to the Embryo or young plant, and hence they are called *Acotyledonous.* Endogens have an Embryo with one cotyledon on the axis, and when sprouting send up a single seed-leaf (Fig. 170 *c*); hence they are *Monocotyledonous.* While Exogens have two such cotyledons or seed-lobes (Fig. 171, *c c*), and are hence *Dicotyledonous.*

Thus, Acrogens are Acotyledonous.
Endogens are Monocotyledonous.
Exogens are Dicotyledonous.

A. *Exogenous Stem or the Stem of Dicotyledonous Plants.*

105. Exogens are the largest class of plants in all parts of the globe, and the structure of their stems is familiar to us in the trees of cold and temperate climates. In Britain the trees of our forests are all exogenous in their formation. Such trees, however, occur also in warm regions, associated with others exhibiting endogenous and

Fig. 172.

Fig. 173.

acrogenous structures. Exogenous trees are illustrated in Figures 172-176, representing the Scotch Fir (Fig. 172), the Cork Oak (Fig. 173), the American Plane Tree (Fig. 174), the Cedar of Lebanon (Fig. 175), and the Baobab of Senegal (Fig. 176).

106. An exogenous stem, in its earliest condition, is entirely cellular. When the plant begins to grow and sends up its first leaves, the cellular tissue of the axis is seen to be traversed by bundles of vessels (vascular bundles), which soon divide the stem into two marked portions; an internal, forming the central pith or medulla, and an external, forming the cortical pith or bark, covered by epidermis. The

Fig. 172. Scotch Fir (*Pinus sylvestris*), an exogenous or dicotyledonous tree of the colder regions of the temperate zone.

Fig. 173. Cork-oak (*Quercus Suber*), an exogenous or dicotyledonous tree of the warmer regions of the temperate zone. Its outer layer of bark supplies cork.

connection between the central pith and cellular bark is kept up by means of lines of cellular tissue, called medullary rays, which are in-

Fig. 174.

Fig. 175.

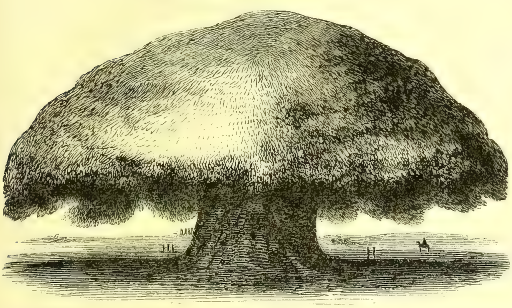


Fig. 176.

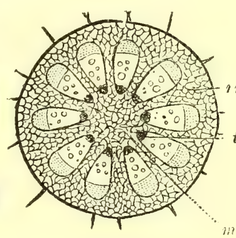


Fig. 177.

terposed between the vascular bundles. At the end of a year's growth,

Fig. 174. American Plane (*Platanus occidentalis*), an exogenous tree of temperate regions.

Fig. 175. Cedar of Lebanon (*Cedrus Libani*), an exogenous or dicotyledonous tree of temperate regions. It is remarkable for its wide-spreading branches, and used to abound on Lebanon. It is the Eres or Æres of the Old Testament, and is alluded to in various passages in the books of Samuel, Kings, Chronicles, Psalms, &c.

Fig. 176. Baobab-tree, or Ethiopian Sour-gourd (*Adansonia digitata*), an exogenous tree of hot climates. It is found on the west coast of Africa, and on the Cape de Verde islands. Its trunk attains sometimes a circumference of ninety feet, but its height is moderate. Some Baobabs are reckoned to be of a very great age.

Fig. 177. Horizontal section of the stem of a melon, shewing exogenous structure of one year's growth. Pith, *m*, consisting of loose cells often hexagonal; *t*, tracheæ, or unrollable spiral vessels, forming the medullary sheath, which is interrupted at different points to allow medullary rays, *r m*, to pass from the pith to the bark. The medullary rays divide the stem into ten wedge-shaped vascular bundles, the outer part of the bundles forming the fibrous layer of bark, and the inner constituting the wood; the pitted vessels are represented by large round openings. The circumference is the outer portion of the bark, consisting of cells which are covered by the general integument bearing hairs.

we observe, in the exogenous stem, a central cellular pith, a circle of vascular bundles in the form of wedge-shaped masses, an external bark and integument, and rays passing from the pith to the bark. This is the complete structure of exogenous herbaceous stems, which die down annually. The appearance is exhibited in Figure 177, which is the young stem of a melon cut horizontally; *m* is the medulla or pith, composed of loose cells containing fluid; *t*, tracheæ or spiral vessels immediately surrounding it, and forming a medullary sheath; *r m*, medullary rays, composed of more or less flattened cells, which extend from the pith to the external cellular bark or cortical layers; on the outside of the bark is the integument with projecting hairs, and between the medullary rays are ten wedges of fibro-vascular bundles, consisting of woody, porous, annular, reticulated, and spiral vessels; in these wedges the porous vessels are represented by large rounded openings. In Figure 178 is given a horizontal section of one of the fibro-vascular bundles, in order to shew its composition. The section extends from the pith to the outer integument; *m*, medulla or pith; *t*, tracheæ or spiral vessels, forming the sheath round the pith, the fibres being unrollable; *r m*, cellular medullary ray at the side of the vascular wedge; *f*, woody, annular, and reticulated vessels; *v p*, porous or pitted vessels of large calibre (Fig. 62, p. 26); *c*, a layer of green and active cells, forming what is called the cambium layer; *l*, woody fibres, constituting a layer called the inner bark (Fig. 45, p. 23); *v l*, ramifying laticiferous vessels (Fig. 70, p. 30); *p c*, cortical cells, constituting the cellular bark, which is covered by the common integument, *e*.

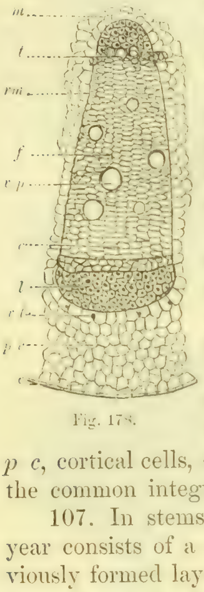


Fig. 178.

107. In stems which are not annual, the growth of the second year consists of a new formation of vascular bundles outside the previously formed layer, between it and the bark—the connection between the pith and the bark being still kept up by cellular rays. Between the pith and the bark there are annually formed a layer of active formative cells, called cambium cells, which are concerned in the development of new woody fibres. In Figure 179 is shewn a transverse section, *A*, and a vertical section, *B*, of one of the fibro-vascular bundles of the maple at the commencement of the second year of growth—the letters referring to both sections; *t*, tracheæ, or spiral vessels, forming the medullary sheath, which allows the medullary rays to pass through at different points; *v p*, porous or pitted vessels, constituting bothrenchyma or taphrenchyma, and presenting large rounded openings; *f*, *f*, fibres formed of fusiform tubes, the inner, *f*, marking the fibres form-

Fig. 178. One of the vascular wedges of the melon separated to shew its composition; *m*, medulla or pith; *t*, spiral vessels of medullary sheath; *r m*, medullary ray; *f*, woody fibres; *v p*, pitted vessels; *c*, cambium cells between wood and bark; *l*, inner bark, consisting of woody fibres, and called endophlœum; *v l*, laticiferous vessels; *p c*, cellular envelope of the bark; *e*, general integument.

ing the wood of the stem, and the outer, *f*, those which form the cortical fibres of the inner bark; *c*, cambium cells between the wood and bark; *p c*, *p c*, cortical polyhedral cells, often of a greenish colour, forming a cellular layer of bark; *s*, outer cellular layer of bark, composed of cubical or tabular colourless cells, often of a corky nature, and hence called suberous; this cortical layer is covered by the general integument. Thus, at the commencement of the second year's growth there is a distinct formation of cambium cells, by the action of which a new layer of wood, and a new layer of fibrous bark is formed, and these cambium cells, being in connection with the medullary rays, keep up the connection between the medullary and cortical cells.

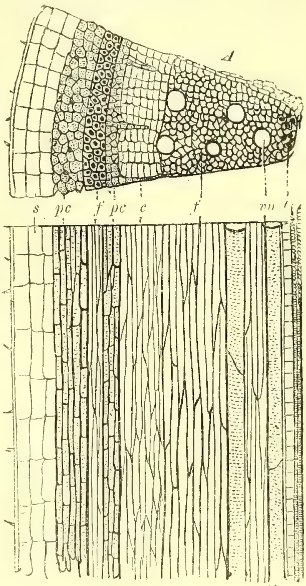


Fig. 179.

108. Let us now trace the changes which take place in the permanent woody stem of the Maple, after three years' growth, as represented in Figure 180. The yearly growth of the woody bundles is marked by the Figures 1, 2, 3:—1. The Pith, *m*, is surrounded by tracheæ, *t*, which are not repeated in the growths of subsequent years; outside these are the pitted vessels, *v*, and fibrous tissue, *f*, of the first year's growth. 2. Pitted vessels, *v*, and *f*, fibres, or woody and other vessels of the second year's growth. 3. Pitted vessels, *v*, along with fibres, *f*, of third year; *c*, layer of cambium cells outside the wood of third year. The outer part of the section consists of the layers of bark; *s*, the suberous, or outer layer of bark cells; immediately within, is *p*, cellular layer, and *l l*, fibrous layer of bark of first year; then follows the bark of the second year, *p l*; and, finally, the cortical layers of the third year, *p l*, which are separated from the wood by a cortical layer of new cells, *m c*, and the cambium layer, *c*.

109. In examining, therefore, the growth of an Exogenous stem, it will be seen, that while additions are yearly made to the layers of wood in an outward direction, so as to give rise to the term Exogen, or outside grower, the bark, on the contrary, increases by annual additions on the inside. The increase of the diameter of such stems takes place by successive deposits of vascular wedges in concentric circles,

Fig. 179. Section of the stem of a maple at the commencement of its second year's growth. *A*, Horizontal section; *B*, Vertical section. Spiral vessels round the pith *t*, pitted vessels *v p*, and woody fibres *f*, forming the layer of wood of the first year; *c*, cambium cells formed between wood and bark in second year's growth; *p c*, *p c*, cellular layer of bark with fibres, *f*, constituting the inner bark (liber or Endophlœum); *s*, suberous layer of bark (Epiphlœum), seen in the second year's growth as distinct from the cellular layer below; on the outside of the suberous layer is the general integument, with projecting hairs.

year after year, and during this growth the bark will become gradually distended. On examining old stems the different annual layers can be counted, especially in trees of cold and temperate climates, where there is a marked cessation of growth during winter. The parts of an Exogenous stem of three year's growth are displayed in a diagramatic manner in Figure 181—A being a horizontal, and B a vertical section of part of the stem. The cells of pith of an hexagonal form are marked *a a;* the pitted vessels, with large openings placed towards the inner part of each year's circle, *b b b;* the woody fibres of successive annual layers, *c c c;* spiral vessels of the medullary sheath, *d;* cambium layer of cells, *e;* inner fibrous bark, *f;* cellular cortical envelope, *g;* outer suberous layer of bark, *h;* medullary ray, *i i;* the figures 1, 2, and 3, indicating the growth of the different years.

110. Let us now proceed to examine the different parts of an Exogenous stem proceeding from the centre to the circumference. The *Pith* (Fig. 181, *a*), consists of cellular tissue (parenchyma), at first

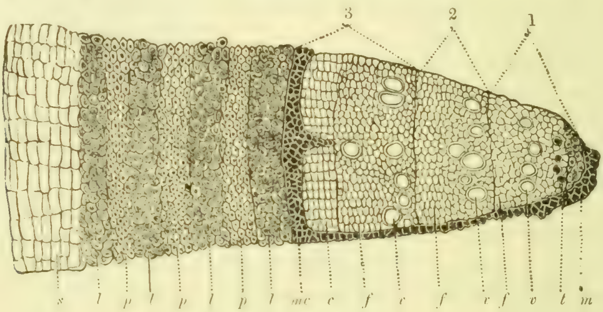


Fig. 180.

succulent, but afterwards becoming dry, as its juices are absorbed for the use of the young plant. In the progress of growth its cells are sometimes broken up, so as to form large empty cavities, as in the Walnut, Poke, Jessamine, and Horse-chesnut; at other times the whole pith gives way, owing to the rapid distension of the outer part of the axis in its early state, and then the stem becomes hollow, with shreds of pith attached to its interior, as in Umbelliferæ and Grasses. The cells of pith are well seen under the microscope, in the Elder, Papyrus (Fig. 26, p. 20), and Rice-paper.* The *Medullary Sheath* is the first

Fig. 180. Horizontal section of one of the vascular wedges of the maple, taken from a stem three years old. During the first year—1, there exist, *m*, medulla or pith; *t*, spiral vessels round pith, and, outside of these, pitted vessels, *r*, with large round openings, and woody fibres, *f*. In the second year—2, pitted vessels, *r*, and woody fibres, *f*. In third year—3, pitted vessels, *v*, along with woody fibres, *f*. During this third year the cambium layer of cells, *c*, is formed, on the outside of which are the layers of bark. The suberous layer of bark (Epiphlœum), consisting of tabular and cubical cells, is marked *s*, within this is seen the cortical layer of the first year, *l*, *p*, *l*, consisting of cells, *p*, and fibres, *l*, then that of the second year, *p*, *l*, and then that of the third year, *p*, *l*; *mc* being the bark in the progress of formation, next to the cambium layer, *c*.

* For remarks on Pith, see Guillard, sur la moelle des plantes ligneuses. Ann des Sc. Nat. 3 ser. Botan. t. viii. 295.

formed vascular layer (Fig. 181, *d*). It consists principally of spiral vessels (Fig. 63, p. 27), the fibres of which can be uncoiled. This is the only part of an exogenous stem in which these vessels ordinarily occur. This medullary circle is not always complete, spaces being left between the vessels where the medullary rays and the pith communicate. The tracheæ traverse the cellular tissue so as to reach the leaves.

111. *The Wood.*—The layers of wood (Fig. 181, *b c*), are formed outside the medullary sheath (Fig. 181, *d*). They consist of woody fibres (prosenchymatous tubes) such as those represented in Figure 45, p. 23, mixed with dotted ducts (Figs. 61 and 62, p. 26), and occasionally with a few annular (Fig. 66, p. 28) and reticulated (Fig. 67, p. 28) vessels belonging to the spiral type. On making a trans-

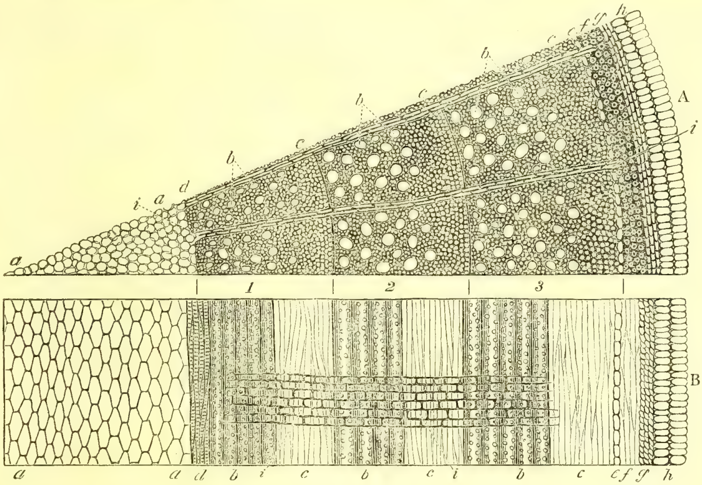


Fig. 181.

verse section of the stem of the Chesnut, Ash, or Oak (Fig. 182), the extremities of the dotted ducts (pitted vessels) will be seen in the form of large rounded openings on the inner side of the woody circle or zone. In Figure 182 they are represented as dark points on the inner margin of each circle. In the Maple (Figs. 179, 180), Plane, Lime, and Hornbeam, the openings are not so large, and are diffused through-

Fig. 181. Diagram of the structure of an Exogenous or Dicotyledonous stem of three years' growth, A being a transverse section, and B a vertical section. This is taken from the third edition of Dr. Carpenter's valuable work on Physiology. The Figures 1, 2, 3, mark the years of growth, and the letters refer to the same parts in both figures; *a a*, medulla or pith, consisting of hexagonal cellular tissue; *b b b*, pitted or dotted vessels (Bothrenchyma, and Taphrenchyma), and *c c c*, woody fibre of successive annual layers; *d*, spiral vessels of the medullary sheath; *e*, layer of cambium cells between wood and bark; *f*, inner fibrous layer of bark (Liber, Endophlœum); *g*, cellular envelope, forming middle layer of bark (Mesophlœum); *h*, outer corky layer of bark (Epiphlœum); *i i*, medullary ray which, in the transverse section, is seen running continuously from the pith to the bark; but in the vertical section, B, is seen interrupted, owing to the slight flexure which usually occurs, and which generally prevents us from tracing the ray in a continuous straight line when the stem is cut longitudinally.

out the annual zones, mixed with pleurenchyma. In coniferous (cone-bearing) plants, as the Fir and Pine, the woody layers are composed of disc-bearing pleurenchyma (Figs. 52-58, pp. 25, 26), without any dotted ducts, and hence, under the microscope, no large rounded openings are seen in the woody layers. This is represented in Figure 183, where the two rounded openings are not the extremities of dotted ducts, but lacunæ or cavities containing resin.

112. In the young state the pleurenchymatous tubes of the woody zones are pervious, but by degrees they are obliterated by the deposits of ligneous matter (lignin). In old exogenous trees the central wood is hard and durable, constituting the *Heart-wood* or *Duramen*, while the exterior wood is soft, forming the *Sap-wood* or *Alburnum*. The lignin deposited in the heart-wood frequently acquires a marked colour, as in the Ebony tree, where it is black; in the Black Walnut, where it is dark brown; in the Barberry and Judas-tree, where it is yellow; in the Red Cedar, where it is purplish-red; and in the Guaiac tree, where it is greenish.

113. The relative proportion between alburnum and duramen varies in different trees. Those in which the hard wood predominates

Fig. 182.

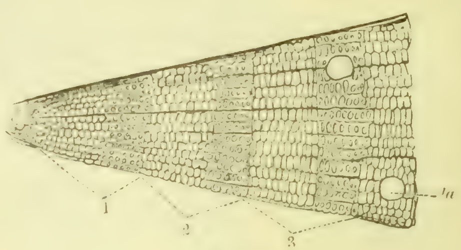


Fig. 183.

are best fitted for building, and for withstanding the effects of moisture, dry rot, and the attacks of insects and other animals. The durability of woods depends on the nature of the ligneous matter deposited in their pleurenchyma, and this varies much. The following are the particulars given in the Nautical Magazine of experiments made on several kinds of wood $1\frac{1}{2}$ inches square and 2 feet long, placed vertically in the ground, and about 1 foot 6 inches exposed to the atmosphere, on the 1st January 1831; examined at two different times, viz., 8th May 1833 and 24th February 1836:—

Fig. 182. Transverse section of the stem of an Oak, shewing the pith in the centre; the woody layers formed in concentric circles around it, and the layers of bark on the outside. There are six woody circles, indicating that the stem is the growth of six years, and the same age is indicated by the cortical layers. The dark dots on the inner side of the different woody layers mark the situation of the dotted vessels.

Fig. 183. Transverse section of the stem of a Fir three years old, as indicated by the Figures 1, 2, 3, which mark the annual layers of wood. In this plant there are no large openings of dotted ducts seen. The woody circles are made up chiefly of disc-bearing woody tissue. The two large rounded openings, one of which is marked *la*, are lacunæ, or cavities containing resinous matter, such as abound in the fir tribe.

Wood.	8th May 1833.	24th February 1836.
Teak, East Indian . . .	Very good	Rather soft, but good.
Teak, African	Very good	A little decayed.
Oak, English	Much decayed	Very much decayed.
Oak, Italian	Good, but decay had commenced in surface	Very much decayed.
Oak, Canada, White . .	Very much decayed .	Very bad, and rotten.
Oak, Memel	Very much decayed .	Very bad, and rotten.
Oak, Dantzic	Very much decayed .	Very bad, and rotten.
Mahogany	Good	Tolerably good.
Fir, Dantzic	Much decayed	Very much decayed, and rotten.
Fir, Riga	Much decayed	Do.
Fir, Memel	Much decayed	Do.
Larch, Polish	Decayed $\frac{1}{4}$ in the surface	Decayed $\frac{1}{4}$ of an inch.
Larch, Scotch, Treenails	Surface $\frac{1}{4}$ inch decayed and brittle.	Surface $\frac{1}{2}$ inch decayed, the rest brittle.
Elm, English	Very rotten	All rotten.
Ash, American	Very rotten	All rotten.

In making experiments as to the durability of timber for lighthouse purposes, Mr. Robert Stevenson sunk various kinds of wood into the sea, and he found that teak was the best for resisting the attacks of the Limnoria terebrans.

114. The woody zones annually formed are not always of the same size. Much depends on the state of the climate and season, the exposure of the plant to air and light, and the nourishment which it receives. A narrow ring of wood may be considered as recording a cold season, while a wide one indicates a warm season. The thickness of the layers of the Scotch Fir is small as we approach the Poles. Between 50° and 60° N. latitude, it is difficult, according to Bravais and Martins, to find annual layers of a thickness less than one-third of a millimeter ; in the north, on the contrary, the thickness is not $\frac{1}{16}$ of a millimeter.* The same zone also varies in size at different parts, so that, in many cases, the pith is excentric—that is, not exactly in the centre of the stem, owing to the circles being thicker on one side than on the other. Bravais and Martins notice a Scotch Fir in which the two semidiameters of the stem were to each at nine to nineteen, or the one more than double the other. In such cases, it usually happens, that the side of the tree having the greatest thickness is that which has been best exposed to air and light.

115. From the mode in which layer after layer of wood is formed, it follows that the age of an exogenous tree may be estimated by

* See Bravais and Martins' Observations in Annales des Sciences Nat. 2 ser. t. xix. p. 129.

counting the number of woody circles. In trees of cool climates, where there is a marked cessation of growth, this may be done with tolerable accuracy up to a certain age at least; but in trees of warm climates, where there is a less marked period of repose, this cannot always be done accurately. It is said that in some of the trees of tropical America monthly circles are formed; while in species of Cactus and Cycas more than one year is required to form a single zone. In estimating the age of trees in temperate climates, the rings or zones of woody matter must be counted from the pith to the bark. Mistakes have been committed, in many instances, by merely making a section of a stem, embracing a few zones, and then estimating from their size for the whole diameter of the tree. This is well illustrated by Lindley in the case of the following specimens of foreign wood, in which the semi-diameters of the stem are different :—

	Semi-diameter A.	Semi-diameter B.	Total Diameter.	Real Age or No. of Zones.
Benthamia fragifera	9 Lines.	36 Lines.	45 Lines.	40
Pyrus foliolosa .	8 Lines.	22 Lines.	30 Lines.	36
Magnolia insignis .	11 Lines.	20 Lines.	31 Lines.	17
Alnus nepalensis .	11 Lines.	23 Lines.	34 Lines.	8

In the first of these woods, if a portion of the semi-diameter A were examined, we would find that each zone was 0·225 of a line deep, and as the whole diameter of the stem is 45 lines, we would estimate the side examined to be 22·5 lines deep. Hence we would conclude, that as the plant took one year to grow 0·225 of a line, it would be 100 years in growing 22·5 lines, while in fact it was only 40 years. In the same way, any calculation founded on a section taken from one side of the other woods mentioned, would be far from the truth.

116. A simple way, according to De Candolle, of estimating the age of a tree, is to make two notches on opposite sides of a tree, and ascertain the mean of the number of the annual layers. Suppose two inches in depth thus extracted, and that the one has 10 annual rings, while the other has 16, it is evident that the average rate of growth will be 13 rings per inch. If we then ascertain the diameter of the tree, deduct the thickness of the bark, and multiply one-half the remaining diameter by 13, we shall have a close approach to the true age of the tree.*

* De Candolle, in his Physiologie Végétale, gives the following formulæ, by Otto, for measuring trees. Ascertain the diameter at the height of about five feet, and make a notch at the same point on the circular surface, to count a certain number of annual layers which we measure. We then find the annual growth of those trees which have left off growing in height, by the formula $\frac{4\,d\,(D-d)\,V}{n\,d^2}$; and for those which continue to grow in height by the formula, $\frac{D^3-(D-2\,d)^3\,V}{n\,D^3}$. D being the diameter of tree; V, volume of same; d, thickness of annual layers which have been counted; n, the

117. The following is given by De Candolle as the general rate of growth of the woody layers in different trees :—

	First Year.		Second Year.		Third Year.	
	Feet.	Inches.	Feet.	Inches.	Feet.	Inches.
Oak, circumference . .	0	$10\frac{1}{2}$	0	$11\frac{1}{2}$	1	$0\frac{1}{2}$
Larch, do.	1	$0\frac{1}{2}$	1	3	1	4
Elm, do.	2	$7\frac{1}{2}$	2	9	2	11
Lombardy Poplar, do. .	1	8	2	0	2	$3\frac{3}{4}$
Lime, do.	1	$8\frac{1}{2}$	1	$10\frac{3}{4}$	2	0

De Candolle states that the rate of the formation of timber diminishes rapidly after a given period, varying with the species. In the Oak the vigour of growth appears to diminish after 60 years, in the Larch after 40, in the Elm after 50, in the Beech after 30, in the Spruce Fir after 40, and in the Yew after 60 years. These statements, however, still require confirmation.

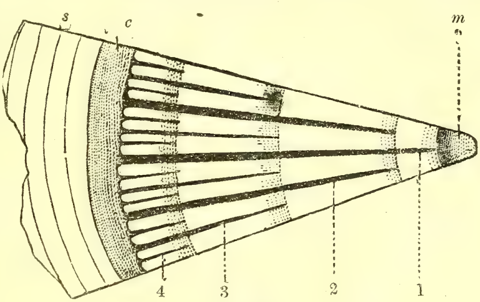


Fig. 184.

118. *Medullary Rays.* These connect the pith and the bark (Fig. 184, 1). They consist of flattened quadrangular cellular tissue, having an appearance like bricks in a wall, and

Fig. 184. Transverse section of part of the stem of the Cork Oak (*Quercus Suber*). The outer corky layer of bark (Epiphlœum), *s*, is very thick; *c* is the inner cellular envelope (Mesophlœum); immediately below it, is the liber, inner bark (Endophlœum), succeeded by woody circles, and then by the pith, *m*. Medullary rays are seen traversing the woody layers—one of these, 1, is complete, proceeding from the pith to the bark; the others, 2, 3, 4, are incomplete, proceeding only through some of the woody layers, and not reaching the pith.

number of these layers. These formulæ depend on two theorems:—1. That cones or cylinders of the same altitude are to one another as the squares of their diameters. 2. That similar cones or cylinders are to one another as the cubes of their diameters. In fact, calling n the number of layers, whose volume is C, we have two propositions, viz.:—$V : C :: D^2 : D^2-(D-2d)^2$, and $V : C :: D^3 : D^3-(D-2d)^3$. Whence we have $C = \frac{4d(D-d)V}{D^2}$, and $C = \frac{(D^3-(D-2d)^3)V}{D^3}$. Dividing this total growth of layers by n, we have the growth of one year.

The formulæ are correct if we admit, that during any ten or twenty years a tree does not acquire more or less wood than in an equal number of other years. But if the layers of growth, calculated every twenty years for about eighty years, are of equal thickness, the quotient will be too small, and in this case we must make use of the following formulæ :—

1. For trees which do not increase in height, we have $V : C :: D^2 : (D+2d)^2-(D-2d)^2$; whence we have $C = \frac{8d \times V}{D}$, and the annual growth will be $\frac{8d \times V}{2nD} = \frac{4d \times V}{nd}$.

2. For trees which grow in height we have $V : C :: D^3 : (D+2d)^2-(D-2d)^3$, and the annual growth will be $C = \left(\frac{(D+2d)^3-(D-2d)}{2nD^3}\right)V$. Reducing this for convenience, when we work

hence called muriform (Fig. 181, *i i*, p. 77). In the young stem these rays are large (Fig. 177, *r m*, p. 73), while in the more advanced woody stem they are seen as lines only. They constitute the silver-grain so conspicuous in maple, and they give the peculiar silvery lustre to many woods when cut in the direction from the pith to the bark. These rays do not proceed in a continuous plane from the top to the bottom of the tree. They pass through the woody layers in such a way as to be interrupted in their course (Fig. 181, B, *i i*, p. 77); and when a section is made perpendicularly to the rays, or, in other words, as a tangent to the circumference of the stem, their ends are seen projecting irregularly through the woody fibres. They are said by some authors to represent the horizontal system of the stem, or, as it were, the woof, which is traversed by the vertical woody bundles, like the warp. The medullary rays are in some cases, as in Clematis and Aristolochia, large and broad, while the woody wedges are comparatively small. Besides complete medullary rays, there exist others which only extend partially through the stem. This is represented in the horizontal section of a part of the stem of the cork oak, Figure 184. From the pith, *m*, to the cellular portion of the bark, *c*, the cellular line 1 extends completely, constituting a perfect medullary ray; but other minor rays marked 2, 3, 4, are seen extending only partially through the stem, and dividing the woody bundles into a different number of wedges at different parts.

119. *Cambium Layer.*—This is a layer of nucleated cells, lying between the wood and the bark, and originally connected with both (Fig. 181, *e*, p. 77). They are formed in a mucilaginous fluid called Cambium, and they are concerned in the formation of the woody tubes of the inner bark, and of the pleurenchyma, as well as in the additions made to the cells of the medullary rays. When these cells are carrying on the process of growth with activity, during the flow of the sap in spring, the bark can be easily separated from the wood. We shall have occasion to allude to them afterwards, in speaking of the formation of wood.*

120. *The Bark* is at first composed of uniform cellular tissue, resembling that of the central part of the stem (Fig. 177, p. 73). In the progress of growth transformations of the tissue take place, by which fusiform prosenchymatous tubes are formed in the inner portion of the bark next to the woody circle. This portion is called the *Inner Bark* or *Liber* (Endophlœum). It consists of thickened pleurenchyma (Fig. 45, p. 23), with some laticiferous vessels (Fig. 70, p. 30). It is

with large numbers, this expression becomes $C = \frac{(6\,D^2+8\,D^2)\,d\,V}{n\,D^3}$. The estimator who prefers measuring the circumference of the tree after having determined the diameter, may use the following formulæ:—

Let P be the circumference of the tree, and p = the circumference of a circle, whose diameter = 1; these 2 formulæ then become $C = \frac{4\,p\,d\,(P-p\,d)\,V}{n\,P^2}$, and $C = \frac{4\,p\,d\,V}{n\,P}$.

* Mirbel sur le Cambium, Archives du Museum, tom. i. 303.

the fibrous part of the bark (Figs. 178, *l*, 180, *l*, 181, *f*), and is often called *Bast* tissue. The fibres of the liber are long and tenacious, and are employed for various useful purposes. Those of the Lime-tree, Hemp (Fig. 47, p. 23), Flax (Fig. 46, p. 23), Mallow, Hibiscus, Boehmeria, Nettle, and Daphne cannabina, are employed for different articles of manufacture. The fibres sometimes separate, so as to form meshes, as in the Lace-bark tree; at other times they form a continuous layer, as in Horse-chesnut and Negundo. The inner bark of Antiaris saccidora has tenacious fibres, which are used in India for cordage and matting. The tree is common in the jungles near Coorg, according to Dalzell, and the people manufacture curious sacks from it. A branch is cut corresponding to the length and breadth of the sack wanted. It is soaked a little, and then beaten with clubs until the liber separates from the wood. The liber, in the form of a sack, is then turned inside out until the wood is sawed off, with the exception of a small piece left to form the bottom of the sack. These sacks are in general use among the villagers for carrying rice. The inner bark of various trees has been used for writing upon, and hence the name liber.

121. On the outside of the liber lies the cellular portion of the bark, consisting of two layers, the *Cellular Envelope* (Fig. 181, *g*, p. 77), called also Mesophlœum, and the *Corky* or *Suberous Envelope* (Fig. 181, *h*, p. 77), called also Epiphlœum. The former is composed of loose thin-walled polyhedral cells, containing chlorophyll, and hence often denominated the green layer; the latter consists of flattened tabular parenchyma, giving the peculiar colour to the branches and young stems of trees and shrubs. The Epiphlœum is rarely green; it is generally some shade of ash-colour or brown. It is sometimes developed to a great extent (Fig. 184, *s*, p. 81), constituting the cellular substance called cork, procured from the Cork oak (Fig. 173, p. 72), and produced also by various species of Elm.* In some trees the Epiphlœum falls off at certain intervals. In the Cork oak it does so in eight or nine years, leaving a tabular layer of cells below. In the Birch the outer bark is the part which separates in layers, owing to the formation of a stratum of thin-sided cells below the lamellæ, which easily separate into fine powder when disturbed. On the outer surface of the Epiphlœum is the Epidermis, or general integument, which in old trunks is thrown off.

122. The different layers of bark increase by additions of new cells to their inner surface. The cellular layers, however, soon cease to

* Cork, next to cellulose, is said by Mitscherlich, to be a most important constituent of the cell-wall. He states, that in the potato, the cells, consisting of cellulose, are filled with starch, and they are easily distinguished from the cork-cells by their chemical re-action. Concentrated sulphuric acid dissolves cellulose immediately, but does not act on cork until after the lapse of a considerable time. Nitric acid of sp. gr. 1·2, oxidises cork even below the boiling point of water; the cells first swell, and the product is then soluble in potash; they afterwards separate from each other, and by the continued action of nitric acid a series of acids is formed, the final members of which are suberic and succinic acids. See paragraph 52, p. 31.

grow, while the liber continues to increase by additions from the cambium layer. The thickening of the pleurenchyma of the liber takes place by concentric deposits of lignin, in the same way as in the case of woody tubes. Sometimes the different annual circles of bark may be traced, as shown in the young oak stem (Fig. 182, p. 78); but in general, after a certain length of time, all the layers are more or less amalgamated by the growth and pressure of the parts below, so that it is impossible to ascertain the age of the tree by the cortical layers. It is obvious that, by the constant additions to the wood on its outside, and the bark on its inside, the latter is distended, and when the cellular portion has ceased to grow, it cracks and splits in various ways, and ultimately falls off. The distention and increase in diameter of an Exogeneous stem is such, that a woody climbing plant, for example Bauhinia or Honeysuckle, when surrounding it, gives rise to marked grooves on the surface (Fig. 185), and often arrests its growth entirely by pressure on the sap wood.


Fig. 185.

123. Recapitulation of the different parts of an Exogenous Stem :—

1. Pith, Medulla, in the centre, composed of cells, frequently hexagonal.
2. Medullary Sheath, consisting chiefly of Spiral Vessels.
3. Woody layers, composed of Pleurenchyma and Dotted Vessels, arranged in zones, which are formed successively one outside the other.
4. Medullary Rays, formed of muriform cellular tissue, connecting the pith and bark.
5. Cambium layer, composed of cells, often fusiform, separating the wood and bark, and concerned in the formation of new wood and bark.
6. Liber, Inner Bark, Endophlœum, woody in structure, made up of long pleurenchymatous tubes, and some laticiferous vessels, additions being made internally.
7. Outer Bark, consisting of—
   a. Green Cellular Envelope, Mesophlœum.
   b. Corky or Suberous Envelope, Epiphlœum. The additions to the outer bark are made internally, and the parts are often thrown off in the progress of growth.
8. Epidermis, or Condensed Cellular Integument, covering all the organs, frequently thrown off in the progress of growth, and replaced by other cellular formations.

124. Although all these parts are generally observed in Exogenous stems, and present the order now mentioned, still, various peculiarities occur, especially among exogenous trees of warm climates, which often obscure the arrangement. Thus, in some trees of great age only one marked zone or circle of woody matter is seen, consisting of a series of separate wedges; in other trees there are several such

Fig. 185. Stem of an Exogenous tree, surrounded by a woody climber, which has caused contractions at different parts. In the West Indies such climbers constitute the Bush rope, an excellent specimen of which has been deposited, by W. H. Campbell, Esq. of Demerary, in the Museum of the Edinburgh Botanic Garden.

zones, each of which is the produce of more than one year's growth. In such cases the stem increases in diameter by the formation of new wedges, or by additions to the old ones. Occasionally the woody matter is so formed as to be in separate masses, surrounded by cellular tissue, which presents the same appearance as the outer bark (Fig. 186). Such a stem looks as if it were formed by several united together.*

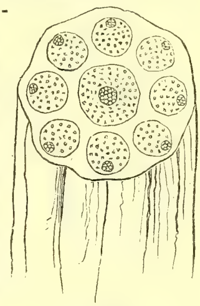


Fig. 186.

125. Many Exogenous plants with twining stems become much altered by compression. Other exogens exhibit fluted stems. In the Yarroura wood,† or Paddle-wood (Aspidosperma excelsum), large specimens of which have been presented by Dr. W. H. Campbell and Mr. Gourlie, to the Edinburgh Botanic Garden Museum, the stem is singularly fluted, and presents a waved or sinuous aspect. The same kind of appearance is seen in some woods which are imported for the purpose of furnishing dyes, such as Logwood, Nicaragua wood, and Rio de la Hache wood (Cæsalpinia echinata), &c.‡ In many anomalous stems the separable bark will lead the student to the determination of the Exogenous structure. In some of the lower class of plants a cellular stalk is produced, which on a transverse section presents an appearance like that of an Exogenous stem. Thus Lessonia fuscescens, a species of sea-weed, has stems which are often five to ten feet long, and as thick as the human thigh, and which show concentric elliptic cellular rings. Such is also the case with Usnea melaxantha, a tree-like lichen. In these plants, however, the structure is entirely cellular, and quite distinct from that of Exogenous plants.

126. *Branches of Exogens.*—In Exogenous stems a provision is usually made for the formation of branches, or, in other words, the stems grow, not merely by producing buds at the apex, which cause an increase in height, but also by lateral buds which give origin to branches (Figs. 172-5, pp. 72, 73). These are connected with the centre of the stem, and their tissues can be traced to the pith and its sheath.

Fig. 186. Peculiar fasciculated stem of a Malpighiaceous plant of South America. The plant is Dicotyledonous. The stem presents an example of an anomalous Exogen. It consists of numerous woody masses, having each distinct pith, and surrounded by cellular tissue, resembling that of the outer bark.

* For an account of anomalous Exogenous stems, see De Jussieu, Monographie de la Famille des Malpighiaceæ, Archives du Museum, tom. iii., 5, 255; Mirbel, sur l'organisation de la tige d'un tres vieux Calycanthus floridus, Annales des Sciences Nat. 1st ser., tom. xiv. 367; Gaudichaud, Recherches generales sur l'organographie, la physiologie, et l'organogenie des Vegetaux, Paris 1841; also article Exogen in the Penny Cyclopædia. Some interesting specimens of anomalous Brazilian Exogenous stems, collected by the late Dr. Gardner, are now deposited in the Museum of the Edinburgh Botanic Garden.

† The wood is the Yarroura or Hussara of the Indians, according to Bentham. The trunk of the tree has a fluted appearance. The wood is elastic, and very strong. The fluted projections of the trunk are used for the construction of paddles. The wood was formerly used for the formation of what are termed gin-rollers in manufacture.

‡ Specimens have been deposited in the Edin. Bot. Museum by Michael Connal, Esq.

From this mode of growth Exogenous trees have a form more or less tapering as regards their stem and branches. In the arrangement of their parts, branches resemble the stems from which they proceed. When regularly developed they taper to a point, and continue to produce buds, which again form smaller branches and twigs by constant subdivision.

127. The mode in which branches grow and subdivide gives rise to different aspects in forest trees. In the Cedar (Fig. 175, p. 73), the branches spread nearly at right angles; in the Italian Poplar they come off at an acute angle with the upper part of the stem; in some plants, as the Weeping Elm, they come off at an obtuse angle. In the Birch and Willow the branches become so slender at their extremities that they bend by their own weight. When the terminal bud of a stem or branch of an Exogen is cut off or arrested in its growth, the lateral buds are produced abundantly, and thus give rise to the appearance seen in pollard trees, and in the clustering of the twigs of the Birch and other trees. The comparative length of the branches in the upper and lower parts of trees tends also to give them a peculiar physiognomy. When the lowermost are longest, and the others are gradually shorter as we proceed upwards, the conical form is produced, as seen in the Douglas Pine (Abies Douglasii). When the uppermost are longest, as in Pinus pinea, the form is somewhat like that of an inverted cone.* When branches are produced under ground, and in darkness, they frequently become thickened and contorted in various ways, as seen in the potato, the tuber of which is a branch of this kind. When the potato is allowed to grow above ground, but in darkness, the ordinary branches sometimes assume the form of tubers.

B. *Endogenous Stem, or the Stem of Monocotyledonous Plants.*

128. This kind of stem is not seen in its fullest development in northern climates. We must look to the palms and screw-pines of warm regions, in order to see the striking effect produced by its mode of growth. The trunks of palms differ much in their aspect from the trees of this country. They have usually simple unbranched, cylindrical stems, towering to a great height, and covered by a large mass of remarkable foliage. The general physiognomy of palms is seen in the form of the Date-Palm (Fig. 187), the Wax-Palm (Fig. 188), the Oil-Palm (Fig. 189), the West Indian Cabbage-Palm (Fig. 190), the Talipot Palm (Fig. 191), and the Coco-nut Palm (Fig. 166, p. 70).†

129. In the structure of the woody endogenous stem there is no marked distinction between pith, wood, and bark, there are no medullary rays, nor concentric circles. Definite vascular bundles are dif-

* The forms presented by trees are well given in Selby's work on British Forest Trees; and their effect on the landscape is noticed by Mr. H. Twining, in his work on Picturesque Scenery, p. 83; as well as in Gilpin's Remarks on Forest Scenery.

† See Martius's large work on Palms, for delineations of their forms, and the character which they give to tropical scenery.

fused through the cellular tissue without apparent regularity, and the whole is enclosed by an external covering which differs from the bark of Exogens, in not having annual layers, and in not being separable from the wood. In Figure 192, which exhibits a transverse section of a Palm stem, this arrangement of tissues is seen. On the outside is the cortical portion not separable from the rest; the vascular bundles are marked *f*, and the cellular portion, which is looser towards the centre, *m*. In the early state the stem is entirely cellular, but in the progress of growth vascular bundles are produced, consisting of woody, spiral, dotted, and laticiferous vessels. In Figure 193, there is represented a transverse section of one of the fibro-vascular bundles of an Endogenous stem; upper *p* marking the general cellular parenchyma surrounding the bundle; lower *p*, woody fibres; *l l*, woody

Fig. 187.

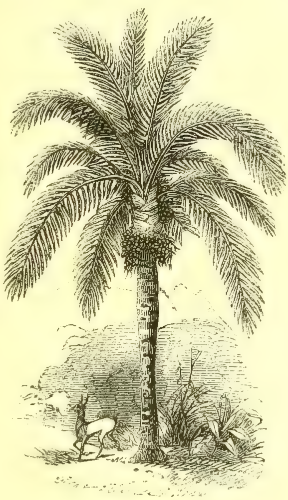


Fig. 188.

Fig. 189.

vessels analogous to those of the liber; *t*, tracheæ (spiral vessels); *v*, dotted vessels of large calibre; *v l*, laticiferous vessels. The vascular bundles are most abundant near the circumference, while the cellular tissue is in larger quantity in the centre (Fig. 192). In the bundles the woody vessels (Fig. 193, *l l*), generally surround the other vessels. A diagram of the stem of a monocotyledonous plant is given in Figure 194, A being a transverse, and B a longitudinal section. The cellular tissue which abounds in the centre, and which also exists between the

Fig. 187. Date Palm (*Phœnix dactylifera*). This is the Tamar of the Bible. (Exod. xv. 27; Psalm xcii. 12).

Fig. 188. Wax-Palm of South America (*Ceroxylon Andicola*). On the surface of its stem a waxy matter exudes, which is used by the natives.

Fig. 189. Oil-Palm (*Elais guineensis*). The palm which yields solid palm-oil, imported from Guinea in Africa. It also yields some of the best palm-wine. A specimen of the clustered fruit has been deposited in the Museum of the Edinburgh Botanic Garden, by Mr. Anderson of Liverpool.

vascular bundles, is marked *a a*. The vascular bundles are more abundant towards the circumference, consisting of dotted vessels, *b b*; woody fibres, *c c*; and spiral vessels, *d d*; besides laticiferous vessels.

130. The vascular bundles may be traced from the leaves downwards, some proceeding more or less directly towards the root, others curving outwards towards the cortical integument or rind (Fig. 195, *f v*). The mode in which these bundles proceed from the leaves towards the centre, in the first instance, has given rise to the term Endogenous, or inside-growers; the idea originally entertained by physiologists being, that the vascular bundles were always produced on the inside of those which preceded them. The bundles, however, although they have a tendency towards the centre at first, do not always remain there, but follow a curved course towards the periphery (Fig. 195), and in this way the outer rind becomes completely incorporated with them, so as not to be separable. The structure of the

Fig. 191.

Fig. 190.

Fig. 192.

bundles varies in different parts of their course. Near the base of the leaves they contain all the vessels already mentioned, but as we trace them downwards, the spiral, dotted, and laticiferous vessels disappear, and the woody fibres alone remain when they reach the rind, or, as it is often termed, the false bark.

131. From the mode in which the vascular bundles are added, it will be seen, that the tendency is to push the older vessels outwards, and to render the periphery hard. In Palms, therefore, the hardest part of the stem is external, which is the reverse of what takes place

Fig. 190. West Indian Cabbage-Palm (*Areca oleracea*). The large terminal bud is used in the same way as cabbage.

Fig. 191. Talipot-Palm (*Corypha umbraculifera*). The fan-shaped leaves of this palm are of enormous size.

Fig. 192. Transverse section of the stem of a Palm, which is endogenous; *m*, the central loose cellular portion; *f*, the outer fibrous portion, shewing numerous vascular bundles. The whole being covered by a false bark or rind.

in Exogens. By the internal addition of vascular bundles from terminal buds only, and by the interstitial growth of cells, the stem of a Palm increases in diameter until it acquires the full limit to which the outer rind can be distended, and attains ultimately a uniform diameter throughout. Thus, there appears to be a definite limit to the lateral growth of a Palm, while no such limit can be seen in the case of Exogens, in which vascular bundles go on increasing indefinitely, and the bark is separable. Palms consequently do not exhibit trunks of a diameter equal to that of Exogenous trees, nor does their bole present a tapering form. The first part of the stem of a Palm is formed by vessels which are connected with the first crown of leaves; the next crown, or terminal bud, produces more woody bundles internal to the first, and thus the stem is thickened during successive seasons, until at length the lower part is fully

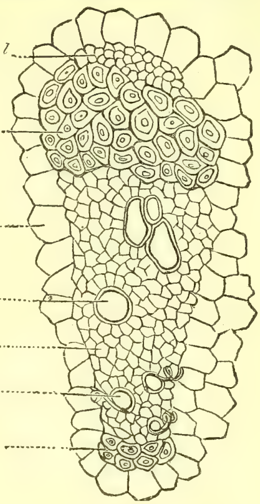


Fig. 193.

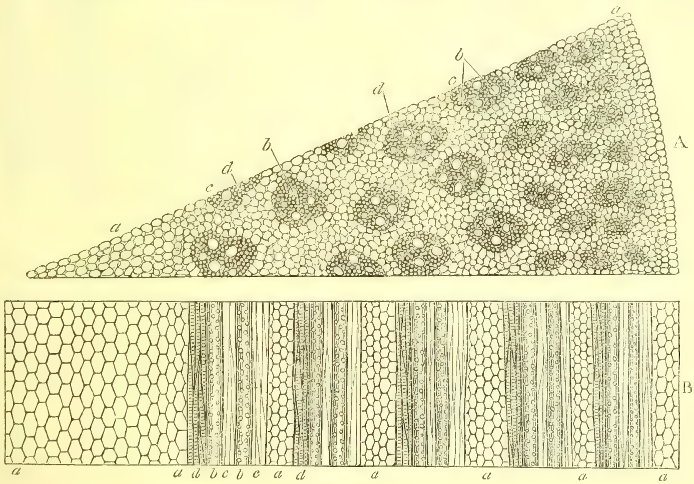


Fig. 194.

formed. The same process goes on throughout the whole stem, until it acquires a continuous cylindrical form.

Fig. 193. One of the vascular bundles of a Palm-stem, the lower part of the figure being that next the centre. Upper *p*, the general cellular parenchyma surrounding the bundle; lower *p*, woody fibres; *l*, *l*, fibrous thickened woody vessels, resembling those of the liber of exogens; *t*, tracheæ (spiral vessels); *v*, large dotted vessels; *v l*, laticiferous vessels.

Fig. 194. Diagram of a monocotyledonous stem, after Carpenter. A, Transverse section; B, longitudinal section; *a*, *a*, cellular tissue (Parenchyma); *b*, *b*, dotted vessels (Bothrenchyma); *c*, *c*, woody fibres (Pleurenchyma); *d*, *d*, spiral vessels (Trachenchyma).

132. From the structure and mode of growth of a Palm-stem, it follows, that a woody twining plant does not produce the same injury as in the case of an Exogen. In Figure 196 is shewn a Palm-stem, surrounded by a twining woody Bauhinia, which does no injury to the form of the stem. The contrast between the effects of such twiners on Exogenous and Endogenous stem, is seen in Figures 197 and 198. The stem of the former showing swellings and contractions, while that of the latter is unaffected. In the Exogenous stem the soft wood is external, and the stem increases much in diameter, while in the Endogenous Palm the soft part of the stem is internal, and the diameter is limited.

133. Palms grow in a uniform manner as regards height in their native countries, and their age may in general be determined by the length of their stem. The destruction of the terminal bud of a Palm

Fig. 195.

Fig. 196.

Fig. 197.

Fig. 198.

stops its growth, in consequence of there being no provision for lateral buds. In some instances, however, Palms have lateral buds. This is particularly seen in the Doum Palm of Egypt (Hyphæne thebaica), which gives off branches in a forked, or what is called a dichotomous manner (Fig. 199). There are also many endogenous stems which produce lateral buds. The Screw Pine (Pandanus), for instance, has a branching stem (Fig. 167, p. 70, and Fig. 200); so also Dracæna, Bamboo, and Asparagus. In the Dragon trees (Dracæna), a remarkable increase of stem takes place in consequence of the cortical integument remaining soft, and capable of unlimited distension. The vascular bundles, after reaching the circumference in these plants,

Fig. 195. Vertical section of a Palm-stem, shewing the vascular bundles, *f v*, curving downwards and interlacing. They proceed at first towards the centre of the stem, and then curve outwards.

Fig. 196. Stem of a Palm, surrounded by a woody twining Bauhinia. The palm-stem being uninjured.

Fig. 197. Exogenous stem, surrounded by a woody twining plant (Bush rope), which causes contractions and swellings of the stem.

Fig. 198. Endogenous stem, surrounded by a twining woody plant, and remaining uninjured.

descend towards the root, and being produced both by terminal and lateral buds, they are developed in large quantity, and thus give rise

Fig. 199.

Fig. 200.

Fig. 201.

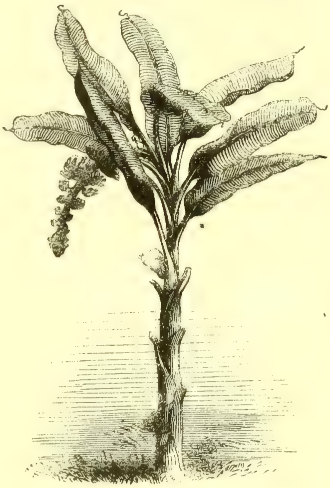


Fig. 202.

to enormous stems. Such a stem is seen in the famous Dragon tree of the Canaries (Fig. 201), which near the ground is 70 feet in circum-

Fig. 199. Doum Palm of Egypt (*Hyphæne thebaica*), with its dichotomous stem. The stem is forked, and divides always by twos. It is one of the branching palms. Its fruit is used as food, and from the taste of the rind, it has been called gingerbread tree. It yields a resin called Egyptian Bdellium.

Fig. 200. Screw Pine (*Pandanus*), a branching Endogen, which sends off aërial adventitious roots abundantly from the lower part of its stem.

Fig. 201. Dragon-tree (*Dracæna Draco*) of Orotava, a branching Endogen, with a remarkably thick stem. See Humboldt's Vues des Cordilleres, &c.

Fig. 202. Banana (*Musa sapientum*), having an underground Endogenous stem, and sending up a herbaceous shoot, which bears leaves, flowers, and fruit.

ference. When numerous buds are produced laterally, the lower part of the stem receives more bundles than the upper, and thus the stem tapers. This is seen in the Asparagus and Bamboo, which in this respect resemble Exogens.

134. In some Endogenous stems the rapid growth of the outer part gives rise to a rupture of the central cells, and thus the hollow stems of many grasses are produced. In the Bamboo the hollow cavities in the stem are separated by partitions formed by the crossing of the vascular bundles. In Xanthorrhæa hastilis, the grass-tree of New Holland, a liliaceous plant, the structure of the stem and branches is peculiar. On making a vertical section the structure appears to be that of an Exogen. The woody part is formed of vertical loose fibres like Palms, and there are other fibres, radiating from the centre, and cutting the preceding at right angles. These horizontal fibres resemble the medullary rays, but differ in their structure. They probably serve for the origin of leaves, which are numerous, and are disposed throughout the whole length of the stem.*

135. Endogenous stems sometimes remain under ground. The corm (Figs. 159 and 161, p. 67, 68) is in part a shortened endogenous subterranean stem. Bulbs (Figs. 162 and 164, p. 68), are underground endogenous stems, covered with scales. In the Banana (Fig. 202), as well as in the Asparagus, the true stem is subterranean, and sends up shoots bearing leaves, flowers, and fruit, which, after dying down, are succeeded by other shoots. The peripherical portion of some subterranean endogenous stems, as Sarsaparilla, presents a circle of vascular wedges, resembling in appearance the stem of certain exogens; and the false bark of some aerial endogenous stems, as Testudinaria, becomes much thickened by the formation of cellular matter resembling cork.

C. *Acrogenous Stem, or the Stem of Acotyledonous Plants.*

136. This stem, in its complete development, is seen in the Tree-ferns of foreign countries (Fig. 165, p. 70). It resembles the Endogenous stem in being unbranched, and in producing a crown of leaves at its summit. The Tree-fern form gives a peculiar aspect to the vegetation of the countries in which it occurs. The structure of the stem, which is called a caudex, consists of cells and vessels, arranged in a peculiar manner. The vascular bundles are formed simultaneously. They consist of woody tissue, often of a dark colour, surrounding a paler layer of vessels, chiefly scalariform (Fig. 68, p. 29), and dotted. The bundles assume various shapes, giving rise to the zig-zag appearance, presented in a transverse section, as seen in Figure 203. The basis of these leaves (or fronds as they are called), by their union form the stem, which is increased by additions to the summit (Fig. 165,

* A specimen of the stem of a Grass-tree (probably *Xanthorrhæa arborea*), has been presented to the Edinburgh Botanic Garden Museum by Dr. Neill.

p. 70); hence the name given of *Acrogens*, or summit-growers. The growing point is carried upwards by the leaves, and when once formed the stem increases very little in diameter. It is often hollow by the rupture of the internal cellular portion. On its outside the scars of the leaves remain (Fig. 204, *c*), with the markings of the vascular bundles. These bundles follow a course similar to that of the woody tissue of the liber of Exogens. The stem of Tree-ferns, then, is of moderate diameter, and does not produce lateral buds. Sometimes it terminates in two buds, which, by their growth, produce a forked stem. In the stems of the ordinary ferns of this country the acrogenous structure is seen, although they seldom attain any height, but usually

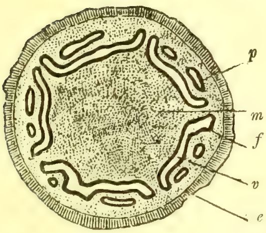


Fig. 203.

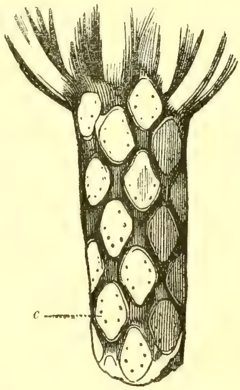


Fig. 204.

creep along the ground, forming rhizomes. In Figure 205 is shewn a fern called Asplenium, with a creeping rhizome, giving off roots on its lower surface, and fronds (leaves) on the other, some of the fronds being rolled up in a circinate manner. The bases of the leaves are seen persistent, that is, remaining attached to the stem. Figure 204 exhibits the rhizome of the common Male Fern (Lastrea Filix-mas), with the scars, *c*, of the leaves.

137. The acrogenous stem occurs in Horsetails (Fig. 34, p. 20), in Club-mosses, and in true Mosses, but in these plants it does not exhibit the same marked characters as in the permanent woody stems of Ferns. Many acotyledonous plants produce stems which consist entirely of cellular tissue without any admixture of woody fibre or vessels. Such stems are either aerial or subterranean. They appear as rounded stalks or flattened expansions rising into the air, or lying on the surface of the ground (Fig. 15, p. 12, and Fig. 50, p. 24).

Fig. 203. Transverse section of the stem of a Tree-fern (Cyathea); cellular tissue in the centre, *m*; that of the circumference, *p*; vascular bundles, *f v*, consisting of dark coloured woody fibres, *f*; and paler vessels, chiefly scalariform and dotted, *v*; the outer cortical portion formed by the basis of the leaves, *e*.

Fig. 204. Rhizome of Male Fern (Lastrea Filix-mas), shewing the scars (cicatrices) of the leaves (fronds), with the markings of the vascular bundles, *c*.

Sometimes they float in water like Seaweeds (Fig. 84, p. 37), at other times they creep under ground, or among the tissues of other plants, as in the case of Fungi. In Figure 11, p. 11, a representation is given of a Mould fungus, with root-like filaments at the base, consti-

Fig. 205.

tuting the spawn (mycelium) or creeping stem, which insinuates itself among the dead tissues of plants and other decaying substances. Occasionally, as noticed at paragraph 125, the cellular stems of seaweeds and lichens exhibit the appearance of concentric circles.

Fig. 205. Rhizome and fronds of Asplenium. The Rhizome, *r*, is covered with the bases of the leaves. Some of the fronds are in the bud, and are rolled up in a circinate manner, *f*. The fructification is seen on the back of the separated portion of the frond, *a*.

III. LEAVES AND THEIR MODIFICATIONS.

138. Leaves are important organs of nutrition, being the parts by means of which the sap of the plant is exposed to the agency of air and light. They proceed from the nodes (Fig. 146, *f*, p. 61) of the axis, and commence as cellular processes at the extremities of the medullary rays (Fig. 181, *i*, p. 77.) In the progress of development the cells multiply, vessels are produced which ramify in the form of veins, chlorophyll (¶ 59) is elaborated, and the foliar or leaf-organs, are thus completed. These organs usually spread horizontally, so as to expose one surface to the sky and the other to the earth—the surfaces differing in appearance and structure. When the position of their surfaces is reversed by artificial means, there is seen a marked tendency to recover their natural position. In some plants, as Alstroemerias, the leaf is twisted naturally upon itself, so that what should be the under surface becomes the upper. Erect or vertical leaves occur, in which both sides are equally exposed to light. In erect folded leaves, such as those of the Iris (Fig. 154, p. 65), the upper surface becomes lateral. In some New Holland plants the leaf-organs present their edges to the earth and sky.

1. ARRANGEMENT OF LEAVES ON THE AXIS.

139. The mode of arrangement of leaves on the stem has been denominated *Phyllotaxis.* It is regulated by certain definite laws, and depends on the development of the nodes and internodes of the stem and branches. When the internodes are so short that the stem is apparently awanting, the leaves are denominated *radical*, as in the Cowslip (Fig. 144, p. 60), and in the Dandelion. In such cases there is often at first sight some difficulty in determining the leaf-arrangement. When the internodes are elongated, and the nodes thus separated from each other, then the phyllotaxis is easily seen.

140. Each node is capable of producing a leaf or leaf-bud. When each of the nodes on an elongated axis produces a single leaf, the leaves are said to be *alternate* (Fig. 206), because they are placed alternately on different sides of the axis. When two leaves are produced at a node, they are called *opposite* (Fig. 207), because they are situated on opposite sides of the axis; while the production of three or more leaves at a node, gives origin to a circle or whorl of leaves, which are then said to be *verticillate* (Fig. 208).

141. *Alternate Leaves.*—This arrangement is a very common one, occurring generally in Monocotyledonous or Endogenous plants, and also being frequent among Dicotyledons or Exogens. The simplest arrangement is that in which the third leaf is placed directly above the first, while the second is placed on the opposite side of the stem,

separated by half the circumference of the circle. In this case there are two rows of leaves, one on each side of the stem, and the arrangement is said to be *distichous* (Fig. 209.) When the fourth leaf is above the first, on the same principle of the leaves being placed at equal distances on the axis, the arrangement will be *tristichous*, or in three rows, each leaf being separated from that next to it by one-

Fig. 206.

Fig. 207.

Fig. 208.

Fig. 209.

third of the circumference of the circle. If the fifth leaf is placed above the first, the arrangement will be *tetrastichous*, or in four rows; if the sixth leaf, *pentastichous*, or in five rows. The last-mentioned arrangement is delineated in Figure 210, which represents the branch

Fig. 206. Alternate leaves of Snap-dragon (*Linaria*). Each node gives off one leaf, or is unifoliar, and the leaves are placed alternately on the stem.

Fig. 207. Opposite leaves of St. John's wort (*Hypericum*). The nodes produce two leaves, or are bifoliar.

Fig. 208. Verticillate or whorled leaves of one of the Madders (*Rubia*). There are five leaves in the verticil or whorl.

Fig. 209. Distichous leaves of the Yew (*Taxus baccata*). The leaves are in two rows, the third leaf being directly above the first.

of an oak with six alternate leaves, the sixth being placed vertically over the first.

142. It will be observed that, in following the course of the alternate leaves on the stem, we proceed in a spiral or screw-like manner, and that the termination of the spiral cycle is to be found in the leaf directly above that from which we commenced. On reaching it the cycle begins again, and goes through the same course as regards the number and arrangement of the leaves. Thus, in Figure 210, the cycle ends at the sixth leaf, which, in fact, commences the new spiral coil. In completing this spiral cycle we may make a single turn round the stem, as in distichous leaves (Fig. 209), or we may make

Fig. 210.

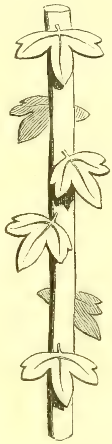


Fig. 211.

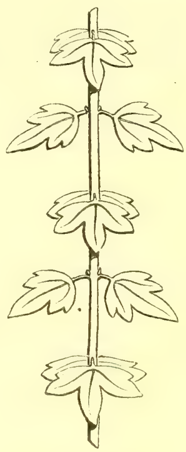


Fig. 212.

two or more. Thus, in the pentastichous cycle we make two turns round the stem, and encounter five leaves besides the first (Figs. 210 and 211). The arrangement has, therefore, been marked by a fraction, of which the numerator indicates the number of turns round the stem, and the denominator the number of leaves in the cycle. This fraction, at the same time, gives the angular divergence of the leaves, or their distance from each other, expressed in parts of the circumference of the circle. Thus the fraction $\frac{1}{2}$ indicates distichous leaves (Fig. 209), where the angular divergence is one-half of the circumference of the circle, or 180°; the fraction $\frac{1}{3}$ implies tristichous leaves where the angular divergence is one-third of the circumference

Fig. 210. Branch of oak *(Quercus pedunculata)*, shewing the pentastichous or Quincuncial arrangement of leaves. The leaves are placed alternately, so that the sixth is directly above the first, and commences the second cycle. The leaves are numbered 1, 2, 3, 4, 5, 6, according to their position.

Fig. 211. A stem with alternate leaves, arranged in a pentastichous or quincuncial manner. The sixth leaf is directly above the first, and commences the second cycle. The fraction expressing the divergence of the leaves is $\frac{2}{5}$. It is common among Dicotyledons.

Fig. 212. A stem with opposite leaves. The pairs are placed at right angles alternately, or in what is called a decussate manner. In the lowest pair one leaf is in front, and the other at the back; in the second pair the leaves are placed laterally, and so on.

of the circle, or 120°; the fraction $\frac{2}{5}$ applies to the pentastichous or Quincuncial arrangement (Fig. 211), a very common one among Exogens, in which the sixth leaf is immediately over the first, and two turns of the circumference are made before coming to it, the angular divergence being 144°.

143. The alternate phyllotaxis, and the angular divergence of leaves is explained more fully by Figures 213 and 214. In these it is shown that, in the case of alternate leaves, perpendicular lines may be drawn through the leaves placed directly over each other, and that the number of these lines indicates the number of leaves in each spiral cycle, or the number of leaves between any leaf on the stem and that directly above it. In both these Figures it will be seen that the number of these lines is seven, and this, consequently, is the number of leaves in each cycle. It is, therefore, a Heptastichous cycle, ending with the eighth leaf which commences the new spiral coil. But it will also be noticed that the number of turns made round the stem in completing the cycle is different. Thus, in Figure 213, commencing with leaf

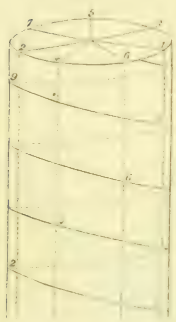


Fig. 213.

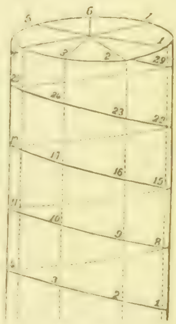


Fig. 214.

Fig. 215.

No. 1, we reach leaf No. 8, or that directly above 1, after making three turns round the stem, and the fraction indicating this is $\frac{3}{7}$; whereas, in Figure 214 we reach No. 8 after one turn, and the fraction, therefore, is $\frac{1}{7}$. These fractions mark the angular divergence between any two leaves of the cycle, as represented in the divided circles at the upper part of the stems. In Figure 213, between 1 and

Figs. 213 and 214. Diagrams to illustrate the arrangement of the leaves on the stem. In each figure the spiral cycle consists of seven leaves. In Figure 213 the divergence between every two leaves is $\frac{3}{7}$. This will be seen by looking at the circle at the upper part, where the distance between 1 and 2 is obviously 3 of the seven divisions. In Figure 214 the divergence between every two leaves is $\frac{1}{7}$, as seen by the marks on the circle.

Fig. 215. Fir cone, consisting of numerous scales, which are metamorphosed leaves, arranged on a common axis, and covering the seeds. The scales are arranged in a spiral manner. One generating spiral passes through all the scales of the cone. There are numerous secondary spirals. The number of secondary spirals running parallel to each other indicates the difference between each scale in a single spiral. By this means all the scales may be numbered.

2 the angular divergence is obviously $\frac{3}{7}$ of a circle, or $\frac{3}{7}$ of $360^{\circ} = 154\frac{2}{7}^{\circ}$, while, in Figure 214, the divergence is $\frac{1}{7}$ of the circle, or $\frac{1}{7}$ of $360^{\circ} = 51\frac{3}{7}^{\circ}$.

144. The following are some of the usual modes of divergence of leaves, and their modifications :—

DIVERGENCE.	DICOTYLEDONS.	MONOCOTYLEDONS.	ACOTYLEDONS.
$\frac{1}{2}$ Distichous.	Asarum, Lime, Vicia, Orobus, Pea.	Common in Gramineæ, Cyperus, Acorus Calamus.	Fissidens, Didymodon capillaceus.
$\frac{1}{3}$ Tristichous.	Cereus triangularis (green fleshy divisions of the axis).	Carex, Colchicum autumnale.	Gymnostomum æstivum, Jungermannia trichophylla.
$\frac{2}{5}$ Quincunx.	Common in this class, Apple, Pear, Poplar, Cherry, Mezereon.	Eleocharis acicularis, Rhynchospora fusca.	Common.
$\frac{3}{8}$	Laurus nobilis, Holly, Aconite, Plantago.	Lilium candidum, Scirpus lacustris.	Common in mosses, Lycopodium Selago.
$\frac{5}{13}$	Wormwood, Euphorbia segetalis, Convolvulus tricolor, cones of White Pine, and White Spruce.	Agave americana, many species of Orchis.	Orthotrichum affine, Lastrea Filix-mas.
$\frac{8}{21}$	Isatis tinctoria, Plantago lanceolata, cones of Pinus Picea.	Gymnadenia conopsea, many species of Yucca.	Hypnum alopecurum, Polytrichum piliferum.
$\frac{13}{34}$	Euphorbia cæspitosa, Plantago media, cones of some Pines, Sempervivum arboreum.	Yucca aloefolia, Ornithogalum pyrenaicum.	Sphagnum, Polytrichum formosum.
$\frac{21}{55}$	Cones of some Pines. Mammillaria coronaria (protuberances on the axis).		

145. On looking at these fractions, and they embrace the common arrangements, it will be seen that they bear a constant relation to each other, for the numerator of each fraction is equal to the sum of the numerators of the two preceding fractions, while the denominator is the sum of the two preceding denominators; and the numerator of each is likewise the denominator of the next but one preceding.

146. In the case of stems with marked internodes, with few leaves in the cycle, and with the points of insertion small, these arrangements can be easily detected; but when the internodes are much shortened, and the leaves are very numerous, it is difficult to trace the arrangement. The general spiral arrangement, however, is well seen in cases where numerous leaves are approximated, as in the Screw-pine (Fig. 200, p. 91), and the number of vertical rows in such cases may

be easily detected. In the instance of the Fir cone (Fig. 215), which is composed of a series of scales, or metamorphosed leaves, covering the seeds, there is a very evident spiral arrangement, and a continuous series of spiral cycles will be found which pass through every scale of the cone. This generating spiral is not always readily detected, and it is difficult to determine the successive scales through which it passes. By examining the cone, however, there are seen numerous secondary spirals, proceeding some to the right, and others to the left. The scales in these stand to each other in regular arithmetical progression—the numbers indicating the differences between each scale being determined by the number of spiral cycles running parallel to each other. By this means all the scales may be numbered, and the generating spiral detected. A general tendency to alternation has thus been shown in the foliar arrangements of plants, and when they grow regularly the law of phyllotaxis can be ascertained correctly. The arrangement, however, is often much altered by interruption in growth, and other causes, so that we cannot in *all* cases detect its normal condition.

147. The Phyllotaxis is uniform in the same species, but it frequently varies in species of the same genus. Thus, in the European Larch, it is $\frac{8}{21}$, while, in the American Larch, it is $\frac{2}{5}$. The spirals proceed either to the right or to the left. The phyllotaxis of the branches is usually the same as that of the axis, and it is then called homodromous (a like course); but sometimes it is different, and called heterodromous (unlike course).

148. In typical arrangements, such as those noticed, there are always certain leaves placed directly over others in a straight series, the angle of divergence dividing the circumference into an exact number of equal parts. Such leaves are *rectiserial*, and are considered as being normal. Cases, however, occur, in which the angle of divergence is such, that it is not possible to divide the circumference by means of it an exact number of times, and hence no leaf can be exactly placed above another. Such cases are called by Bravais *curviserial*, being disposed in an infinite curve, and hence incapable of being placed in straight rows.*

149. *Opposite* and *verticillate leaves* are those in which two or more leaves are given off at a node (Figs. 207 and 208, p. 96). In them also there is seen a tendency to alternation and spiral arrangement as regards the pairs and whorls. Thus, in opposite leaves, the second pair is not directly above the first, but is placed either at right angles (Fig. 212, p. 97), and then called *decussate*, as in the mint tribe (Labiatæ), or slightly to one side, so that the third, or some higher pair of leaves, is that which is superimposed over the pair with which we commence, as in the Box (Fig. 216). So, also, in verticils, as in Galium and Madder (Fig. 217), the leaves of the second verticil are not directly over those of the first verticil, but are so situated as to be above the

* Bravais, essai sur la disposition des Feuilles curvisériées. Ann des Sciences Nat. 2d ser. vii.

intervals between the leaves of the lower whorl. Verticillate leaves, as in Hippuris, sometimes become alternate, and then exhibit a distinct spiral arrangement.

150. The arrangement of the leaves furnishes characters in some families of plants. Thus, the Cinchona-bark tribe have opposite leaves; the Borage tribe, alternate; Labiate plants, opposite and decussate; the Madder tribe, verticillate or whorled. The arrangement of the leaves,

Fig. 216.

Fig. 217.

however, is not always constant, and we occasionally meet with alternate and opposite leaves in the same plant. In some instances this anomaly may be traced to a non-development of the internodes,

Fig. 216. Branch of the Box-tree (*Buxus sempervirens*), showing opposite leaves with the pairs alternating. It appears to be the Teashur of the Bible, mentioned in Is. xli. 19, and lx. 13. In Ezek. xxvii. 6, it is translated Ashurites, but the passage seems more properly rendered thus, "Of the oaks of Bashan have they made thine oars; and the benches of the rowers are made of Ashur-wood (box), inlaid with ivory."

Fig. 217. Verticillate or whorled leaves of Madder (*Rubia tinctoria*). The different verticils are arranged alternately with respect to each other.

by which two or more single-leaved (unifoliar) nodes are brought together. Thus, in Rhododendron ponticum, the alternate leaves, by such an arrestment, are sometimes seen almost verticillate. Again, in such plants as the Larch, Cedar, and Pine (Fig. 218), the arrestment of the internodes, according to a certain natural law in their development, gives rise to clustered or fascicled leaves. In the case of Pines, the clusters consist of two, three, four, or five leaves; while in the Larch and Cedar the leaves are indefinite. In the young elongating shoots of the Larch, the leaves assume an alternate arrangement.

Fig. 218.

151. In the embryo state of dicotyledons, the leaves or cotyledons are opposite, (Fig. 113, *c c*, p. 49); while in monocotyledons, the production of one leaf at the node, shows the tendency to alternation (Fig. 114, *c*, p. 49). The early cotyledonary leaves are called *seminal* (Fig. 113, *c c*, p. 49); those afterwards produced, and constituting the ordinary leaves, are called *primordial* (Fig. 113, *g g*, p. 49). Leaves inserted on a shortened stem close to the ground, have been already noticed as *radical*, those on the main axis are *cauline*, on the branches, *ramal*, and on the flowering stalks, *floral* (Fig. 232, p. 105).

152. The form of the stem and branches appears to be in some degree regulated by the arrangement of the leaves. M. Cagnat thinks that the influence of Phyllotaxis is seen sometimes in both the wood and bark of the stem; sometimes in one of these parts only. He states that the form of the wood and bark do not always correspond. In European Rubiaceæ and Jasminum fruticans, the bark is angular, and yet the wood and pith are cylindrical. In Populus nigra the bark gives a round appearance to the stem and branches, while the wood and pith present distinct angles. In Nerium Oleander the young stem has three angles, and the leaves are in verticils of three, (Fig. 219); Labiatæ have opposite leaves and tetragonal stems; Hypericum tetrapterum has opposite leaves, and four wings on the stem. Again, as regards the form of the pith, which depends on the woody matter of the stem, Cagnat remarks that the leaves of Juniper are in verticils of three, and the pith is triangular; the leaves of Cypress are opposite, and the pith in the form of a cross. He thinks that, in the case of alternate leaves, the number of angles and wings is equal to the de-

Fig. 219.

Fig. 218. Clustered or fascicled leaves of Weymouth Pine (*Pinus Strobus*). There are five leaves in the cluster, surrounded by scales at the base.

Fig. 219. Acute leaves of Rose-bay (*Nerium Oleander*), arranged in a verticil of three in the young state.

nominator of the cycle, or a multiple of it, or sometimes equal to the denominator minus the numerator.*

153. *Vernation*, or *Præfoliation*.—These names are applied to the arrangement of the leaves in the leaf-bud, and include both the mode in which each leaf is folded, and the relation which the leaves bear to each other. The leaf-bud is produced in the angle where a leaf joins the stem (Fig. 146, p. 61). It contains the growing point of the stem or branch, with its leaves and certain protective appendages called scales, tegmenta or perulæ (Fig. 145, *a*, p. 61). These scales or outer leaves are often of a coarse nature, covered with resinous matter, and arranged differently from the leaves in the interior, as may be seen in the common Sycamore.

154. The individual leaves in the bud are folded and rolled up in different ways. When the leaf is folded from its midrib, so that its halves are applied with their upper surfaces towards each other, as in the Oak and Magnolia, it is *conduplicate* (Fig. 220); when the apex is bent towards the base, as in the Tulip-tree, it is *reclinate*, or *inflexed;* when folded like a fan, as in the Maple and Vine, the leaf is *plaited*, or *plicate* (Fig. 224); when the leaf has each of its edges rolled inwards towards the midrib, as in the Violet and Water-Lily, the vernation is *involute* (Fig. 222); when outwards, as in Rosemary and Azalea, *revolute* (Fig. 221); when the leaf is rolled from one edge into a single coil, with the other edge exterior, as in the Apricot and Plantain, it is *convolute* (Fig. 223), when rolled from apex to base like a crosier, as in Ferns and Sundew, it is *circinate* (Fig. 225).

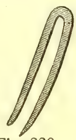
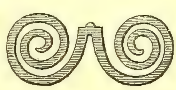


Fig. 220.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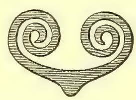


Fig. 222.


Fig. 223.

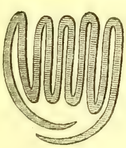


Fig. 224.


Fig. 225.

Fig. 220. Transverse section of a conduplicate leaf. The two sides of the leaf are folded on each other.

Fig. 221. Transverse section of a revolute leaf. The two edges are rolled outwards, away from the axis.

Fig. 222. Transverse section of an involute leaf. The two edges are rolled inwards towards the axis.

Fig. 223. Transverse section of a convolute leaf. It is rolled upon itself, so as to form a single continuous coil.

Fig. 224. Transverse section of a plicate or plaited leaf. Its parts are folded together like a fan.

Fig. 225. Circinate vernation, in which the leaf is rolled up from apex to base like a crosier.

* Those who wish to examine the subject of Phyllotaxis more fully, may consult Steinheil, sur la Theorie de la Phyllotaxis. Ann. des Sciences Nat. 2d ser. Bot. iv. 100, 142; and xix. 321. Bravais sur la disposition des Feuilles. Ann. des Sciences Nat. 2d ser. Bot. vii. 42, 193; viii. 11, 161; xii. 5, 65. Cagnat sur la disposition des Feuilles. Ann. des Sciences Nat. 3d ser. Bot. ix. 362. Lestiboudois, Phyllotaxie Anatomique. Ann. des Sciences Nat. 3d ser. Bot. x. 15, 136. Henslow's Principles of Descriptive and Physiological Botany, page 123. Naumann, ueber den Quincunx als Grundgesetz der Blattstellung im Pflanzen-reiche, in Poggendorff's Annalen for 1842. Link, Elementa Botanica, ed. 2, ii. 448; Dutrochet, Mémoires, &c., i. 238. Schimper et Braun, Archives de Botanique, i.

155. The relative position of the leaves in the bud gives origin to the following terms :—*Valvate*, when leaves are placed in a circle, so as to touch each other at their edges only, without overlapping ; *imbricate*, when the outer leaves successively overlap the inner to a greater or less extent (Fig. 226). These kinds of vernation occasionally become *twisted* or *contortive*. When involute leaves are applied in a circle without overlapping the vernation, is *induplicate ;*

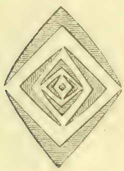


Fig. 226.


Fig. 227.


Fig. 228.


Fig. 229.

when conduplicate leaves successively embrace each other, as at the base of the Iris, they are equitant (Fig. 227); and when the half of one conduplicate leaf covers half of another, the term *half-equitant* or *obvolute* is applied (Fig. 229) ; when a convolute leaf incloses another which is rolled up in a similar manner, the vernation is *supervolute* (Fig. 228).

2. ANATOMY OR STRUCTURE OF LEAVES.

156. The Leaf consists of a cellular and vascular portion ; the former constituting the Parenchyma—the latter, the Ribs and Veins. The whole is covered by an integument. The flat expanded portion is called the *Lamina*, blade or limb, (Fig. 230, *l*), consisting of cells traversed by vessels, and the narrow portion is called the *Petiole*, or leaf-stalk (Fig. 230, *p*), in which the cellular tissue is less abundant, and the vessels are more closely united. At the base of the petiole there are sometimes certain leafy appendages denominated *Stipules* (Fig. 231, *s*). The petiole is sometimes awanting, and the leaf is then *sessile* (Fig. 232) ; at other times the blade is transformed, so as to appear like a petiole, as in some aquatics such as Sagittaria. The leaf may be called generally a flattened expansion of the green layer of the bark, strengthened by woody fibres and vessels.

157. The Parenchyma varies much in its extent, and in the form of its cells. In fleshy leaves it is abundant, and its cells are loose, and more or less rounded. In an ordinary flat leaf there are two surfaces, one of which (the upper) is exposed to the light. The epidermis covering these surfaces consists of compressed colourless cells. That of the lower surface is often of a paler colour, and is provided with stomata (Figs. 92 and 93, p. 42) and hairs ; while on the upper

Fig. 226. Transverse section of a bud, in which the leaves are arranged in an imbricate manner.

Fig. 227. Transverse section of a bud, in which the leaves are arranged in an equitant manner, overlapping each other at the edges.

Fig. 228. Transverse section of a bud, shewing two leaves arranged in a supervolute manner. Both the leaves are convolute, and one is rolled up within the other.

Fig. 229. Transverse section of a bud, shewing two leaves folded in an obvolute manner. Each is conduplicate, and one embraces the edge of the other.

side the epidermis is more tough and dense, and is either entirely destitute of stomata, or possesses them in small number. In leaves placed vertically, the stomata sometimes exist in equal number on both sides; in floating plants, as water-lilies, the stomata exist only on the upper surface of the leaf; while in submerged leaves no stomata occur on either surface, and the true epidermal layer of cells is absent (¶ 69).

158. The *Parenchyma* of ordinary leaves consists of two distinct

Fig. 230.

Fig. 232.

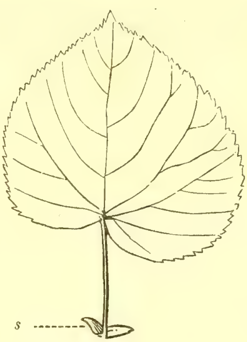


Fig. 231.

layers of cells, one connected with the upper surface (looking to the sky), and consisting of compact oblong cells placed endwise (Fig. 233, *ps*); the other, connected with the lower side, consisting of loosely-aggregated cells, having numerous cavities between them (Fig 233, *pi*), and, when of an elongated form, placed with their long diameter parallel to the epidermis. The cavernous nature of the lower epider-

Fig. 230. Leaf of Pellitory (*Parietaria officinalis*), shewing the petiole or leafstalk, *p*, and the lamina or blade, *l*. The leaf is petiolate and acuminated or drawn out at the apex, and the venation is reticulated. The margin or circumscription is entire (integer).

Fig. 231. Oblique, petiolated and serrated leaf of Lime (*Tilia*), with stipules, *s*, at the base of the petiole. The leaf is obliquely-cordate at the base.

Fig. 232. Flowering stalk of Scarlet Pimpernel (*Anagallis arvensis*), shewing sessile or non-petiolated leaves, which are opposite to each other, the pairs being alternate and decussate. Single-flowered peduncles arise from the axils of the leaves, which are hence called floral.

mis seems to be connected in some degree with the stomata and their functions. The cells on the upper side are usually placed close to each other, without any space between them, except in cases where stomata occur (Fig. 233, *st*). In Figure 233 is given a section of a melon leaf perpendicular to the surface. The upper integumentary system is marked *es*; it shows hairs, *p*, on its surface, and two openings of stomata, *st*. Below the upper epidermis are layers of oblong cells, *ps*, with two spaces between them, *m*, communicating with stomata. The lower integument, *ei*, also exhibits hairs and stomata; and above it are layers of loose cells, *pi*, with numerous lacunæ, *l*. The vascular bundles running through the parenchyma are marked *fv*.*

159. Sometimes there are several layers of epidermal cells, more particularly in plants exposed to the heat of the tropical sun, as the

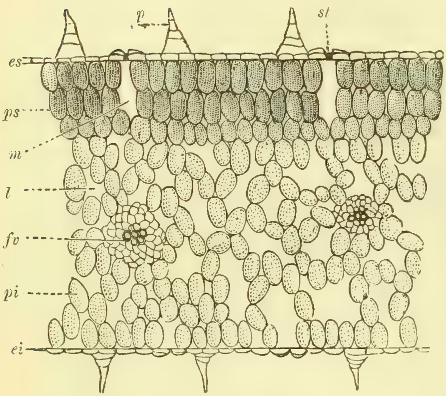


Fig. 233.


Fig. 234.

Oleander (Fig. 234). When the lower surface of leaves is exposed to the sun, their moisture is rapidly evaporated, and they soon fade. The parenchyma is occasionally deficient at some parts of leaves, giving rise to deep indentations or to perforations. In Dracontium there are distinct holes in the leaves; and, in an aquatic plant of

Fig. 233. Section of Melon-leaf, perpendicular to the surface; *es*, upper epidermis; *ei*, lower epidermis; *p*, hairs; *st*, stomata; *ps*, upper layers of parenchymatous cells; *pi*, lower layers of parenchymatous cells; *m*, meatus, or canals connected with stomata; they are sometimes called hypostomatic spaces; *l*, lacunæ, or cavities between the loose cells in the cavernous lower parenchyma; *fv*, bundles of fibro-vascular tissue, consisting of woody, dotted, spiral, and other vessels.

Fig. 234. Nerium Oleander, Rose-bay, Laurier-rose of the French, with long narrow lanceolate leaves, the upper epidermis of which is very dense. In the leaves are cavities with hairs, supposed to be a substitute for stomata. It would appear to be the *Rhodon* of the Apocrypha, translated Rose in Ecclesiasticus xxiv. 14, and xxxix. 13.

* A full account of the anatomy of the leaf is given by Adolphe Brongniart, in Annales des Sciences Nat. 1st series, xxi. 420.

South Africa (Ouvirandra fenestralis), the tissue of the leaf is made up of interlacing filamentous cells, with perforations between them, giving the appearance of a skeleton leaf. In Victoria regia (Fig. 235) there are peculiar perforations in the leaves. These are formed by depressions of two corresponding points of the upper and under surface of the leaf, and are at first closed by a transverse membrane; after a short time the membrane disappears, and a clear passage is formed through the leaf. Some suppose that this contrivance is with the view of allowing the air to escape upwards, which would otherwise collect below the under surface of the leaf, in the spaces included by its deep ribs, and which would have a tendency to prevent the leaf from coming into contact with the water. In the plant called Hermas, the two layers of the leaf may be separated by a little effort, the hand being introduced between them. The surface of

Fig. 236.

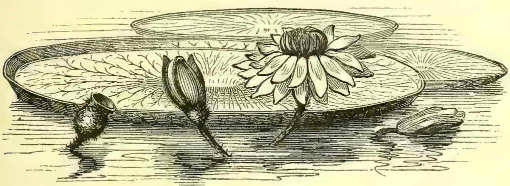


Fig 235.

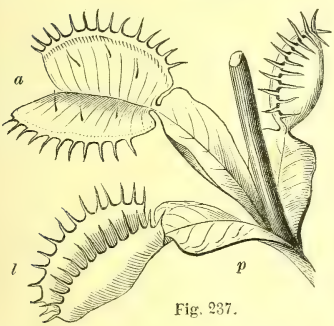


Fig. 237.

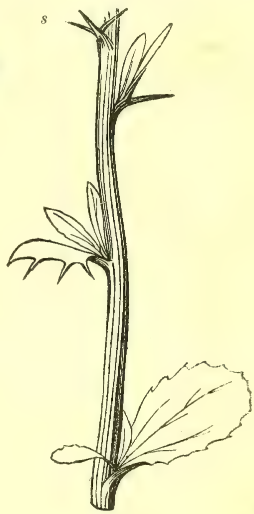


Fig. 238.

leaves is sometimes smooth (glabrous), at other times hairy (hirsute),

Fig. 235. Victoria regia, the largest known Water-lily, found in lagoons in South America. Its leaves are from 4-6½ feet in diameter, and its flowers one foot across. Besides stomata, there are peculiar perforations through the leaves to allow air to pass from the under to the upper surface. The plant has recently flowered in warm tanks in several hot-houses in Britain, as at Chatsworth, Sion House, Kew, Regent's Park, Veitch's Nursery Exeter, Knight and Perry's Nursery Chelsea; and in a heated pond in the open air at the Nursery of Messrs. Weeks and Co. Chelsea.

Fig. 236. Leaf of Sundew (*Drosera rotundifolia*), covered with glandular hairs. On account of the fringe of hairs round the margin, the leaf is called ciliated.

Fig. 237. Leaves of Venus's Fly-trap (*Dionæa muscipula*). The expanded blade of the leaf, *a*, exhibits three hairs on the surface of each half. These hairs when touched cause the folding of the blade, as shewn in the figure. The winged petiole, *p*, supports a half-closed lamina, *l*.

Fig. 238. Branch and leaves of the Barberry (*Berberis vulgaris*). The leaves are spiny. Some of them, as at *s*, are composed of hardened vascular tissue only.

downy (pubescent), or woolly. The hairs are either lymphatic or glandular. In the case of the Sundews (Drosera) the leaves are fringed with glandular hairs (ciliated), and their surface is covered with them (Fig. 236); while in Venus's Fly-Trap (Dionæa muscipula) there are irritable hairs on the leaves, which, when touched, cause the two sides of the leaf to fold together (Fig. 237).

160. The *Vascular system* of the leaf (Fig. 233, *fv*) is composed of a double layer of vessels which may be separated by maceration. It consists of woody, laticiferous, dotted, and various kinds of spiral vessels. These vessels collectively form the petiole or stalk, and spread out in the lamina or blade, so as to constitute the veins. When a leaf is macerated, the cellular tissue is separated, and the vascular bundles alone remain. In some leaves, as in the Barberry, the vessels forming the veins are hardened, producing spines without any parenchyma (Fig. 238, *s*). The hardening of the extremities of the vascular tissue is the cause of the spiny margin of many leaves, such as the Holly (Fig. 239), of the sharp-pointed leaves of Madder (Fig. 217, p. 101), and of mucronate leaves, or those having a blunt end with a hard projection in the centre.

161. De Mercklin* states, that leaves have their origin in cellular papillæ arising from the axis. Their apex is the first part formed, and it is pushed forward by the growth of the part below. The leaf-stalk is formed after the blade, the lower part of it being the last developed. Leaves are undivided in their early state, all the divisions which take place in them are subsequent formations. The mode in which the parenchyma increases, and the arrangement of the veins, give to the leaves their varied forms.

162. *Venation.*—This term has reference to the arrangement of the vascular tissue of the leaf. This tissue consists of firm and prominent bundles of vessels called *ribs*, and others less conspicuous, denominated *veins*. The term nerve, as applied to the vessels of the leaf, is now generally given up to avoid ambiguity as to function. In Figure 240 there is given a representation of a vertical section of a branch, shewing the mode in which the vascular bundle, *fv*, gives off a prolongation to the leaf-stalk, *f*; the vessels passing from the sheath surrounding the pith, *m*, through the parenchyma, *pc pc*, and communicating with the young bud, *b*, in the axil of the leaf.

163. There are two marked forms of venation, one in which the vessels from the petiole or stem, on entering the leaf, are continued in the form of one or more ribs, which give off branches on either side, and form an anastomosis or net-work of vessels (Figs. 241, 242); the other, in which the vessels, when entering the leaf, divide into several veins or ribs, which run more or less parallel to each other, and are united by simple transverse veins, as in Palms (Fig. 243), the leek (Fig. 244), and grasses; or in which the midrib gives off lateral veins

* De Mercklin, observations sur l'histoire du développement des Feuilles, Annales des Sciences Nat. Bot. 3d ser. vi. 215.

which run parallel, as in the Banana (Fig. 245). The former are *Reticulated* or *Netted* leaves, and are common in dicotyledons,

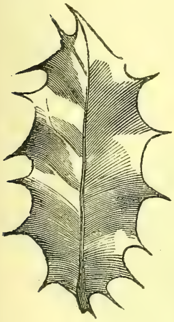


Fig. 239.

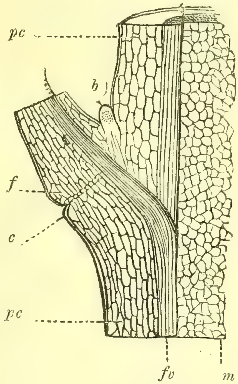


Fig. 240.

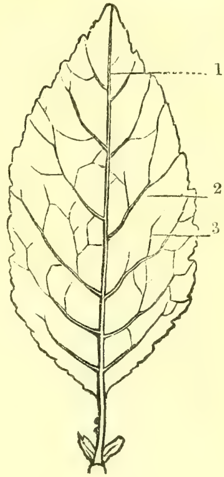


Fig. 241.

Fig. 242.

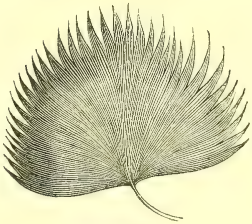


Fig. 243.

while the latter are *Parallel-veined*, and are characteristic of monocotyledons.

Fig. 239. Spiny leaf of Holly (*Ilex Aquifolium*). The spines are formed by the hardened extremities of the veins proceeding from the midrib to the margin.

Fig. 240. Vertical section of a branch, shewing the mode in which the vascular tissue of the leaf communicates with the centre of the stem; *m*, pith; *fv*, fibro-vascular tissue around the pith, giving off a branch to the leaf, *f*, which is articulated to the axis; *pc*, *pc*, parenchyma of the stem; *c*, cushion or cellular swelling below the leaf; *b*, bud in the axil of the leaf.

Fig. 241. Petiolate and stipulate leaf of Cherry, shewing the reticulated venation with a single midrib (unicostate). The midrib, 1, is a continuation of the petiole, and it gives off primary veins, 2, which again sub-divide into secondary veins, 3, curving within the margin.

Fig. 242. Three-ribbed (tricostate) leaves of Cinnamon (*Cinnamomum zeylanicum*). In these leaves there is one central rib and two lateral ones. The venation is reticulated. The plant is the Kinnamon and Kinnamomum of the Bible, noticed in Exod. xxx. 23; Prov. vii. 17; Cant. iv. 14; and Rev. xviii. 13.

Fig. 243. Leaf of Fan-Palm (*Chamærops*), shewing the veins running from the base to the margin, and not forming an angular net-work.

164. In reticulated leaves there is either one primary rib called *midrib* (Fig. 241, 1), or there are several prominent ribs, as in Cinnamon (Fig. 242), and Cassia (Fig. 246). When a single midrib is present it gives off branches or veins, which either proceed directly to the margin, as in the *feather-veined* leaves of the Oak (Fig. 210, p. 97), Chestnut, and Holly (Fig. 248), or which end within the margin in curved veins as in Lilac, Cherry (Fig. 241), and Dead-nettle (Fig. 247); in the latter case, marginal veinlets proceed from the curved veins. When there are three prominent ribs, as in Cinnamon (Fig. 242), and Cassia (Fig. 246), the leaf is *tricostate;* when five, *quinquecostate.*

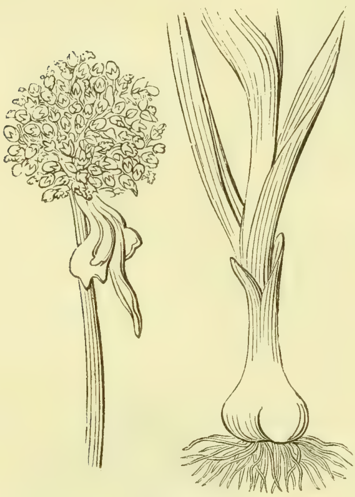


Fig. 244.

Fig. 245.

When the midrib gives off two ribs a little above the base, the leaf becomes *triplicostate;* when it gives off five, *quintuplicostate.*

165. In a leaf having many ribs, they may converge towards the apex, as in Cinnamon (Fig. 242), or they may diverge. In the latter case, they are said to radiate, and they give origin to *palmate* and *palmatifid* leaves, as in Sycamore, Mallow, and Castor oil (Fig. 249). Parallel-veined leaves have either a single midrib, the veins from which come off in a parallel manner, and run to the margin without forming a net-work, as in the Banana (Fig. 245), and Indian Shot (Canna);

Fig. 244. Leek *(Allium Porrum)*, with parallel-veined sheathing leaves, proceeding from a bulb or underground bud. The flower-stalk is separated, showing the umbellate cluster of flowers, and below it the bract or floral leaf. The plant seems to be the *Chatzir* of the Bible, which is translated Leeks in Numb. xi. 5; but in other places is translated grass, herb, hay, &c. It is the *Prason* of the Greeks.

Fig. 245. Banana (*Musa sapientum*), shewing parallel-veined leaves, with sheathing petioles, which form the temporary stem. There is a single midrib in the leaf, from which parallel veins proceed to the margin. The leaf splits easily in the direction of these veins. There is no angular net-work of vessels.

or they have numerous veins or ribs running from base to apex, converging as in Grasses (Fig. 250), and Lilies; or diverging, as in Palms (Fig. 243).

166. In very succulent plants, as the American Aloe (Agave americana), and Fig-Marygolds, where the parenchyma abounds, the veins are obscure, and in plants such as Mosses and Sea-weeds, the so-called veins are composed of an aggregation of long cells, without any woody fibre. In many plants belonging to the Myrtle order (Myrtaceæ), which have ribbed leaves, there is an obscure vein which runs from the base to the apex of the leaf, close to the margin, and in which the lateral veinlets end. The primary veins come off from the midribs of leaves at different angles, and thus contribute to give form to the leaf. Primary veins coming off at a very acute angle, and converging, give rise to narrow leaves; those proceeding more at

Fig. 246.

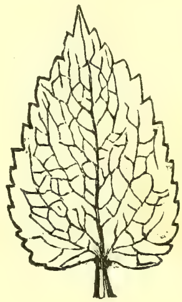


Fig. 247.

a right angle frequently produce broad leaves; while those coming off at obtuse angles cause prolongations at the base of the leaf. So also with veins radiating from a point, their greater or less divergence gives origin to leaves of a broader or a narrower form.

167. Lestiboudois remarks that the arrangement and form of the foliaceous appendages of plants depend much on the number, the development, and the relation of the fibro-vascular bundles of the stem. In vascular plants the skeleton of the leaf is formed by an expansion of the fibro-vascular bundles of the stem. The leaves contain vessels similar to those forming the bundles at the point where they escape from the axis. The vascular bundles, as well as the parenchyma of

Fig. 246. Cassia-bark tree *(Cinnamomum Cassia)*, shewing ribbed leaves. There are three marked ribs, and the leaf is hence called tricostate. Venation is reticulated.

Fig. 247. Leaf of Dead-nettle *(Lamium)*, shewing reticulated venation, the primary veins ending within the margin in curved veins. The edge of the leaf is serrated (saw-like).

the stem, expand in the leaf in various ways. In the cicatrices of fallen leaves (Fig. 145, *b*, p. 61), the number and arrangement of the ruptured bundles are seen. In each plant the leaves receive a special number of vascular bundles; sometimes a single bundle, as in Dianthus, sometimes several, as in Clematis, Horse-chestnut, and Elder, sometimes all the bundles which surround the axis of the stem, as in a great number of Monocotyledons. These bundles constitute the ribs

Fig. 248.

of the leaves; amongst these ribs there is usually one which is median, and it marks the true position of the foliaceous expansion, determining the real point of emergence. It is distinguished from the others by bearing a bud in its axil. The caulinary bundles, after their exit from the stem, ramify, at other times they remain undivided for a longer or shorter space. Hence the differences of petiolate, sessile, and sheathing leaves. The bundles which constitute the

Fig. 248. Holly *(Ilex Aquifolium)*, shewing spiny single-ribbed (unicostate) leaves, with the primary veins going directly to the margin, their extremities being hardened and pointed. The leaf is said to be feather-veined.

frame-work (venation) of the leaves issue from the stem at different points. The disposition of the leaves on the stem, and their relation to each other, therefore, vary. The latter depends on the number and the symmetry of the caulinary bundles, and their mode of evolution.*

168. Dr. M'Cosh† thinks that the venation of leaves bears an analogy to the distribution of the branches, so that the leaf and its veins represent the stem and branches of the plant. He considers that in plants there are three homotypal parts, morphologically allied, and representatives of each other, viz. the root and its ramifications, the stem and its branches, and the leaf with its veins. These parts he

Fig. 249.

Fig. 250.

looks upon as typically analogous. He has carried out his researches chiefly in regard to reticulated leaves. The angles at which the veins

Fig. 249. Castor-oil plant *(Ricinus communis)*, shewing palmately-cut leaves, with radiating and reticulated venation. It seems to be the Hebrew *Kikayon*, translated Gourd, in Jonah iv. 6, 7, 8, 10, &c. It has been called Pentadactylus and Palma Christi, from the palmate division of its leaves. The Greeks called the plant *Kiki*.

Fig. 250. Spelt, a kind of wheat *(Triticum Spelta)*, shewing a parallel-veined leaf. The veins run along the whole length of the leaf, slightly convergent towards the apex. There are no reticulations. This kind of wheat is by some supposed to be the Hebrew *Kussemeth*, translated Rye, in Exod. ix. 32, and Isa. xxviii. 25; and Fitches, in Ezek. iv. 9.

* Lestiboudois, Phyllotaxie Anatomique, ou Recherches sur les causes organiques des diverses distributions de Feuilles, Annales des Sciences Nat. Botan. 3d ser. x. 15, 136.

† M'Cosh on the plant morphologically considered, in the Proceedings of the Edin. Botanical Society for July 1851, Botanical Gazette, Sept. 1851, p. 118. Also, in the Transactions of the Edin. Bot. Soc. vol. iv.

are given off, he considers as being the same as those at which the branches come off, and he has attempted to prove this position by numerous measurements of angles. In trees there is a certain normal angle at which branches are given off, producing a peculiar physiognomic effect. This angle may be much modified by circumstances, and it may vary according to the age of the branches. The determination of this angle is a point to which M'Cosh calls attention, and his researches lead him to adopt the view that the same angle will be found to prevail in the leaf-formation.

169. The following table gives the results of numerous measurements, by M'Cosh, of the angles of branching and venation, where these were found to agree—the angles being those formed below the points where the veins and branches arise :—

	Deg.		Deg.
Alder	50	Lilac	58
Ash	60	Lime	40
Bay Laurel	50-60	Mountain-Ash	45
Beech	45	Oak (large branches)	50
Birch	48-35	(small branches and veins)	65-70
Bird Cherry	60	Portugal Laurel	50-60
Box	60	Privet	50
China Aster	28-30	Raspberry	42
Cherry	50	Red Dog-Wood	45
Clarkia elegans	36-40	Rhododendron	60
Elm	50	Rose	50
Fuchsia	60	Service tree	48
Hazel	42-43	Solidago Virgaurea	30
Holly	55	Spiræa Ulmaria	30-35
Horse-chestnut	50-55	Sycamore	45
Jessamine	40-45	Thistle	60-70
Laburnum (small branches)	60	Thorn (lowest branches)	35-50

In some leaves the small veins come off at a wider angle than the large veins; and in many trees, as in the Oak, the small branches come off at a wider angle than the large branches.

170. Dr. M'Cosh is disposed to think that the mode in which the vascular bundles come off from the axis has a counterpart in the branching of the stem. In some leaves the vascular bundles, on leaving the axis, are united together, so as to form a petiole, and afterwards diverge, while in others there is no stalk, and the vascular bundles at once spread out as veins on leaving the axis. In woody plants, he thinks, that a similar variety takes place in the branching. Thus, in the Privet, Box, Bay and Portugal Laurel, the leaves have little or no petiole, and the branches proceed from near the base of the stem or main axis ; in the Cherry, Sycamore, Horse-chestnut, and Laburnum, the leaves have a pretty long petiole, and these plants have a considerable extent of unbranched axis or trunk.

171. The mode also in which the primary ribs are distributed in

costate leaves, has, according to Dr. M'Cosh, a counterpart in the branching. Thus, Sycamore, Currant, Vine, Geranium, and Mallow, have several ribs proceeding from the base of the leaves, and their branches tend to whorl round the axis. The Laburnum and Broom have three leaflets coming off from one point of the petiole, and their branches are also in threes. In some recent observations, Dr. M'Cosh also thinks that he has ascertained that the curve of the veins and that of the branches corresponds.

3. CONFORMATION OF LEAVES.

172. With few exceptions, every plant has leaves at some period of its growth. Even those which produce leafless stems have generally seed-leaves (Cotyledons) in their embryo state (¶ 74). The Dodders (Fig. 128, p. 54), and a few other plants, are exceptions to this rule. Leaves present various forms from the scales of Broom-rapes (Fig.

Fig. 251.

Fig. 252.

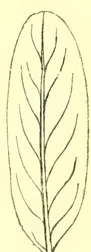


Fig. 253.

126, p. 54), and the linear leaves of Asparagus and Pines (Fig. 218, p. 102) up to the large foliar expansions of the Banana (Fig. 245, p. 110), and of the Talipot Palm (Fig. 191, p. 88). To the nature of the venation and the development of parenchyma all the leafy forms must be traced. Leaves are usually arranged under the heads of *Simple* and *Compound;* the former having a blade composed of one piece, and having no articulation beyond the point where they join the stem, as in the Oleander (Fig. 234, p. 106), and Castor-oil plant (Fig. 249); the

Fig. 251. Lentil *(Ervum Lens)*, having compound pinnate leaves ending in tendrils (cirrhi). Each leaf is composed of several (often six) pairs of leaflets (foliola, pinnæ), which are stalked and articulated to the midrib or common petiole, which terminates in a spiral tendril. The leaves are cirrhose. It is the Hebrew *Adashim*, and the Greek *Phacos*. It is mentioned in Gen. xxv. 34; 2 Sam. xvii. 28, xxiii. 11; Ezek. iv. 9.

Fig. 252. Ovato-lanceolate leaves of a species of Senna, probably a variety of *Cassia lanceolata*. The leaves are unequal or oblique at the base. The apex is acute.

Fig. 253. Oblong leaf of a species of Senna. The apex is obtuse or blunt, and the base is unequal.

latter having a blade divided into separate pieces or leaflets, which are articulated with the petiole (Fig. 251).

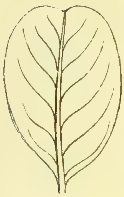


Fig. 254.

Fig. 255.

Fig. 257.

Fig. 256.

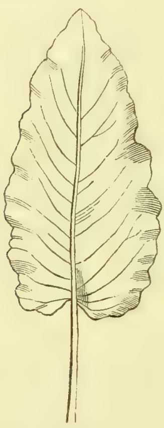


Fig. 258.

Fig. 259.

173. *Simple Leaves.*—These, although formed of one piece, may have their blades variously divided, provided the separate portions are

Fig. 254. Emarginate leaf of a species of Senna. The leaf in its contour is somewhat obovate, or inversely egg-shaped, and its base is oblique.

Fig. 255. Lanceolate leaf of a species of Senna. It is oblique at the base.

Fig. 256. Leaf of Ground Ivy *(Nepeta Glechoma)*, having a kidney-like form, and hence called reniform. Its margin is crenate. The venation is radiating.

Fig. 257. Branch of Great prickly-cupped oak *(Quercus Ægilops* or *Valonia).* The leaves are feather-veined, and have a serrated margin. The cup of the acorn is large and prickly. It is one of the oaks found in Palestine, and is probably included in the Hebrew *Allon*, which occurs in Gen. xxxv. 8; Josh. xix. 33; Is. ii. 13, vi. 13, xliv. 14; Hos. iv. 13; Amos ii. 9; and Zech. xi. 2.

Fig. 258. Undulated petiolate leaf of Rumex Patientia. The leaf is oblong-ovate, and cordate at the base, while its margin is wavy, sinuous, or crisp.

Fig. 259. Flowering branch of the Tulip-tree (*Liriodendron tulipifera*). Its leaves are truncate or abrupt, ending in nearly straight transverse lines, as if they were cut across at the apex.

not supported on stalks, nor articulated to the petiole, nor to the mid-

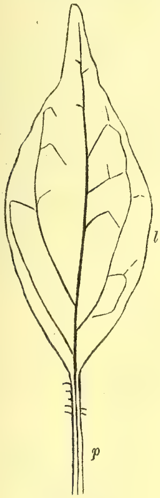


Fig. 260.

Fig. 261.

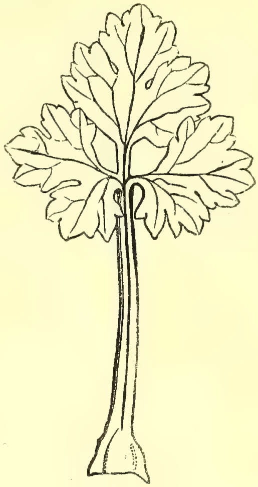


Fig. 262.

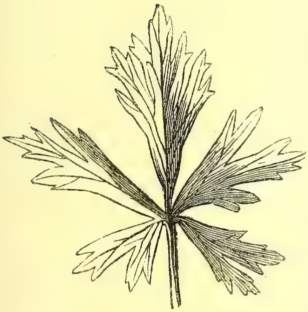


Fig. 263.

Fig. 264.

rib (Figs. 258, 263, 264). In their very young state they are entire or

Fig. 260. Acuminated leaf of Pellitory *(Parietaria)*. The leaf has an elliptical form, and is drawn out at the apex into a long point. The blade is marked *l*, the petiole, *p*.

Fig. 261. A species of Saxifrage (*Saxifraga tridactylites*), having the radical leaves trifid. The leaves are cuneate, or wedge-shaped, as regards their general form.

Fig. 262. Tripartite leaf of Ranunculus. Each of the segments is lobed, and toothed at the margin. The petiole is dilated at the base. Venation radiating.

Fig. 263. Five-partite leaf of Aconite. Such a leaf is sometimes called palmi-partite, palmately-partite, or dissected. The venation is radiating, and the segments of the leaf are narrow, and each of them is cleft and toothed at the apex.

Fig. 264. Leaf of Castor-oil plant (*Ricinus communis*). It is palmately-cleft, and exhibits seven lobes at the margin. The petiole is inserted a little above the base, and hence the leaf is called peltate or shield-like.

undivided, and equally developed. When they increase more on one side than on the other, they become either oblique, as in the Begonia and Lime (Fig. 231, p. 105), or slightly unequal at the base, as in Senna (Figs. 252-255); and when the cells and vessels increase and elongate, only at certain points, divisions take place in the margin of the leaves, and in the substance of their laminæ (Figs. 264, 267, 268).

174. In the circumscription or margin of the leaf, the following varieties occur :—*Entire*, without any divisions (Figs. 252 to 255); *crenate*, with superficial rounded divisions (Fig. 256); *serrate*, with acute points, arranged like the teeth of a saw (Fig. 247, p. 111, and Fig. 257); *dentate*, with similar pointed projections, not arranged in a saw-

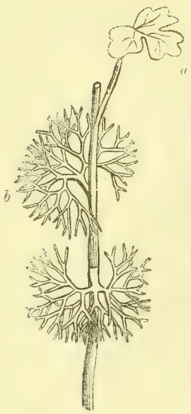


Fig. 265.

Fig. 266.

like manner (edges of Fig. 297, *b*, p. 128, and Fig. 327, p. 139); *repand* and *undulated*, when the margin is wavy and sinuous, or, as it is often called, crisp, as in curled dock, and other curled leaves (Fig. 258); sometimes, as in the Holly (Fig. 248, p. 112), the leaf is undulated, with spiny teeth. When the apex of a leaf is blunt and rounded, it is called *obtuse* (Fig. 253); when sharp, and forming an acute angle, it

Fig. 265. Leaves of water Crowfoot (*Ranunculus aquatilis*). *a*, Three-lobed floating leaf. *b*, Filiformly dissected submerged leaves. The venation is radiating. In the submerged leaves the segments are very narrow, and called capillary or hair-like.

Fig. 266. Flowering stalks of Nigella sativa, with filiformly dissected leaves, having capillary segments. The venation is radiating. The plant is supposed to be the *Ketzach* of Scripture, translated fitches, in Is. xxviii. 25, 27.

is *acute* (Fig. 234, p. 106). The apex is *abrupt* or *truncate*, when it is terminated by a straight transverse line, as in the Tulip tree (Fig. 259); *retuse*, when it is rounded and slightly depressed; *emarginate*, when there is a deficiency or notch at the apex (Fig. 254); *obcordate*, when the deficiency is very evident, and the lobes large, so as to resemble an inverted heart on cards. When the apex is drawn out into a long point, as in Ficus religiosa, and Pellitory, the leaf is *acuminate* or pointed (Fig. 260); when the apex is blunt, and presents a stiff hard point, it is *mucronate* (Fig. 297, *a*, p. 128).

175. When the substance of the lamina is divided to about the middle, the terms *cleft* (in composition *fid*) and *lobed* are applied; and

Fig. 267.

Fig. 268.

when the division extends to near the base or midrib, the term *partite* is used. These divisions, occurring in a radiating-veined leaf, give origin to the terms, *bifid* (twice cleft), *trifid* (thrice cleft), as in the leaves of some saxifrages (Fig. 261), *quinquefid* (five cleft), and *multifid* (many-cleft); also to the terms *bilobate* (two lobed), *trilobate* (three lobed) as in the floating leaves of water Crowfoot (Fig. 265, *a*), &c., when the divided portions of the leaf are large; and *tripartite* (Fig. 262), *quinquepartite* (Fig. 263), and *multipartite*, when the divisions extend to the base; *palmate* (like the palm of the hand),

Fig. 267. Pedate leaf of stinking Hellebore (*Helleborus fœtidus*). The venation is radiating. It is a palmately-partite leaf, in which the lateral lobes are deeply divided. When the leaf hangs down it resembles the foot of a bird, and hence the name.

Fig. 268. A Pinnati-partite leaf of a species of Poppy. The leaf is feather-veined, and the divisions take place laterally to near the midrib. The segments are pinnatifid, and pinnati-partite. The leaf may be called bipinnati-partite.

when there is a broad lamina, divided into five parts, as in some species of Passionflower, in palmate Rhubarb, and in the Vine (Fig. 152, p. 64); *palmatifid*, or *palmately cleft*, when the divisions are more than five, as in Castor oil (Fig. 264, p. 117). The terms palmate and palmatifid are, however, often used indiscriminately to mark a leaf having a broad portion like the palm of the hand, and either five or more lobes. When the parts of a palmatifid leaf are narrow, like the fingers, the term *digitilobed*, *digiti-partite*, and *dissected*, are applied; and when they are cut into thread-like divisions, as in the submerged

Fig. 269.

Fig. 270.

leaves of Ranunculus aquatilis (Fig. 265, *b*), and in Nigella arvensis (Fig. 266) they are said to be *filiformly dissected.* The term *pedate* (like the foot of a bird) is applied when the lateral divisions of a three-lobed leaf are again divided, as in stinking Hellebore (Fig. 267).

176. In a feather-veined leaf similar divisions give origin to the terms *pinnatifid*, with large lateral divisions, as in the Oak (Fig. 269);

Fig. 269. Branches of Oak (*Quercus pedunculata*), shewing pinnatifid leaves, and male flowers, *a*, in catkins (amenta). The female flowers forming acorns are attached to a long peduncle.

Fig. 270. Lyrate leaf of Turnip (*Brassica Rapa*). It is a simple leaf with reticulated venation, in which the terminal lobes are united, so as to make the leaf resemble an ancient lyre. When the lateral divisions of such a leaf become leaflets articulated to the petiole, then the leaf is compound, and is said to be lyrately-pinnate.

pectinate (comb-like), with very narrow divisions; *pinnatipartite*, when the divisions extend to near the midrib (Fig. 268); *pinnately-divided*, when the divisions extend to the midrib. When the primary divisions of such leaves are again subdivided in a similar way, the terms *bipinnatifid* and *bipinnatipartite* (Fig. 268) are applied; and when not only the primary, but also the secondary segments are divided in a similar way, the terms *tripinnatifid* and *tripinnatipartite* are used. In a pinnatifid leaf it sometimes happens that there are few divisions, in consequence of the lobes at the apex or base being united, thus giving rise to the *lyrate* leaf (like an ancient lyre), with a large terminal lobe, and segments becoming smaller as they approach the petiole (Fig. 270);

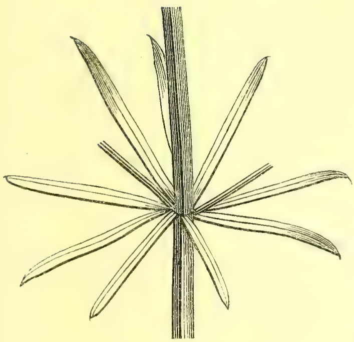


Fig. 272.

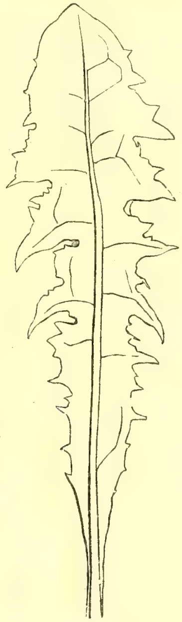


Fig. 271.

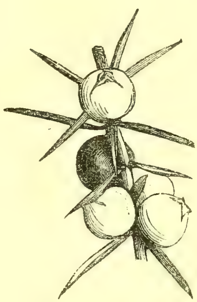


Fig. 273.

and the *panduriform*, when the lobes have a recess or sinus between them, so as to make the leaf resemble a violin. When the divisions of a lyrately-pinnatifid leaf have acute terminations, and point downwards, as in the Dandelion, the term *runcinate* is applied (Fig. 271).

177. In the case of reticulated leaves, the angle which the veins form with the midrib, and their comparative lengths in different parts determine in a great measure the contour of the leaf. The following

Fig. 271. Runcinate leaf of Dandelion (*Leontodon Taraxacum*). It is a pinnatifid leaf, with the divisions pointing towards the petiole.

Fig. 272. Stem of Goose-grass (*Galium Aparine*), shewing verticils of linear-pointed leaves (sometimes called linear-lanceolate). The points of the leaves are bristly. Two flowering stalks have been cut across.

Fig. 273. Linear Acerose leaves of Juniper (*Juniperus communis*). The leaves end in short and hardened points like needles. The fruit is a succulent kind of cone called Galbulus.

are some of the usual terms employed:—*Linear* (Fig. 272), when the leaf is narrow, and the veins proceeding from the midrib are very short, and nearly equal. When linear leaves are sharp-pointed, as in Pines and Juniper (Fig. 273), they are called *accrose*, and the plants, on this account, are called by the Germans needle-trees (Nadel-hölzer); when linear leaves taper, so as to be like an awl, they are called *subulate;* leaves are *oblong*, when the veins from the midrib are longer than in linear leaves, but still nearly equal, and the apex is rounded (Fig. 274); *rounded* (Fig. 236, p. 107, and Fig. 313, p. 134), *oval* (Figs. 276 and 278); and *elliptical* (Figs. 277 and 279), when the veins from the centre of the midrib are longest, and the forms approach more or less to the circle or ellipse.

178. When the veins coming off from near the base are the longest, and the leaf has the shape of an egg, it is called *ovate* (Figs. 275 and 288, *a*); it is *obovate* (inversely egg-shaped) when the veins at the apex are longest, and the leaf is thus like an ovate one reversed (Fig. 254, p. 116); when the apex of an obovate leaf is straight, or not uniformly

Fig. 274. Fig. 275. Fig. 276. Fig. 277. Fig. 278. Fig. 279.

rounded, it becomes *cuneiform* (wedge-shaped), as in the lower leaves of Saxifraga tridactylites (Fig. 261, p. 117), and in the segments of the leaf of Aconite (Fig. 263, p. 117); when an obovate leaf, with a round apex, tapers to the base, as in the Daisy, it is called *spathulate;* a leaf is *lanceolate* (Figs. 255 and 280) when the veins near the base are longer than those above and below, and the leaf tapers towards the apex; *ovato-lanceolate*, when the general form is lanceolate, but the base is broad (Fig. 252, p. 115).

179. When the lower veins come off at an obtuse angle from the

Fig. 274. Oblong leaf of Bladder-senna (*Colutea arborescens*). It approaches to the oval form, but the ends are blunter.

Fig. 275. Ovate acute leaf of Coriaria myrtifolia, one of the adulterations of Senna. Besides the midrib there are two intramarginal ribs which converge to the apex. The leaf is therefore tricostate.

Fig. 276. Oval tricostate leaf, with an acute point.

Fig. 277. Elliptical unicostate leaf, with reticulated venation well seen. The leaf is that of Argel (*Cynanchum Argel*), one of the adulterations of Senna.

Fig. 278. Oval unicostate leaf, with reticulated venation, taken from specimens of Argel.

Fig. 279. Elliptical unicostate leaf of a Tephrosia, found among senna. The primary veins come off from the midrib at acute angles.

midrib, and are curved back so as to form with the parenchyma two large round lobes at the base, with a narrow recess or sinus, like the heart on cards, the leaf is *cordate* (Figs. 281 and 282); it is *reniform* when the recess is large, and the contour rounded, so that the leaf resembles a kidney (Figs. 256 and 283); *sagittate*, when the lobes of a cordiform leaf are acute, so as to resemble the head of an arrow, as in the Scammony plant (Fig. 284), and other species of Convolvulus (Fig. 285), as well as in Sagittaria; *hastate*, when the lower veins proceed nearly at right angles, and form two lateral narrow lobes, as in Rumex Acetosella (Fig. 286); *auriculate*, when the lobes at the base of a hastate leaf are separated from the lamina, so as to be distinct segments; *deltoid-hastate*, when a hastate leaf is short, and resembles the Greek letter delta, as in Ivy (Fig. 288, *b*). Sometimes a leaf cordate at the base (next the petiole), has a rounded contour, and it becomes *rotundato-cordate* (Fig. 287).

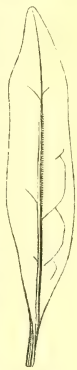


Fig. 280.

180. The lobes at the base of leaves are sometimes united more or less completely, thus giving rise to the *peltate* or *shieldlike* form, as

Fig. 281.

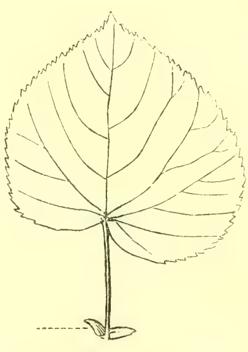


Fig. 282.

in the Indian Cress (Fig. 289), and Castor oil (Fig. 264, p. 117), and the *orbicular* form, when the petiole is attached in the centre of a

Fig. 280. Lanceolate leaf of Privet (*Ligustrum vulgare*). It is narrowed toward each extremity.

Fig. 281. Cordate leaf of Birthwort (*Aristolochia Clematitis*). The cluster of flowers arises from the axil of the leaf.

Fig. 282. Cordate leaf of Lime-tree (*Tilia*). The leaf is serrated at its margin, and its base is oblique. It may be called unequally cordate at the base.

large rounded leaf, as in Pennywort (Hydrocotyle vulgaris), and Victoria regia (Fig. 235, p. 107).

181. Very succulent leaves, with obscure veins, assume certain thickened forms, so as to become cylindrical, conical, sword-shaped, and axe-shaped. These are seen in some species of Fig-Marygold (Fig. 290, *a*).

182. The same terms are applied to all simple leafy appendages, and to the various modifications of leaves forming the parts of the flower.

183. Simple parallel-veined leaves usually have their margins

Fig 283.

Fig. 285.

Fig. 284.

entire, especially when the veins converge. They assume some of the forms already noticed, such as linear (Fig. 154, p. 65, and Figs. 291 and 292), oval, elliptical, oblong, ovate (Fig. 156, p. 65). It is comparatively rare to find any marked divisions of their laminæ. When the veins diverge at the base, or come off at obtuse angles, we meet with

Fig. 283. Reniform (Kidney-shaped) leaves of Asarabacca (*Asarum europæum*).

Fig. 284. Sagittate (Arrow-shaped) leaves of Scammony (*Convolvulus Scammonia*). The plant is a twiner, with a large thickened root.

Fig. 285. Sagittate leaf of another species of Convolvulus. The apex is more rounded than in the Scammony plant.

hastate, sagittate (Fig. 158, p. 67), and cordate forms (Fig. 293), and their various modifications. In some Palms, where the veins running in straight lines diverge, the margin of the leaf is cut into linear segments of different lengths (Fig. 243, p. 109). In some Monocotyledons the leaves present a reticulated venation (Fig. 326, p. 139). Such plants are called Dictyogenous monocotyledons.

184. *Compound Leaves.*—These originate, like simple leaves, in the form of undivided cellular projections from the axis. When fully formed, they consist of laminæ divided down to the petiole or

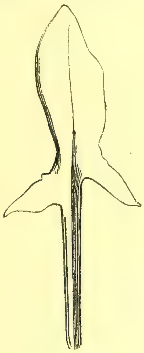


Fig. 286.

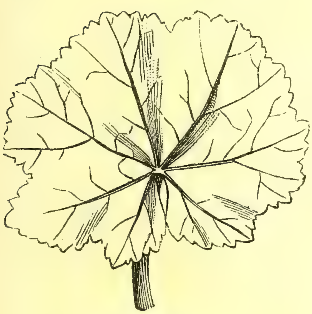


Fig. 287.

Fig. 288.

midrib into distinct pieces or leaflets, which are articulated, more or less distinctly, to the common stalk (Fig. 299, p. 128). These leaflets (foliola) are either supported on stalklets of their own, or are sessile. Compound leaves may be reduced to two well-marked forms; those formed by the divisions of a feather-veined unicostate leaf, and including

Fig. 286. Hastate (Halbert-shaped) leaf of Sheep's sorrel (*Rumex Acetosella*). The lobes at the base are in this specimen unequal.

Fig. 287. Rounded leaf of Mallow (*Malva rotundifolia*). It is cordate at the base, and is hence called rotundato-cordate. The margin is toothed and crenate.

Fig. 288. Branch and leaf of Ivy (*Hedera Helix*). The leaves, *a*, on the flowering branch are ovate acute, while the separate leaf, *b*, in the lower figure resembles the Greek Delta, and is called deltoid-hastate. It is the *Kissos* mentioned in the Apocrypha, 2 Maccab. vi. 7.

the various pinnate forms (Fig. 294); and those traced to the division of a radiating-veined multicostate leaf, including the various digitate forms (Fig. 295.)

185. When there is a distinct midrib giving off primary veins laterally, which are covered with parenchyma in such a way as to

Fig. 289.

Fig. 290.

Fig. 292.

Fig. 291.

form separate articulated leaflets, the leaf is *pinnate*, as seen in Figure 294, which represents a compound leaf composed of nine pairs (juga), of shortly petiolated pinnæ, and an odd leaflet at the end. If a pinnate leaf ends in a pair of leaflets, the extremity of the midrib being

Fig. 289. Peltate (Shield-like) leaves of Indian Cress (*Tropæolum majus*). The venation is radiating, and the lobes are united at the base, so that the petiole seems to be attached above it. When the petiole is attached in the centre, the leaf is called orbicular.

Fig. 290. Falciform (scimitar-like) leaves of a species of Fig-Marygold (*Mesembryanthemum falciforme*). The leaves are fleshy and succulent.

Fig. 291. Linear leaf of wheat (*Triticum*). The venation is parallel, and the margin of the leaf is not divided. The stalk of the leaf sheathes the stem.

Fig. 292. Linear subulate leaves of a kind of reed (*Cyperus esculentus*). It is a monocotyledonous plant. It is supposed to be the Hebrew *Achu*, translated flag in Job. viii. 11.

either leafless or ending in a tendril or point, the leaf is said to be *equally* or *abruptly* pinnate (pari-pinnate), as seen in Figures 296 and

Fig. 293.

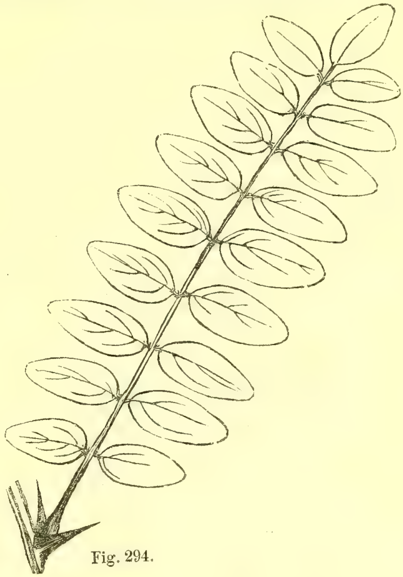


Fig. 294.

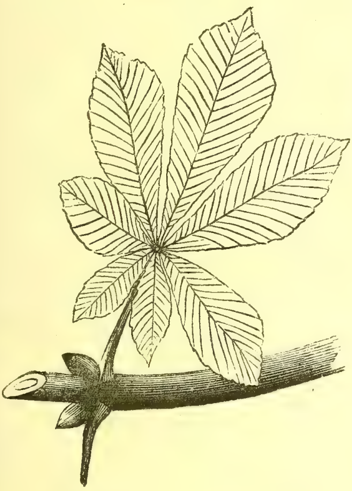


Fig. 295.

Fig. 296.

297. When there is a leaflet at the point, the leaf is said to be *unequally* pinnate (impari-pinnate), as in Figure 294. When a lyrate

Fig. 293. Cordate leaves of Smilax rudis. The leaves are multicostate, and their margins are entire.

Fig. 294. Impari-pinnate (unequally pinnate) leaf of Robinia. There are nine pairs of shortly-stalked leaflets (foliola, pinnæ), and an odd one at the extremity. At the base of the leaf stipules are seen.

Fig. 295. Septenate leaf of the Horse-chestnut (*Æsculus Hippocastanum*). Such leaves, especially when there are five leaflets, are called digitate.

Fig. 296. Pinnated leaf of Lathyrus. The petiole is winged. Two pinnæ are developed, the rest are transformed into tendrils. The leaf is said to be pari-pinnate, although, morphologically considered, it is impari-pinnate. The leaf has semi-sagittate (half arrow-shaped) stipules at the base.

leaf (Fig. 270, p. 120), becomes truly pinnate, *i. e.*, has its divisions articulated to the midrib, it is *lyrately-pinnate;* and when the leaflets of a pinnate leaf are of different sizes, the term *interruptedly-pinnate*

Fig. 297.

Fig. 298.

Fig. 299.

is applied (Fig. 298). Some parallel-veined leaves, as those of the Coco-nut, Date, and Sago Palms, are pinnate.

186. The number of pairs (juga) of leaflets in a pinnate leaf

Fig. 297. Flowering stem of common Pea (*Pisum sativum*), shewing an equally pinnate (paripinnate) leaf. There are three pairs of leaflets, and above these, three pairs of tendrils, with an odd tendril at the extremity. These tendrils are modified or transformed leaves, and therefore, morphologically, the leaf should be called impari-pinnate. At the base of the leaf there are two large stipules. The flower-stalk is two-flowered. The leaflets are mucronate, that is, blunt with a hard point.

Fig. 298. Interruptedly-pinnate leaf of Agrimony (*Agrimonia Eupatoria*). The leaflets are of different sizes, some small, others large. There are stipules at the base.

Fig. 299. Pinnate leaf of Melilot (*Melilotus officinalis*), consisting of three leaflets (pinnæ), two of which are lateral, and one terminal. The leaves do not all come off at one point, as in the ternate leaf. The leaf is sometimes said to be pinnately-trifoliolate. Adherent stipules, *s*.

varies. There may be only three leaflets (Fig. 299), in which case two are lateral, and one is terminal. Such a leaf approaches to the

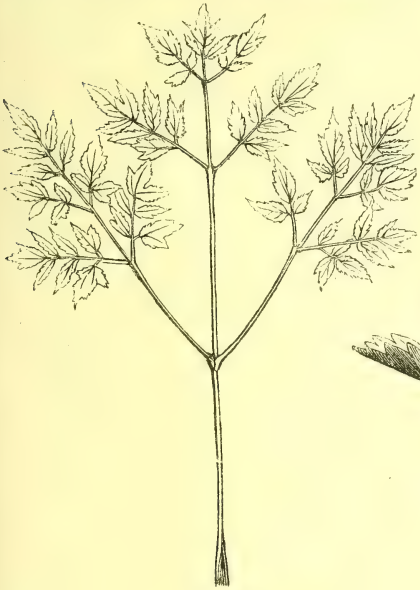


Fig. 301.

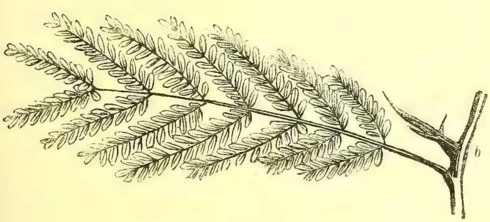


Fig. 300.

Fig. 302.

ternate leaf in the radiating venation (Fig. 302), and is distinguished by the distance intervening between the two articulated lateral

Fig. 300. Bipinnate (doubly pinnate, twice pinnate), leaf of Gleditschia triacanthos. Each of the primary pinnæ is divided into small leaflets. It may be said to be a pinnate leaf, with the leaflets also pinnate. When the small leaflets are divided the leaf becomes tripinnate, and still further divisions render it decompound. From the axil of the leaf arises a bud, *b*, which is transformed, so as to produce three spines in place of leaves. The bud is slightly extra-axillary by adhesion.

Fig. 301. Tripinnate leaf of Meadow Rue (*Thalictrum*). The primary veins coming off from the midrib are not covered with parenchyma, neither are the secondary veins, but the tertiary veins have laminæ connected with them.

Fig. 302. Ternate or digitately-trifoliolate leaf of the Strawberry (*Fragaria vesca*). The three leaflets (foliola) come from the point of the petiole. The petiole has adherent stipules *s*, at the base. The flower-stalk arises from radical leaves, and is called a scape.

pinnæ, and the terminal one. When the *leaflets* of a pinnate leaf are divided into separate pieces or pinnules, the leaf becomes *bipinnate* (twice pinnate), as in Figure 300. When the sub-division takes place to a further extent, the leaf becomes either *tripinnate* (Fig. 301), or *decompound.*

187. Compound leaves referred to the radiating venation, *i. e.*, multicostate with diverging ribs, are distinguished from those referred to the feather-venation, by the leaflets coming off from one point. When the leaflets coming from one point are two, the leaf is *binate* or *unijugate* (one pair); when three, *ternate* or *trifoliolate*, as in Wood-sorrel and Strawberry (Fig. 302); when five, *quinate* or *quinque-*

Fig. 303.

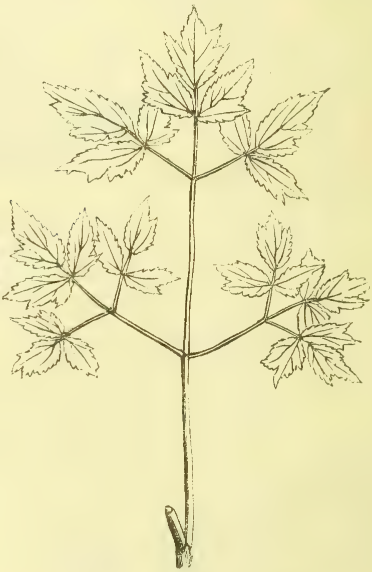


Fig. 305.

Fig. 304.

foliolate, as in Hemp (Fig. 303); when seven, *septenate* or *septem-foliolate*, as in the Horse-chestnut (Fig. 295, p. 127). When the leaflets are five, the leaf is often called *digitate.* Similar forms may occur among pinnate leaves, but in them the leaflets will be seen not to come off from the point of the petiole, but at certain distances from

Fig. 303. Flowering branch of Hemp (*Cannabis sativa*), shewing a quinate leaf. The five leaflets arise together from the extremity of the petiole. From the axil of the leaf a cluster of male flowers springs.

Fig. 304. Leaf of the Orange-plant (*Citrus Aurantium*). The lamina, *l*, is articulated to the winged petiole, *p*. It is called a compound leaf, being looked upon as an impari-pinnate leaf, with the lateral leaflets awanting, and the terminal leaflet developed. The articulation between the petiole and lamina indicates its compound nature.

Fig. 305. Triternate leaf of Bane-berry (*Actæa*). Three primary veins come off at one point; these divide into three secondary veins; and the latter subdivide into three tertiary veins, with laminæ or parenchyma covering them.

each other. We have already seen that trifoliate compound leaves may occur in both series. Some distinguish the two forms by calling the one (Fig. 302) *digitately-trifoliolate*, and the other (Fig. 299) *pinnately-trifoliolate.* In the case of a ternate leaf, the two lateral leaflets may disappear, while the central one remains articulated to the petiole. Some consider this as being the case in the Orange leaf (Fig. 304), which is therefore looked upon as a compound leaf with a single jointed leaflet. A ternate (trifoliolate) leaf may divide in such a way as to form three leaflets on the secondary veins proceeding from each of its primary veins, and thus become *biternate* (doubly ternate); while a further sub-division, in a similar way, will render it *triternate* (triply ternate), as in Figure 305.

188. General summary of facts connected with the venation and conformation of leaves :—

1. Leaves are either netted-veined (reticulated), or parallel-veined.
2. Leaves have either a single midrib (unicostate), or several ribs (multicostate); and the latter are either radiating (spreading out from one point), or convergent.
3. Unicostate leaves have veins proceeding at different angles from various points of the midrib, and arranged more or less like the parts of a feather.
4. The conformation of leaves depends partly on the venation, and partly on the mode in which the parenchyma is developed.
5. Leaves are either simple, *i. e.*, composed of one piece, or compound, *i. e.*, composed of one or more articulated leaflets.
6. Simple leaves are either entire or divided into segments. When the divisions are superficial, they are dentate, serrate, or crenate; when the divisions are deeper, cleft or partite.
7. Simple unicostate (one-ribbed) leaves having their parenchyma cut laterally into various lobes, and so that the divisions extend to about the middle of each half of the lamina, exhibit pinnatifid, pectinate, panduriform, runcinate, and lyrate forms; when the divisions extend nearly to the midrib the form is pinnati-partite.
8. Simple multicostate (many-ribbed) leaves, with the ribs divergent, when cut longitudinally into various lobes, the divisions extending to about the middle, exhibit palmately-cleft forms; when the divisions extend to near the base, the forms are palmately-partite or dissected.
9. Simple leaves, with convergent ribs, are rarely divided deeply, and such is also the case with parallel-veined leaves, the margins of which are often entire.
10. Simple leaves, whether unicostate or multicostate, with lobes or divisions at their base, exhibit reniform, cordate, sagittate, and hastate forms; with lobes or divisions at their apex, emarginate and obcordate forms.
11. Compound unicostate leaves, having the parenchyma divided laterally into separate articulated leaflets, exhibit pinnate, bipinnate, tripinnate, and decompound forms.
12. Compound multicostate leaves, with divergent ribs, having the parenchyma divided longitudinally into separate articulated leaflets, exhibit the ternate, quaternate, quinate, and digitate forms.

4. PETIOLE OR LEAF-STALK.

189. The stalk supporting the blade of the leaf is denominated the *Petiole* (Fig. 306, *p*). It is absent in the case of *sessile* leaves (Fig. 232, p. 105); and, in certain instances, the distinction between

the lamina and the stalk is not well defined. The petiole consists of a definite number of vascular bundles enclosed in a small amount of parenchyma. The vessels are woody, dotted, spiral, and laticiferous, and they are derived from the internal part of the stem, as shewn in Figure 307, where the vessels, *fv*, surrounding the pith, *m*, are traced into the leaf-stalk, *f*.

Fig. 308.

190. At the point where the vessels leave the stem there is often a small enlargement (pulvinus), composed of cellular tissue (Fig. 307, *c*), and an articulation or joint. When the leaf dies, it separates from the stem at the joint, leaving a mark or scar (cicatrix, cicatricula) in which the ends of the different vascular bundles are seen arranged in a definite order (Fig. 308, *b*). The form of the scar, and the arrangement of the bundles, differ in different plants, and furnish, in some instances, distinct characters. The number of these vascular bundles, and their mode of distribution, determine, in some measure, the phyllotaxis and conformation of the leaves.* In the

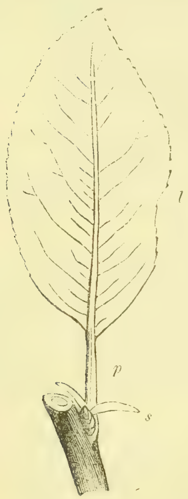


Fig. 306.

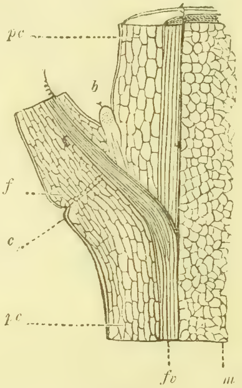


Fig. 307.

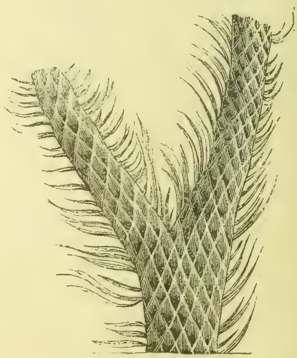


Fig. 309.

Fig, 306. Oval leaf of Pear-tree (*Pyrus communis*); *l*, lamina or blade, with primary veins coming off from the midrib, and with a serrated margin; *p*, petiole or leaf-stalk, with straight venation; *s*, stipules, or small leaves at the base of the petiole. In the axil of the leaf, *i. e.*, the angle where it joins the stem, a bud is seen.

Fig. 307. Section of a stem, and the origin of a leaf, shewing, *m*, cellular pith; *fv*, vascular bundle, which sends off a branch to the leaf-stalk; *p c*, *p c*, the parenchyma of the stem and petiole; *c*, cellular swelling at the base of the petiole, called pulvinus or cushion; above it is the articulation between the petiole and stem; *b*, bud in the axil of the leaf.

Fig. 308. Stem, with a terminal bud, *a*, and lateral bud, *b*. At the lower part is seen the scar (cicatricula), left by the fallen leaf, and in it are observed the vascular bundles.

Fig. 309. Stem of a fossil plant of the coal Epoch (*Lepidodendron elegans*), shewing scars apparently indicating the places where leaves existed. The form of the markings is characteristic of the genus, and the name is derived from their scaly appearance.

* Lestiboudois, Phyllotaxie Anatomique, ou Recherches sur les causes organiques des diverses distributions des feuilles. Ann. des Sciences Nat. 3d ser. Bot. x. 15, 65, 136.

case of many Palms, and of Tree-ferns (Fig. 204, p. 93), the scars left by the leaves are very conspicuous; in fossil plants important characters are founded on them (Fig. 309).

191. When there is no articulation between the petiole and the stem, as is the case with many Endogens, the leaf is continuous with the axis, and is not deciduous, but withers on the stalk. In many Liliaceous plants (Fig. 90, p. 38), Orchids (Fig. 143, p. 60), and grasses (Fig. 291, p. 126), the leaves during their decay continue attached to the plants. In compound leaves there is usually an articulation, where the leaflet or leaflets join the petiole (Figs. 310 and 311). At this joint also a cellular swelling (struma) occurs. In many pinnate leaves, as those of the Sensitive plant (Fig. 312), the axial and foliolar joints and swellings (pulvinus and struma), are very evident, and appear to be connected with the folding of the leaflets under certain conditions. In ternate leaves, such as those of the

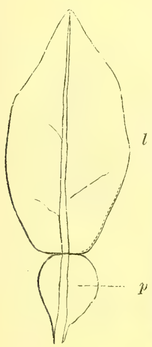


Fig. 310.

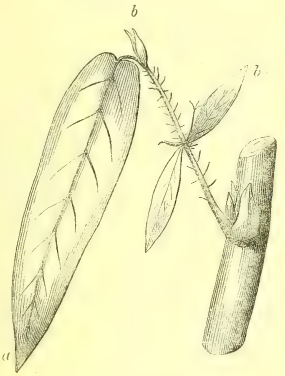


Fig. 311.

Fig. 312.

Wood-sorrel, similar swellings are often seen. Where the petiole joins the blade its vessels diverge, so as to form the ribs and veins—the vascular bundle which continues in the direction of the stalk being the midrib. The epidermis of the petiole has few stomata.

192. The petiole is usually either round, or half cylindrical, with a flattening or grooving on the upper surface. In the Aspen (Fig. 313), it is compressed laterally, or at right angles with the blade, and

Fig. 310. Leaf of Orange (*Citrus Aurantium*), shewing a winged petiole, *p*, which is articulated to the lamina, *l*. It is considered a compound leaf, having only one leaflet.

Fig. 311. Compound leaf of moving plant of India (*Desmodium gyrans*). There is a swelling (pulvinus), where the leaf-stalk joins the stem, and another swelling (struma) at the base of each of the leaflets. The leaf is unequally pinnate. The odd leaflet, *a*, at the end is large, the two pairs of pinnæ, *b*, *b*, are small. The latter exhibit evident movements. Stipules are seen close to the pulvinus at the base of the leaf-stalk.

Fig. 312. Branch and leaves of the Sensitive plant (*Mimosa pudica*). There are distinct joints and swellings at the base of the petiole, and at the base of each pinna. The leaf is bipinnate, and exhibits distinct movements when touched. Some look upon the leaf as a digitate one, with four pinnate leaflets. Stipules, with pulvinus, are seen at the points where the leaf-stalks join the stem. Leaf partially expanded, *a*. Leaf folded, with depressed petiole, *b*.

hence the trembling of its leaves from the slightest breath of air. When the leaves of a plant float on water, the petiole is sometimes distended with air cavities, as in the Water Chestnut (Fig. 314). The edges of the petiole in plants such as the Orange (Fig. 315), the Quassia plant (Fig. 316), Venus' Fly-trap (Fig. 237, p. 107), and the Sweet Pea, and other species of Lathyrus (Fig. 296, p. 127), are bordered by a leaf-like expansion called a *wing*, and hence they are denominated *winged* or *bordered* petioles. Such leaf-stalks are occasionally united to the axis for some extent, and thus become *decurrent*. In many Endogens, especially grasses, the leaf-stalk forms a *sheath* round the stem (Fig. 317); this sheath in grasses terminates at the upper part, in a process called a *ligule*, as seen in Figure 317, where *g* is the sheath (vagina), *l* the blade of the leaf, and *lig* the ligule. In Umbel-

Fig. 313.

Fig. 314.

liferous plants the petiole is expanded, and forms a conspicuous sheath round the stem (Fig. 318). This sheathing portion of the petiole is formed by the divergence of the vascular bundles on either side. The vessels thus surround the stem, and are covered with parenchyma. This petiolary sheath may be considered as a modification of stipules.

193. In some Australian plants belonging to the genera Acacia and Eucalyptus, the petiole is flattened, and becomes a foliar expansion, which occupies the place of true leaves. Such petioles have received

Fig. 313. Leaves and flowering branch of the Aspen (*Populus tremula*). The petiole is flattened laterally, and allows the leaves to move easily in the wind. Hence the plant is called trembling Poplar. The leaves are round and toothed at the margin. It appears to be one of the plants included in the terms *Baca* and *Becaim*, and translated Mulberry trees in Scripture (2 Sam. v. 23, 24; 1 Chron. xiv. 14, 15; also Psalm lxxxiv. 6). "The sound of a going on the tops of the Mulberry trees," is considered as referring to the mobility of the Poplar leaves. The flowers are in a catkin.

Fig. 314. Plant of Water-chestnut (*Trapa natans*). The submerged leaves are much divided; those which float have inflated petioles, containing numerous air cells. The swelling below the blade of the leaf indicates the situation of the air cavities.

the name of *Phyllodia.* The trees bearing them give a peculiar character to some forests in New Holland. These phyllodia are usually placed vertically, presenting their edges to the sky and earth, and their venation is parallel. They occasionally bear pinnate or bipinnate laminæ, and in such cases they are frequently much narrowed in their dimensions. In Figure 319 a bipinnate leaf is represented, with its flattened petiole or phyllodium, the venation of which is straight. On the same tree may be seen naked and leaf-bearing phyllodia. By this, as well as by their venation, their petiolary character is determined.

Fig. 315.

Fig. 316.

Trees producing naked vertical phyllodia only have a singular effect as regards light and shade. Travellers have noticed this in some of the Australian forests. Some shrubby species of Wood-sorrel exhibit phyllodia, which are either naked, or bear ternate leaflets.

Fig. 315. Branch of Orange-tree (*Citrus Aurantium*). The leaves exhibit winged or bordered petioles, united to the lamina by a joint. They are compound leaves, with a single leaflet connected with each petiole. The flowers are shewn both in bud (imbricate æstivation), and fully expanded, with the five petals spread out.

Fig. 316. Flowering branch of Quassia plant (*Quassia amara*). The leaves are impari-pinnate, and the petiole is winged. The flowers are arranged in a raceme. The young fruit, consisting of five drupes united, is seen in a separate Figure below.

These phyllodia are often placed like leaves with their flat surfaces towards the sky and the earth. The peculiar narrow leaves which

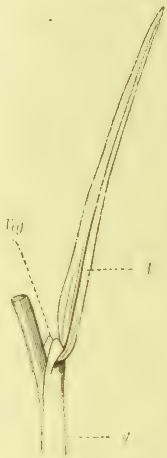


Fig. 317.

Fig. 319.

Fig. 318.

occur in certain species of Ranunculus and Bupleurum may be considered as petioles of this nature not producing laminæ.

Fig. 317. Stem of a grass (*Poa*) with leaf. The sheathing petiole, *g*, ending in a process, *lig*, called a ligule; the blade of the leaf, *l*.

Fig. 318. Flowering stalk of Dill (*Anethum graveolens*). The leaf is divided into linear segments, and the petiole is broad and sheathing, and ends in two projecting processes at the base of the divided lamina. In the case of this and other umbelliferous plants, the leaf stalk sometimes receives the name of Pericladium. The flowers are arranged in a compound umbel. The plant is the *Anethon* mentioned in Matth. xxiii. 23, and translated anise.

Fig. 319. Leaf of an Acacia (*Acacia heterophylla*), from the island of Bourbon, shewing a flattened leaf-like petiole, *p*, called a phyllodium, with straight venation, and a bipinnate lamina, *l*. In many Acacias the laminæ are awanting, and phyllodia only are produced. On that account the name of leafless Acacias has been given.

5. STIPULES OR STIPULARY APPENDAGES.

194. Stipules are leafy appendages situated at the base of the petiole, and having normally a lateral position as respects the leaf. They have usually the same structure as leaves, and, in some instances, as in Lathyrus Aphaca, they constitute the only leaves which the plant produces. In the pansy (Figs. 320, 321) they are as conspicuous as the ordinary leaves. In the Pea (Fig. 297, p. 128) they are also large, and in many of the pea tribe (Fig. 296, p. 127), they assume peculiar sagittate forms. Stipules are not present in all plants. Those having stipules are called *stipulate*, those without stipules are *exstipulate*. In the classification of plants the presence and absence of stipules supply

Fig. 321.

Fig. 320.

Fig. 322.

distinctive marks. At a certain stage of their growth stipules are usually larger than the leaves or leaflets produced before them. Thus they serve as a protection to the leaves in the young state, as in the India-rubber Fig, Potamogetous, Magnolias, and the Beech. These protective stipules generally fall off when the leaf expands.

195. The form and appearance of stipules vary ; some are leaf-like (Fig. 321, *s*), others cirrhose (Fig. 322, *s*) ; some are small (Fig. 231, *s*, p. 105, and Fig. 306, *s*, p. 132), others large (Fig. 297, *b*, p. 128); some assume a scaly or membranaceous appearance, others are hard and spiny

Fig. 320. Pansy (*Viola tricolor*), shewing the ovate-lanceolate leaf, and the stipules, placed laterally at the base of the petiole. On the flowering stalk a small floral leaf (bract) is seen.

Fig. 321. Leaf of Pansy, *l*, separated from the flower; the lyrate-pinnatifid stipules, *s*, are distinctly visible, and their lateral position is seen.

Fig. 322. Melon *(Cucumis Melo)*, with its undulated leaf, and its single cirrhose stipule, *s*. The position of the tendril (Cirrhus) points out its stipulary nature. This kind of stipule is characteristic of Cucurbitaceæ.

(Fig. 294, p. 127); some are separate and free, others are united. In this way the nature of the stipules gives characters in many natural orders.

Fig. 323.

In the Cinchona bark trees (Fig. 323), which have opposite leaves, the stipules unite, so as to form one on each side of the stem between the petioles, hence they are called *interpetiolar*. At the base of the stipules of Cinchona, and other allied genera, there are numerous small glands which secrete an oily and resinous matter (¶ 71, p. 46). In the Rhubarb tribe, which have alternate leaves, the stipules unite, so as to form a sheath or *ochrea* round the stem. In the Plane tree, and in the Astragalus, they unite, so as to form a leafy expansion on the opposite side from the leaf, and in the Rose tribe (Fig. 324), they are united to each other and to the petiole, thus becoming *adnate*. The petioles of many plants have a sheathing portion at their base (Figs. 318 and 325), which may be considered as adherent stipules. On this

Fig. 324.

Fig. 325.

account the reticulum, or mat-like substance, at the base of the leaves of palms, is often called stipular. Besides the leaves at the base of the petiole, smaller leaflets (stipels) are occasionally produced at the base of the pinnæ of compound leaves, as in the bean.

Fig. 323. A species of Peruvian bark tree (*Cinchona*), shewing opposite leaves, with inter-petiolar stipules. The flowers are in a sort of corymbose cyme, the fruit, as shewn in the lower figure, consists of two carpels united.

Fig. 324. Branch of the Rose, with adnate or adherent stipules, united to each other, and to the lower part of the petiole. They are sometimes called Petiolar. The leaves are unequally pinnate. The stem is covered with hooked aculei or prickles.

Fig. 325. Tripartite and lobed leaf of Crowfoot (*Ranunculus*), with the lower part of the petiole dilated and sheathing. The dilated portion, *a*, may represent adnate stipules.

6. TRANSFORMATIONS OF LEAVES AND THEIR APPENDAGES.

196. Some of these transformations have been already noticed, but there are others to which it is necessary to direct attention. The morphological relations between leaves, scales, and spines—between petiole and laminæ, and between stipules and petioles, have been adverted to. All these nutritive organs are sometimes changed into tendrils (cirrhi), with the view of enabling the plants to twine round others for support. In leguminous plants (the pea tribe) the pinnæ are frequently cirrhose; thus, in Figure 297, p. 128, a pea leaf is represented with three pair of cirrhose (tendril-like) pinnæ, and an odd leaflet, in the form of a tendril, at the extremity of the midrib. So also, in Figure 296, page 127, the leaf ends in three tendrils which morphologically are to be considered pinnæ. Sometimes a whole leaf

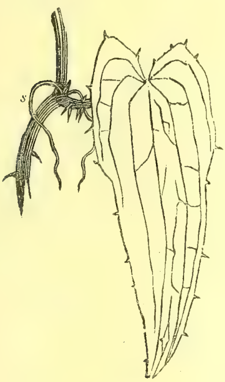


Fig. 326.

Fig. 327.

becomes cirrhose, as in some species of Lathyrus. In the Vanille plant some of the leaves are frequently changed into tendrils. In Smilax (Fig. 326), there are two stipulary tendrils, while in the Cucumber tribe there is a single one (Figs. 322 and 327) at the base of each leaf. In the Passion-flower the lateral leaf-buds, and in the Vine (Fig. 153, p. 64), the terminal ones become tendrils.

197. The leafy parts of plants are also liable to become hardened and spinescent. The leaves of some species of Astragalus and Barberry (Fig. 238, p. 107), and the stipules of the false acacia (Robinia) are spiny. In these instances the vascular bundles are developed in

Fig. 326. Leaf and petiole of Smilax, with two stipulary tendrils, *s*. The leaf is ovate, acute, and cordate at the base. The venation is reticulated, although the plant is monocotyledonous. It is denominated by Lindley Dictyogenous on that account.

Fig. 327. Flower, fruit, and leaves of the Melon (*Cucumis Melo*). The leaves are rounded, cordate at the base, the margin toothed, and the venation radiating. The stipule is transformed into a tendril. The fruit is a Pepo. The plant seems to be included in the Hebrew word *Abbatachim*, translated melons (Numbers xi. 5).

a marked degree, while the parenchyma is deficient. To the same cause is attributed the spiny margin of the Holly-leaf. In the Gooseberry (Fig. 328), the swelling (pulvinus) at the base of the petiole, and below the leaf, *f*, assumes a spinose character.

198. Changes in the appearances of leaves are produced by adhesions and foldings of various kinds. When two leaves unite at their bases, as in some species of Honeysuckle (Fig. 329), they are called *connate*, a similar appearance is produced by the partial union of two sessile leaves, as in the Caper-Spurge. When the lobes at the base of a leaf unite on the opposite side of the stem from the laminæ, a *perfoliate* leaf is the result, as seen in some species of Bupleurum, (Fig. 330), and Baptisia. The formation of peltate (Fig. 289, p. 126), and Orbicular (Fig. 235, p. 107), leaves have been traced to the union of the lobes of a cleft leaf. In the case of the Victoria

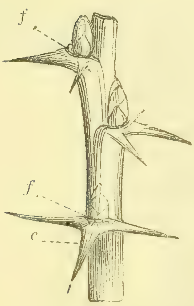


Fig. 328.

Fig. 329.

Fig. 330.

leaf the transformation may be traced during germination. The first leaves produced by the young plant are linear, the second are sagittate and hastate, the third are rounded cordate, and the next are orbicular. The cleft indicating the union of the lobes remains in the large leaves.* Many forms of stipules, such as petiolar, interpetiolar, and sheathing, are traced to adhesion.

199. Folding of the leafy appendages, and union of their edges, give rise to the formation of a hollow leaf or pitcher (ascidium, ascus). In the Side-saddle flower the ascidia are considered as being formed by the petiole or phyllode, a part of which, in an unadherent state, is pro-

Fig. 328. Branch of Gooseberry (*Ribes Grossularia*), shewing the cushion (pulvinus), producing spines, *c*. These spines are considered as an altered state of the cushion. They arise below the scars of the leaves, *ff*, from the axils of which buds are produced.

Fig. 329. Connate leaves of a species of Honeysuckle (*Lonicera Caprifolium*). Two leaves are united by their bases. They are sometimes said to be confluent.

Fig. 330. Perfoliate leaf of a species of Hare's-ear (*Bupleurum rotundifolium*). The two lobes at the base of the leaf are united, so that the stalk appears to come through the leaf.

* See Hooker, Victoria regia, or Illustrations of the Royal Water Lily. 1851.

longed upwards (Fig. 332). In the Pitcher-plant there is an evident lid, united to the pitcher by a joint (Fig. 331, *l*). The lid is looked upon as the metamorphosed lamina, articulated to the hollow petiole or

Fig. 331.

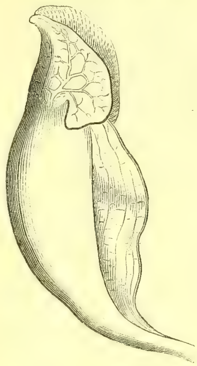


Fig. 332.

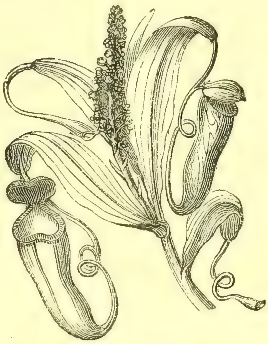


Fig. 333.

phyllode. It may be said to resemble the jointed leaves of the Orange (Fig. 304, p. 130), or Dionæa (Fig. 237, p. 107), with their petioles folded so as to adhere by the edges, and their laminæ reduced in size, so as to form a lid (operculum). In the pitcher-plant we perceive transitions from a winged to a rounded, and then to a hollow petiole. Thus, in Figure 333, the petiole arising from the stem is first broad and leaf-like, then it becomes narrow and rounded, and ultimately it assumes the form of a pitcher, with the lamina in the form of a lid. In an East Indian twining pitcher-plant, called Dischidia Rafflesiana, the pitchers are considered by Griffith as formed by folded laminæ. The hollow (fistular) leaves of the onion, and of other species of allium, may be traced to the folding and adhesion of the margins of the foliar appendages.

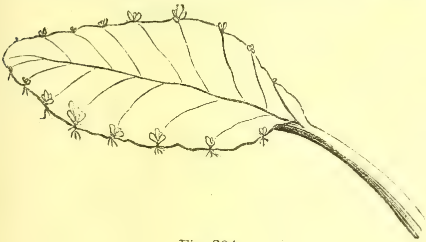


Fig. 334.

Fig. 331. Pitcher (*Ascidium, ascus*) of a species of Pitcher-plant (*Nepenthes destillatoria*). It is supposed to be formed by a folded petiole, *p*, or phyllode, the edges of which are united. The lid, *l*, at the top is supposed to represent the lamina, united by articulation to the pitcher. Part of the petiole is narrow and twisted.

Fig. 332. Pitcher (*Ascidium*) of a species of Side-saddle plant (*Sarracenia purpurea*). The pitcher is supposed to be formed by the folded petiole, which is prolonged upwards. There is no articulated lid.

Fig. 333. Flowering branch of a pitcher-plant (*Nepenthes destillatoria*). The petiole, as it arises from the stem, is broad and leafy, with straight venation; it then becomes small and round, and coils at one part of its course; ultimately it is folded on itself, and its margins unite so as to form a pitcher; at the mouth of which the lamina appears in the form of a lid or operculum.

Fig. 334. Leaf of Bryophyllum calycinum, producing buds along the margin, at the extremities of the primary veins. When placed on the surface of moist soil young plants are produced at the edges of the leaf. The leaf is called proliferous.

200. It has been already remarked, that buds and bulbils (Fig. 146, p. 61, and Fig. 163, p. 68), are produced at the points where leaves join the stem. In some instances, however, we find that buds are produced from the margins or surfaces of leaves.* In Bryophyllum (Fig. 334), this is a common occurrence, and it is met with in many plants of the order Gesneraceæ, the leaves of which, when placed on the surface of moist earth, become what is called *proliferous*, or bud-bearing. In Nymphæa micrantha buds appear at the upper part of the petiole. The leaf of Venus' Fly-trap (Fig. 237, p. 107), when cut off and placed in damp moss, with a pan of water underneath, and a bell-glass for a cover, has produced buds from which young plants were obtained. Some species of Saxifrage, and of Ferns, also produce buds on their leaves and fronds.

* Trecul, Recherches sur l'origine des Bourgeons adventifs. Ann. des Sciences Nat. Botan. 3d ser. viii. 268.

CHAPTER III.

REPRODUCTIVE ORGANS OF FLOWERING PLANTS.

201. The flower or Floral organs concerned in the production of seed, containing the young plant, are called *Organs of Reproduction.*

Fig. 335.

Fig. 336.

In Dicotyledons and Monocotyledons they are usually obvious, and hence these plants are called *Phænogamous* or *Phanerogamous* (Fig.

Fig. 335. Flowering branch of the Horse-chestnut (*Æsculus Hippocastanum*). The flowers and organs of reproduction are conspicuous; hence the plant is Phanerogamous, or Phænogamous. The flowers are arranged in a racemose cyme.

Fig. 336. A moss (*Funaria hygrometrica*) having no flowers, and no conspicuous organs of reproduction; hence called Cryptogamous. Leaves, *f*, connected with the fruit stalk, *p*; *u*, urn-like spore-case, with its calyptra, *c*, and operculum, *o*.

335); while in Acotyledons they are obscure, and hence the plants are called *Cryptogamous* (Fig. 336), the former being *Flowering* plants, the latter *Flowerless*.

I. THE INFLORESCENCE.

202. This term designates the arrangement of the flowers on the flowering stem or branch. Flowers are produced from flower-buds, as

Fig. 337.

Fig. 338.

leaves are from leaf-buds. These two kinds of buds have a resem-

Fig. 337. Flowering stalk of Acrid Crowfoot (*Ranunculus acris*). An expanded flower, *a*, terminates the axis. The flower-buds, *b*, are produced on separate floral axes, each terminated by a single flower. The inflorescence is definite or determinate.

Fig. 338. Indefinite flowering stalk of Pimpernel (*Anagallis arvensis*). Single flowers, *b*, are produced in the axils of leaves, *a*, called Bracts or Floral leaves. The bracts resemble the ordinary leaves of the plant. The stalk continues to elongate, bearing axillary flowers. The Inflorescence is indefinite or indeterminate.

blance to each other as regards the arrangement and the development of their parts; and it sometimes happens, from injury and other causes, that the part of the axis which, in ordinary cases, would produce a leaf-bud, gives origin to a flower-bud. It will be afterwards shewn that, morphologically considered, the flower is to be looked upon as a shortened branch bearing parts analogous to leaves. The flower-bud contains either one or many flowers.

203. *Bracts.*—Like leaf-buds, the flower-buds arise either from the extremity of an axis, and are then terminal (Fig. 337), or they are

Fig. 339.

Fig. 340.

produced from the axil of leaves called *bracts* (Fig. 338). These bracts are sometimes like the ordinary leaves (leafy or leaf-like bracts), as in

Fig. 339. Flowering stalk of the White Dead-nettle (*Lamium album*). The Bracts, *b*, are like the ordinary leaves of the plant, and produce clusters of flowers in their axil. The clusters are called Verticillasters, and consist of flowers which are produced in a centrifugal manner, the central one expanding first. Hence the Inflorescence is definite. The flowering stalk continues, however, to elongate in an indefinite manner.

Fig. 340. Branch of a kind of Speedwell (*Veronica officinalis*). The flowering stalks are produced in the axil of ordinary leaves, *a*, called Bracts. The flowers are in racemes, and at the base of each flower is a small leaf called a bracteole or bractlet. The Inflorescence is indefinite or indeterminate.

many species of Speedwell, Periwinkle, and Pimpernel (Fig. 338),

Fig. 341.

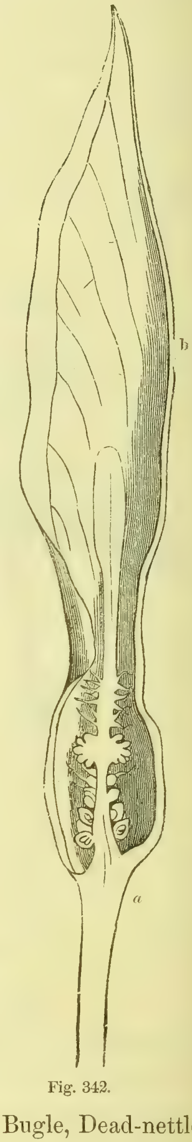


Fig. 342.

where they bear single flowers, and in the common Bugle, Dead-nettle

Fig. 341. Flowering stalk of a Fan-palm (*Chamærops*). The flowers are produced on a spadix, *c*, or succulent spike, which is in this case branched, and all are enclosed in a sheathing bract, *a*, called a Spathe. Besides the general sheathing bract, there are others of a partial nature, *b*. Large specimens of Palm spathes are in the Museum of the Ed. Botanic Garden.

Fig. 342. Flowers of Cuckow-pint (*Arum maculatum*), cut vertically, shewing the succulent spadix continuous with the stalk, *a*, covered with sessile flowers, the lower female, the upper male, and the large sheathing bract or spathe, *b*. The spadix terminates in a succulent club-shaped cellular mass.

(Fig. 339), and some species of Veronica (Fig. 340), where they produce several flowers. They have the colour of leaves in such instances, and consist of cells and vessels, similarly arranged, in the form of parenchyma, ribs and veins, with epidermis and stomata.

204. Bracts, however, in many plants, as regards colour, size, and form, present a different appearance from leaves. In Amherstia nobilis, and in some species of Salvia, they are large, and of a fine scarlet colour, so as to give a marked character to the flowers. In Palms (Fig. 341, *a*), and in species of Arum (Fig. 342, *b*), the bracts are large and sheathing, and are called *spathes;* they enclose numerous flowers, supported on a common succulent stalk (spadix). In some South American Palms, such spathes enclose upwards of 200,000 flowers, and

Fig. 343.

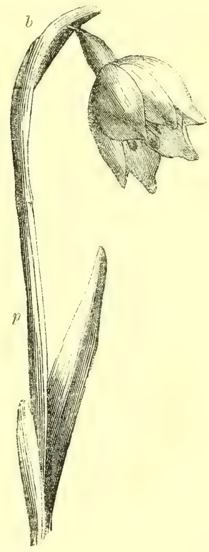


Fig. 344.

they are sometimes twenty feet long. In the species of Narcissus (Fig. 343), and Snowflake (Fig. 344, *b*), sheathing bracts are seen. In Grasses, the bracts constituting the outer covering of the spikelets of flowers are called *glumes* (Fig. 345, *gl*).

205. In the case of numerous flowers on a common stalk, the bracts are often numerous also, and are arranged in a whorl or *involucre*, as it is called. An assemblage of involucral bracts is seen in

Fig. 343. Flowers of Polyanthus-Narcissus (*Narcissus Tazetta*), bursting from a sheathing bract. The common flower-stalk is called a scape, and the flowers are supported on partial stalks called pedicels. The inflorescence is umbellate and cymose. The plant is supposed to be the *Chabazzeleth* of Scripture, translated Rose (Song of Solomon ii. 1; Is. xxxv. 1.)

344. Flower of spring Snow-flake (*Leucojum vernum*), supported on a peduncle, *p*, called a scape, and coming out from a sheathing bract, *b*. The flower is drooping and solitary, and the perianth is above the ovary.

composite flowers, such as the Daisy, Dandelion, and Marygold (Fig.

Fig. 345.

Fig. 346.

Fig. 347.

Fig. 348.

346), and in umbelliferous plants, such as Hemlock and Cummin (Fig.

Fig. 345. Spikelet of Oat (*Avena sativa*) laid open, shewing the bracts, *gl*, *gl*, which are denominated Glumes; *p e*, the outer pale or glumellule, with a dorsal awn, *a*; *p i*, the inner pale; *f s*, an abortive flower. The two pales (*paleæ*, *glumellulæ*) enclose the essential organs of reproduction.

Fig. 346. Head (Capitulum) of Marygold (*Calendula*), shewing a congeries of flowers, *f*, enclosed by rows of bracts, *i*, at the base, which are collectively called an Involucre.

Fig. 347. Umbels of the Cummin plant (*Cuminum Cyminum*). The leaves are cut into filiform segments. At the base of the general umbel there are cut leaves (bracts), which form the general or universal involucre, and at the base of the smaller umbels (umbellules) other narrow leaves are seen forming the partial involucre. The plant is the *Cummin* or *Kammon* of the Old Testament (Is. xxviii. 25, 27), the *Kuminon* of the New Testament (Matth. xxiii. 23). What are commonly called Cummin seeds are in reality the achænia, or fruit containing the seeds.

Fig. 348. Catkin (Amentum) of Willow, bearing male flowers, each of which arises from a scale (Squama), or, in other words, a scaly bract. There are numerous flowers and bracts in the catkin.

347). In the last-mentioned plant there are two rows of bracts in each head of flowers, one, *a*, denominated the general involucre, at the base of the large umbel; the other the partial involucre, or involucel, at the base of the smaller umbels, or umbellules. The bracts connected with the flowers, in the catkins of the Poplar (Fig. 313, p. 134), of the Willow (Fig. 348), the Walnut (Fig. 349), and other amentiferous (catkin-bearing) plants, are called *scales*.

206. Bracts sometimes fall off when the flowers expand, at other

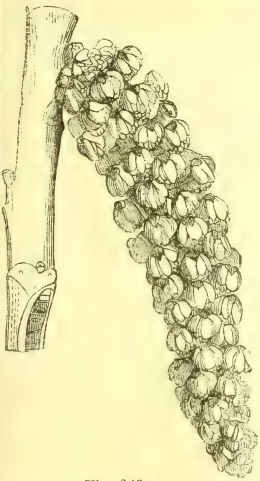


Fig. 349.

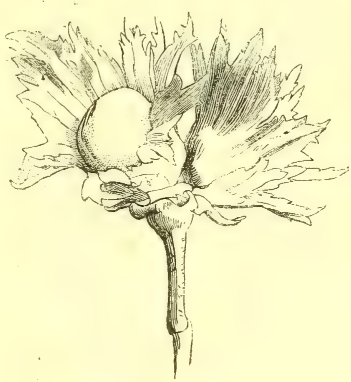


Fig. 351.

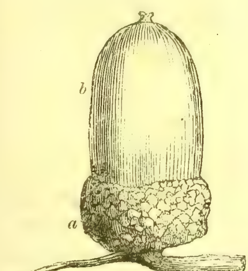


Fig. 350.

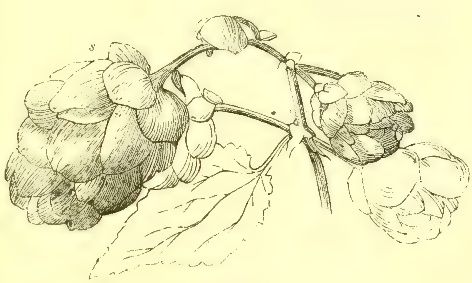


Fig. 352.

times they continue during flowering, and, in certain instances, they form part of the fruit. The cup (cupula) of the Acorn (Fig. 350, *a*),

Fig. 349. Male Catkin (Amentum) of Walnut (*Juglans regia*), shewing numerous scaly bracts among the flowers.

Fig. 350. Fruit of the Oak (*Quercus pedunculata*), shewing a collection of bracts, *a*, forming the cup (cupula) of the acorn, *b*.

Fig. 351. Fruit of the Hazel (*Corylus Avellana*), shewing bracts which form the husk of the nut.

Fig. 352. Fruit of the Hop (*Humulus Lupulus*), shewing scales, *s*, which are bracts covering female flowers. The scales are arranged in a spiral manner like those of the cone. They are soft and membranous. The fruit is compound or anthocarpous, and is called a Strobilus.

and the husk of the Hazel-nut (Fig. 351) are formed by bracts; so also are the scales of the Hop-fruit (Fig. 352), of the Fir cone (Fig. 353), and of the Pine apple (Fig. 354).

207. Bracts are said to be *empty* when they do not give origin to flowers. Thus, in Salvia Horminum, the top of the flowering axis ends in a series of coloured empty bracts, and in the Pine-apple plant the fruit (Fig. 354) is terminated by a crown of leaves, which are to be considered as empty bracts, terminating the axis. The outer row of scales in the involucre of some compound flowers are empty bracts, which occasionally produce buds, as in the case of the Hen-and-chickens daisy. In Cruciferous plants, such as Wallflower, and in the Borage tribe, such as Forget-me-not (Fig. 400, p. 169), bracts are very rarely developed, and hence they are called ebracteated.

208. When an axis bearing numerous stalked flowers arises from

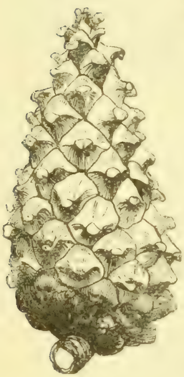


Fig. 353.

Fig. 354.

Fig. 355.

a bract, there are sometimes smaller leaves, called *bractlets* or *bracteoles*, at the base of the small flower-stalks. Thus, in Figure 340, p. 145, the cluster of flowers arises from a bract, and each flower has a bractlet at the base of its stalk. When bracts or bractlets are placed, so as to be close to the outer envelope (calyx) of the flower, there is occasionally some difficulty in determining what parts are to be referred to each of these organs. In the Mallow tribe (Figs. 355 and 356, *e*) the outer calyx (epicalyx) seems to be of this nature. When

Fig. 353. Fir cone, composed of numerous scales, arranged round an axis in a spiral manner, each scale covering a female flower. The scales are hardened bracts.

Fig. 354. Fruit of Pine apple *(Ananassa sativa)*, composed of numerous flowers, on a common axis, each covered by a scale or bract, *a*. The crown, *b*, of the Pine-apple may be considered as composed of a series of empty bracts, *i.e.*, bracts not bearing flowers. These bracts terminate the flowering axis.

Fig. 355. Flower of Mallow *(Malva sylvestris)*, cut vertically. The Epicalyx, *e*, composed, according to some, of bracts which cover the true calyx; petals, *p*; cluster of monadelphous stamens in the centre.

bracts adhere to the flower-stalk and become decurrent, as in the Lime tree (Fig. 357, *b*), they appear like winged branches, giving origin to the inflorescence.

209. *Flower-stalk.*—The axis bearing the flower or flowers, is called the floral axis (Fig. 335, p. 143, and Fig. 337, p. 144). It is a branch

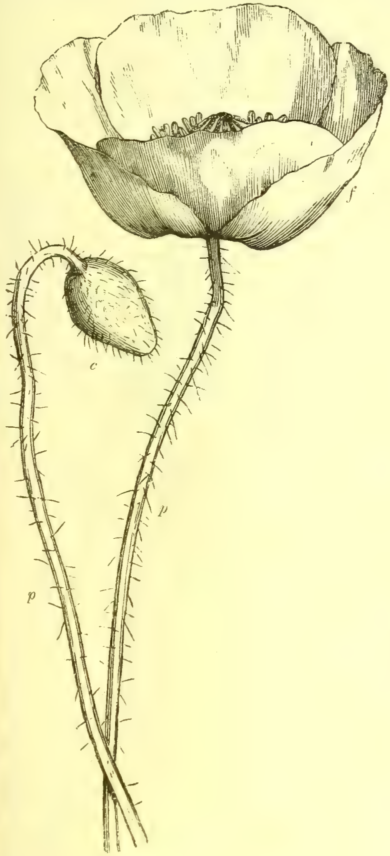


Fig. 358.

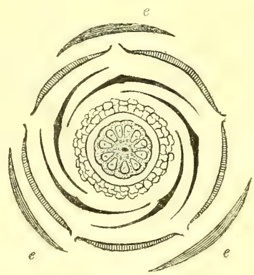


Fig. 356.

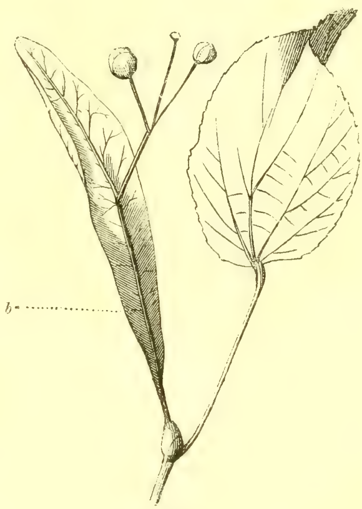


Fig. 357.

coming from a flower-bud. The term *Peduncle* is that usually given to a stalk supporting a single flower (Fig. 358, *p*), or numerous flowers

Fig. 356. Diagram of the flower of the Mallow, shewing the relation of the different parts of the flower; *e*, *e*, *e*, the three parts of the Epicalyx, within which are five valvate sepals, then five twisted and imbricate petals, then numerous stamens, united by their filaments, and in the centre numerous carpels.

Fig. 357. Leaf and flowering branch of the Lime tree *(Tilia)*. The bract, *b*, is adherent to the peduncle or flower-stalk. The flowers are arranged in a corymbose cyme.

Fig. 358. Flower-stalks of the common red Poppy *(Papaver Rhœas)*, each bearing single flowers (unifloral). Peduncles, *p*, *p*, are covered with spreading hairs; the flower-bud, *c*, is unexpanded, and the calyx is hairy; when the flower expands, the two sepals fall off, and the four petals, *f*, remain, enclosing numerous stamens, and a single pistil.

(Fig. 359), which are either sessile (applied closely to the peduncle) as in the catkin (Fig. 349, p. 149), or are placed on stalks called *pedicels* (Fig. 359). When the peduncle proceeds in a straight line from the base to the apex of the whole inflorescence, it is often called the *Rachis*, or axis of inflorescence (Fig. 335, p. 143). A Peduncle arising from a stem, either subterranean or close to the ground, and bearing a solitary flower, as in the Primrose and Snowflake (Fig. 344, p. 147), in Sowbread (Fig. 360), and in some violets, or bearing numerous stalked (pedicellate) flowers, as in the Cowslip (Fig. 144, *b*, p. 60), Narcissus (Fig. 343, p. 147), or numerous sessile flowers, as in the Daisy and Dandelion (Fig. 361), is called a *Scape* or Radical peduncle. In the female flower of Vallisneria (Fig. 362, *b*), the scape

Fig. 359.

Fig. 360.

is spiral, and uncoils, so as to allow the flowers to appear above the surface of the water in which the plant grows.

210. The Peduncle is usually rounded like a branch, but this is by no means its invariable form. Thus, in various species of Butchers-broom (Fig. 363), and Epiphyllum, it is a broad leaf-like (phylloid) expansion. In the Cashew-nut the pedicels supporting single flowers become succulent, and are used as food. When the peduncle bears numerous flowers, in place of being elongated, it sometimes is shortened

Fig. 359. Peduncle or floral axis of Fumitory *(Fumaria officinalis)*, bearing numerous flowers (multifloral). Each flower is attached to the rachis or floral axis by a short stalk called a pedicel, at the base of which a bractlet is produced. The length of this bractlet, as compared with the pedicel of the fruit, is useful in determining the species of Fumitory.

Fig. 360. Cordate leaf, *a*, and unifloral radical peduncles (scapes) of Sowbread *(Cyclamen europæum)*. The flowering stalks, *b*, arise from a short thickened underground stem. The segments of the corolla in the expanded flower, *c*, are reflexed. In the flower-bud, *d*, the æstivation is contortive (imbricate and twisted).

and thickened, especially at its apex, so as to form a broad flattened disk, as in the Thistle (Fig. 364), Dandelion (Fig. 365), a conical projection, as in the Daisy, a concave surface, as in Dorstenia (Fig. 367), or a hollow fleshy pear-like body, as in the Fig (Fig. 366). The peduncle is transformed, in some instances, into tendrils or spines,

Fig. 361.

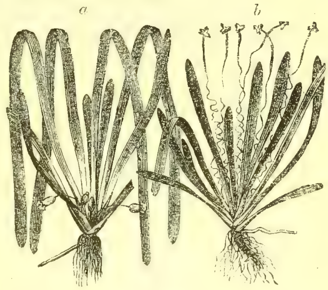


Fig. 362.

Fig. 363.

at other times its apex is hollowed out, so as to form part of the calyx, as in Eschscholtzia, or of the fruit. Flower-stalks, bearing hairs in place of flowers, occur in the Wig-tree (Fig. 368).

Fig. 361. Runcinate leaves, *a*, and radical peduncles or multifloral scapes, *b*, *c*, of Dandelion (*Leontodon Taraxacum*). In the unexpanded head (capitulum) of flowers, the row of bracts forming the involucre are seen. The expanded head, *c*, consists of numerous flowers, sessile on a flattened receptacle.

Fig. 362. Plants of Vallisneria spiralis; the male plant, *a*, with its flowering stalks spreading outwards. The Female plant, *b*, with its flowers supported on spiral peduncles, which, by their uncoiling, enable the flowers to float on the surface of the water in which the plant grows.

Fig. 363. Branch of Butchers-broom (*Ruscus aculeatus*), bearing male flowers, *a*, on the upper surface of leaves, which must be reckoned leafy (phylloid) pedicels. The flowers are sometimes called epiphyllous, from growing on leaves.

211. The arrangement of the flowers on the peduncle or floral

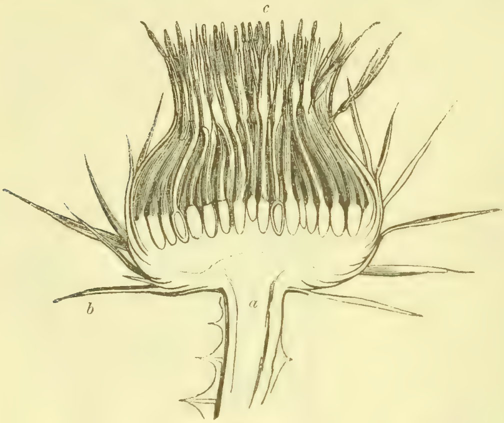


Fig. 364.

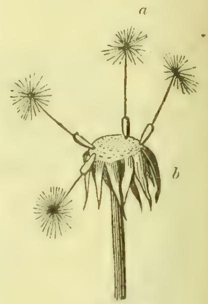


Fig. 365.

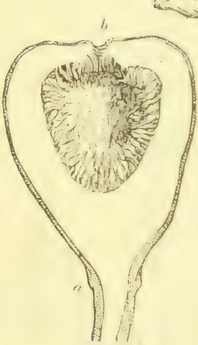


Fig. 366.

Fig. 367.

Fig. 368.

axis, exhibits considerable variety. The simplest kind of inflorescence

Fig. 364. Head (capitulum) of flowers of the Scotch Thistle (*Onopordum Acanthium*), shewing the peduncle, *a*, with the flattened receptacle at the top of it, the involucre, *b*, and the congeries of flowers, *c*.

Fig. 365. Receptacle or flattened apex of the scape of Dandelion (*Leontodon Taraxacum*), in a dry state, throwing off the fruit, *a*, with its stalked hairs (stipitate pappus). The Involucre, *b*, is turned downwards (deflexed), in order to allow the scattering of the fruit, and for the same reason the receptacle becomes slightly convex.

Fig. 366. Peduncle, *a*, of Dorstenia, ending in a multifloral concave receptacle, *b*. The broad receptacle bears numerous flowers.

Fig. 367. Peduncle, *a*, of Fig (*Ficus Carica*), ending in a hollow receptacle, *b*, enclosing numerous male and female flowers.

Fig. 368. Flowering branch of the Wig-tree (*Rhus Cotinus*). Only one of the pedicels bears a flower, the others are abortive, and are covered with hairs.

(floral arrangement) is that in which single flowers are supported on flower-stalks, as is seen in the Gentianella (Fig. 369), and in the common Periwinkle, or in the Pimpernel (Fig. 338, p. 144). In these instances there is a difference in the mode of floral development. In the Gentianella (Fig. 369) the flower, *b*, with two leaves at its base, terminates the general or primary flowering axis, *a*; in the Periwinkle and Pimpernel (Fig. 338) the floral axis elongates, producing leaves, while the flowers, *b*, are borne on secondary axes or stalks, which are axillary and lateral. In the former cases the axis is arrested in its growth, and the inflorescence is *Definite* or *Determinate*;

Fig. 369.

Fig. 370.

in the latter the axis is progressive, and the inflorescence is *Indefinite* or *Indeterminate*. These plants illustrate, in their simplest forms, two marked forms of Inflorescence, which it is necessary to bring more fully under notice.

212. *Indeterminate or Indefinite Inflorescence.*—The simplest form of this inflorescence is that in which the flowers arise singly from the

Fig. 369. Flowering stem of Gentianella (*Gentiana acaulis*). The plant produces a single flower, and it is called unifloral. The termination of the axis, *a*, bears two leaves or bracts, *c*. The flower, *b*, with its calyx and corolla, terminates the axis. This is the simplest form of definite inflorescence. If other axes are produced in such a case, they arise from the axil of the bracts, *c*, and the flowers expand after the central one, *b*, or in what is called a centrifugal manner. Each axis ends in a solitary flower.

Fig. 370. Simple Raceme of Mignonette (*Reseda odorata*). The flowers arise singly from the axil of bractlets, and they expand in a centripetal manner, the lowest opening first. Each flower is supported on a pedicel, by which it is connected with the peduncle or rachis.

axil of ordinary leaves, which, in this instance, serve the purpose of bracts, while the axis goes on elongating and bearing leaves at its apex (Fig. 338, p. 144). In place of a single flower, however, there are frequently several flowers produced on a floral axis in this kind of inflorescence, as is seen in some species of Speedwell (Fig. 340, p. 145), in which there arises from the axil of a bract a cluster of flowers expanding in an ascending series from below upwards. As the flowers in the indefinite inflorescence are produced as buds in the axils of leaves, they are denominated *axillary;* and, when numerous, they follow the ordinary law of leaf development—the lowest (*i. e.*, those

Fig. 371.

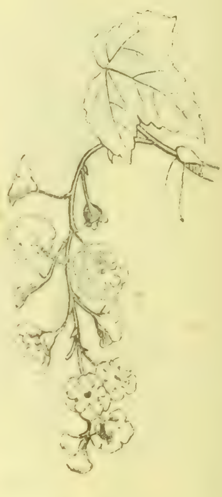


Fig. 372.

next the primary axis), expanding first when the floral axis is elongated (Fig. 338, p. 144, and Fig. 340, p. 145), or the outermost when the axis is depressed or abbreviated (Fig. 318, p. 136, and Fig. 371). The expansion of the flowers, in such cases, is denominated *centripetal* in consequence of proceeding in a progressive manner towards the centre or apex.

Fig. 371. Head (Capitulum) of the Common garden Marygold (*Calendula officinalis*). The flowers have no pedicels, and are arranged in numerous rows on a flattened peduncle (receptacle). The expansion of the flowers is centripetal, *i. e.*, from without inwards.

Fig. 372. Simple Raceme of Currant (*Ribes rubrum*). A multifloral peduncle arises from a bract, and bears pedicellate flowers. The pedicels (partial flower-stalks) are nearly equal in length, and each arises from a bractlet. The flowers nearest the stem of the plant expand first, hence the order is centripetal.

213. Axillary flowers, on elongated and shortened axes, present different forms of inflorescence, according as the flowers are stalked or sessile, the stalks simple or branched, and equal or unequal in length.

Fig. 373.

Fig. 375.

Fig. 374.

When the primary floral axis (peduncle or rachis) lengthens and bears equally stalked (pedicellate) flowers, each originating from a bractlet,

Fig. 373. Simple indefinite corymb of a kind of Cherry (*Cerasus Mahaleb*). A multifloral peduncle, *p*, arises from a bract, and bears pedicellate flowers, the lower pedicels being longer than the upper, so that the flowers form nearly a flat surface above. The lowest flowers expand first, and hence the order is centripetal.

Fig. 374. Inflorescence of a cruciferous plant, a kind of mustard (*Sinapis orientalis*). In the young state the flowers are corymbose, while in the advanced state they become racemose. The fruit-pods (*Siliquæ*) are supported on nearly equal pedicels, while the lowest flowers, in their partially expanded state, have the longest pedicels, and thus form a corymb. The plant shows the transition from a corymb to a raceme. It is said to be the *Charul* of the Bible, translated nettles in the authorised version (Job. xxx. 7; Prov. xxiv. 30, 31; Zeph. ii. 9).

Fig. 375. Simple umbel of the Cherry (*Prunus Cerasus*). The flowers are pedicellate, and arise from a common point, surrounded by bracts, the pedicels being nearly equal. The flowers expand centripetally.

a *raceme* is produced, as in the Hyacinth, Barberry, Currant (Fig. 372), Mignonette (Fig. 370), and Fumitory (Fig. 359, p. 152). In this instance, the lowest flowers, *i. e.*, those next the primary axis, are first expanded, and the others follow in succession from base to apex. When the raceme has the lower flowers supported on longer stalks than the upper, in such a way that all form nearly a level top, as in the Hawthorn, and some species of Cerasus (Fig. 373), a *corymb* is formed. In Cruciferous plants (Fig. 374), the flowers, when first

Fig. 376.

Fig. 377.

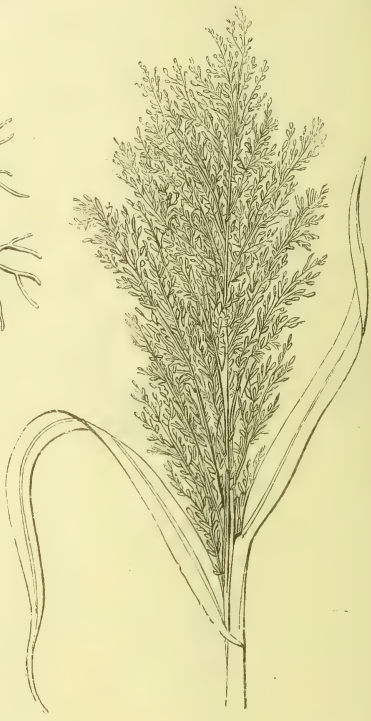


Fig. 378.

produced, frequently appear as a corymb, and when the floral axis elongates, they form a raceme. If the primary axis of a raceme is shortened, so that the floral stalks all proceed from apparently the

Fig. 376. Compound umbel of Common Dill (*Anethum graveolens*), having both primary and secondary umbels, without either involucre or involucel. The petiole of the leaf is large and sheathing, and has been denominated pericladium. The plant is the *Anethon* of the New Testament, translated Anise in Matth. xxiii. 23.

Fig. 377. Compound umbel of the Carrot (*Daucus Carota*), with a general involucre (verticillate bracts), *a*, and partial involucres (involucella), *b*.

Fig. 378. Panicle, or loose branching raceme of a kind of Reed (*Arundo Donax*). The flowers are arranged in small spikelets, which are supported on a branching peduncle. The plant is supposed to be the *Kaneh* of the Bible translated Reed (1 Kings xiv. 15; 2 Kings xviii. 21; Job xl. 21; Is. xix. 6; xxxv. 7; xxxvi. 6; xlii. 3; Ezek. xxix. 6).

same point, forming nearly equal *radii*, as in Crow-garlic, Cowslip,

Fig. 379.

Fig. 381.

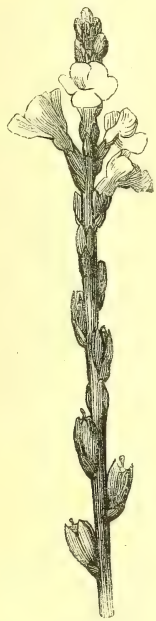


Fig. 382.

Fig. 380.

Auricula, and Cherry (Fig. 375), an *umbel* is produced. In the inde-

Fig. 379. Compound umbel of Fool's-parsley (*Æthusa Cynapium*). The peduncle, *a*, bears a general umbel without an involucre, while the radii bear umbellules, *b*, *b*, with an involucellum composed of reflexed pendulous bracts.

Fig. 380. Panicled Inflorescence of a Rush (*Luzula nivea*), presenting the characters both of a raceme and a corymb.

Fig. 381. Spike of Rib-grass (*Plantago*) consisting of a rachis (general peduncle), bearing sessile flowers, which expand centripetally from below upwards.

Fig. 382. Spike of Vervain (*Verbena*), consisting of sessile flowers arranged alternately on a common floral axis, and with a centripetal order of expansion.

finite umbel, the outermost flowers, *i. e.*, those of the circumference, expand first. The simple Raceme, Corymb, and Umbel, may become compound by the stalks of the flowers branching. Thus, in the Horse-chestnut (Fig. 335, p. 143), there is a compound raceme. In the case

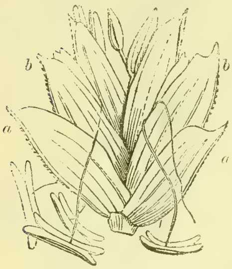


Fig. 383.

Fig. 385.

Fig. 384.

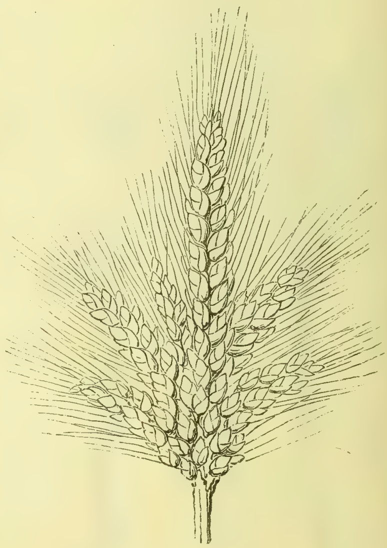


Fig. 386.

of the umbel, the branching takes place by the secondary stalks coming off from a point like radii of a circle, in the same way as the primary

Fig. 383. Spikelet of Wheat (*Triticum*), composed of a number of sessile flowers, *b*, *b*, enclosed within two bracts (glumes), *a*, *a*. The stamens hang by long thread-like filaments, and the anthers are versatile.

Fig. 384. Compound Spike of Wheat (*Triticum*), formed by numerous spikelets (Fig. 383), arranged alternately on a common rachis, which has a zig-zag form.

Fig. 385. Compound Spike of Darnel-grass (*Lolium temulentum*), shewing awned (aristate) spikelets, arranged alternately on a common rachis. The plant is supposed to be the *Zizanion* of the New Testament, and translated *tares* (Matth. xiii. 25, &c.), the *infelix Lolium* of Virg. Georg. i. 154.

Fig. 386. Branching compound Spike of Egyptian Wheat (*Triticum compositum*). Several compound spikes come off from the rachis, so as to form a sort of cluster. The wheat is awned. It appears to be the *Chittah*, or wheat of Scripture, which is mentioned in some places as bearing several ears on one stalk (Gen. xxx. 14; Exod. ix. 32, xxix. 2, xxxiv. 22; Deut. viii. 8; xxxii. 14, &c. &c.)

ones did (Fig. 376). The bractlets at the base of the primary stalks, or, in other words, at the base of the primary umbel (Fig. 377, *a*, and Fig. 347, *a*, p. 148), are arranged in a whorled manner, and form an involucre, and such is also the case with the bractlets at the base of the secondary flower-stalk or secondary umbel (Fig. 377, *b*, and Fig. 347, p. 148). The secondary, or partial umbels, are called *Umbellules*, and the verticillate bractlets receive the name of *Involucel*. In some instances, as in Fool's-parsley (Fig. 379), there is no general involucre, but simply an involucel (Fig. 379, *b b*, p. 159); while, in other cases, as in Fennel, neither involucre nor involucel are developed. Compound umbels are frequent in umbelliferous plants, such as Hemlock, Carrot, and Parsley.

214. In compound inflorescences, there occurs a combination of

Fig. 387.

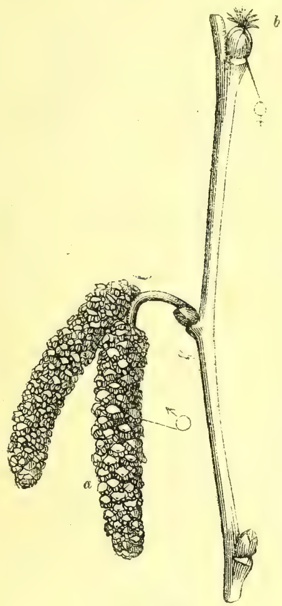


Fig. 388.

Fig. 389.

these forms. Thus, the primary divisions may be racemose, or corymbose, or umbellate, while the secondary are of a different nature. A

Fig. 387. Spadix of Cuckow-pint (*Arum maculatum*), consisting of numerous male flowers, *b*, female, *a*, and abortive flowers, *c*, sessile on a succulent rachis, and enclosed in a spathe, which in the figure has been removed. The rachis ends in a succulent club-shaped mass of cellular tissue, *d*.

Fig. 388. Flowering branch of Hazel (*Corylus Avellana*), bearing male flowers, *a*, and female flowers, *b*. The former are in catkins (amenta), composed of numerous flowers arising from scaly bracts arranged on a common rachis, and all falling off at once; the latter consist of several flowers covered with bracts, sessile on a common rachis, and producing nuts. The tree is said to be amentiferous (catkin-bearing).

Fig. 389. Flowering branch of Birch (*Betula alba*), bearing male and female amenta. The male catkin, *a*, is composed of sessile flowers, with scaly bracts, and such is also the case with the female catkin, *b*. The tree is also amentiferous.

raceme in which the secondary branch assumes the form of a corymb, or a corymb in which the secondary branches are racemose, is called a *Panicle*, a form of inflorescence met with in many grasses (Fig. 378), and in some rushes (Fig. 380). This term, however, is rather vaguely applied, and includes often definite, as well as indefinite, forms of inflorescence. It is usually applied to any loose racemose inflorescence in which the stalks are irregularly elongated and branched. When the panicle is shortened, as regards its secondary branches, and forms a compact cluster resembling a bunch of grapes, as in Lilac and Horse-chestnut (Fig. 335, p. 143), it is called a *Thyrsus.*

Fig. 390.

215. In the instances of inflorescence which we have noticed, the flowers are all supported on stalks either of the same or different lengths. When the flowers are sessile, *i. e.*, without stalks, different forms of the indefinite inflorescence arise. A raceme, with sessile flowers, becomes a *Spike*, as in Plantago (Fig. 381), and Vervain (Fig. 382). In grasses the flowers are arranged in small spikes called Spikelets (locustæ), as seen in Figure 383, and these spikelets are themselves arranged either in a panicled form, as in Oats, or in a spiked form, as in Wheat (Fig. 384), and Darnel grass (Fig. 385). The latter may be called a compound spike, consisting of a series of small spikes sessile on a common rachis. Occasionally, as in Egyptian wheat (Fig. 386), several compound spikes proceed from the top of the stalk or culm. A *Spadix* is a succulent spike, enclosed in a sheathing bract called a Spathe, as in the Cuckow-pint (Fig. 342, p. 146, and Fig. 387), and Æthiopian Calla, where it is simple, and in Palms (Fig. 341, p. 146), where it is branching and compound. A *Catkin*, or *Ament*, is a spike having scaly bracts. It occurs in the Willow (Fig. 348, p. 148), in the Walnut (Fig. 349, p. 149), in the Hazel (Fig. 388, *a*), the Birch (Fig. 389, *a*) the Poplar (Fig. 313, p. 134), and in many trees which are hence called *Amentiferous.* Catkins bearing sterile flowers only (Fig. 388, *a*) generally fall off early, and in one piece. Some restrict the term catkin to such deciduous forms of inflorescence; while others include also the fertile scaly spikes of Hazel (Fig. 388, *b*), of Birch (Fig. 389, *b*), and of Willow (Fig. 390). The catkin is sometimes branching, *i. e.*, produces numerous separate catkins on a common axis, as in the male flowers of the Fir. The *Cone* (Fig. 353, p. 150) of the Pine, Spruce, Fir, and other cone-bearing plants, is a female spike of flowers with hard scales, while the *Strobilus*

Fig. 390. Female spike or catkin of another amentiferous tree, the Willow (*Salix*). The flowers are nearly sessile, and are arranged along a common rachis.

(Fig. 352, p. 149) of the Hop is a similar kind of spike with membranous scales. Some of these modes of inflorescence determine the nature of the fruit, and will be noticed again when describing it.

216. In the Spike, the Spadix, and the Catkin, the floral axis is elongated. Other cases occur in which sessile flowers are produced on a shortened axis. The *Head* (capitulum) is a congeries of sessile flowers, supported on a more or less flattened axis (receptacle), and

Fig. 391.

Fig. 392.

expanding centripetally. In the American Button-bush the heads are globular, in some species of Teazel, elliptical, while in Scabious (Fig. 391), and in composite plants, as Sunflower, Dandelion (Fig. 361, p.

Fig. 391. Head (capitulum) of Scabious (*Scabiosa*) consisting of numerous sessile, or nearly sessile flowers, arranged on a common flattened receptacle, and expanding centripetally, *i. e.*, from the circumference towards the centre. The flowers are surrounded by a series of bracts, which form an involucre.

Fig. 392. Heads (Capitula) of Corn Bluebottle (*Centaurea Cyanus*). One of the heads has the flowers expanded, the other contains the flowers in bud. Each head consists of numerous sessile flowers on a flattened receptacle, surrounded by involucrate bracts, called phyllaries, and expanding centripetally. The separate heads are produced in a centrifugal manner, and form a sort of corymb. This is an instance of mixed inflorescence, in which the general inflorescence is centrifugal, and the partial inflorescence centripetal.

153), Thistle (Fig. 364, p. 154), Centaury (Fig. 392), and Marygold (Fig. 371, p. 156), they are somewhat hemispherical, with a flattened, slightly hollowed, or convex disk. In the latter class of plants, besides the general bracteal envelope (Fig. 346, *i*, p. 148), called the involucre, there are frequently *chaffy* and *setose* bracts at the base of each flower.* In Dorstenia (Fig. 367, p. 154), the receptacle of the flowers varies from a flattened disk to one in which the edges are in-

Fig. 393.

curved and turned upwards. When this incurvation of the receptacle is complete, so as to form a hollow cavity bearing the flowers inside, the inflorescence is like that of the Fig (Fig. 366, p. 154). By this

Fig. 393. Flowering stem of Columbine *(Aquilegia vulgaris)*. The Inflorescence is a corymbose cyme, or a definite corymb. The axes bear solitary flowers, and are developed in a centrifugal manner. The central flower, *a*, was first expanded, terminating the primary axis; then the secondary axis was produced, bearing a solitary flower, *b*; then the tertiary unifloral axis, *c*, and so on. The axis, *a*, has passed into fruit.

* Occasionally the bracts of the Capitulum produce pedicels bearing small capitula. In this way there is a resemblance to the umbel. Dr. Murchison noticed a peculiar umbellate form of inflorescence occurring in the Dandelion, where each stalk arising from a common point bore on its extremity tubular florets. In the Hen-and-Chicken Daisy there is a similar tendency to form umbellate capitula.

mode of formation the flowers at the circumference are turned towards the apex, while the real centre remains next to the stem of the plant.

217. *Determinate or Definite Inflorescence.*—In this inflorescence, the flowers, in place of arising from axillary buds, are considered as represented by terminal buds, beyond which the axis does not extend. The simplest form is that in which a single floral axis is produced, terminated by a solitary flower, as in Gentianella (Fig. 369, p. 155), with two opposite leaves, *c*, at the base of the inflorescence. When such an inflorescence branches, it is by the production of axillary buds, whence arise floral axes, terminated, as the first axis, by solitary flowers.

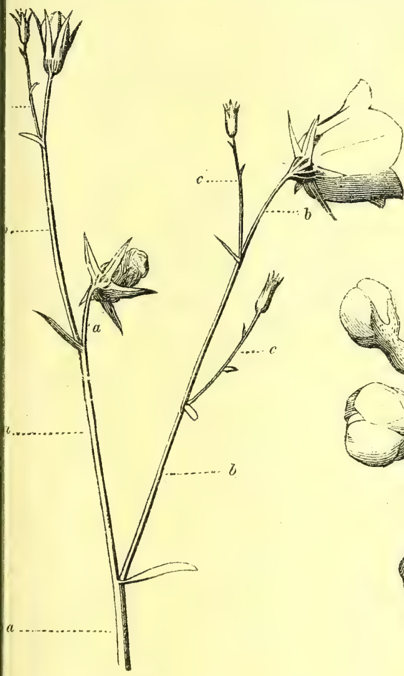


Fig. 394.

Fig. 395.

The axes are thus arrested in their development, and do not grow in an indeterminate manner. This kind of inflorescence is very commonly associated with opposite leaves, but it occurs also in plants with alternate leaves (Fig. 393).

218. If such a plant as Gentianella, with opposite leaves, produces

Fig. 394. Racemose cyme, or definite raceme of Rampion (*Campanula Rapunculus*). The primary axis, *a a a*, ends in a flower which was the first expanded. From bracts on this axis arise secondary axes, *b b b*, each ending in a solitary flower. These axes gave off tertiary axes, *c c c*, also unifloral. The order of expansion centrifugal.

Fig. 395. Definite corymb or corymbose cyme of the Pear tree (*Pyrus communis*). The flower, *a*, is first expanded, and terminates the primary axis. The other axes expand their flowers in succession in a centrifugal manner.

additional flowers, it does so in a descending series, that is to say, the buds produced by each of the opposite leaves on the stem (Fig. 369, *c*, p. 155), and bearing solitary flowers, expand after the flower terminating the primary axis, and successively later as we proceed downwards. Thus, the expansion of the flowers is *centrifugal*, *i.e.*, farther and farther from the central terminal bud of the primary axis, and later as regards time. A racemose or spiked inflorescence of this kind would be at once distinguished by the upper flowers being first expanded, and not the lower, as in the indefinite raceme and spike. Thus, in Figure 393, we have an example of a definite raceme (nearly a corymb), in which the separate floral axes end in solitary flowers, and the upper ones are first expanded. The flower at *a* ends the primary axis, and it has passed into fruit, the flower at *b* succeeded it, then that at *c*, and so on—the expansion of the flowers being the reverse of what is seen in the indefinite raceme or corymb. The flower

Fig. 396.

terminating the primary axis has sometimes a shorter stalk than those arising subsequently, and in such cases there may be a difficulty in distinguishing between the definite and indefinite forms. In Figure 394, the inflorescence of Rampion is given, in which *a a a* is the primary floral axis, ending in a solitary flower, which has passed into fruit, *b b b* are secondary floral axes, arising from bracts below the first flower, and ending in single flowers, which are expanded more or less completely; while *c c c* are tertiary floral axes, ending in flower-buds unexpanded. The order in which the flowers expand determines the nature of the inflorescence. Attention must be paid to the axis terminating in a single flower, the bract which it gives off laterally, and the flower-bud produced between the bract and the axis. In Figure

Fig. 396. Umbellate and racemose cyme of Elder (*Sambucus nigra*). The different unifloral axes seem to arise from one point, and then subdivide. The inflorescence consists of a series of unifloral axes, aggregated together, producing flowers in a centrifugal manner. The mode of floral expansion distinguishes this from the umbellate, corymbose, and racemose forms of Indefinite Inflorescence.

395 is shewn the definite corymb of the pear tree, in which the solitary flower, *a*, ends the primary axis, and is first developed, the other unifloral axes being subsequently formed, and their flowers expanding centrifugally.

219. When the different floral axes in the definite inflorescence come off close to each other, and are much shortened, there is often apparent confusion in the arrangement, and it is only by noticing the development of the flowers in the different clusters that we can pronounce on the nature of the inflorescence. The branched kind of definite inflorescence is seen in the *Cyme*. This is a corymbose inflorescence, more or less branched, forming a cluster of flowers, which is either flattened at the top, or has a rounded contour. It is illustrated in the Elder (Fig. 396), the Hydrangea, and the Laurustinus. It appears like a combination of the umbel and corymb, but is known by its centrifugal floral expansion.

220. The mode in which the cyme is formed may be studied in the common spearwort, and other species of chickweed. In them, as shewn in Figure 397, there is a solitary flower, *a*, which terminates the primary axis, and has two opposite leaves, *b*, at its base. Each of these leaves (bracts) gives origin to flower-buds, which form axes, *c c*, ending in solitary flowers. Each of these secondary axes, in their turn bear opposite bracts, or leaflets capable in the same way of forming tertiary axes, with solitary flowers, and so on until the plant is exhausted, or the axes produced have no leaf-nodes. This division, by pairs of axes, forms a spreading, loose, *dichotomous* (dividing by pairs) cyme. If three whorled leaves develope axes the cyme becomes *trichotomous* (dividing by threes). Sometimes the two bracts on the axis do not produce flower-buds, and then the primary axis, with its single flower, is alone present, with two empty bracts on the stalk, as seen in the Hearts-ease (Fig. 398, *b*) which produces a unifloral cyme. At other times the primary axis produces a solitary flower, and only one of the bracts developes a flower-bud, as in the common Bind-weed (Fig. 399), in which we meet with a bifloral cyme, *a*, and also unifloral cymes, as at *b b*.

221. If the flower-buds on one side of a dichotomous cyme are the only ones developed, it becomes *unilateral*, and often turns round in a peculiar way, so as to resemble a snail, or the tail of a scorpion, and hence it is denominated *helicoid* or *scorpioid*. The terms gyrate and circinate are also sometimes applied. The same thing occurs also in alternate-leaved plants, where each leaf or bract produces one flower, and a flower-bud which elongates into an axis between the first flower and the bract. In such cases the flowers seem to be placed opposite the leaves, and when the leaves disappear, or are abortive, as in many of the Borage tribe (Fig. 400), it is difficult to determine whether the inflorescence is a one-sided (unilateral) raceme, or a series of single-flowered axes, produced in a racemose manner. The appearance of the helicoid cyme is represented in Figure 400, in the case of the

Forget-me-not; on the axis a leaf, *c*, gives origin to a flower-stalk, ending in a solitary flower, *a;* there are no bracts developed on this

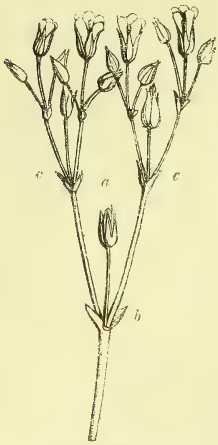


Fig. 397.

Fig. 398.

Fig. 399.

primary floral axis, but two racemose cymes, *b b*, are given off, each

Fig. 397. Dichotomous cyme of Mouse-ear Chickweed (*Cerastium*). The primary floral axis ends in a solitary flower, *a*, which expands first. The axis bears two bracts, *b*, each of which gives origin to secondary axes, each ending in a solitary flower, and bearing two bracts, *c c*, which in their turn give rise to unifloral tertiary bract-bearing axes, and so on. When three bracts are produced, and three axes, the cyme becomes Trichotomous. When the axes are much shortened, and the flowers are brought nearer to each other, the formation of the cyme is rendered obscure.

Fig. 398. Unifloral cyme of the Pansy (*Viola tricolor*). The primary axis bears a single flower, and below it are two bracts, *b*, indicating the points where secondary axes would appear if present. The bracts are empty. *f*, the leaf; *s s*, stipules.

Fig. 399. Bifloral, *a*, and unifloral, *b b b*, cymes of Convolvulus. The axis, *a*, arising from a leaf, *c*, ends in a solitary flower, and produces two bracts, one of which gives origin to a secondary floral axis. The axes, *b b b*, produce solitary flowers with empty bracts.

of which curls up in a circinate manner. These cymes are formed by a series of single-flowered axes, which are produced in a secund manner, *i.e.*, only on one side. The theoretical formation of this inflorescence is given in Figure 401, where the primary floral axis, 1, ends in a solitary flower, and so do the other axes from 2 to 10. The small dotted lines indicate the points where floral leaves (bracts) occur. The expansion of the flowers is centrifugal. The flower of axis 1 expands first; this axis gives origin to a flower-bud forming axis 2; in its turn axis 2 expands its solitary flower, and gives rise to axis 3,

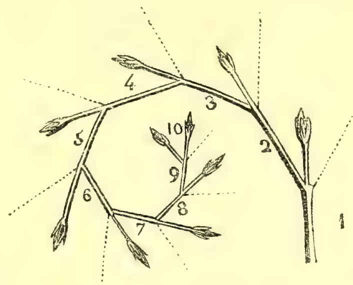


Fig. 401.

Fig. 400.

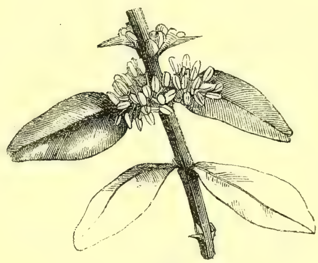


Fig. 402.

and so on. Thus, the inflorescence is composed of a series of unifloral axes produced from each other, and not alternating to right and left, but always developed on one side, forming a broken line, which has a

Fig. 400. Helicoid cymes of Forget-me-not *(Myosotis palustris)*. The floral axis arises from a leaf, *c*, and ends in a solitary flower, *a*. From this axis proceed in a dichotomous manner helicoid or scorpioid cymes, *b b*. Each flower is the termination of a separate axis, developed on one side only (unilateral or secund), and the whole inflorescence is curved like the shell of a snail, or the tail of a scorpion. The inflorescence is ebracteated, *i.e.*, the bracts are suppressed.

Fig. 401. Diagram to illustrate the formation of a scorpioid cyme. The first axis, 1, ends in a solitary flower. On one side of this axis a node is produced, which gives rise to the secondary axis, 2, bearing a solitary flower, which is developed after 1. This axis in its turn produces a floral node, giving rise to a tertiary unifloral axis, 3, and so on, up to 10. At the same time the inflorescence becomes curved, as the development of the axes takes place on one side. The non-developed nodes are marked by dotted lines opposite the points whence the floral axes arise.

Fig. 402. Clustered flowers of the Box (*Buxus sempervirens*). Each cluster is produced in the axil of one of the opposite entire leaves. The flowers expand centrifugally and form a glomerulus.

tendency to return upon itself. In the Diagram ten unifloral axes are shewn, each bearing a solitary flower. When the bracts are abortive, as in the Borage tribe, the nature of the inflorescence is not detected at first sight. The formation of the different axes between the previously expanded flower and the bract, indicates the nature of the inflorescence. When the internodes of such a floral axis are shortened, and the bracts disappear, some anomalous inflorescences are produced, as in Solanaceæ. The appearance of a peduncle opposite a leaf leads often to a correct conclusion in regard to the morphology of the inflorescence ; in the same way as has been already noticed, in the case

Fig. 403.

Fig. 404.

of the tendrils of the Vine (¶ 95), which are leaf-buds producing separate axes, in a centrifugal manner.

222. In some kinds of cymose inflorescence the flowers are sessile on an elongated axis, forming a cymose spike ; in other instances they are nearly sessile, and form a rounded head or short spike, called a *Glomerulus*, as seen in species of nettle (Fig. 403), and in the

Fig. 403. Flowering stalk of Nettle (*Urtica urens*), with clustered definite inflorescence, *a a*, called a glomerulus. The leaves are serrated, and covered with stinging hairs.

Fig. 404. Flowering stalk of Clove-pink (*Dianthus Caryophyllus*). The flowers form a fascicle The inflorescence is definite and centrifugal. The plant is the origin of all the varieties of Carnation.

Box (Fig. 402). Sometimes stalked flowers arise from the same part of the axis, in the form of a cluster, called a *Fascicle*, as in the Mallow (Fig. 405), and in species of Pink (Fig. 404). In the case of Labiate plants, as Mint (Fig. 407), and Dead-nettle (Fig. 339, p. 145), the flowers appear to be in whorls, but in reality they arise in two clusters or fascicles, called *Verticillasters*, which are cymes bearing a few nearly sessile flowers, expanding centrifugally. Each cluster is produced from one of the opposite leaves. Truly whorled flowers are seen in the Common Mare's tail (Hippuris vulgaris), in which each leaf of the whorl produces a single flower.

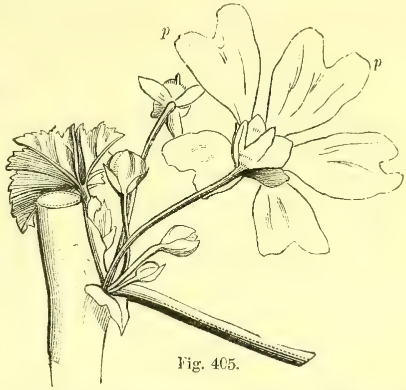


Fig. 405.

Fig. 406.

Fig. 407.

Fig. 405. Fascicle of Mallow (*Malva sylvestris*). The inflorescence is definite, with centrifugal expansion. The flowers come off from the same point, and are supported on stalks. The stem is prolonged beyond the flowers, so that the general development is indefinite, while the clusters of flowers are definite. The petals of the flower, *p*, are obcordate, and the calyx is double.

Fig. 406. Flowering stalk of a kind of Groundsel (*Senecio*). The flowers are in heads (capitula), and open from the circumference inwards in an indefinite centripetal manner. The heads of flowers, on the other hand, taken collectively, expand centrifugally—the central one, *a*, first. Each head of flowers terminates a separate axis. They form together a definite corymb. The inflorescence is called mixed.

Fig. 407. Flowering stalk of Mint (*Mentha sylvestris*). The flowers, taken collectively, have a spiked appearance. The separate verticillasters (clusters) are produced in the axils of small leaves, and the flowers forming them are developed centrifugally; while the clusters, taken as a whole, are developed centripetally from below upwards. It is a mixed inflorescence, and exhibits what has been called a Definite Spike. The plant is probably the *Heduosmon* of the Greeks, mentioned in Matth. xxiii. 23, and in Luke xi. 42.

223. *Mixed Inflorescence.*—There are certain kinds of inflorescence in which there is a combination of the definite and indefinite forms. These have been called *Mixed.* They are by no means uncommon in the Vegetable Kingdom, and they require to be studied carefully. In Composite plants, the branches bearing the heads of flowers (capitula) are often developed centrifugally, while in the individual heads the expansion is centripetal. The general inflorescence, in such a case, may be said to be definite, while the partial inflorescence is indefinite. Thus, in Figure 406, the central head of flowers is expanded, while the others are only partially so; the inflorescence is mixed, and the whole puts on the aspect of a corymbose cyme, with the flowers in each head centripetal. Such is also the case in Figure 392, page 163. In Labiate plants, the general inflorescence is centripetal, while the verticillasters are centrifugal (Fig. 407).

224. Recapitulation of the different kinds of Inflorescence or Anthotaxis:—

1. Indefinite or Indeterminate Inflorescence, in which the floral axis is prolonged beyond the flowers, which are produced, either singly or in clusters, in the axil of leaves, the order of expansion being centripetal, *i.e.*, from the circumference towards the centre of the inflorescence, or from the base towards the apex.
2. The Indefinite Inflorescence may have unifloral or multifloral axillary peduncles.
3. In the Unifloral form the axis usually bears the single flowers in the axil of ordinary leaves. This is the simplest kind of Indefinite Inflorescence.
4. In the Multifloral form, the general peduncle, arising from an ordinary leaf or a modified leaf (bract) bears smaller leaves (bractlets), which produce flowers either sessile or pedicellate.
5. Multifloral peduncles, with sessile flowers, give origin to the various forms of spiked and clustered Indefinite Inflorescence, such as the Spike, Spikelet, Amentum, Spadix, Cone, and Capitulum.
6. Multifloral peduncles, with pedicellate flowers, give origin to the various forms of racemose, corymbose, panicled and umbellate Indefinite Inflorescence, such as the simple and compound Raceme, Corymb, and Umbel.
7. Definite or Determinate Inflorescence is that in which each floral axis ends in a solitary flower, and the order of expansion is centrifugal. The Cyme is considered as characteristic of this Inflorescence, and hence it is called Cymose.
8. The Definite Inflorescence may be either unifloral, *i.e.*, having a single primary axis ending in a flower, or it may be multifloral, having primary, secondary, and tertiary axes, &c., each ending in single flowers, but all combined, more or less so as to form a Compound Inflorescence.
9. The simplest form is the unifloral, in which the plant produces a single terminal flower, and no more.
10. The Multifloral forms are various, and their appearance depends on the lengths of the axes, and the mode in which they arise from each other.
11. When the different axes are elongated we meet with racemose, corymbose, and umbellate Cymes.
12. When the different axes are shortened, clustered kinds of inflorescence are produced, such as the Verticillaster, Fascicle, and Glomerulus.
13. Mixed Inflorescences combine the characters of the Indefinite and Definite; the separate clusters of Inflorescence exhibiting the character of the one, while the whole Inflorescence of the plant presents that of the other.
14. In all cases the Centripetal or Centrifugal expansion of the flowers, or of the clusters of flowers, indicates the nature of the Inflorescence.*

* For a complete view of the different kinds of inflorescence, see Bravais, Essai sur la disposition symetrique des Inflorescences. Ann. des Sciences Naturelles, 2d Series, vii. 193, 291; viii. 11.

II. THE FLOWER AND ITS DIFFERENT PARTS.

1. SYMMETRY AND MORPHOLOGY OF THE FLOWER.

225. The term Flower, in botanical language, is not confined to the mere showy parts in which the gay and brilliant hues reside, but embraces all the organs, however inconspicuous, which are concerned in the production of seed. These organs, or parts of the flower, must all be considered as modifications, or, as it may be more properly expressed, *analogues* of leaves. In their structure and arrangement they are similar to the foliar organs, and they follow the same laws of development. When a student, therefore, has acquired a knowledge of the anatomy and arrangement of leaves, he is prepared to enter upon the consideration of the floral organs.

226. When the flower is complete it consists of four whorls (verticils), placed alternately within each other. The two internal are the

Fig. 408.

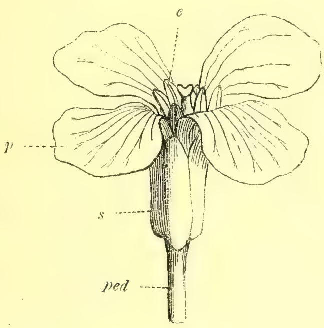


Fig. 409.

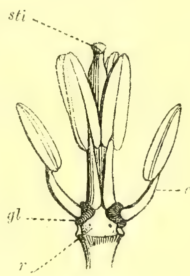


Fig. 410.

Stamens and *Pistils*, which are the essential organs of reproduction, and the two external are the *Calyx* and *Corolla*, constituting the floral envelopes, or protective coverings. In Figure 408, an ideal section of a complete flower is given, each whorl consisting of five parts, which are arranged alternately. In Figures 409 and 410 the parts of the flower are represented; the calycine whorl (calyx), *s*, the corolline

Fig. 408. Diagram of a completely symmetrical flower, consisting of four whorls, each consisting of five parts. The outer row is the calyx formed of five sepals; the second is the corolla of five petals, alternating with the sepals; the third is the andrœcium, consisting of five stamens, alternating with the petals; the central whorl is the gynœcium, consisting of five carpels, alternating with the stamens.

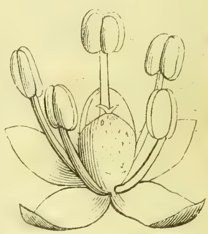
Fig. 409. Flower of Wallflower (*Cheiranthus Cheiri*). The stalk of the flower is called the peduncle, *ped*; the calyx, *s*, consists of four sepals; the corolla, *p*, is formed of four petals, arranged crosswise; the stamens, *e*, constitute the andrœcium or staminal whorl, and in the centre is the pistil.

Fig. 410. The Essential organs of reproduction of Wallflower. The stamens, *e*, are tetradynamous, *i.e.*, four long and two short, with glands, *gl*, at their base, and inserted into the receptacle or torus, *r*; the pistil is in the centre, and the summit of it, or the stigma, is marked, *sti*.

whorl (corolla), *p*, the staminal whorl (stamens), *e*, and the pistilline whorl (pistil), *sti*, being all inserted into a common receptacle, *r*, which may be considered as the termination of the peduncle, *ped*, or flower-stalk.

227. The Calyx is the outer covering (Fig. 409, *s*), formed of whorled leaves, called *sepals*, which are generally of a greenish colour. The Corolla is the next covering, composed of whorled leaves, called *petals* (Fig. 409, *p*), often showy, arranged alternately with the sepals (Fig. 408). The calyx and the corolla are sometimes included under the common name of *Perianth* or *Perigone*, especially in cases where both these coverings are similar in appearance, as in the Tulip,

Fig. 413.



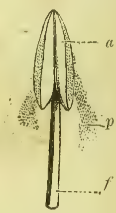


Fig. 411. Fig. 412. Fig. 414.

the Crocus (Fig. 160, p. 68), and the Lily (Figs. 411 and 413). A flower with a single perianth (Fig. 412) has a calyx only, while

Fig. 411. The flowers of the scarlet Martagon Lily *(Lilium chalcedonicum)*. The three sepals and three petals are similar in colour, and collectively constitute the perianth or perigone. The stamens are six in number, in two rows, and the pistil is formed of three carpels. It is a Trimerous symmetrical flower. In the bud the two divisions of the perigone are seen. The plant appears to be the *Krinon* of the New Testament, mentioned in Matth. vi. 28, and in Luke xii. 27.

Fig. 412. Flower of Goosefoot (*Chenopodium*), consisting of a single perianth (calyx) of five parts, enclosing five stamens, which are opposite the divisions of the perianth, owing to the absence of the petals. The corolla being suppressed, the flower is apetalous, and as there is only one floral envelope it is called Monochlamydeous. In the centre of the flower is the pistil, with a large ovary containing young seeds.

Fig. 413. Flower of White Lily *(Lilium album)*, consisting of a six-leaved perianth, the parts of which are arranged in two alternate rows of three. The outer division of the perianth is in reality the calyx, with its three sepals, and the inner is the corolla, with three petals; but as they are similar in colour they are included in the term perianth. Within the floral envelopes are placed six stamens, in two rows of three each, and in the centre is the tricarpellary pistil.

Fig. 414. Stamen, consisting of a filament (stalk), *f*, and an anther, *a*, containing powdery matter, *p*, denominated pollen, which is discharged through slits in the two lobes of the anther.

one with a double perianth (Fig. 413) may be considered as having both calyx and corolla.*

228. The Stamens (Fig. 410, *e*) are placed within the petals, with which they alternate (Fig. 408). Each stamen consists of a peculiar folded leaf, called the *anther* (Fig. 414, *a*), either sessile (unstalked) or supported on a stalk, denominated a *filament* (Fig. 414, *f*), and containing powdery matter called *pollen* (Fig. 414, *p*), which is discharged through slits or holes. The whole staminal whorl, taken collectively, is styled the *Andrœcium.*

229. The Pistil is the central organ (Fig. 415), below and around which the other floral whorls are arranged. It consists of one or more folded leaves, called *carpels*, either separate (Fig. 416), or combined (Fig. 415), and collectively forming the pistilline whorl, which

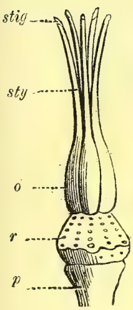


Fig. 416.

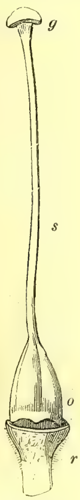


Fig. 415.

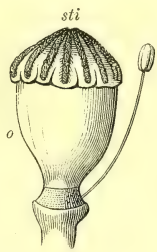


Fig. 417.

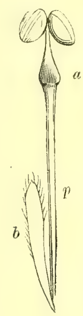


Fig. 418.

is denominated the *Gynœcium.* The parts distinguished in the pistil are the *ovary* (Fig. 415, *o*), which is the lower portion enclosing the

Fig. 415. The pistil of Tobacco *(Nicotiana Tabacum)*, consisting of the ovary, *o*, containing ovules, the style, *s*, and the capitate stigma, *g*. The pistil is placed on the receptacle, *r*, at the extremity of the peduncle.

Fig. 416. The Gynœcium (Pistil) of Columbine (*Aquilegia vulgaris*), situated on the receptacle, *r*, which occupies the summit of the peduncle, *p*. The pistil consists of five carpels, each of which has an ovary, *o*, containing ovules, a style, *sty*, and a stigma, *stig*.

Fig. 417. Pistil of Poppy (*Papaver*), consisting of several carpels united. The united ovaries, *o*, are surmounted by the stigmas, *sti*, which are sessile, or, in other words, are not supported on a style. A single stamen is left to shew its insertion on the receptacle below the pistil (hypogynous).

Fig. 418. Male flower of Spurge *(Euphorbia)*, consisting of a single stamen, *a*, without any envelope. The flower is hence called Achlamydeous. The peduncle, *p*, has a bract, *b*, at the base, and is united to the flower by a joint at *a*. This articulation indicates the nature of the flower. In some of the Euphorbias floral envelopes are produced at the joint. The solitary stamen constitutes the entire male (staminiferous) flower.

* Some restrict the term perianth to cases where the envelope surrounds a staminiferous flower, while perigone is applied to the envelope of a flower having both stamens and pistil, or pistil only.

ovules destined to become seeds, the *stigma* (Fig. 415, *g*), a portion of loose cellular tissue, uncovered by epidermis, which is either sessile on the apex of the ovary, as in the Poppy (Fig. 417, *sti*), or is separated from it by a prolonged portion called the *style* (Fig. 415, *s*). The essential organs must be present, in order that seed may be produced, but the floral envelopes are often deficient. When both calyx and corolla are present (Fig. 409), the flower is *Dichlamydeous*, when the corolla is awanting (Fig. 412), the flower is *Monochlamydeous*, and when both are wanting (Fig. 418), it is *Achlamydeous*.

230. All the organs of the flower are attached to the extremity of

Fig 419.

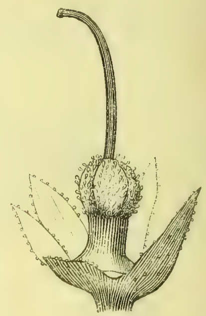


Fig. 421

Fig. 420.

the flower-stalk, and the part on which they are situated has received the names of *Thalamus*, *Torus*, and *Receptacle* (Figs. 410, *r*, and 416, *r*). The different organs are verticillate leaves, produced at nodes which are placed close to each other, without the intervention of marked internodes. Each organ forms one or more whorls, and the parts of each whorl are placed alternately in relation to those of the

Fig. 419. The Caper plant *(Capparis spinosa)*, shewing an expanded flower, and several flower-buds, which constitute the capers of commerce. In this plant the pistil represented in the figure on the left, is supported on a stalk or Gynophore, which is an elongation of the receptacle. There are numerous spines on the plant. These are either abortive leaves or abortive flower-stalks. This plant or another species of Caper (*Capparis ægyptiaca*), is supposed to be the Hyssop of Scripture —the *Esobh* of the Old Testament, and the *Hyssopos* of the New Testament. (Exod. xii. 22; Lev. xiv. 4, 6, 52; Numb. xix. 6, 18; 1 Kings iv. 33; Psalm li. 7; John xix. 29; and Heb. ix. 19).

Fig. 420. The pistil of the Caper-plant, with the stalk or gynophore which supports it.

Fig. 421. Calyx and pistil of Fraxinella *(Dictamnus Fraxinella)*. The pistil consists of several carpels, which are elevated on a stalk prolonged from the receptacle. The stalk is called Gynophore or Thecaphore. The long narrow prolongation at the upper part is the style, terminating in a stigma.

whorls next it. In certain instances the internodes are lengthened, and thus the different whorls are separated from each other, just as in verticillate leaves (Fig. 217, p. 101). Thus, in some plants of the Caper tribe, there is an enlarged, rounded, disk-like receptacle (anthophore), bearing the petals, from the centre of which arises a stalk or internode (androphore) bearing the stamens, and finally, another lengthened internode (gynophore), bearing the pistil. In this instance the separate

Fig. 422.

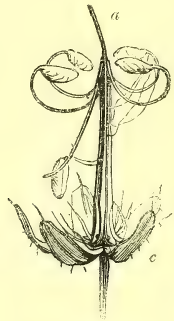


Fig. 423.

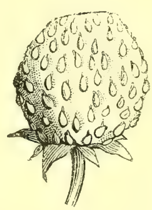


Fig. 424.

nodes, with their whorled leaves, and the interposed internodes, are easily seen. Occasionally, while the internodes connected with the calycine, corolline, and staminal whorls are shortened, that below the pistilline

Fig. 422. Branch of a species of Cranesbill (*Geranium robertianum*), shewing at *a a* the beak-like process projecting beyond the flower, to which the carpels are attached.

Fig. 423. The calyx and beak-like process of Geranium, with the parts of the pistil (the carpels) curled upwards, so as to scatter the seed; *a*, the extremity of the rostrum or beak, whence the name crane's-bill is derived; *b*, the carpels curled up by means of the styles which are attached to the beak; *c*, the calyx.

Fig. 424. Fruit of the Strawberry (*Fragaria vesca*), consisting of an enlarged succulent prolongation of the receptacle, bearing on its surface numerous carpels, which are often erroneously called seeds. The calyx is seen at the lower part.

whorl is elongated. In such cases the pistil is supported on a stalk which proceeds from the centre of the receptacle. In the Caper-plant (Fig. 419), a stalked pistil occurs, which is represented in Figure 420. This is also the case in the Passion-flower, and in some of the Chickweed order, and in Fraxinella (Fig. 421). Such pistils are called *stipitate.*

231. In the Geranium, the part of the receptacle bearing the pistil is prolonged in the form of a long beak-like (rostrate) process, to which the styles are attached (Fig 422, *a*). When the pistil of the Geranium comes to maturity its parts separate from the beak,

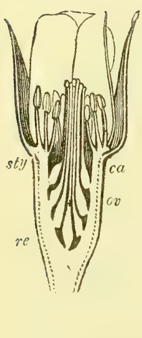


Fig. 425.

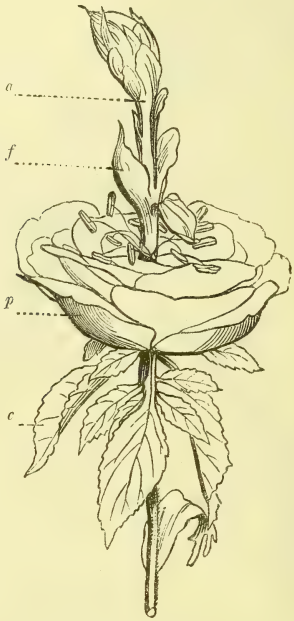


Fig. 426.

Fig. 427.

a, in the manner represented in Figure 423, *b*. In the Strawberry (Fig. 424) the receptacle, after giving origin to the calyx, corolla, and stamens, becomes enlarged and succulent, bearing the parts of the pistil on its surface, and constituting what is commonly called the fruit.

Fig. 425. The fruit of the Rose cut vertically. The receptacle, *re*, lines the interior of the calyx, *ca*, and the carpels with their ovaries, *ov*, and styles, *sty*, are attached to it. The stamens and petals are seen at the upper part, attached to the calyx.

Fig. 426. Monstrous flower of the Rose. The calyx, *c*, consists of sepals like the ordinary leaves; the corolla consists of numerous rows of petals, *p*; the stamens are partially changed into petals; the axis, *a*, is prolonged beyond the flower, bearing leaves, *f*, in place of carpels, and ending in an abortive flower-bud.

Fig. 427. The same monstrous rose, with the sepals and petals removed. The stamens are attached to the receptacle, *r*, which is prolonged in the form of a stalk bearing leaves, *f*, in place of carpels, and ending in a bud which contains abortive stamens, *s*, and undeveloped petals, *p*.

The sacred Bean of India and of the Nile (Nelumbium), has a large top-shaped (turbinate) receptacle enclosing the pistils. In the fruit of the Rose the portion of the receptacle (Fig. 425, *re*), bearing the parts of the pistilline whorl, *ov*, is adherent to the inner surface of the calyx, *ca*.

232. In some monstrous specimens of Avens and Rose there is occasionally an unusual development of the central part of the receptacle, so that the pistilline leaves become arranged alternately on an axis which ends in an abortive flower-bud. In Figures 426 and 427 representations are given of a Rose, in which the axis, *a*, is prolonged beyond the floral envelopes and stamens, *c p*, and bears the parts of the pistil in the form of alternate leaves, *f*, while at its extremity it produces a barren flower-bud, with undeveloped stamens, *s*, and abortive petals, *p*.

233. The leaves and the different parts of the flower are considered by botanists as homologous. In other words, they are constructed on the same plan, and the forms which they assume depend on the nature of the functions which they are required to perform. Leaves being concerned in nutrition and in the assimilation of food, assume an arrangement and colour fitted for these purposes, and have all their parts developed in conformity with the functions allotted to them. The parts of the flower, on the other hand, are concerned in the function of reproduction, and in their structure and development are fitted for the office which they have to perform. The parts of the flower originate in the same way as the leaves, in the form of simple cellular projections from the axis. The appearances which they afterwards present depend on organogenic (organ-producing) laws of development—the arrangement of the cells and vessels, and their contents being modified in each special organ.

234. The leaf is considered as the *type* of all. This idea was started by Linnæus, and was afterwards more fully brought forward by Goethe.* In speaking of the parts of the flower as metamorphosed or modified leaves, it must not be supposed that we mean that these parts have, at any period of their existence, been true leaves. All that is implied in the statement is, that both are formed on the same general plan, that both are arranged upon the same principle, and that one law pervades their morphology. The cell from which the leaf is formed is no doubt very different as regards the organogenic law impressed upon it from the cell which gives rise to a sepal, a petal, a stamen, or a carpel. Nevertheless, when we examine the parts scientifically, we perceive certain homologies in form and structure belonging to the one set of organs which are represented in the other. This morphological view of the organs of the flower associates

* Linnæus, Prolepsis plantarum, Upsal, 1760; Amœnitat, Acad. vi.; Philosophia botanica. Wolf, Theoria generationis, Berlin, 1759. Goethe, Versuch die Metamorphose der Pflanzen zu erklären, Gotha, 1790. English Translation of Goethe's work, Pennsylv. 1830; also French Translation by Fred. de Gingins Lassaraz, Geneve, 1829. Linnæa vii. 1832. De Candolle Theorie elementaire de Botanique. Auguste de Saint Hilaire, Morphologie Vegetale; and Comptes rendus de l'Acad. des Sciences, 20th August 1838.

them with the leaves in a very interesting manner, and enables us to give a philosophical exposition of the harmonies subsisting between them.

235. In passing from leaves to flowers, there are certain intermediate organs called bracts (Fig. 338, *a*, p. 144, and Fig. 340, *a*, p. 145), which are merely altered or modified leaves, producing flower-buds at the part where they emerge from the stem. From these we proceed to the flower-stalks, which are branches bearing flower-buds in place of leaf-buds. The outer whorl of the flower (Fig. 426, *c*), has generally more or less of the appearance and colour of leaves, and, in many instances, the leaflets produced on the flower-stalk pass by insensible gradations into sepals (Fig. 369, p. 155). Between sepals and petals there are transition forms, as seen in the White Water Lily, the Magnolia, and many plants where the colour of both is similar. The petals, in their turn, sometimes become narrowed and altered, so as to pass into stamens, as in the White Water Lily, where it is scarcely possible to say where the different whorls end. It is very rare to find the stamens passing into the pistil. In the case of monstrosities, however, produced by cultivation, the pistil undergoes such changes as to prove that it is formed on the same type as the rest. Occasionally all the parts of a flower, as in some monstrous specimens of Dutch Clover, are converted into leaves.

236. When sepals are changed into petals, petals into stamens, or the latter into carpels, the alterations are said to be in the ascending series, and it is called a case of ascending or progressive metamorphosis. By cultivation, and other causes, this series of phenomena is sometimes reversed. Thus, in the double cherry, the pistil is frequently altered, so as to appear in the form of one or more leaves (Fig. 428, *a* and *b*); in double flowers the stamens are changed more or less completely into petals. In Figure 429 is exhibited the series of changes through which a stamen of the Rose passes, from the normal state, 6, until the complete petal, 2, is formed, and this, in its turn, becomes altered, as seen in 1, so as to resemble a coloured sepal, with a prominent and projecting midrib. In some cultivated flowers the petals assume a green colour, so as to resemble the calyx, which, in its turn, often appears like true leaves (Fig. 426, *c*). This is called retrograde metamorphosis.

237. In certain cases the floral axis, in place of bearing flowers, produces whorls of leaves. The alteration in such instances is either complete, or there is a partial change of the organs, some of them remaining unaltered. It sometimes happens that, from the centre of the flower, a leaf-bearing axis is prolonged at the expense of the pistil (Figs. 426 and 427, p. 178). Occasionally, after the fruit is formed, the axis begins to lengthen and bear leaves, as seen in the pear, represented in Figure 430. In the centre of the flower, or from the bases of the petals, additional flowers arise in certain instances, in the same way as buds come off from the axil of leaves. All these cases prove the general law of development in leaves and flowers to be in reality

the same, and they point out the means of explaining many of the anomalous appearances presented by the flower.

238. The parts of the flower being thus considered as modified leaves, we naturally look for a similar mode of arrangement. As leaves are alternate, opposite, and verticillate, we may expect the parts of the flower to be arranged in the same manner. We might conceive a flower, as in the ideal representation in Figure 431, to be formed of a sepal, *c*, a petal, *p*, a stamen, *s*, and a pistil, *f*; each of the parts alternating with that next to it, and separated by an internode, and all arising from a single bract, *b*. In plants such as Hippuris, with

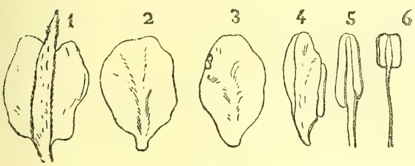


Fig. 429.

Fig. 428.

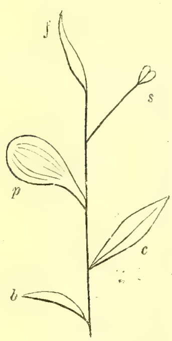


Fig. 431.

Fig. 430.

one stamen, and one pistil, and an abortive calyx, such may be reckoned the tendency, although, from non-development of certain parts, the

Fig. 428. The carpel of the double flowering Cherry. In this plant the fruit is abortive, and in its place one or more leaves are produced. The carpellary leaf is either expanded, *a*, or folded, *b*. This shows that the fruit of the Cherry is formed on the same type as the leaf.

Fig. 429. Transformations in the stamen of the Rose. The complete stamen, 6, is altered gradually, passing through the states represented at 5, 4, and 3, until it becomes a complete petal, 2, and the petal at 1 begins to assume the appearance of a sepal, with a strongly-marked midrib prolonged beyond the apex.

Fig. 430. The axis prolonged beyond the fruit in the Pear-tree, and bearing a series of leaves. In general the production of fruit arrests the axis.

Fig. 431. An ideal representation of a flower arising from a bract, *b*, and formed by a single sepal, *c*, a single petal, *p*, a single stamen, *s*, and a single carpel, *f*; the parts being alternate, and separated by internodes.

flower becomes incomplete. We generally find that the parts of the flower are arranged in twos, threes, fours, or fives.

239. When the parts of a flower appear in pairs, they may be considered as formed of opposite decussate leaves. In Figure 432, there is an ideal representation of such a flower, with its bracts, *b*, its sepals, *c*, petals, *p*, stamens, *s*, and carpels, *f*, separated by marked internodes. If the internodes in Figures 431 and 432 were taken away, or very much shortened, we would then have the arrangement usually seen in the flower. These diagrams also illustrate what occurs in the case of some plants, where (as already stated, ¶ 230), the different floral whorls are distant from each other. When the parts of a flower are arranged in threes, fours, or fives, they may, if placed in a circle at the same level, be regarded as verticils, or, if at different levels, as following a spiral arrangement.*

240. A flower is said to be *symmetrical* when each of its whorls consists of an equal number of parts, or when the parts of any one

Fig. 432.

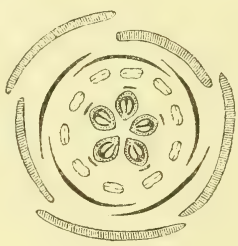


Fig. 433.

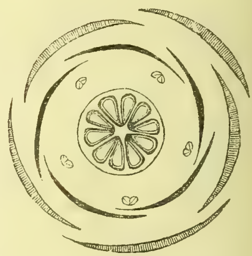


Fig. 434.

whorl are multiples of that preceding it. Thus, a symmetrical flower may have five sepals, five petals, five stamens, and five carpels, or the number of any of these parts may be ten, twenty, or some multiple of five. In Figure 408, page 173, there is a diagram of a symmetrical flower, with five parts in each whorl, alternating with each other. In Figure 433, there is a section of a symmetrical flower of Stone-crop, with five sepals, five alternating petals, ten stamens in two rows, and

Fig. 432. An ideal representation of a dimerous flower, formed of two parts in each whorl. The bracts, *b*, the sepals, *c*, petals, *p*, stamens, *s*, and carpels, *f*. The parts of the flower are decussate, and thus follow a law of alternation. Each whorl is separated by an internode. If the internodes were removed the whorls would be closely applied to each other, as in ordinary flowers.

Fig. 433. Diagramatic section of a symmetrical pentamerous flower of Stone-crop (*Sedum*), consisting of five sepals externally, five petals alternating with the sepals, ten stamens in two rows, and five carpels containing seeds. The dark lines on the outside of the carpels are glands.

Fig. 434. Diagram of the flower of Flax (*Linum*), consisting of five sepals, five petals, five stamens, and five carpels each of which is partially divided into two. It is pentamerous, complete, symmetrical, and regular.

* See paper by Brongniart in Annales des Sciences Nat. xxiii. 226.

five carpels. In Figure 434, there is a symmetrical flower, with five parts in the three outer rows, and ten divisions in the inner, caused by the partial subdivision of each of the five central parts into two. Figure 435, shows a flower of Heath, with four divisions of the calyx and corolla, eight stamens in two rows, and four divisions of the pistil. In Figure 436, there are three parts in each whorl; and in Figures 437 and 438, there are three divisions of the calyx, corolla, and pistil, and six stamens, in two rows. In all these cases the flower is symmetrical. Flowers in which the number of parts in each whorl is the same, are *isomerous* (equal number); when the number in some of the whorls is different, the flower is *anisomerous* (unequal number).

241. When the parts of any whorl are not equal to, or some multiple of the others, then the flower is *unsymmetrical.* This is seen in Veronica as given in Figure 439, where there are four divisions of the calyx, four of the corolla, and only two stamens, and two parts of the pistil; so also in Lamium and Verbena, Figures 440 and 441, where the two outer rows have five parts, and the two inner only four

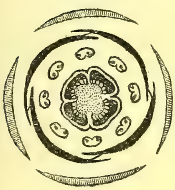


Fig. 435.

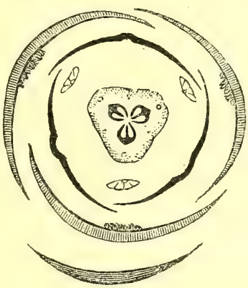


Fig. 436.

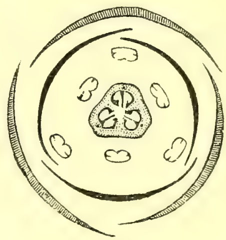


Fig. 437.

242. Symmetry, then, in botanical language, has reference to a certain definite numerical relation of parts. A flower, in which the parts are arranged in twos, is called *dimerous*, the symmetry being *binary*, and the arrangement marked thus $\sqrt{2}$. This may be considered either as analogous to opposite decussating leaves (Fig. 212, p. 97), or as composed of distichous alternate leaves belonging to the $\frac{1}{2}$ series (Fig. 431), the internodes between which are undeveloped. When the parts of the floral whorls are three, the flower is *trimerous* (Figs. 437 and 438), and the symmetry being *ternary* or trigonal, is marked $\sqrt{3}$. This may be looked upon as composed of verticillate leaves, or of tristichous alternate leaves, represented by $\frac{1}{3}$, the internodes between which are not developed.

243. When the floral pieces are in a series of four, the flower is

Fig. 435. Diagram of the flower of Heath (*Erica*), having four sepals, four divisions of the corolla, eight stamens in two rows, and four divisions of the pistil. The flower is tetramerous, complete, symmetrical, and regular.

Fig. 436. Diagram of the trimerous symmetrical flower of Iris. There are three alternating divisions of each whorl. Below is a single bract.

Fig. 437. Diagram of the symmetrical trimerous flower of Fritillary, having three divisions of the two outer whorls, and of the pistil in the centre, and six stamens in two rows.

tetramerous, its symmetry being *quaternary*, and marked $\sqrt{}^4$. It may be regarded as composed of verticils of four leaves, or of decussating leaves combined in pairs, without internodes. A *pentamerous* flower, marked $\sqrt{}^5$, has *quinary* or pentagonal symmetry, and may be formed of verticils of five leaves, or of alternate leaves, arranged according to the $\frac{2}{5}$ series (Fig. 211, p. 97), with undeveloped internodes. The symmetry which is most commonly met with in the vegetable kingdom is trimerous and pentamerous—the former occurring generally among Monocotyledons, the latter among Dicotyledons. Tetramerous symmetry occurs also among Dicotyledonous plants, and we shall afterwards see that the numbers 2 and 4 prevail in the reproductive organs of Acotyledons.

244. The parts of the flower are, generally speaking, arranged so that those of one whorl are alternate with those of the next whorl. Thus, the petals alternate with the sepals, the stamens with the petals, and so on (Fig. 408, p. 173). When the numbers in any series, such as the stamens, are multiplied, and the flower is still symmetrical, then the organ is found to consist of a definite number of

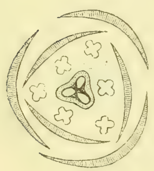


Fig. 438.


Fig. 439.


Fig. 440.


Fig. 441.

whorls alternating with each other. Thus, in diagram 442, the stamens are six in place of three, and they are arranged in two alternating whorls—the parts of the outer whorl alternating with the petals, and with those of the inner series. In Figure 443, the stamens are ten, in two alternating rows of five each. In Figure 445, the parts of the flower of the Strawberry are shown, consisting of ten divisions of the calyx, in two alternating rows of five each, five petals, twenty stamens, in four alternating rows of five each, and numerous carpels also in similar rows. Figure 444 represents the flower of Ranunculus, with five sepals, five petals, numerous stamens and carpels, in alternating rows of five each.

Fig. 438. Trimerous symmetrical flower of Woodrush (*Luzula*), showing an arrangement similar to that in Figure 437.

Fig. 439. Unsymmetrical flower of Speedwell (*Veronica*). The two outer whorls consists of four parts each, while the two inner have only two parts. The parts of the corolla are unequal, and the flower is therefore irregular.

Fig. 440. Unsymmetrical flower of Dead-nettle (*Lamium*). The two exterior whorls have five parts, while the two interior have only four, owing to the permanent abortion of one part in each. The parts are also unequally united, so as to render the flower irregular. One division of the calyx is superior, and two inferior, and the reverse is the case in the corolla.

Fig. 441. Diagram of the unsymmetrical flower of Vervain (*Verbena*). The two outer whorls have five parts, the two inner only four. A bract is represented below the flower.

245. The pistilline whorl is more liable to changes than the other parts of the flower. It frequently happens, that when it is fully formed, the number of its parts is not in conformity with that of the other whorls. In such circumstances, however, a flower is still called symmetrical, provided the parts of the other whorls are normal. Botanists are in the habit of neglecting the permanent state of the pistil in determining symmetry. Thus, Figures 446 and 448 show pentamerous symmetrical flowers, with dimerous pistils. Figure 447 is the diagram of a pentamerous symmetrical flower, with a trimerous pistil.

246. The various parts of the flower have a certain definite relation to the axis. The terms superior and inferior have reference to their position. Thus, in axillary tetramerous flowers (Fig. 449), one sepal is next the axis, and is called *superior* or *posterior;* another next the bract, is *inferior* or *anterior*, and the other two are *lateral;* the petals (when present) being alternate with the sepals, are so

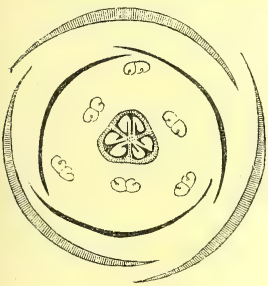


Fig. 442.

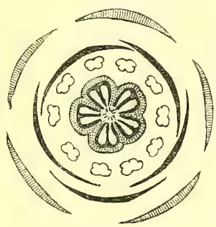


Fig. 443.

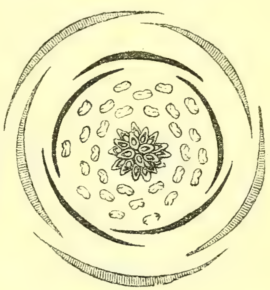


Fig. 444.

placed, that two are posterior, and two anterior; while the four stamens are arranged like the sepals. In a pentamerous flower it happens, that either one sepal is superior, two inferior, and two lateral, as in the calyx of Rosaceæ (Fig. 450), and Labiatæ (Fig. 440); or two are superior, one inferior, and two lateral, as in the calyx of Leguminosæ (Fig. 451). The reverse, of course, by the law of alternation, is the case with the petals. Thus, in the blossom of the Pea (Fig. 452), the odd petal (vexillum), *st*, is superior, while the odd sepal is inferior. In the Figwort order one of the two carpels is posterior, and the other anterior, as represented in the centre of Figure 453.

247. A flower normally consists of four whorls, calyx, corolla,

Fig. 442. Diagram of the flower of Snow-flake (*Leucojum*), consisting of three parts of the two outer whorls, six stamens in two alternating rows, and three carpels. The flower is symmetrical, complete, regular, and trimerous.

Fig. 443. Diagram of the flower of Rue (*Ruta*), consisting of five parts of the calyx, five of the corolla, ten stamens in two alternating rows, and five carpels. The flower is symmetrical, complete, and pentamerous.

Fig. 444. Diagram of the symmetrical pentamerous flower of Crowfoot (*Ranunculus*). The sepals and petals are five, the stamens and carpels are numerous (indefinite), in alternating rows of fives.

stamens, and pistil, and, when these are all present, the flower is *complete*. When each whorl consists of the same number of parts, or of a multiple of the parts, successively alternating with one another, we have seen that the flower is *symmetrical*. When the different parts of each whorl are alike in size and shape, the flower is *regular*. The absence of any of the whorls renders the flower *incomplete*, as in Figure 454, where the corolla is absent; in Figure 455, where the corolla and stamens are awanting; in Figure 449, where the corolla and pistil are deficient; and in Figure 418, p. 175, where calyx, corolla, and pistil, are awanting. Want of correspondence in the

Fig. 446.

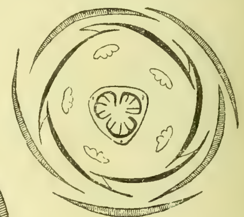


Fig. 447.

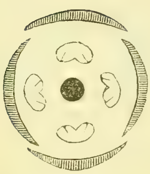


Fig. 449.

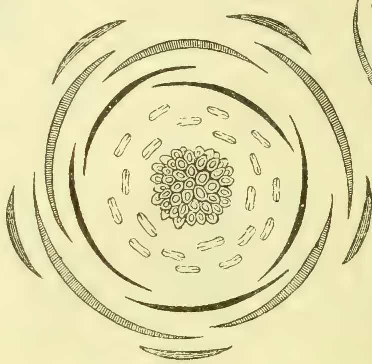


Fig. 445.

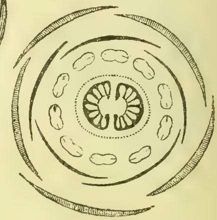


Fig. 448.

number of the parts of the whorls causes want of symmetry, as has been already shown, while differences in the size and shape

Fig. 445. Diagram of the symmetrical pentamerous flower of the Strawberry (*Fragaria vesca*). The calyx consists of two whorls of five parts each, the outer being called the epicalyx; there are five petals; the stamens are about twenty, constituting four alternating rows of five stamens each; the carpels are very numerous, but are some multiple of five, and are arranged in alternating rows.

Fig. 446. Flower of Madder (*Rubia tinctoria*). The outer circle is the obsolete calyx, with its parts united; there are five petals and five stamens, while the parts of the pistil are only two (dimerous). The flower is, nevertheless, said to be symmetrical.

Fig. 447. Diagram of flower of Greek Valerian (*Polemonium cæruleum*), having five divisions of the calyx and corolla, five stamens, and only three parts of the pistil. The flower is called symmetrical, although the carpellary whorl does not correspond in number with the others. The three outer whorls are pentamerous, the central one is trimerous.

Fig. 448. Diagram of the flower of Saxifrage (*Saxifraga tridactylites*). The calyx and corolla consist of five parts, the stamens are ten in two rows, while the pistil has only two parts developed. The flower is, nevertheless, called symmetrical, although the outer whorls are pentamerous, and the central one dimerous.

Fig. 449. Tetramerous male (unisexual) flower of the Nettle (*Urtica*). It is incomplete, as it wants petals and pistil; and it is said to be monochlamydeous. One sepal is next the axis, and is called posterior or superior, another is next the bract, called anterior or inferior, and two are lateral, that is, to the right and left of the axis. This is the usual occurrence in normally tetramerous flowers. In plants, however, such as Veronica, belonging to a natural order where the normal number is five, there are often irregularities.

of the parts of a whorl makes the flower *irregular*, as in the papilionaceous flower represented in Figure 452.

248. In their earliest stage of development all the parts of the floral whorls are regular and symmetrical, consisting of similar minute cellular papillæ arising from the axis. The alterations in their regularity and symmetry depend on changes taking place during their growth.* These alterations depend on the adhesion of one part to another, the union of different whorls, irregular growth, complete suppression of one or more parts or whorls, degeneration or degradation, multiplication of parts, and chorisis or deduplication.

249. A flower becomes incomplete by the non-development, or by the transformation of one or more whorls. It becomes irregular by one or more parts of a whorl being enlarged or diminished in size, and by irregular cohesions; and it becomes unsymmetrical when some of the parts of one or more whorls are suppressed, so that their numerical relations do not correspond. Thus, in Figure 457, by the disappearance of the whorl of stamens, the flower becomes incomplete, and,

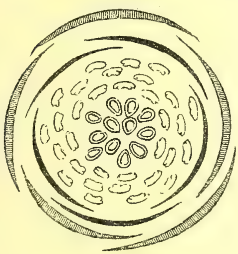


Fig. 450.

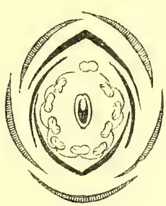


Fig. 451.

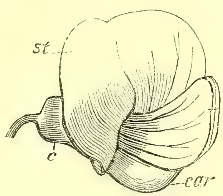


Fig. 452.

in Figure 456, the same thing takes place by the suppression of the pistil. By the difference in the form and size of the parts of the corolla of a Pea (Fig. 452), the flower becomes irregular, and, by the non-development of a stamen in the Dead nettle (Fig. 339, p. 145, and Fig. 440, p. 184), the flower is unsymmetrical.

250. The consideration of all the changes which the parts of plants undergo, or, in other words, the permanent deviations from what may be considered as their normal state, is included under the

Fig. 450. Diagram of flower of Rose, showing one division of the calyx superior or next the axis, and two inferior or next the bract. The petals are arranged alternately with the calycine segments, and hence two of them are superior, and one inferior.

Fig. 451. Diagram of flower of Sweet-pea (*Lathyrus*), showing five parts of the calyx, of which two are superior, one inferior, and two lateral; five parts of the corolla, of which one is superior, two inferior, and two lateral; ten stamens in two rows; one carpel, in consequence of four being undeveloped.

Fig. 452. Flower of Pea (*Pisum sativum*), showing a papilionaceous corolla, with one petal superior, *st*, called the standard (vexillum), two inferior, *car*, called the keel (carina), and two lateral, *a*, called wings (alæ). The calyx is marked *c*.

* Barneoud sur l'organogenie des corolles irrégulières. Ann. des Sciences Nat. 3 ser. Bot. viii. 344.

term Teratology.* Every alteration in the organs of the flower may be traced to the morphological laws to which we have already alluded. In treating of the separate floral whorls, notice will be taken of the changes which they undergo; in the meantime some general remarks will be made on the causes to which these changes are referred.

251. *Union* or *adhesion* of the floral whorls, or of the parts composing them, gives rise to various changes in form and symmetry. The adhesion is sometimes very irregular, so that certain parts are more completely united than others. Many forms of irregular flowers are due to this cause. The *non-development* of whorls gives incompleteness to the flower. The absence of the corolline whorl renders a flower *apetalous* or *monochlamydeous* (Fig. 412, p. 174, and Fig. 454), the absence of both the calycine and corolline whorl makes the flower *naked* or *achlamydeous* (Fig. 418, p. 175). The suppression of the stamens (Fig. 455), or of the pistil (Fig. 456), renders the flower *unisexual*. The non-appearance of a whorl deranges the relation of the different parts, and destroys their alternation.† Thus, in the

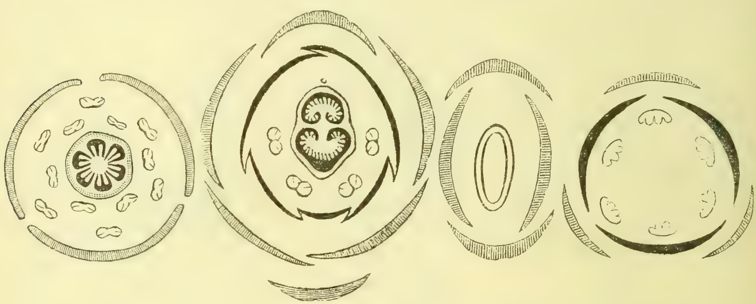


Fig. 454. Fig. 453. Fig. 455. Fig. 456.

apetalous flower of the Nettle (Fig. 449, p. 186), the stamens, in place of being alternate with the whorl on their outside, are opposite to it,

Fig. 453. Diagram of flower of Frogsmouth (*Antirrhinum*). The flower is unsymmetrical and irregular. Below is represented a single bract. There are five divisions of the calycine whorl, and five of the corolline, but the parts are unequal; there are only four stamens, one being abortive, as represented above the pistil; the pistil consists only of two carpels, one being superior, and the other inferior (next the bract). In the calyx one part is superior, two inferior, and two lateral; while in the corolla, two are superior, one inferior, and two lateral.

Fig. 454. Diagram of the flower of Asarabacca (*Asarum europæum*). The flower is incomplete, owing to the absence of petals. It is called monochlamydeous. The arrangement is trimerous, there being three divisions of the calyx, nine stamens in three rows, and six carpels.

Fig. 455. Diagram of the female flower of the Nettle (*Urtica*). It is monochlamydeous (with calyx only), and incomplete, as the petals and stamens are absent. The flower is unisexual.

Fig. 456. Incomplete flower of a Fan Palm (*Chamærops)*. The pistil is suppressed, so that the flower is unisexual, and male or staminiferous. The flower is trimerous.

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* For a full view of this subject, consult Moquin-Tandon, Tératologie Végétale, and Martins, de la Tératologie Vegetale, Montpellier, 1851.

† The change in the alternate arrangement of the parts may be said to give rise to a want of symmetry, even although the parts which remain correspond in number. In this sense symmetry would include both the number and the arrangement of the parts of different whorls.

and this relation of parts leads to the detection of the suppressed whorl. So also, in Geranium (Fig. 458), the outer row of stamens is opposite the petals, showing that there is a still more external whorl suppressed, as indicated in the figure by the black dots. It will thus be seen that many anomalies in this arrangement of the floral verticils may be accounted for by changes such as those we have mentioned.

252. Various parts of the flower are apt to become abnormal, or degenerate by *transformations* of different kinds. Some of the parts may be converted into scales or into hairs. The floral leaves of the catkin of the Willow (Fig. 348, p. 148), and those of the Hop (Fig. 352, p. 149), are membranous scales, while those of the Cone (Fig. 353, p. 150), are hard scales; the Wig-tree (Fig. 368, p. 154) produces hairs instead of flowers on some of its peduncles, and the calyx of the Dandelion, and other compound flowers (Fig. 365, p. 154), assumes the form of hairs, which remain attached to the fruit. In double flowers the stamens and pistils degenerate by being converted into petals.

253. Sometimes the parts of a flower are increased in number by

Fig. 457.

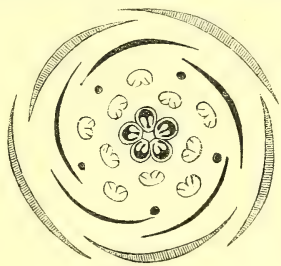


Fig. 458.

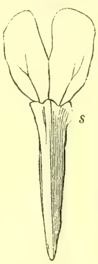


Fig. 459.

the growth of additional parts, or by the splitting of organs during their development. This latter process is called *Chorisis*, and seems to account satisfactorily for the appearance of certain anomalous parts which do not follow the law of alternation. This chorisis (separation) consists in the formation of two parts out of one, the separated parts being either placed one in front of the other by transverse chorisis, or side by side by collateral chorisis. The lamina of a petal may be split

Fig. 457. Incomplete flower of a Fan Palm *(Chamærops)*. The stamens are suppressed, so that the flower is unisexual, and female, or pistilliferous. The flower is trimerous.

Fig. 458. Diagram of the flower of Geranium, showing five parts of the calycine and corolline whorls, ten alternating perfect stamens in two rows, and five carpels. The outer row of stamens is, however, opposite to the petals, in place of being alternate, and consequently there is a row absent to make up the perfect symmetry. The undeveloped row is marked by black dots. It appears in the form of five abortive stamens. The relation of the different parts of a flower thus leads to the detection of abnormalities.

Fig. 459. Forked petal of Rose-campion (*Lychnis*), showing a lamina, *s*, detached from it, and standing opposite to it. This scale on the petal is supposed to be produced by transverse chorisis or dilamination. Had the scale been alternate with the petals, it would have been looked upon as an abortive state of another whorl. The petal has a narrow part below, which is called an unguis or claw.

in such a way that a scale is produced on part of it, as seen in Lychnis (Fig. 459, *s*); stamens may be divided so that two standing collaterally are produced in place of one. In this way some account for the abnormal state of the stamens in cruciferous flowers, such as Stock and Wallflower (Fig. 410, p. 173, and Fig. 460). In these plants, while the calyx and corolla consist of four parts, the stamens are six, owing, it is said, to collateral chorisis of two of them. The flowers are thus considered normally tetramerous. In the Fumitory (Fig. 461), there are two sepals, four petals in two rows, and six stamens. The latter consist of two perfect stamens, and four incomplete, which are considered as being produced by collateral chorisis of two stamens. In this way the flower would be normally dimerous. When the parts of contiguous floral whorls are opposite to each other, in place of being alternate, the occurrence may be accounted for, either by suppression of a whorl, or by chorisis. The scales in Figure 433, marked by lines within and opposite the stamens, may be traced to chorisis, so also the arrangement of stamens, in Figure 462. Collateral chorisis may be con-

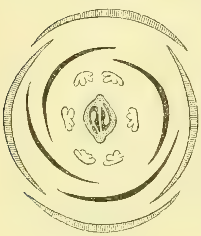


Fig. 460.

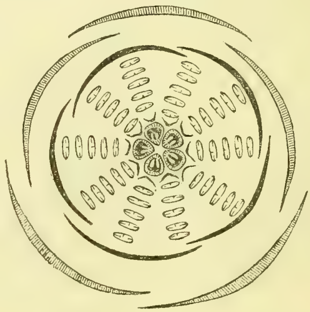


Fig. 462.

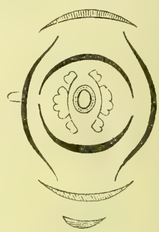


Fig. 461.

sidered as equivalent to the division of a leaf into a number of separate leaflets, each resembling the other, while transverse chorisis may have its analogue in the ligule of grasses (Fig. 317, p. 136). There are many anomalous changes in flowers which depend on cultivation. Such monstrosities, however, will be easily accounted for by bearing in mind the morphological laws on which these metamorphoses depend.

Fig. 460. Diagram of the flower of the common Stock (*Matthiola incana*). The calycine whorl consists of four parts, the corolline also of four, but the stamens are six, of which four are long and two short. The four long are placed together in pairs, as shown in the diagram, and some suppose that each pair is originally one stamen, which splits into two by collateral chorisis. The divisions of the pistil are two, a state which some consider as being produced by the abortion of other two carpels. The flower is thus considered as being normally tetramerous.

Fig. 461. Diagram of the flower of Fumitory (*Fumaria*). A bract is represented below, then two segments of the calyx, then four parts of the corolline whorl, in two rows, then six stamens, and one carpel forming the pistil. Of the six stamens two only are perfect, and the other four are imperfect, having only one antherine lobe. Some suppose, therefore, that these four imperfect stamens are in reality produced by the collateral chorisis of two perfect ones. The stamens may thus be considered four in two rows, and the flower would then be called dimerous.

Fig. 462. Diagram of flower of Columbine (*Aquilegia vulgaris*), in which there are five sepals, and five alternating petals, numerous stamens (multiple of five), and five carpels. The rows of stamens being placed opposite, in place of alternate, are considered as formed by transverse chorisis.

2. THE FLOWER-BUD.

254. The various parts of the flower consisting of the floral envelopes, and the essential organs of reproduction are contained in the flower-bud. They appear at first in the form of small cellular mammillæ, or prominences, the parts of each verticil being equal and separate. In their development (organogeny) they follow the same order as leaves—the extremities of each of the parts being first formed, and irregularities, caused by adhesion and other causes, occurring only during the progress of growth. In general the whorls are developed successively, from the calyx to the pistil; but, in some instances, the petals are retarded in their growth, so that the stamens are completed before them.

255. The terms *Præfloration* and *Æstivation* are used to express the arrangement of the different parts of the flower in the flower-bud. The relation of these parts to each other is similar to that which

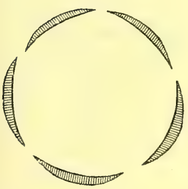


Fig. 464.

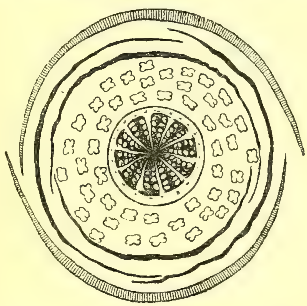


Fig. 463.

Fig. 465.

occurs in the leaf-bud, and which has been considered under præfoliation (¶ 153). The same terms are also used to express the nature of many of these arrangements. As regards each leaf of the flower, it is either spread out, as the sepals in the bud of the Lime tree, or folded upon itself (conduplicate), as in the petals of some species of Lysimachia, or slightly folded inwards or outwards at the edges, as in the calyx of some species of Clematis, and of some herbaceous plants, or rolled up at the edges (involute or revolute), or corrugated and crumpled, as the petals of the Poppy (Fig. 463).

256. The position of the parts of the flower relative to each other, in the bud, gives origin to the terms *valvular*, *contortive* or *twisted*, and

Fig. 463. Diagram of the flower of Poppy (*Papaver*), shewing two sepals placed externally and arranged in an obvolute manner, four crumpled petals, arranged alternately in pairs, numerous stamens, arranged in verticils, and ten divisions of the pistil. All the parts are multiples of two, and the flower may be called dimerous.

Fig. 464. Diagram to illustrate Valvular or Valvate æstivation, in which the parts are placed in a circle, without overlapping or folding.

Fig. 465. Diagram to illustrate Induplicative or Induplicate æstivation, in which the parts of the verticil are slightly turned inwards at the edges.

imbricated. In the first two the parts are placed at the same level, in a circular manner, while in the latter they are at different heights, and follow a distinctly spiral order. The æstivation is *valvular*, or the parts are arranged in a valvate manner (Fig. 464), when they are so applied as to be in contact at their edges without any folding. They are in a circular verticil. When the parts of the verticil are slightly folded inwards at their edges the æstivation is *induplicative* (Fig. 465), when folded outwards *reduplicative* (Fig. 466). When the parts of the corolla are united they are occasionally folded in a plaited manner.

257. In *Contortive* æstivation the parts are in a circle, or apparently so, and one edge of each is directed inwards, so as to be overlapped by the contiguous part, while the other edge covers the margin of the part adjacent on the other side; each part also is, as it were, twisted on its axis, and the whole whorl exhibits a convolute appearance (Fig. 467). It is well seen in the unexpanded petals of Malvaceous plants (Fig. 468), in the corolla of Cyclamen (Figs. 469

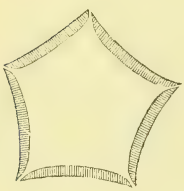


Fig. 466.

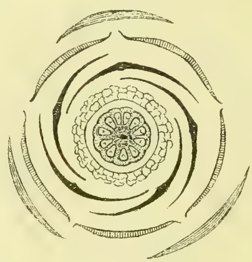


Fig. 468.

Fig. 467.

and 470), and in that of many Apocynaceæ, which were called Contortæ by old authors.

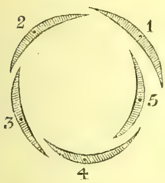
258. The æstivation called *imbricated* or *imbricative*, embraces those bud arrangements in which the parts are placed at different heights so as to overlie each other, and form a more or less evident spiral cycle (Fig. 471). When the parts of a floral whorl are five, as is the case in many Exogens, it is often found that there are two parts wholly on the outside, two completely internal, and one intermediate, overlapped at one edge by one of the outer parts, whilst its other edge covers one of the inner parts (Fig. 472). This is *quin-*

Fig. 466. Diagram to illustrate reduplicative or reduplicate æstivation, in which the parts of the whorl are slightly turned outwards at the edges.

Fig. 467. Diagram to illustrate contortive or twisted æstivation, in which the parts of the whorl are overlapped by each other in turn, and are twisted on their axes. This is common in the Mallows.

Fig. 468. Diagram of flower of Mallow, in which there are three outer sepals, forming the epicalyx, five inner sepals, arranged in a somewhat reduplicate manner, and five petals, each of which is partially covered by that next to it, and in its turn overlaps its neighbour, the whole being twisted on their axis. Numerous stamens and carpels occupy the centre, the stamens being united by their filaments.

cuncial or *spiral* imbrication, and is the normal arrangement in pentamerous flowers, corresponding with the $\frac{2}{5}$ arrangement in leaves. In personate flowers, as Frogsmouth, a variety of imbricated æstivation occurs, called *cochlear* (Fig. 473), in which the second part of the cycle, in place of being external (as in the ordinary quincuncial arrangement), becomes wholly internal. When imbricated æstivation occurs in trimerous flowers (Fig. 474), there is one part outside, one inside, and one intermediate, the arrangement being $\frac{1}{3}$, as in leaves. When the flower is tetramerous (Fig. 475), there are two outer parts and two inner parts; this being analogous to what occurs in opposite decussating leaves. In pea-like blossoms (Fig. 452, p. 187), it is usual to find a modification of imbricated æstivation, called *vexillary*, in which the large petal called the vexillum, and which is superior or



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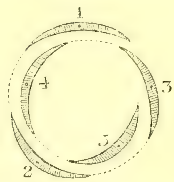

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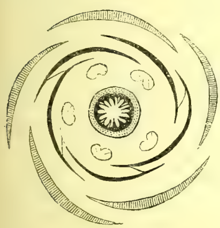

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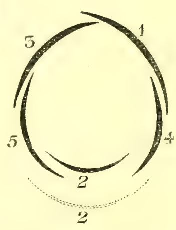


Fig. 473.

next the axis, overlaps the rest (Fig. 476). In some instances, as in the Judas-tree, the vexillum is included between the lateral petals (alæ), as represented by the dotted lines, 4, Figure 476. The different

Fig. 469. Expanded flower, flower-bud, and leaf of the Sowbread (*Cyclamen europæum*). The leaf, *l*, is sagittate-cordate, the petals of the flower, *p*, are reflexed, and those in the bud, *b*, are contorted, so as to exhibit twisted æstivation.

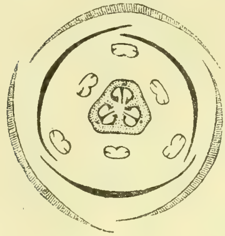
Fig. 470. Diagram of the flower of the Sowbread (*Cyclamen*), shewing the five sepals overlapping each other in turn, and five petals arranged in a contortive manner, five stamens, and the pistil in the centre.

Fig. 471. Diagram to illustrate imbricative or imbricated æstivation, in which the parts are arranged in a spiral cycle, following the order indicated by the figures 1, 2, 3, 4, 5.

Fig. 472. Diagram to illustrate the quincuncial æstivation, in which the parts of the flower are arranged in a spiral cycle, so that 1 and 2 are wholly external, 4 and 5 are internal, and 3 is partly external and partly overlapped by 1. This is common in pentamerous flowers.

Fig. 473. Diagram of cochlear æstivation, in which the petal 2 is wholly internal, in place of being external. Its normal position in the imbricate æstivation is indicated by the dotted line.

verticils of the flower have not always the same æstivation. In the Mallow tribe (Fig. 468, p. 192), the calyx is valvate, while the corolla is twisted; in St. John's Wort (Fig. 477) the calyx is imbricated



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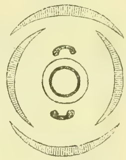

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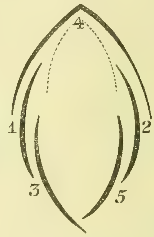

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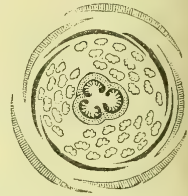

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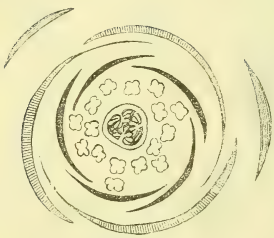

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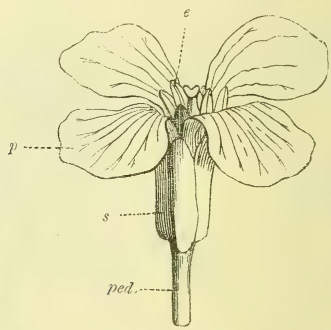


Fig. 479.

Fig. 480.

and the corolla twisted; in the Rock-rose (Fig. 478) the three inner sepals are twisted in one direction, while the petals are twisted in an opposite direction.

Fig. 474. Diagram of imbricate æstivation in a trimerous flower (*Fritillaria*), in which one part is outside, one inside, and one intermediate, the latter partially overlapping the inner part, and being in its turn partially overlapped by the outer.

Fig. 475. Diagram of a flower having four parts, of which two are outer, overlapping the edges of the two inner.

Fig. 476. Diagram of a papilionaceous flower, shewing vexillary æstivation, 1 and 2 the alæ or wings, 3 a part of the carina or keel, 4 the vexillum or standard, which, in place of being internal, as marked by the dotted line, becomes external, 5 the remaining part of the keel. The order of the cycle is indicated by the figures.

Fig. 477. Diagram of the flower of St. John's Wort (*Hypericum*), in which the sepals and petals are imbricated, and the latter are contorted. The stamens are numerous in three bundles, and there are three divisions of the pistil.

Fig. 478. Diagram of the flower of the Rock-rose (*Helianthemum*), in which there are two outer sepals and three inner ones, the latter being twisted in one direction, while the five petals are twisted in the opposite direction. The stamens are numerous, the pistil in the centre shews three divisions.

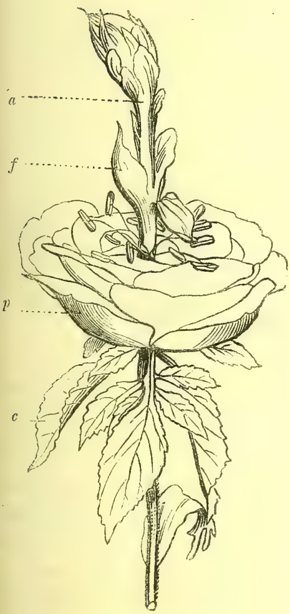
Fig. 479. Flower of Wallflower (*Cheiranthus Cheiri*), shewing the peduncle, *ped*, the calyx composed of four sepals, *s*, the corolla of four petals, *p*, and the stamens, *e*.

Fig. 480. The calyx of Wallflower separated, shewing the four sepals, two of which are gibbous at the base, *i.e.*, exhibit slight projections or swellings.

3. THE FLORAL ENVELOPES.

A. *The Calyx or Outer Floral Envelope.*

259. The Calyx is the outer floral envelope, and is composed of a whorl of leaves called *Sepals* (Figs. 479, *s*, and 480). These leaves have usually the structure and appearance of ordinary leaves, as regards the distribution of their cells and vessels. They are frequently of a greenish hue, having chlorophyll in their cells, and stomata on their lower (outer) epidermal covering. In Gentiana campestris, and



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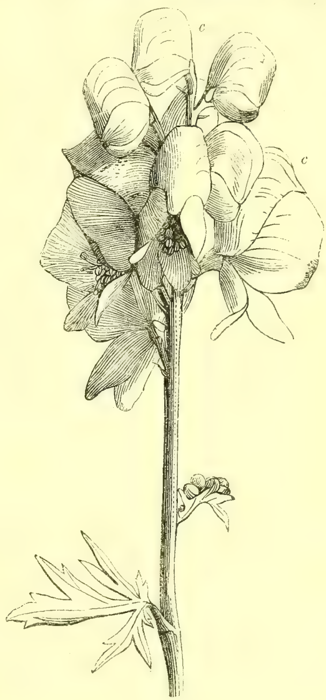


Fig. 482.

G. crinita, the sepals resemble the ordinary leaves of the plants. In proliferous states of the Rose (Fig. 481), Dutch Clover, Oriental Poppy, and Primrose, the calyx assumes a leafy form. In a specimen of Lycium europæum, Turpin noticed one sepal resembling the ordinary leaves; and in Mussænda macrophylla, one of the sepals is deve-

Fig. 481. Monstrous flower of the Rose, showing the calyx, *c*, with the sepals like true leaves, the petals, *p*, multiplied at the expense of the stamens, the carpels, *f*, transformed into coloured leaves, and the axis, *a*, prolonged, and bearing an abortive flower-bud.

Fig. 482. Flower of Monkshood (*Aconitum Napellus*), showing the peculiar helmet-shaped calyx, *c c*, which is of the same colour as the petals. It is called a coloured calyx.

loped as a large white leaf, while the others are small and green. When not green the calyx is said to be coloured, as in Columbine (Fig. 393, p. 164), in Monkshood (Fig. 482), Larkspur, Fuchsia, Indian-cress (Fig. 483), Lily (Figs. 411 and 413, p. 174), Iris, and Narcissus (Fig. 343, p. 147). In the three last mentioned plants, and in most monocotyledons, the name perianth (¶ 227) is applied to the calyx and corolla. In Fumitory (Fig. 522, p. 203), the calyx consists of two coloured scales.

260. It is not common to find the individual sepals divided. Sepals are usually sessile leaves, having no stalks. They are either distinct from each other, as in Wallflower (Fig. 479, *s*), or they are combined, as in the Melon (Fig. 484, *c*). When the sepals are separate the calyx is *polysepalous*, *polyphyllous*, or *dialysepalous*, the number of sepals being marked by the Greek numerals prefixed. Thus, disepalous means a calyx with two distinct sepals; trisepalous with three; tetrasepalous with four; pentasepalous with five; hexasepalous with

Fig. 484.

Fig. 483.

Fig. 485.

Fig. 486.

six; or the Greek word *phylla*, meaning leaves, is used, and a disepalous calyx is denominated diphyllous, and so on.

261. When sepals are united by adhesion, they form a *gamosepalous* or *gamophyllous* calyx, terms implying union of sepals or leaves, and therefore preferable to *monosepalous* and *monophyllous*, which mean literally one sepal or leaf. This adhesion of sepals varies in extent, and thus gives rise to the terms, *entire*, when the union is complete, and there are no division at the top, as in Correa, *toothed* (Fig. 485), *cleft* (Fig. 486), and *partite* (Fig. 487), when the divisions are mere toothings, extend to the middle, or to near the base. Thus, a gamosepalous calyx, as shown in the figures, may be five-toothed (quinque-dentate), five-cleft (quinquefid), or five-partite (quinque-partite),

Fig. 483. Flower of Indian Cress (*Tropæolum majus*), in which the calyx, *c*, is coloured, and three of its sepals are prolonged in the form of a spur, *s*, (calcar).

Fig. 484. Male flower of Melon (*Cucumis Melo*), showing a gamosepalous calyx, *c*, having tooth-like projections at the margin, and covered with hairs. The petals are five, beautifully veined, and imbricated in æstivation.

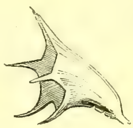
Fig. 485. Gamosepalous, five-toothed (quinque-dentate) calyx of Campion (*Lychnis*).

Fig. 486. Gamosepalous five-cleft (quinquefid) calyx of Centaury (*Erythræa*).

the number of divisions usually indicating the number of sepals of which the calyx is composed. In an entire gamosepalous calyx the venation assists in the determination of the number of sepals.

262. When the union of the sepals is not equal in all the parts, the calyx has an irregular form, as in Lathyrus (Fig. 488), and in Labiate flowers (Fig. 489). In the latter case the calyx is *two-lipped* (bilabiate), the upper lip being composed of three sepals, one of which

Fig. 487.



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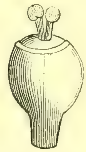
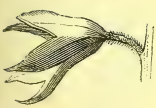


Fig. 493.



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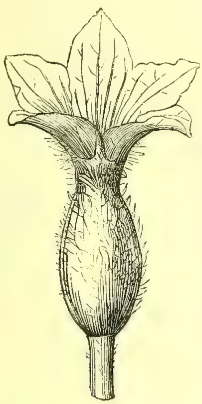


Fig. 490.

Fig. 491.

Fig. 492.

Fig. 494.

is either arched or stands out from the rest in a marked manner, and the lower lip being formed of two sepals. The united parts of a gamosepalous calyx form the *tube*, the free portions at the apex are

Fig. 487. Gamosepalous five-partite (quinque-partite) calyx of Pimpernel (*Anagallis*), surrounding the pistil, which is composed of ovary, style, and stigma.

Fig. 488. Irregular gamosepalous calyx of a species of Lathyrus. The sepals are united unequally, so as to form apparently two lips, the upper composed of two sepals, the lower of three.

Fig. 489. Bilabiate gamosepalous calyx of the Dead-nettle (*Lamium*). It is composed of two lips, the upper lip formed by three sepals, the lower by two. One of the upper sepals stands prominently out from the rest. The tube is formed by the united sepals, the free parts of the calyx forming the limb, and the opening being the faux or throat.

Fig. 490. Female flower of Melon (*Cucumis Melo*), showing the gamosepalous calyx united to the pistil, and forming part of the fruit. It is called an adherent calyx. It is also denominated superior, as the limb appears above the fruit. There are five beautifully veined imbricated petals.

Fig. 491. Tubular flower of Ox-eye (*Chrysanthemum*). The corolla is gamopetalous and regular, formed by five petals, the calyx is completely adherent to the single-seeded fruit below. There is no calycine limb visible.

Fig. 492. One of the central flowers of the Sun-flower (*Helianthus*). The corolla is gamopetalous, five-toothed at the apex, the calyx is adherent to the fruit, and the limb of the calyx appears above the fruit in the form of a membrane, with pointed projections. The calyx is called superior, because its free portion is above the fruit. Extending beyond the flower are seen the stamens and pistil.

Fig. 493. Calyx of Madder (*Rubia*), adherent to the pistil, its limb appearing in the form of a rim. The calyx is called obsolete.

Fig. 494. Feathery pappus attached to the fruit of Salsafy (*Tragopogon porrifolius*). The calyx adheres to the fruit, and its limb is pappose.

the lobes or segments of the *limb*, and the orifice of the tube is the *throat* (faux).

263. The tube of a gamosepalous calyx frequently adheres more or less completely to the other whorls, especially to the pistil. In the latter instance the calyx remains persistent, and forms part of the fruit, as in the Apple, Pear, Gooseberry, Pomegranate, and Melon (Fig. 490). In such instances the limb of the calyx often becomes degenerate, and is either absent (Fig. 491), or appears in the form of scales or pointed projections (Fig. 492), or of a circular rim (Fig. 493), or of pappus, as in Composite flowers (Figs. 494 and 495). In the adherent calyx of Valerian (Fig. 496), the limb is at first a ring, but ultimately expands in the form of hairs (Fig. 497), and hence is called *pappose*.

264. The calyx may continue persistent, and yet be separable from the fruit, as in Henbane (Fig. 498), in Mallow (Fig. 499), and

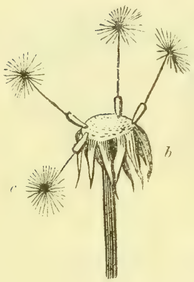


Fig. 495.

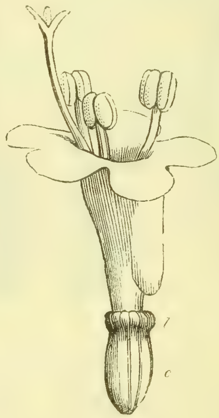


Fig. 496.

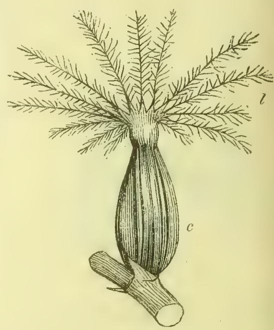


Fig. 497.

in the Peruvian Winter-cherry and other species of Physalis (Figs. 500 and 501), where it increases after the flower has withered, and surrounds the fruit like a bladder. It sometimes continues in a withered state, as in the Heath, and is called *marcescent*. The term *superior* is applied to the calyx or perianth when it is so united to the fruit as to appear to arise from its summit, as in Melon (Fig. 490), and Iris (Fig. 502). In the Rose (Figs. 503 and 504), the tube of the calyx bears numerous carpels on its concave surface, and the limb at the summit is divided into five segments.

Fig. 495. Receptacle and reflexed involucre, *b*, of Dandelion (*Leontodon Taraxacum*), with the fruit and calyx, *c*, adherent to it. The limb of the calyx appears in the form of stalked hairs (pappus). The calyx is said to degenerate, so as to become pappose.

Fig. 496. Flower of Valerian (*Valeriana*), with the calyx, *c*, adherent to the fruit. The limb, *l*, of the calyx appears as a ring, composed of numerous hairs which are coiled up, from without inwards. The corolla is gamopetalous, irregular, gibbous at the base on one side. There are three stamens and one pistil.

Fig. 497. Fruit of Valerian (*Valeriana*), with adherent calyx, *c*; the limb of the calyx, *l*, has now expanded, so as to appear as feathery pappus. In Figure 496, this limb is in the form of a ring.

265. In place of being persistent, the calyx is frequently *deciduous*,

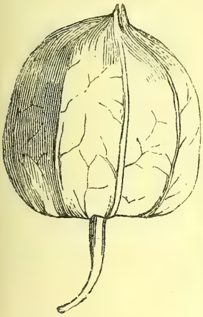


Fig. 500.

Fig. 498.

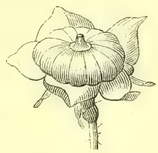


Fig. 499.

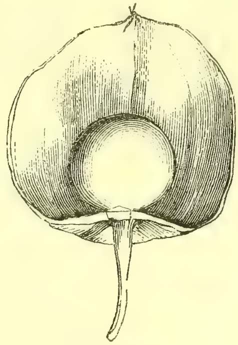


Fig. 501.

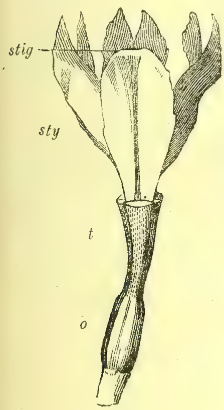


Fig. 502.

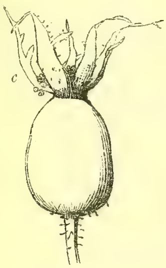
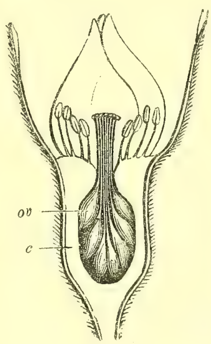


Fig. 503.



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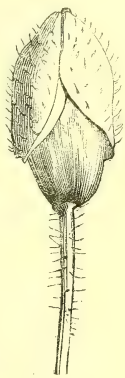


Fig. 505.

falling off immediately after the flower expands, as in Crowfoot (Fig.

Fig. 498. Urceolate (pitcher-like) calyx of Henbane (*Hyoscyamus*), applied closely to the seed-vessel (capsule), but separable from it. The limb shows five lobes, indicating the five sepals which form the calyx.

Fig. 499. Persistent calyx of Mallow (*Malva*), remaining attached to the fruit, after the flower withers.

Fig. 500. Bladder-like calyx of the Winter Cherry (*Physalis Alkekengi*), which is persistent, or remains after the corolla and stamens have fallen.

Fig. 501. Bladder-like calyx of the Winter Cherry (*Physalis Alkekengi*), laid open to show the mode in which it surrounds the fruit without adhering to it. The calyx is persistent, but not adherent. It enlarges after the flower withers, and is called accrescent.

Fig. 502. Flower of Iris, with the upper part of the perianth cut away. The perianth is adherent to the lower portion of the pistil, *o*, and part of the tube of the perianth, *t*, is seen above the ovary, *o*. Hence, the perianth is superior, and the ovary inferior. The styles are marked *sty*, and the stigmas *stig*.

Fig. 503. Fruit of the Rose (*Rosa*), consisting of the thickened calyx bearing the carpels inside. The limb of the calyx, *c*, is divided into five segments.

Fig. 504. Fruit of the Rose cut vertically, showing the concave tube of the calyx, *c*, bearing numerous separate carpels, *ov*, with styles attached. The stamens are attached to the calyx. Some look upon the part bearing the carpels as a hollow portion of the receptacle, while others consider it as really the tube of the calyx lined with a fleshy disk.

Fig. 505. Caducous calyx of Poppy (*Papaver*). It is composed of two sepals, which fall off before the petals expand.

337, p. 144). In the Poppy (Fig. 505), the two sepals are detached before the anthesis or the opening of the flower, and they are said to be *caducous.* In Eschscholtzia, the calyx is composed of sepals united together, and joined by an articulation to the thalamus. As the flower expands, they give way at the joint, and fall off in the form of a candle-extinguisher.

266. By the irregular development of one or more sepals, the *spurred* (calcarate) calyx of Larkspur and of Indian Cress (Fig. 483, p. 196), is produced, as well as the *hooded* or helmet-shaped (galeate) calyx of Monkshood (Fig. 482, p. 195). In Grasses and Rushes the perianth assumes a glumaceous or scaly appearance. In Diplolæna, the sepals are reduced to five scales. Occasionally there is a suppression of one

Fig. 506.

Fig. 507.

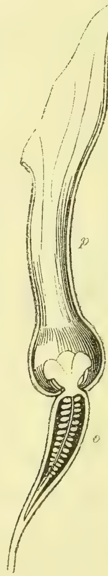


Fig. 509.

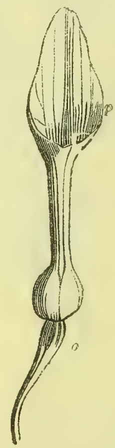


Fig. 508.

or more sepals, as in some species of Chenopodium and Blitum. Accidental suppressions of this kind have also been seen in the proliferous variety of Arabis alpina.

267. It is very rare to find the calyx wholly absent. This, however, occurs in some of the Euphorbias, in which the flowers are naked (achlamydeous), as shown in Figure 418, p. 175. In these

Fig. 506. Calyx-like (Calyciform) involucre of Euphorbia, enclosing numerous male flowers, and one female flower, *f*, with three forked styles. The individual flowers are really naked or achlamydeous, in consequence of the floral envelopes being suppressed.

Fig. 507. Double calyx (Calyculate calyx) of Strawberry (*Fragaria vesca*). The outer calyx is called epicalyx, and consists of five small leaves, while the inner consists of five large sepals. Some consider the epicalyx as a verticil of bracts.

Fig. 508. Flower of Birthwort (*Aristolochia*), consisting of a single floral envelope (calyx), adherent to the pistil, *o*. The flower is monochlamydeous, and the perianth, *p*, superior and irregular.

Fig. 509. Flower of Birthwort (*Aristolochia*), cut vertically, showing the single envelope (calyx) adherent to the ovary, *o*, which contains ovules. The perianth, *p* (calyx) is coloured.

plants there is a series of bracts which at first sight appear to be the calyx; but they are really an involucre inclosing several distinct flowers (Fig. 506). In the Strawberry and Potentilla, the calyx consists of two alternating whorls (Fig. 507), the exterior of which has been called *epicalyx*, and is by some considered a row of bracts. The same thing occurs in the Mallow tribe (Fig. 355, p. 150, and Fig. 356, p. 151). The nature of this epicalyx serves to distinguish some of the genera. This epicalyx is also seen in the Carnation (Fig. 404, p. 170). When there is only one floral envelope present, as in Goosefoot (Fig. 412, p. 174), and in Birthwort (Figs. 508 and 509), it belongs to the calycine whorl, whatever may be its form or colour.

B. *The Corolla or Inner Floral Envelope.*

268. The Corolla is the inner envelope of the flower, and is composed of a whorl of leaves called *petals*, which alternate with the sepals, as seen in Figure 510, and are frequently equal to them in number (isomerous), or some multiple of them. The petals differ from the sepals in being rarely green. They usually exhibit showy colours, and are often odoriferous. Structurally they are composed of cellular and vascular tissue, the latter being spiral vessels and delicate tubes. The epidermis of petals does not in general exhibit stomata, but it sometimes displays beautiful hexagonal and radiating markings under the microscope. It is usually smooth (glabrous), but occasionally coloured hairs occur on it, as in the Buckbean.

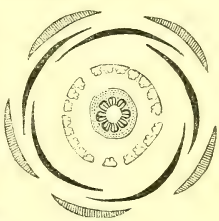


Fig. 510.

269. Petals originate in cellular projections, which are either connected by a ring of cellular tissue, or are separate, according as the parts are ultimately to be united, or to remain distinct. Even when the petals become irregular in after growth, they are equal in the first instance.* Some petals continue to increase in size after the flower has expanded. Thus, in the long-tailed Ladies'-slipper (Cypripedium caudatum), the petals are very short when the flower opens, but they acquire length day by day, at a rate which would enable an attentive observer to see them grow. Mrs. Lawrence gives the following measurements of a plant which flowered at Ealing Park :—

	Inches long.
When the flower first opened, the petals were	$\frac{3}{4}$
On the second day	$4\frac{1}{2}$
On the third day	$8\frac{1}{2}$
On the fourth day	13
On the fifth day	$18\frac{1}{2}$

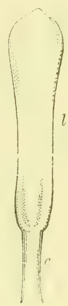
Fig. 510. Diagram of the flower of the Orange, shewing an external whorl of five sepals, and an internal one of five petals, alternating with the sepals. The third whorl is the stamens and the fourth the pistil.

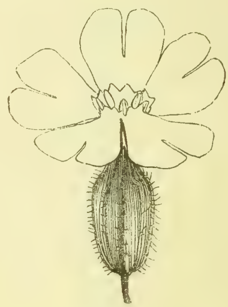
* Barneoud sur le development des Corolles irregulieres, Ann. des Sciences Nat. 3d Ser. Bot. viii. 344.

The same lengthening of the petals occurs in Epidendrum antenniferum, a singular orchid, from Xalapa.*

270. The forms of petals vary. Sometimes they resemble sessile coloured leaves, as in Crowfoot (Fig. 511), and in the Rose and Cinquefoil; at other times they are separated into two portions, as in the Globe-flower (Fig. 512), and Wallflower (Fig. 513), one narrow, *c*, forming the *claw*, and the other broad, *l*, constituting the limb or *lamina*. Petals being like leaves, exhibit varieties in their outline or circumscription. In some plants they are split at the apex, so as to be bifid (Fig. 514), or trifid, or cut into numerous segments (Figs. 515 and 516). When a small portion of their apex is deficient they become emarginate and obcordate (Fig. 405, p. 171), and when lobed at the base they are cordate (Fig. 535, p. 207). The apex of petals is sometimes prolonged in the form of a narrow thread, as in Strophanthus, or it ends in a point, which is either straight or inflexed as in Umbelliferous plants

Fig. 511.





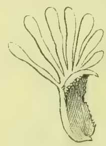
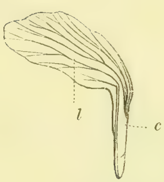


Fig. 515.



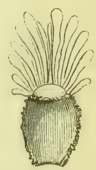


Fig. 513. Fig. 512. Fig. 514. Fig. 516.

(Fig. 517, *p*). Sometimes petals which are bifid or fringed, such as those of the Pink and Caucalis grandiflora, become divided to their base. This division of petals has also been seen in Poppies and in Saponaria. Some petals are folded, so as to assume a tubular or pitcher-like form, as in the Hellebore (Fig. 518), a spurred form, as in Colum-

Fig. 511. Petal of Crowfoot (*Ranunculus*), without a claw, and thus resembling a sessile leaf. At the base of the petal a nectariferous scale is seen. This scale may be considered as produced by transverse chorisis or dilamination.

Fig. 512. Strap-shaped and stalked petal of Globe-flower (*Trollius europæus*); the stalk or claw is marked *c*, the blade *l*.

Fig. 513. Unguiculate or stalked petal of Wallflower (*Cheiranthus Cheiri*); *c*, the claw or unguis; *l*, the blade or lamina.

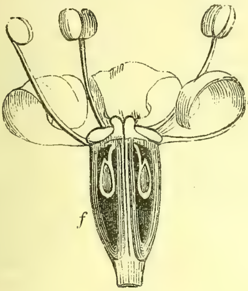
Fig. 514. Flower of Campion (*Lychnis*), with five petals, the laminæ of which are split into two, and are called bifid. Scales occur on the petals at the point where the blade and claw unite.

Fig. 515. One of the lateral petals of Mignonette (*Reseda*). Its blade is cut into numerous segments, and has been called laciniated.

Fig. 516. Inner petal of Mignonette (*Reseda*), shewing a blade divided deeply into numerous segments. The division or laciniation of the petals is common in the natural order Resedaceæ.

* See Paxton's Flower Garden, February and May 1850.

bine (Fig. 519), Violet (Fig. 520), and Larkspur (Fig. 521), a gibbous



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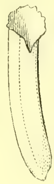
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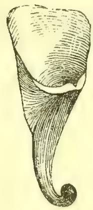
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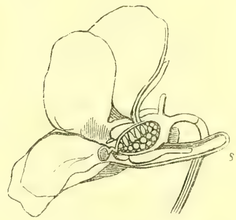
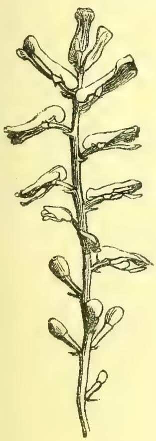


Fig. 520.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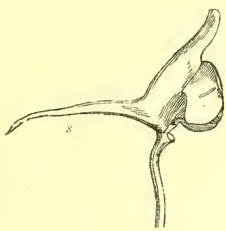

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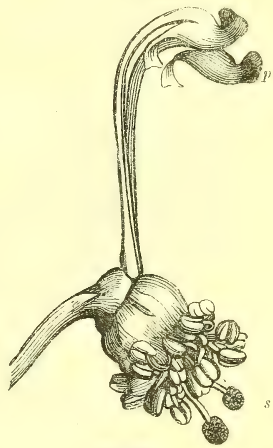


Fig. 523.

form, as in Fumitory (Fig. 522), or a horn-like aspect, as in the petals

Fig. 517. Flower of Fennel (*Fœniculum vulgare*), an umbelliferous plant, cut vertically. The petals, *p*, are shewn with inflexed points (apicula). The calyx is adherent to the fruit, *f*, which is opened, so as to exhibit two achænia, with a single pendulous ovule in each. At the apex of the fruit, and in the centre of the flower, there are two styles and stigmas, with an enlargement at their base, called an epigynous disk. The stamens are united to the calyx.

Fig. 518. Tubular petal of Hellebore (*Helleborus*), formed by folding and adhesion, in the same manner as pitchers (Par. 199). These hollow petals were called nectaries by Linnæus.

Fig. 519. Horn-like hollow petal of Columbine (*Aquilegia vulgaris*), formed by folding and adhesion of the edges.

Fig. 520. Section of flower of Violet (*Viola*), shewing one of the petals with a long hollow spur, *s*. The petal is said to be spurred or calcarate. The ovary is laid open to show the ovules, and the spur is split open to show a staminal process extending into it.

Fig. 521. Spurred (calcarate) petal of Larkspur (*Delphinium*). The long process, *s*, extends into a hollow spur of the coloured calyx.

Fig. 522. Racemose flowers of Fumitory (*Fumaria officinalis*), exhibiting gibbous swellings at their base. In Fumitories one of the petals is gibbous, while in some other genera of the order two of them are in this state. Such corollas are said to be saccate at the base. Small bractlets are seen at the point where the pedicels join the rachis or general peduncle.

Fig. 523. Two peculiar horn-like stalked petals, *p*, of Monkshood (*Aconitum Napellus*). They are situated under the helmet-shaped (galeate) coloured sepal, and they consist of a grooved stalk supporting a hollow spurred petal. These anomalous petals were called nectaries by Linnæus Below the petals in the Figure are seen numerous stamens, *s*, attached to the receptacle.

under the helmet-shaped sepals of Monkshood (Figs. 523, *p*, and 482, p. 195). These anomalous petals sometimes assume a normal form, as in a variety of Columbine, in which the spurs disappear (Fig. 524).

271. When the petals are separate (free and distinct) the corolla is *Polypetalous* or *Dialypetalous* (Fig. 525), and the number of the petals is indicated by prefixing the Greek numerals to the term *petalous*, in the same way as in the case of the sepals (¶ 260, p. 196). Thus, in Figure 525, the corolla is *pentapetalous*, and in Figure 526, it is *tetrapetalous.* In the Vine (Fig. 527), in which the corolla is polypetalous, the petals in their early state are united together by their apices, and afterwards separate and fall off. When the petals are united, the corolla is *Gamopetalous* or *Monopetalous* (Fig. 528), and the number of its parts is marked by the venation, or by the divisions of the apex, just as in the case of the calyx (¶ 261). Thus, in Figure

Fig. 524.

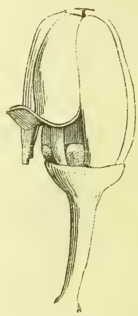


Fig. 527.

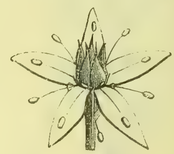


Fig. 525.

Fig. 526.

528, the corolla consists of five petals united, their number being ascertained by the lobes at the apex, as well as by the midribs. The united portion is called the *tube* (Fig. 528, *t*), the divisions are called *lobes*, *l*, and the orifice is the *throat* (faux). The term *limb* is often given to the expanded and free part of a gamopetalous corolla.

Fig. 524. Flowers of Columbine (*Aquilegia vulgaris*), in which the petals have become spurless. The ordinary petal is seen in Figure 519. The coloured sepals are five, and are marked, *s*; they alternate with the five petals marked, *p*. The inflorescence is definite, the terminal flower expanding first.

Fig. 525. Polypetalous or Dialypetalous corolla of Biting Stonecrop (*Sedum acre*). It is composed of five separate petals, and hence is pentapetalous. There are ten stamens in two rows, and five carpels.

Fig. 526. Tetrapetalous corolla of Celandine (*Chelidonium majus*). It is composed of four separate petals. The term dialypetalous means separation of petals, and hence it is applied to all polypetalous corollas. In the Figure are seen numerous stamens, in many rows, surrounding the pod-like pistil in the centre.

Fig. 527. The flower of the Vine (*Vitis vinifera*), in the young state, shewing the union of the petals at their upper part, and the mode in which they separate before they fall off.

272. Some varieties of polypetalous corollas deserve notice. Of the *regular* forms may be mentioned the *rosaceous*, as in the Rose, Rock-rose (Fig. 529), and the Strawberry (Fig. 530), in which there are spreading petals, without claws or with very short claws; the *liliaceous*, where the petals gradually taper from the apex to the base, as in the Lily (Fig. 531); *caryophyllaceous*, where the petals have long, narrow, tapering claws (Fig. 532), enclosed in the calyx, as in the Carnation (Fig. 404, p. 170), Pink, and Catchfly; *cruciferous* or *cruciate*, in which there are four petals, usually with claws (Fig. 513, p. 202), and arranged in the form of a cross, as in common Stock (Fig. 460, p. 190, and Wallflower (Fig. 479, p. 194).

273. Among the *irregular* forms of polypetalous corollas, the fol-

Fig. 528.

Fig. 529.

lowing deserves attention:—The *papilionaceous* (butterfly-shaped) corolla, as seen in the Pea (Fig. 297, p. 128, and Fig. 452, p. 187), in various kinds of Broom (Fig. 533), and in the Judas-tree (Fig. 534), consisting of five parts, differing in size and shape, the upper (Fig. 535), called the *standard* (vexillum), the lower (Fig. 536), called the

Fig. 528. Fascicled Cyme of Tobacco (*Nicotiana Tabacum*), shewing an expanded funnel-shaped (infundibuliform) flower, surrounded by the calyx at the base. There are two parts of the corolla; the tube, *t*, formed by the united claws of the petals. and the five-lobed limb, *l*, formed by the union of the laminæ.

Fig. 529. Flower of a species of Rock-rose (*Cistus creticus*), shewing a polypetalous rosaceous corolla, composed of five petals like those of the rose, having no claws. The Hebrew word *Lot*, which has been translated Myrrh in Gen. xxxvii. 25, and xliii. 11, is supposed to mean Ladanum, which is an odoriferous resin procured from this plant

keel (carina), formed of two partially-united petals, and the two lateral (Fig. 537), called *wings* (alæ).

274. In Monocotyledonous plants the coloured perianths are often polyphyllous, and there is a peculiar irregular kind which is met with among Orchids. It may be called the Orchideous perianth, and consists of six parts, one of which, called the *labellum*, presents many remarkable forms. It is shewn in Figures 538 and 539, the former of which represents an Orchis, with its labellum, *l*, and a spur, *s*, and the latter the flower of Twayblade, with a large bifid labellum, *l*. The labellum varies much in form. In Cypripedium it is hollowed like a slipper, and is called *calceolate*.

275. Gamopetalous corollas are also divided into *regular* and *irregular* forms. In the former the parts are equal in size, and equally

Fig. 531.

Fig. 530.

Fig. 532.

Fig. 533.

united, while in the latter they are unequal in these respects. Regular forms are *bell-shaped* (campanulate), that is, shaped like a bell, and swelling out regularly from base to apex, as in the Hare-bell

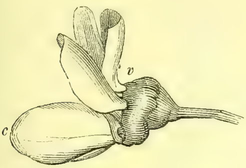
Fig. 530. Rosaceous corolla of the Strawberry (*Fragaria vesca)*, composed of five petals without claws. The points of the calyx are seen alternating with the white petals.

Fig. 531. Flower of Lily *(Lilium album)*, composed of six coloured pieces, in two rows. The outer row may be called the calyx, the inner the corolla. The latter consists of three leaves (petals), which taper gradually towards the base, and the corolla is called liliaceous.

Fig. 532. Petal of the Carnation (*Dianthus caryophyllus*), with a long narrow tapering claw, *c*; a corolla having petals of this kind is called caryophyllaceous.

Fig. 533. Flowering branch of a kind of Broom (*Genista monosperma)*, shewing papilionaceous flowers like those of the pea. The plant has wand-like branches, and a few linear leaves, and is the *Rothem* or *Rotem* of the Old Testament, translated Juniper (1 Kings xix. 4, 5; Job xxx. 4; Psalm cxx. 4).

(Fig. 540); *funnel-shaped* (infundibuliform), in which the tube is narrow below, and expands towards the summit, as in Tobacco (Fig. 541); *tubular*, or nearly uniformly cylindrical, as in some composite flowers (Figs. 542 and 543); *salver-shaped* (hypocrateriform), when



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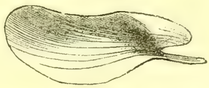

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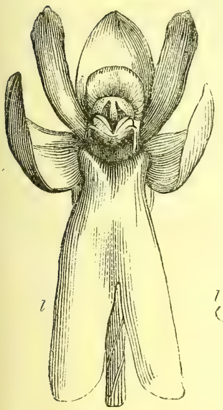

Fig. 539.

Fig. 538.

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Fig. 541.

the limb or lobed portion spreads out at right angles to the tube, which is long, as in Auricula and Primrose; and *wheel-shaped* (rotate), when

Fig. 534. Papilionaceous flower of the Judas-tree (*Cercis Siliquastrum*), with the vexillum, *v*, situated within the two alæ (lateral petals) in place of enclosing them. The keel, *c*, is formed of two petals.

Fig. 535. The Standard (vexillum), or upper petal of the papilionaceous flower of Broom (*Sarothamnus scoparius*). It is cordate at the base. The alæ are overlapped by it in the bud, or, in other words, the æstivation is vexillary.

Fig. 536. Keel (carina) of the papilionaceous flower of the Broom, composed of two petals united partially, in a boat-like manner, and having two thread-like stalks at the base.

Fig. 537. One of the wings (alæ) of the papilionaceous flower of the Broom. It has a projecting portion at the base, and a narrow thread-like stalk.

Fig. 538. Irregular polyphyllous spurred perianth of Orchis. It consists of six parts, one of which, *l*, called the labellum, differs much from the rest, and gives a peculiar character to the flower. A spur, *s*, extends backwards from the labellum. The ovary, *o*, is inferior, *i.e.*, below the divisions of the perianth.

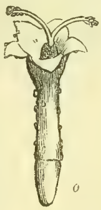
Fig. 539. Flower of Twayblade (*Listera ovata*), seen in front, shewing a large bifid labellum, *l*, which is different from the other five divisions of the perianth. The divisions of the perianth are in two rows of three each. The essential organs of reproduction are placed on a column opposite the labellum. The perianth is irregular polyphyllous, and is denominated Orchideous.

Fig. 540. Regular gamopetalous bell-shaped (campanulate) corolla of Harebell (*Campanula rotundifolia*). It is composed of five petals united. The ovary is inferior, and is united to the calyx, *c*.

Fig. 541. Regular gamopetalous funnel-shaped (infundibuliform), corolla of Tobacco (*Nicotiana Tabacum*). It is composed of five petals united. The calyx, *c*, below, consists of five sepals united.

a salver-shaped corolla has a very short tube, as in Forget-me-not (Figs. 544 and 545). There are also intermediate forms, as in Comfrey (Fig. 546), in which the corolla is campanulately-tubular, presenting a combination of the bell-shaped and tubular forms.

276. Irregular gamopetalous corollas, are seen in the *lipped* (labiate and bilabiate) forms, in which the union of the petals takes place in such a way as to produce an upper and lower portion, with a gap (hiatus) between them, like the mouth of an animal (Figs. 547



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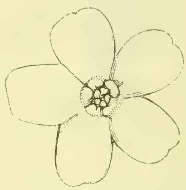

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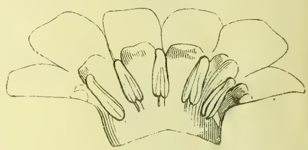

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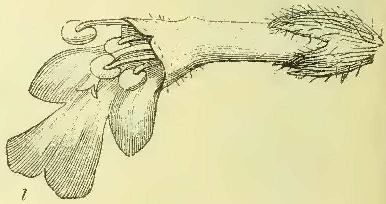


Fig. 542. Fig. 546. Fig. 547. Fig. 548.

and 548). The upper lip is usually composed of two petals, the lower of three. The same form is met with in the calyx (Fig. 489, p. 197), but the number of parts in the lips is reversed. A labiate corolla

Fig. 542. Regular gamopetalous tubular corolla of one of the flowers of Ragwort (*Senecio*). The single-seeded ovary, *o*, is united to the tube of the calyx, while the limb of the latter is seen above the ovary in the form of hairs (pappus) surrounding the corolla. In the centre of the flower above are seen the stamens united into a tube, through which the style passes before it ends in a bifid stigma, *s*.

Fig. 543. Tubular gamopetalous corolla of one of the flowers of Milfoil (*Achillæa*), with the inferior ovary, *o*, and the obsolete limb of the calyx.

Fig. 544. Regular gamopetalous wheel-shaped (rotate) corolla of Forget-me-not (*Myosotis*), consisting of five petals united, with a very short tube. Scales are seen at the throat.

Fig. 545. The wheel-shaped corolla of Forget-me-not (*Myosotis*) laid open to show the short tube, the five stamens attached to the corolla, and the five scales on the petals alternating with the stamens.

Fig. 546. Campanulate tubular corolla of Comfrey (*Symphytum*). It may be considered as combining the bell-shaped and the tubular forms of gamopetalous corolla. It is composed of five petals united, and is surrounded by a five-partite calyx at the base.

Fig. 547. Irregular gamopetalous labiate corolla of the Dead-nettle (*Lamium album*). The upper lip, *u*, is composed of two petals united, the lower lip, *l*, of three. Between the two lips (labia) there is a gap (hiatus). The throat is the part where the tube and the labiate limb join. From the arching of the upper lip this corolla is called ringent.

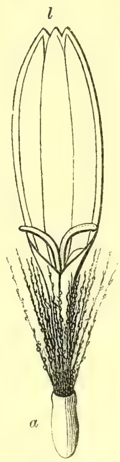
Fig. 548. Irregular gamopetalous labiate corolla of Bugle (*Ajuga reptans*). In this plant the upper lip is nearly awanting, and the stamens are seen, two long and two short, projecting beyond the tube. The lower lip, *l*, is formed of three parts, and is said to be three-lobed.

or calyx, with the upper lip much arched, like a helmet (galea), is

Fig. 549.

Fig. 550.

Fig. 551.



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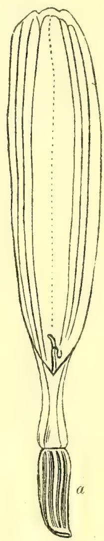


Fig. 553.

said to be *ringent* (Fig. 547). Sometimes the upper lip is very short

Fig. 549. The labiate corolla of the white Dead nettle (*Lamium album*), seen in front, shewing the two lips, *u* and *l*, the gap and throat, as well as the didynamous stamens. The calyx below is also irregular, three parts forming a sort of upper lip, and two forming a lower.

Fig. 550. Irregular gamopetalous labiate flower of Germander (*Teucrium*), seen in profile. The upper lip, *u*, is short, and the stamens, *s*, are much exserted beyond it, the lower lip, *l*, is patent (spreading), and three-cleft.

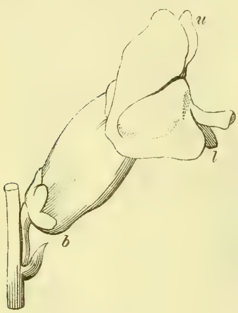
Fig. 551. Flowering raceme of Frogsmouth (*Antirrhinum majus*). The flowers have irregular gamopetalous personate corollas, the lower lip, *l*, with its three parts being pushed upwards on the dimerous upper lip, *u*, so as to leave only a chink between them. The convex projecting portion of the lower lip is called the palate, which is frequently coloured differently from the rest of the corolla. The corolla is also gibbous (saccate) at the base, *b*, on one side.

Fig. 552. Irregular gamopetalous ligulate flower of Ragwort (*Senecio*). It is a tubular floret, split down on one side, with the united petals forming a strap-like projection, *l*. The lines on the flat portion indicate the divisions of the five petals. From the tubular portion below, the bifid style projects slightly. The terete fruit (achænium), *a*, is surmounted by pilose pappus, which is the metamorphosed calycine limb. The flower is female, having no stamens.

Fig. 553. Ligulate flower of Ox-eye (*Chrysanthemum*). It is a tubular floret split down on one side. The fruit, *a*, is adherent to the tube of the calyx, and the calycine limb is obsolete. There is no pappus. The flower is pistilliferous.

and nearly awanting, as in Bugle (Fig. 548), and in Teucrium (Fig. 550, *u*). When the lower lip is approximated to the upper, so as to leave only a chink (rictus), with a projecting portion below it, called the palate, the corolla is denominated *masked* (personate), as seen in Frogsmouth (Fig. 551). In Calceolaria there is a peculiar irregular corolla with two hollow lips. When a tubular corolla is split down on one side (Figs. 552, 553, and 554), as in the white florets of the Daisy, it is called *strap-shaped* (ligulate). This kind of corolla is well seen in composite flowers, such as the Dandelion (Fig. 361, p. 153), in which all the flowers forming the head are ligulate, and the Marygold (Fig. 371, p. 156), in which the outer flowers forming the ray are ligulate, while the central are tubular.

277. The lower part of some gamopetalous corollas, such as Valerian (Fig. 496, p. 198) and Frogsmouth (Fig. 555, *b*), projects in the form of a bag or sac, and is called saccate or gibbous. Sometimes the projecting part assumes the form of a spur (calcar), as in Red Valerian (Fig. 556, *c*), and Snap-dragon (Fig. 557, *c*). In some gamopetalous



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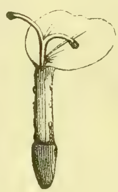

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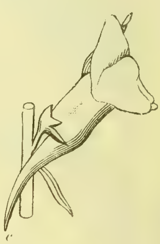

Fig. 557.

Fig. 556.

corollas there is a very slight irregularity of form. Thus, in Digitalis (Fig. 558), the corolla has a somewhat campanulate form, but its development is not equal; the Speedwell (Fig. 559) has a form nearly rotate, but the lobes are unequal; the Bugloss (Fig. 560) has a funnel-shaped corolla with a curved tube. In some gamopetalous corollas with a single spur, it happens occasionally, that what are called Pelorian varieties occur in which five spurs are produced. This occurs in common Snap-dragon frequently, as well as in species of Frogsmouth.

Fig. 554. Ligulate flower of Milfoil (*Achillæa*), with the forked style projecting beyond the tube. There is no pappus. The flower is pistilliferous (female).

Fig. 555. Personate corolla of Frogsmouth (*Antirrhinum majus*), shewing the gibbous base, *b*, of the corolla. The lower lip, *l*, is pushed up on the upper, *u*, leaving a chink (rictus).

Fig. 556. Irregular gamopetalous flower of Red Valerian (*Centranthus ruber*), shewing the projecting spur, *c*, at the base. A stamen and a style are seen projecting beyond the flower above. The flower is monandrous and monogynous. The corolla consists of five united petals, the calyx limb forms a ring at the top of the ovary, and it finally becomes a feathery pappus crowning the fruit.

Fig. 557. Irregular gamopetalous personate flower of Snap-dragon (*Linaria*), with a long spur, *c*, (calcar) at the base. The corolla is denominated spurred or calcarate.

278. In Grasses and Sedges the arrangement of the parts of the flower is peculiar. In place of verticillate leaves forming the flower, there are alternate scales or glumes. The flowers of grasses usually occur in spikelets (Fig. 561), which consist of one or two glumes, *a*, covering several flowers, *b*. In Wheat (Fig. 384, p. 160), these spikelets are arranged alternately along a common rachis. Each spikelet consists of two glumes, having the form represented in Figure 562, and enclosing flowers which are composed of scales (paleæ or glumellæ), delineated in Figures 563 and 564—the former being the outer, and,

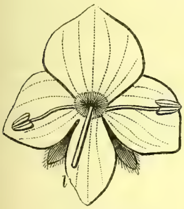

Fig. 559.

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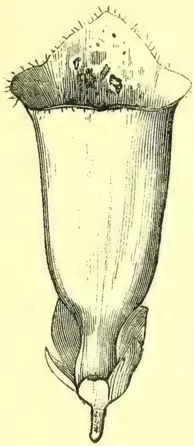

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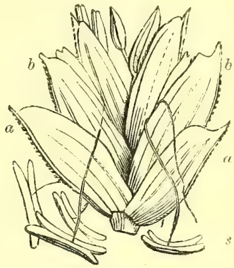

Fig. 561.

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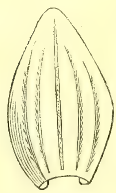

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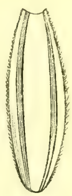


Fig. 564.

the latter the inner pale or glumella—which are placed at different heights in an alternate manner. In the flower of the Oat (Fig. 565),

Fig. 558. Irregular gamopetalous somewhat bell-shaped corolla of Fox-glove (*Digitalis purpurea*). The limb of the corolla is oblique, and there is a short tube below. The corolla has sometimes been called Digitaliform.

Fig. 559. Irregular gamopetalous wheel-like corolla of Speedwell (*Veronica*). The irregularity consists in the different sizes of the lobes of the corolla, especially the lower lobe, *l*, which is much smaller than the rest. There is an approach to a lipped corolla. The stamens are two, and the style one, so that the flower is Diandrous and Monogynous.

Fig. 560. Gamopetalous corolla of Bugloss (*Lycopsis arvensis*), with a curved tube. The corolla is somewhat funnel-shaped, with its mouth closed by connivent convex scales, its limb being five-lobed. The calyx is five-partite.

Fig. 561. A spikelet of Wheat (*Triticum*), consisting of two glumes, *a a*, enclosing several flowers, *b b*, which are composed of two pales (paleæ) covering the essential organs of reproduction. The stamens, *s*, hang out by long slender thread-like filaments. The individual glumes and paleæ are placed alternately on the floral axis.

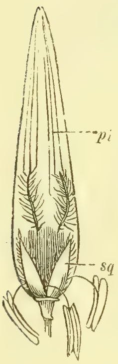
Fig. 562. One of the glumes of Wheat (*Triticum*), seen in profile. These glumes are bracts or floral leaves which constitute the outer covering of the spikelet. They are placed at different levels, following the law of alternation. The glume is marked with three ribs.

Fig. 563. External (outer) palea or glumella of the flower of Wheat. It is a glumaceous scale marked with two ribs on each side of the midrib.

Fig. 564. Internal (inner) palea or glumella of the flower of Wheat. It is thinner and more membranous than the outer glumella, its edges are folded inwards, and its apex is bifid.

after removing the outer pale or glumella, the inner one, *pi*, is seen with two scales (lodiculæ or squamæ), *sq*, at the base, enclosing the essential organs of reproduction. In Carices the male flowers are borne on scales, and so are the female, as shown in Figure 566, in which the scale, *s*, is placed on one side. Within the scale the female flower is situated, having a peculiar bag-like covering, *u*, termed perigynium.

279. *Abnormalities in the Corolline Whorl.*—The parts of the corolla are frequently adherent to those of the calyx, and any change taking place in the latter also causes an alteration in the former. Petals are sometimes suppressed. Thus, Seringe describes a flower of Diplotaxis tenuifolia, with two petals suppressed. The flower of the Haricot has been noticed wanting the carina, and in the blossom of a Pea, Moquin observed the disappearance of all the parts except the standard. Sometimes the entire corolla is wanting. This occurs normally in apetalous



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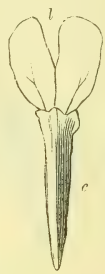

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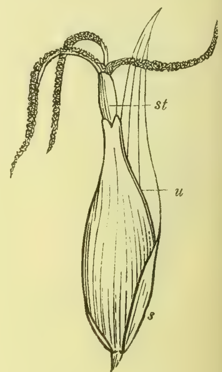

Fig. 566.

monochlamydeous flowers, such as Chenopodium (Fig. 412, p. 174). It also occurs accidentally. Linnæus mentions the absence of the corolla in Campanula perfoliata, and Ruellia clandestina. The same

Fig. 565. Flower of Oat (*Avena sativa*), with the two glumes, and the outer glumella or palea removed. The inner glumella or palea, *pi*, is seen, of a lanceolate form, and bidentate at the apex. The outer glumella has a long twisted geniculate dorsal awn, with two points or bristles at the summit. By removing this glumella there are seen two scales (lodiculæ, squamæ), *sq*, with the three stamens and two feathery styles.

Fig. 566. Female (pistilliferous or pistillate) flower of a Sedge (*Carex*), with a single glume or scale, *s*. The pistil is covered by an urceolate glumaceous bag, *u*, called perigynium. There is one style, *st*, with three stigmas at its summit.

Fig. 567. Regular gamopetalous corolla of Comfrey (*Symphytum*), laid open, shewing the tube, *t*, and the limb, *l*. At the part where the tube and limb unite, the five stamens are placed, attached to the corolla (epicorolline). Between the stamens, and alternating with them, are five coloured scales, which, being opposite the lobes of the corolline limb, are supposed to be formed by transverse chorisis or dilamination. These scales were called nectaries by Linnæus. They are looked upon as modifications of the petals.

Fig. 568. Unguiculate (clawed) petal of Campion (*Lychnis*), with a bifid lamina, *l*, and a scale at the part where the claw, *c*, and lamina unite. This coloured scale is supposed to be produced by transverse chorisis from the petal. It was called nectary by Linnæus.

abnormality has been observed in the March-Violet, and other species of Viola, in Chickweed, Jacob's-ladder, Teucrium Botrys, Lamium amplexicaule, Rosa centifolia, and Melilotus officinalis. In Amorpha and Afzelia the corolla is reduced to a single petal, and in some other leguminous plants it is entirely awanting. In the natural order Ranunculaceæ, some genera, such as Ranunculus, Globe-flower, and Pæony, have both calyx and corolla, while others, such as Clematis, Anemone, and Caltha, have only a coloured calyx; and in a third set, such as Hellebore, Aconite, and Larkspur, the petals assume remarkably abnormal forms.

280. Petals, which are in general coloured, sometimes become green. This has been observed in the flowers of Fraxinella, of Rampion, and of several species of Shepherd's Club. A corolla, normally gamopetalous, is sometimes divided into separate petals. The flower of Cobæa scandens has been observed divided into five petals, and the corollas of Campanula media and of Rhodora canadensis are occasionally deeply divided.

281. Flowers become double by the multiplication of the parts of the corolline whorl. This arises in general from a metamorphosis of the stamens. It is very common in the natural orders Ranunculaceæ, Papaveraceæ, Magnoliaceæ, Malvaceæ, and Rosaceæ; whilst it is rare in Leguminosæ. The tendency to produce double flowers is sometimes very strong; thus Kerria japonica in cultivation is never seen except with double flowers.

282. Union of separate flowers (synanthos) occasionally occurs, and the adhesion which thus takes place causes various changes in the whorls. Flowers may be united by their peduncles, as seen in some anomalous specimens of Dandelion, Hyacinth, and Centaury; or by their outer parts, such as the calyx. At other times there is a complete fusion, as it were, of all the parts of the flowers, some continuing normal, others being suppressed or abortive. It is rare to find the number of parts exactly double that of the flower in the cases when two flowers are joined, or triple when three are united. Martins noticed the union of two flowers of Petunia violacea, in which, in place of ten parts, there were eight sepals, eight divisions of the corolla, and eight stamens. Jussieu gives instances of synanthos in the Periwinkle with the parts varying in number from six to eight. Flowers of Frogsmouth have been seen with seven lobes of the corolla, and seven fertile stamens; also with eight divisions of the calyx, eleven lobes of the corolla, and eight stamens. The union of three flowers of Lilac has produced a flower with eleven lobes of the corolla, and three pistils. Examples of synanthos are common in species of Ranunculus, Aconite, Digitalis. In the latter we often find three or more flowers united at the apex of the raceme, and expanding before the others; thus exhibiting an instance of definite, in place of indefinite, expansion.

283. Connected with the inner surface of the petals, there are

placed occasionally appendages in the form of scales or filamentous processes. These are considered as being modified petals, and they are usually traced to transverse chorisis, in consequence of their being placed opposite to the petals. In many of the Borage order, such as the Comfrey (Fig. 567), Forget-me-not (Figs. 544 and 545, p. 208), Bugloss (Fig. 560, p. 211), and Hound's-tongue, as well as in the Chickweed tribe (Fig. 514, p. 202, and Fig. 568), and in the Crowfoot (Fig. 511, p. 202), petaline scales or lamellæ of this nature are observed, which, like many other processes connected with the flower, received, in the days of Linnæus, the name of Nectaries. Peculiar changes in an inner row of petals and in the stamens may also give rise to corolline appendages, as, for instance, in the beautiful fringes of the Passion-flower, in the crown of the Narcissus (Fig. 343, p. 147,

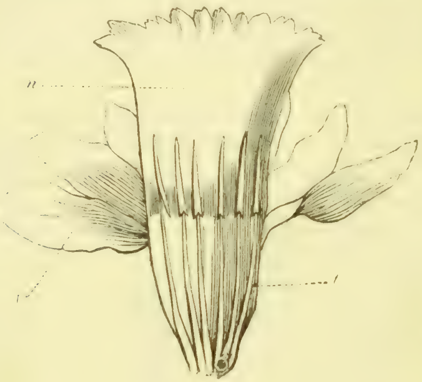

Fig. 569.

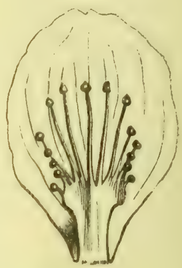

Fig. 570.

and Fig. 569, *n*), and in the glandular scales of the grass of Parnassus (Fig. 570).

284. General recapitulation of facts relative to the floral envelopes :—

1. The floral envelopes consist of the calyx and corolla—in other words, the calycine and corolline whorls, the parts of which alternate with each other.
2. When one of these only is present, it is the calyx, and hence such a flower is apetalous, or has no corolla.
3. When both envelopes are present, the flower is dichlamydeous; when one only is developed, monochlamydeous; when none, achlamydeous.
4. When the floral envelopes are in one whorl, or when both whorls are alike, as in many monocotyledons, the terms perianth and perigone are applied.

Fig. 569. Flower of Daffodil (*Narcissus Pseudo-narcissus*), laid open. The flower consists of a gamophyllous double coloured perianth, composed of six pieces, *l*. The tube of the perianth, *t*, bears the six stamens in two rows. From the tube there is produced a bell-shaped crown (corona), *n*, which has been called a nectary. It is supposed to be either a modification of the perianth, produced by transverse chorisis, or of the stamens.

Fig. 570. Petal of the grass of Parnassus (*Parnassia palustris*), bearing a remarkable fringed glandular scale, which may be considered as a modified petal, produced by transverse chorisis, or as an altered condition of the stamens. It has received the name of nectary.

5. The calyx consists of sepals which are separate in a polysepalous calyx, and united in a gamosepalous one.
6. The corolla consists of petals which are separate in a polypetalous corolla, and united in a gamopetalous one.
7. The sepals and petals follow the same law of development as the leaves, to which they are allied also in structure and form. They are arranged either in verticils or in spiral cycles having scarcely any internodes.
8. Irregularities in the calyx and corolla are caused by suppression or total absence of parts; by degeneration, so that the parts appear in the form of scales, hairs, or a mere rim; by abnormal development of parts in the form of spurs, foldings, and hollow tubes; by adhesion, in an irregular manner; by multiplication, or increase in number; and by chorisis, or splitting of parts.

4. ESSENTIAL REPRODUCTIVE ORGANS.

285. These organs constitute the inner whorls (verticils), and originate, like the floral envelopes, from the thalamus or torus (the upper part of the axis or peduncle), in the form of minute cellular processes. In their development they resemble leaves, but in general they differ much more in their appearance from the leaves than the

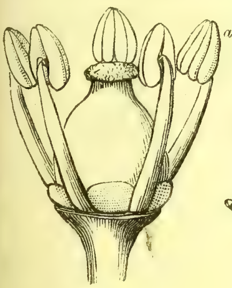

Fig. 571.

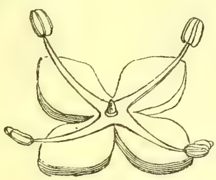

Fig. 573.

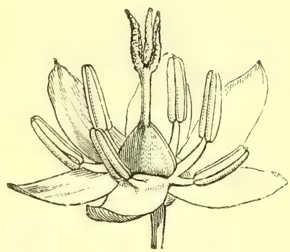

Fig. 572.

floral envelopes do. The essential organs are the stamens and pistil, as shewn in Figure 571, where there are five stamens arising from the thalamus, and surrounding one pistil. The stamens constitute the *Andrœcium*, and the pistil the *Gynœcium*.

286. These organs are necessary to form a perfect flower, and

Fig. 571. Andrœcium and Gynœcium, or, in other words, the essential organs (stamens and pistil) of the Vine (*Vitis vinifera*). There are five stamens, with introrse two-lobed anthers, *a*. The division between the anther-lobes is narrow, and corresponds to the midrib of the leaf. On the face of each lobe of the anther is seen the suture or line of dehiscence. The anthers are inserted into the thalamus (receptacle). Between the anthers at their base are scales forming the disk. These scales are probably abortive stamens. The ŏvary is large, style short, and stigma undivided.

Fig. 572. Flower of Wood-rush (*Luzula*), shewing six divisions of a glumaceous perianth (perigone), in two rows of three each; six stamens, with two-lobed introrse anthers, arranged in two rows alternately. The line in the middle of the anther shews the connective, and some of the lobes shew also the line of dehiscence (suture). The filaments become broader below. In the centre is the pistil with ovary, style, and three stigmas at the apex.

Fig. 573. Staminate, staminiferous, or male flower of Mulberry (*Morus nigra*), shewing a four-partite calyx, and four stamens, with long filaments, and two-lobed anthers. The flower is monochlamydeous, from absence of the corolla, and the stamens are opposite the segments of the perianth on account of the suppression of the corolline whorl.

without them no seed is produced in flowering plants. When, by

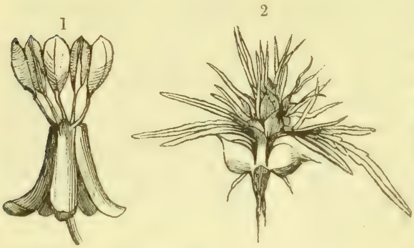

Fig. 574.

Fig. 575.

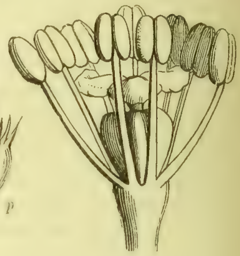

Fig. 577.

Fig. 576.

Fig. 578.

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Fig. 580.

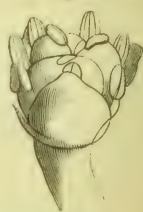


Fig. 581.

cultivation, they are changed into floral envelopes, the flower cannot

Fig. 574. Flowers of Hemp (*Cannabis sativa*), (1) staminiferous flower shewing reflexed perianth (calyx), and five innate (erect) stamens, with short filaments; (2) cluster of pistilliferous, or pistillate flowers, enclosed by bracts, each flower having a perigone split at the side, one ovary, and two pubescent styles.

Fig. 575. Pistilliferous or female flower of the Nettle (*Urtica*), consisting of a two-leaved perigone, *p*, with a single pistil. The Pistil consists of an ovary, and a sessile penicillate stigma, *s*.

Fig. 576. Pistillate flower of the Castor-oil plant (*Ricinus communis*), shewing one of the leaves of the perianth, with the bristly ovary in the centre, consisting of three uni-ovular carpels united. The fruit is called tricoccous, being formed of three cocci or single-celled carpels, which separate from each other in an elastic manner when ripe.

Fig. 577. Essential organs of Rhubarb (*Rheum*), shewing nine stamens, inserted on the thalamus (hypogynous), and the pistil in the centre. The filaments are long, and anthers two-lobed. The stigma is divided into three disk-like parts.

Fig. 578. Staminiferous flower of the Willow (*Salix*), shewing the bract, *br*, the two stamens, with a gland, *g*, at the base. The flower is diandrous.

Fig. 579. Pistilliferous flower of the Willow (*Salix*), shewing the bract, *br*, the stalked ovary, with style, *st*, and bifid stigma, *stig*, and a gland at the base, *g*. The flower is monogynous, having a single pistil. The Willow is diœcious, inasmuch as the male and female flowers are on separate plants.

Fig. 580. Male (staminiferous) flower of a Palm (*Chamærops*), shewing three divisions of the perianth, and six stamens in two rows. The two lobes of the anther are seen separated by the connective.

Fig. 581. Hermaphrodite flower of a Palm (*Chamærops*), shewing the perigone enclosing six stamens surrounding a three-celled pistil. The Palm is polygamous, having male, female, and hermaphrodite flowers

perform its proper functions. These organs are not, however, always present in every flower. When both are present in the same flower, it is *bisexual*, *hermaphrodite*, or *monoclinous* (Figs. 571 and 572), and is marked ☿. When one of the organs only is present, the flower is *unisexual* or *diclinous*, and is marked ♂ ♀; being called *staminate*, male or sterile, when the stamens alone are developed (Figs. 573 and 574, 1), as indicated by the mark ♂; and *pistillate*, female or fertile, when the pistil only is produced (Figs. 575 and 576), as indicated by the mark ♀.

287. It is necessary that there should be some communication between the stamens and pistil, so that the pollen or fertilizing

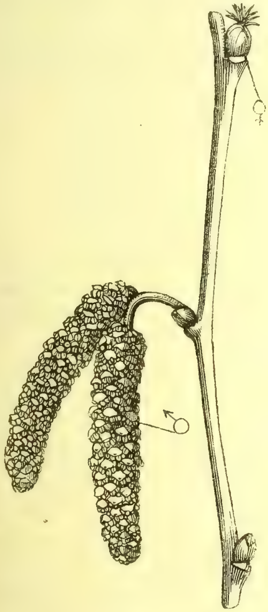


Fig. 582.

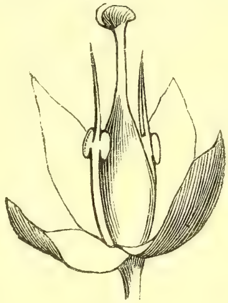


Fig. 584.

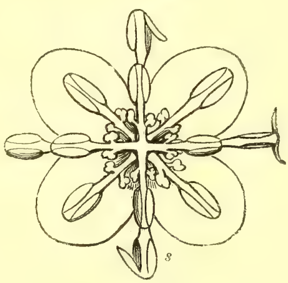


Fig. 583.

powder prepared by the former should be applied to the latter, which contains the rudiments of the seed. In the case of hermaphrodite flowers (Fig. 577) this is readily accomplished, as the two organs are close to each other. In the case of unisexual flowers, in which the staminiferous and pistilliferous flowers are on the same plant, and hence denominated *monœcious* (♂ ♀), such as the Hazel (Fig. 582), Oak

Fig. 582. Flowering branch of Hazel (*Corylus Avellana*), shewing catkins of male flowers, ♂, and female flowers, ♀. The tree is monœcious, having staminiferous and pistilliferous flowers on the same plant.

Fig. 583. Staminiferous flower of Laurel (*Laurus nobilis*). The perianth is in four divisions, the stamens twelve, in three rows, some of them introrse, others extrorse, opening by hinged valves, as shewn in stamen, *s*. Near the base of the stamens peculiar double glands are seen.

Fig. 584. Pistilliferous flower of Laurel (*Laurus nobilis*). The perianth has four divisions, there is a single pistil, and two abortive or rudimentary stamens.

(Fig. 269, p. 120), Cuckow-pint (Fig. 387, p. 161), Birch (Fig. 389, p. 161), and Indian Corn, the application of the pollen to the pistil may also be easily traced; while, in the case of unisexual flowers, in which the staminiferous and pistilliferous flowers are on separate plants, and hence denominated *diœcious* (♂ : ♀), such as the Willow (Figs. 578 and 579), Hemp (Fig. 47, p. 23, and Fig. 574, 1 and 2), and Poplar, the process of fertilization seems to be accomplished with more difficulty.* In the case of Palms it often happens that, while some flowers are staminate (Fig. 456, p. 188 and Fig. 580), and others pistillate (Fig. 457, p. 189), there are others which are perfect or hermaphrodite (Fig. 581); on this account such plants are called *polygamous* (☿ ♂ ♀). In all cases in which one of the whorls of the essential organs is absent, it is considered as depending on suppression or non-development; and this view is confirmed by the fact that, in many unisexual flowers, the rudiments of the suppressed organ may be seen (Fig. 584), and that in certain circumstances it is developed.

A. *Andrœcium or Staminal Organs.*

288. The stamens are placed immediately within the petals. When there is one whorl the stamens are usually equal in number to the petals, and alternate with them (Figs. 585 and 586). When the stamens are twice as many as the petals, they are in two whorls, alternating with each other (Figs. 587 and 588). When there are more than two whorls, each successive verticil alternates with that preceding it (Figs. 589 and 590). When, in place of being alternate with the petals, the stamens are opposite to them, as in the Primrose (Fig. 591), the abnormality is considered as depending, either on the suppression of an outer row, or on transverse chorisis of the petals, or vertical chorisis and union of the stamens. In some cases the stamens are supposed to be opposite the petals, when in reality they are in two rows, as well as the petals. Thus, in the Barberry (Fig. 592), there are six petals in two rows, and six stamens in two rows, and the law of alternation is observed. So also in the Tulip (Fig. 593), and many monocotyledons, with a six-leaved coloured perianth, in two rows, and six stamens.

289. In cases in which the stamens are not equal in number to the petals, the abnormality may be traced to suppression of a certain number, to abortion, adhesion, or chorisis. In Cruciferous plants there are four sepals, four petals, and six stamens, four of which are longer than the others (Figs. 594 and 595). It is supposed that in this case each pair of long stamens is in reality one which has been split by lateral chorisis. This is confirmed by finding teeth only on one side of the filaments of these stamens, while in the two shorter ones

* The facts connected with the application of pollen, and the fertilisation of the pistil, will be fully considered under Physiology.

teeth exist on both sides, and also by the fact that partial adhesions

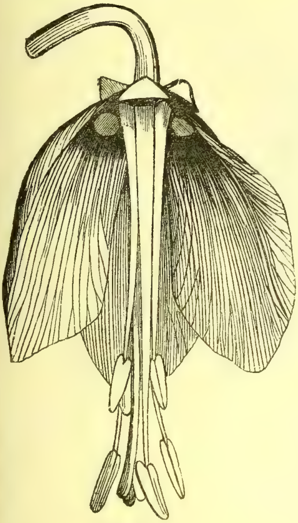


Fig. 587.

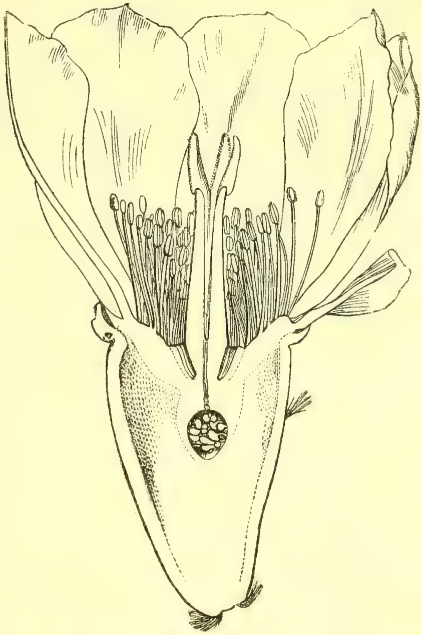
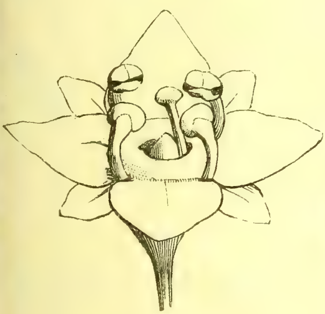


Fig. 589.



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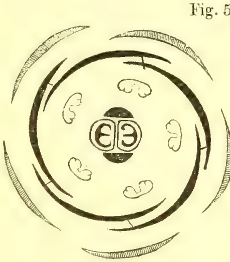

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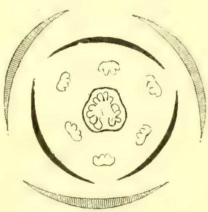


Fig. 588.

Fig. 585. Flower of Lady's mantle (*Alchemilla vulgaris*). It is tetramerous, having four divisions of the calyx or outer perianth, alternating with four of the corolla or inner perianth, and four stamens alternating with the latter. There is a ring and contraction at the opening of the tube of the perianth. The anthers open transversely. The style arises from the apparent base of the ovary, which is seen projecting slightly beyond the ring.

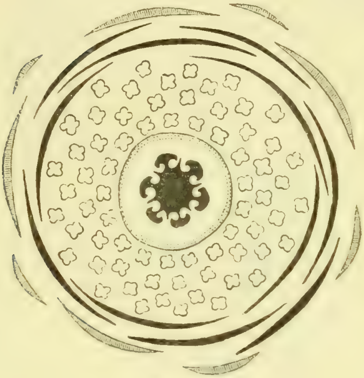
Fig. 586. Diagram of the flower of the Periwinkle (*Vinca*). There are five divisions of the calyx, alternating with five of the twisted corolla, five stamens alternating with the corolline segments, and two divisions of the pistil.

Fig. 587. Flower of Crown Imperial (*Fritillaria imperialis*) laid open. The perigone is in six parts, three of which have been removed. The three outer, one of which is left, may be called the sepals, the three inner, two of which are left, the petals. The stamens are double the number of the petals, and are in two rows. At the base of the petals rounded depressions exist, which are nectariferous glands.

Fig. 588. Diagram of the flower of Meadow Saffron (*Colchicum autumnale*). The divisions of the perianth are six, in two rows, and so are the stamens, while the pistil has three parts.

Fig. 589. Flower of Opuntia vulgaris, laid open vertically, showing numerous stamens attached to the calyx, which is adherent to the ovary and appears above it.

between them are sometimes seen, as in Streptanthus, and that some cruciferous plants have only four stamens.



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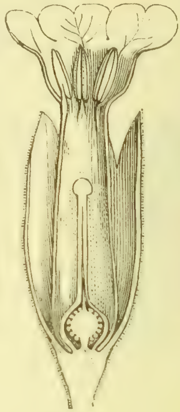

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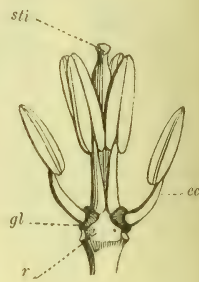


Fig. 595.

Fig. 592.

Fig. 594.

Fig. 593

290. A perfect stamen, consists of two parts, the *filament* (Fig.

Fig. 590. Diagram of the flower of Opuntia, showing the numerous divisions of the calyx and corolla, and the indefinite stamens arranged in a series of verticils.

Fig. 591. Flower of Primrose (*Primula*), cut vertically, showing the stamens, with very short filaments attached to the corolla, and opposite to its segments. This opposition is caused either by the suppression of an outer whorl of stamens, or by chorisis. The pistil is seen in the centre with ovary, style, and stigma, and a free central placenta, bearing numerous ovules or young seeds.

Fig. 592. Flower of Barberry (*Berberis vulgaris*). There are six petals in two rows, and six irritable stamens, also in two rows, following the law of alternation. The peltate stigma is seen in the centre.

Fig. 593. Andrœcium and Gynœcium of Tulip (*Tulipa sylvestris*). The Perigone is in six parts, three being external, representing the sepals, and three internal, representing the petals. The stamens are six, in two rows, an outer, *ee*, alternate with the petals, and opposite the sepals, while the inner row, *ei*, is alternate with the outer row, and consequently opposite the petals.

Fig. 594. Flower of Radish (*Raphanus sativus*), cut vertically, showing the two short stamens opposite to each other, and one of the pairs of long stamens, supposed to be formed by the lateral chorisis, or splitting of a single stamen. The plant is cruciferous and tetradynamous.

Fig. 595. Essential organs of Wallflower (*Cheiranthus Cheiri*). There are four long stamens in pairs, and two short ones, *ec*. The flower is tetradynamous. The receptacle or thalamus is marked *r*, glands at the base of the stamens, *gl*, and the stigma, *sti*.

596, *f*), representing the petiole of the leaf, and the *anther* (Fig. 596, *a*) analogous to the blade, containing minute cells, in the form of *pol-*

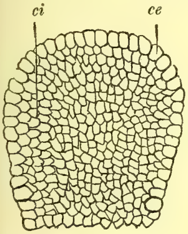
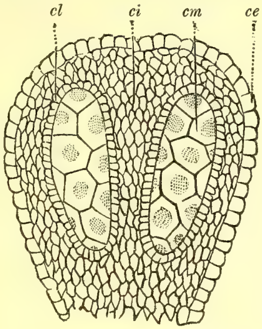


Fig. 597.



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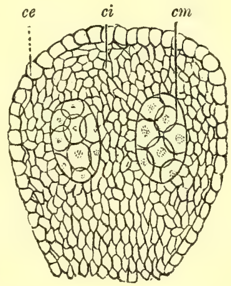

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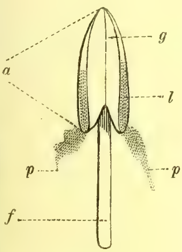

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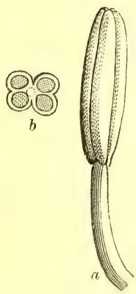


Fig. 602.

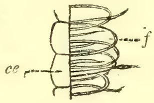


Fig. 601.

Fig. 600.

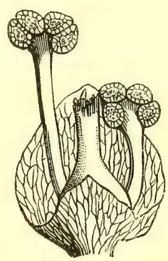


Fig. 603.

len (Fig. 596, *p p*). The filament, like the petiole, is sometimes wanting, and the anther is then sessile. The filament is usually arti-

Fig. 596. Stamen with its filament, *f*, anther lobes, *a*, connective or union of the lobes, *g*, suture or line of dehiscence, *l*, which is longitudinal and lateral, pollen or antherine fertilising powder, *pp*.

Fig. 597. Vertical section of the young anther of Melon (*Cucumis Melo*). It consists entirely of cells, some of which form an outer epidermal row, *ce*, and others fill up the interior, *ci*.

Fig. 598. Vertical section of an anther-lobe of the Melon in the progress of growth, shewing two large central cells, *cm*, filled with smaller nucleated cells. The outer epidermal layer, *ce*; the inner cells, *ci*, being partially absorbed.

Fig. 599. Vertical section of an anther-lobe of the Melon, shewing the two large central cells filled, with other cells, containing pollen, *cm*. The latter are called mother pollen-cells. The two large cells in the centre are now being surrounded by a special covering, *cl*, which constitutes ultimately the endothecium, or inner lining of the anther. The parenchyma, *ci*, is being absorbed. The outer epidermis, *ce*, constitutes the exothecium, or outer covering of the anther. The endothecium, and the cells between it and the exothecium usually contain spiral fibres.

Fig. 600. Cell containing a spiral fibre coiled up in its interior. Such cells constitute the inner antherine lining.

Fig. 601. Broken down fibrous cells, *f*, of the endothecium of the anther of the Melon. The walls of the cells are absorbed, and the fibres are set free. The exothecium or outer epidermis is marked, *ce*.

Fig. 602. Quadrilocular or Tetrathecal anther of the flowering Rush (*Butomus umbellatus*). The anther entire, *a*, with its filament; section of anther, *b*, showing the four loculi.

Fig. 603. Flower of Duckweed (*Lemna*), showing the two stamens, with quadrilocular anthers. The pistil is in the centre, and the whole flower is covered by a membranaceous urceolate (urn-like) spathe.

culated to the thalamus (Fig. 595, *r*), so that the stamen falls off after performing its functions; but in some instances it is persistent and not articulated. In the case of leaves, the petiole is sometimes united to the blade by a joint, and at other times it is continuous with it, and so it is in the case of the union between the filament and the anther.

291. In the filament cellular tissue exists in a condensed form, surrounding a central bundle of spiral vessels, which represents the fibro-vascular system of the petiole. It has a thin epidermal covering, which sometimes presents stomata. Cellular prolongations also occur in the form of hairs, as in the Virginian Spiderwort (Tradescantia), Anthericum, and Verbascum where the stamens are called *stupose*, and in Anagallis tenella, where the hairs have a beautiful knobbed appearance.

292. The anther, like the lamina of the leaf, is developed before

Fig. 604.

Fig. 605.

Fig. 606.

its stalk. It consists originally of a cellular mammilla, containing a mass of thin-walled cells (Fig. 597, *ce* and *ci*). In the progress of growth larger cells are produced in the interior (Figs. 598 and 599, *cm*), forming four separate clusters, each of which is surrounded by a special cellular covering (Fig. 599, *cl*). These larger cells are destined for the formation of pollen, and the four places at which their development commences may be seen on a transverse section of a very young anther. These clusters of pollen-cells increase in size, and gradually cause absorption of the surrounding parenchyma (Figs.

Fig. 604. Andrœcium of Mallow (*Malva*). The stamens are monadelphous, *i. e.* united into one cluster by their filaments. The anthers are one-celled, and open by a slit all round. Some suppose that the anther lobes diverge at the base, and unite at the apex in such a way as to form a single cavity by obliteration of the septum. From its appearance the Andrœcium is sometimes called Columnar.

Fig. 605. Flower of Dead nettle (*Lamium*), cut vertically, showing one of the long and one of the short stamens, with the two antherine lobes in each, united by their base, so as to form apparently one cavity. The corolla is labiate, and the stamens didynamous.

Fig. 606. A branch of the long distractile connective of Sage (*Salvia*), bearing a single anther lobe.

598 and 599, *ci*). It generally happens that two of the adjacent clusters of pollen cells unite by obliteration of their special covering at one side, and thus ultimately two pollen cavities are found in the anther, in place of four.

293. In its fully developed state, the anther presents two *lobes* (Fig. 596, *l*), like the two halves of the blade of the leaf; these lobes being separated by a partition, called the *connective* (Fig. 596, *g*), representing the midrib, and consisting of cells and spiral vessels. Each anther lobe has one or two cavities, which are receptacles of the cellular grains of pollen. These cavities correspond to the large cells seen in Figure 599, *cm*, with their special covering, *cl*, which forms the inner lining of the anther case, called *endothecium.* This lining consists of spiral cells (Fig. 600), which are elastic, and assist in bursting the outer epidermal covering of the anther called *exothecium*, corresponding to the cells marked *ce* in Figures 598 and 599. In the cells of the endothecium, as the anther approaches to maturity, the membrane becomes sometimes obliterated, so that the delicate fibres alone are left, as is seen in the Melon (Fig. 601), and in Cobæa. These spiral fibres appear also to fill up the space between the two coverings in many full-grown anthers.*

294. Thus the anther represents the lamina of a leaf, with its two halves divided by a midrib, surrounded with a double epidermal covering (the inner being fibro-cellular), and containing cellular tissue, which assumes the form of pollen. When there are four cavities (loculi or thecæ as they are called) in the anther, they may be considered as representing the two halves of the leaf, each with its upper and lower stratum of cells. This division into four is seen in the young state of anthers, and is considered as the normal state. When it is seen in the fully developed anthers they are called *quadrilocular* or *tetrathecal* (Figs. 602 and 603). When, owing to obliteration of some of the partitions, only two loculi remain, as is very generally the case, the anther is *bilocular* or *dithecal* (Fig. 596, *a*).

295. It happens occasionally that, by the suppression of one lobe, as in Gomphrena, or by the disappearance of the partition between the two lobes, the anther becomes *dimidiate*, or one-celled. In the Mallow tribe (Fig. 604) the divergence of the base of the anther lobes, and their complete union at the apex, render them one-celled (unilocular, monothecal); while in Labiate plants (Fig. 605), by the turning of one of the lobes, a union takes place by their bases so that they form one cavity. The long connective of the Sage and other species of Salvia separates the anther lobes, so that each appears a monothecal anther (Fig. 606), one of which contains pollen, while the other is abortive.

296. The stamens vary in number, and names are given to flowers accordingly. Thus,—

* See Purkinje, de cellulis antherarum fibrosis, Vratislav. 1830.

A flower having	1 stamen is Monandrous	(Fig. 556, p. 210).	Hippuris.
„ „	2 stamens is Diandrous	(Fig. 578, p. 216).	Veronica.
„ „	3 stamens is Triandrous	(Fig. 561, p. 211).	Grasses.
„ „	4 stamens is Tetrandrous	(Fig. 573, p. 215).	Alchemilla.
„ „	5 stamens is Pentandrous	(Fig. 571, p. 215).	Primula.
„ „	6 stamens is Hexandrous	(Fig. 572, p. 215).	Tulip.
„ „	7 stamens is Heptandrous, as in Trientalis, and Æsculus.		
„ „	8 stamens is Octandrous, as in Heaths, and Epilobium.		
„ „	9 stamens is Enneandrous	(Fig. 577, p. 216).	Butomus.
„ „	10 stamens is Decandrous	(Fig. 448, p. 186).	Saxifrage.
„ „	12 stamens is Dodecandrous	(Fig. 583, p. 217).	Asarum.
„ „	20 stamens is Icosandrous	(Fig. 530, p. 206).	Strawberry.
„ „	numerous and indefinite stamens is Polyandrous ∞ (Fig. 589, p. 219). Poppy.		

The Greek numerals are prefixed to the word, meaning male, or stamen. In the common Mare's-tail there is only one stamen in each flower, while in Cereus nycticalus 400 have been counted. The

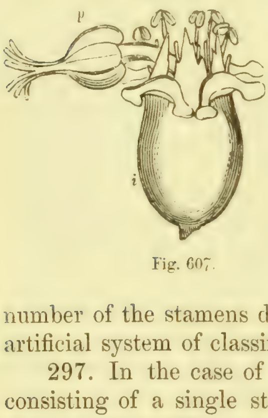


Fig. 607.

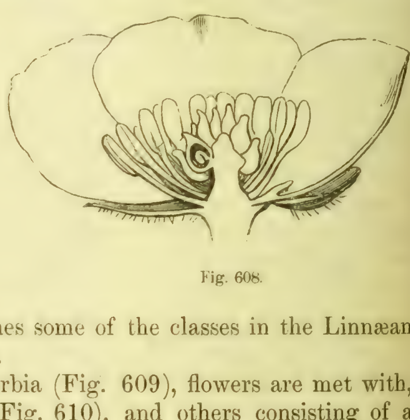


Fig. 608.

number of the stamens determines some of the classes in the Linnæan artificial system of classification.

297. In the case of Euphorbia (Fig. 609), flowers are met with, consisting of a single stamen (Fig. 610), and others consisting of a single pistil. These, when enclosed in one common involucre, or bracteal envelope (Fig. 607, *i*), seem to be stamens and pistils in the same flower. But on examination it is seen that a joint occurs at a part of the supposed filament (Fig. 610, *a*), indicating its connection with the peduncle, *p*, and so also in the case of the pistil (Fig. 607, *p*). In some of the species of Euphorbia a proper floral envelope appears at the joint indicating the true nature of the organ. The flowers represented in Figures 607 and 610 are therefore naked or achlamydeous male and female flowers on one plant, which is therefore said to be monœcious.

Fig. 607. Numerous male and one female flower, *p*, of Euphorbia, enclosed in a common involucre, *i*, composed of gamophyllous bracts. The plant is monœcious.

Fig. 608. Flower of Crowfoot (*Ranunculus*), cut vertically, shewing numerous stamens inserted into the receptacle (thalamus), below the pistil. The stamens are hypogynous. The flower is polyandrous.

298. The position of the stamens is normally within the petals, and outside the pistil. They arise from the part of the peduncle below the latter, and hence they are *hypogynous*, which means under the pistil (Figs. 608 and 611). But, as in all other parts of the flower, adhesions take place by which changes in apparent position are pro-

Fig. 609.

duced. Thus the stamens, in place of being free and truly hypogynous, sometimes adhere to the tube of the calyx, becoming *perigynous*, which means surrounding the pistil (Figs. 612 and 613); while at other times they adhere completely to the ovary, and appear to arise from the top of it, and are hence called *epigynous* (Figs. 614 and 615). When the stamens adhere still more completely to the pistil, the union

Fig. 609. Flowering stalk of Caper Spurge (*Euphorbia Lathyris*), shewing clusters of male and female flowers, surrounded by involucres. The plant yields milky juice of an acrid nature.

extending above the ovary, they become *gynandrous*, as in Orchis (Fig. 616), and Birthwort (Fig. 617), and form with the pistil a column in the centre of the flower.

299. In place of adhering to the contiguous organs, the stamens may be distinct from them, but united to each other either by their anthers or by their filaments. When the filaments are combined into one mass, more or less completely, the flowers are *monadelphous*, as in the Mallow (Fig. 618), and Yew (Fig. 619); when in two sets or bundles they are *diadelphous*, as in Fumitory (Fig. 359, p. 152), and in some papilionaceous flowers, in which the bundles are often unequal, nine stamens being united in one set, and only one (which is superior) in the other (Fig. 620); when in three sets, they are *triadelphous*, as in St. John's Wort (Fig. 621); and when in more sets *polyadelphous*, as in the Castor-oil plant (Fig. 622). The numerous stamens in the Mallow and St. John's Wort, and Castor-oil plant, are by some traced to collateral chorisis, or repeated divisions of the stamens. Sometimes

Fig. 610.

Fig. 611.

the filaments are united by means of an interposed membrane (a sort of crown), as in the Pancratium. When the stamens are united by their anthers, the flowers are termed *syngenesious* or *synantherous*, as in Compositæ (Fig. 542, p. 208), in Violet (Fig. 649, p. 234), and in Lobelia.

300. Stamens are often shorter than the corolla, and are then said to be *included* (Fig. 623); but at times they elongate and extend beyond it, when they are *exserted*, as in the Jalap plant (Exogonium Purga), and in Valerian (Fig. 624). In some flowers we find certain stamens constantly longer than others. Thus, in many Labiate flowers (Fig. 605, p. 222), and in Frogsmouth (Fig. 625), we meet with two long and two short stamens, the flowers being *didynamous*,

Fig. 610. Male flower of Euphorbia. The whole flower consists of a stamen, *b*, supported on a peduncle, *p*, to which it is united by an articulation at *a*. The flower is naked (achlamydeous). In some Euphorbias a perianth appears at the joint.

Fig. 611. Vertical section of the flower of the Poppy (*Papaver*). The stamens are numerous, indefinite, and inserted into the thalamus below the pistil. They are therefore hypogynous. The flower is polyandrous. The plant belongs (like Ranunculus) to the class Polyandria of Linnæus, and to the Dicotyledonous sub-class called Thalamifloræ by De Candolle.

and in Cruciferous flowers (Figs. 594 and 595, p. 220), there are four long and two short, the flowers being *tetradynamous*. Stamens in general stand regularly round the pistil, but occasionally their upper portions are curved to one side of the flower, and they become declinate, as in the Amaryllis and Horse-chestnut (Fig. 335, p. 143).

301. The filament is slender and cylindrical, or slightly flattened. It is curved and elastic in the Pellitory (Figs. 626 and 627) and in the Nettle (Fig. 628), petaloid in the White Water Lily (Fig. 629),

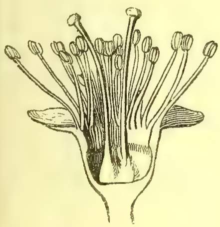


Fig. 612.

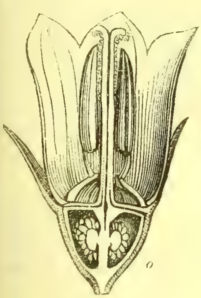


Fig. 615.

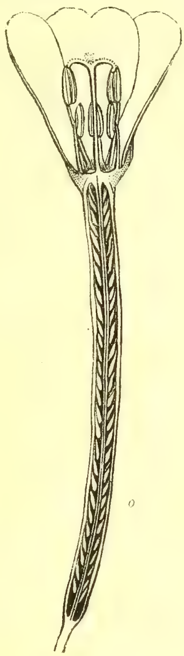


Fig. 614.

Fig. 613.

and in Indian Shot and Ginger, broadened at the base in Campanula (Fig. 630), thickened in Barberry (Fig. 645, p. 233), with appendages

Fig. 612. Vertical section of the flower of the Cherry (*Cerasus*). There are numerous indefinite stamens inserted on the calyx; hence they are perigynous. Some call such a flower Calycandrous, *i.e.*, having numerous stamens adherent to the calyx. In the centre of the flower is the pistil, composed of two carpels.

Fig. 613. Flowering branch of Apricot (*Prunus Armenaica*). The stamens are numerous and adherent to the calyx. The flowers are calycandrous, and the plant belongs to the class Icosandria of Linnæus, and to the Dicotyledonous sub-class called Calycifloræ by De Candolle.

Fig. 614. Flower of Willow-herb (*Epilobium*). The stamens appear to arise from the top of the ovary, *o*, and are called epigynous. They are adherent to the calyx, the tube of which is united closely with the ovary.

Fig. 615. Flower of Bell-flower (*Campanula*), cut vertically. The stamens appear to arise from the summit of the ovary, *o*, and are called epigynous. The tube of the calyx is adherent to the ovary. The lower part of the filament is broad, and conceals the upper part of the ovary when viewing the interior of the flower from above. On the style there are hairs which collect the pollen after it is scattered. The ovary is opened, and shows the placenta and ovules.

in Borage (Fig. 631) and Asclepias (Figs. 632 and 633). Some of the staminal appendages are traced to vertical and transverse chorisis. The filament is attached to the anther lobes, either by adhering along their whole length on one side, called the *back*, and the

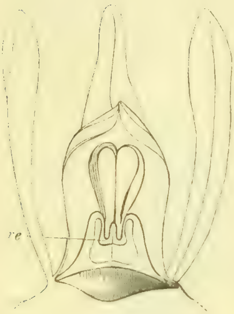


Fig. 616.

Fig. 618.

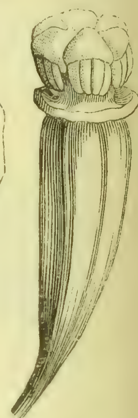


Fig. 617.

Fig. 620.

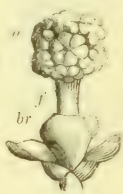


Fig. 619.

Fig. 621.

anther is then *adnate*, as in Magnolia, Crowfoot (Fig. 608, p. 224), and Barberry (Fig. 645, p. 233); or it extends only to the base of the lobes,

Fig. 616. Upper part of the Gynandrous flower of an Orchis. The stamen and pistil are united into a common column (Gynostemium). The lobes of the anther are placed immediately above the stigma. They contain pollen masses (pollinia), which are adherent to a point above the stigma, by means of a viscid tenacious matter, called retinaculum, *re.* Immediately below the anther is a viscid space constituting the stigma. The lower part of the column, with the ovary, have been removed.

Fig. 617. Essential organs of Birthwort (*Aristolochia*). The lower part of the figure is the ovary, and above it are the stamens united in a column with the style, so as to be gynandrous. On the summit is the stigma above the stamens.

Fig. 618. Vertical section of the flower of Mallow (*Malva*). The stamens are monadelphous, being united by their filaments into a cluster round the pistil.

Fig. 619. Male (sterile, staminiferous) flower of Yew (*Taxus baccata*). The bracts, *br*, at the base, are imbricated, the stamens are united into a bundle by their filaments, thus being monadelphous, while their anthers, *a*, are free. Some consider this a single stamen, with the connective dividing into numerous parts, each bearing an anther lobe.

Fig. 620. Stamens and pistil of Sweet Pea (*Lathyrus*). The stamens are diadelphous, nine of them being united by their filaments, *f*, while one of them, *e*, is free; the upper part of the pistil is marked, *st*, the calyx, *c*.

Fig. 621. Vertical section of the flower of St. John's Wort, in which the stamens are formed into three bundles by the union of their filaments. The flower is triadelphous. Two of the bundles are seen in the figures, the third having been removed. In the centre is the pistil, with the ovary containing ovules, ending in the style and stigma.

which are firmly fixed to it, and the anther is *innate*, as in Carex (Fig. 634), and Scirpus (Fig. 635), and Hemp (Fig. 574, 1, p. 216);

Fig. 622.

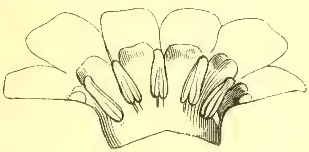


Fig. 623.

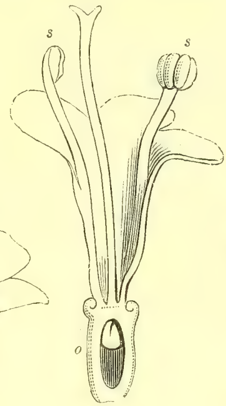


Fig. 624.

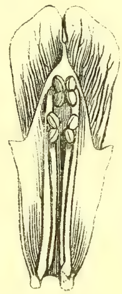


Fig. 625.

Fig. 626.

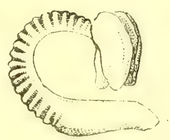


Fig. 627.

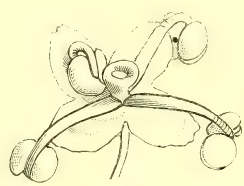


Fig. 628.

or its apex is attached to a single point of the anther, which then

Fig. 622. Male flower of Castor-oil plant (*Ricinus communis*). The perianth is reflexed, and the stamens are seen in numerous clusters, united by their filaments. The flower is polyadelphous. The different clusters are branching, owing to the filaments being united up to different heights.

Fig. 623. Corolla of Forget-me-not (*Myosotis*), laid open and spread out. The five stamens are included, *i.e.* not pushed out beyond the flower; they are attached to the tube of the gamopetalous rotate corolla, and their filaments are very short. Scales exist on the corolla, alternating with the stamens.

Fig. 624. Flower of Valerian (*Valeriana*), cut vertically. There are two exserted stamens, *s s*, left, which are epigynous, or attached apparently to the upper part of the ovary, *o*, which terminates in the style and bifid stigma. The ovule is pendulous.

Fig. 625. Didynamous flower of Frogsmouth (*Antirrhinum majus*), having two long and two short stamens. The anther lobes in each stamen are united by their bases, so that the line of dehiscence passes continuously through both. The stamens are attached to the corolla, and are said to be epicorolline. The flower is unsymmetrical, owing to the suppression of the fifth stamen.

Fig. 626. Male flower of Pellitory (*Parietaria officinalis*). It contains four stamens, the filaments of which are incurved in the early state, and ultimately bend back with elastic force, so as to scatter the pollen. There are four divisions of the perianth. The flower is monochlamydeous. The abortive rudiment of a pistil is seen in the centre.

Fig. 627. Stamen of Pellitory (*Parietaria*), with its two-lobed anther, and elastic curved filament.

Fig. 628. Male flower of Nettle (*Urtica*), with four stamens, having elastic incurved filaments in the young state. When the four-leaved perianth expands, the stamens, as shewn in the figure, bend outwards, and the anthers are pushed beyond the flower.

swings easily about, and is called *versatile*, as in Grasses (Fig. 637),

Fig. 629.

Fig. 630.

Fig. 631.

Fig. 632.

Fig. 634.

Fig. 633.

Fig. 636.

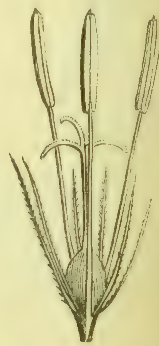


Fig. 635.

the Lily, the Meadow-saffron (Fig. 636, *b*), and the Evening Primrose.

Fig. 629. Section of the flower of the White Water Lily (*Nymphæa alba*). The receptacle ends in a large fleshy disk, *d*, covering the ovaries. Into this prolongation of the receptacle the petals and stamens are inserted. The filaments of the outer stamens are petaloid. In this flower there is a gradual transition from stamens to petals.

Fig. 630. Pistil and stamen of Bell-flower (*Campanula*). The filament of the stamen is dilated at the base. The calyx is attached to the ovary, *t*, which opens by slits through the calyx. The disk-like upper portion of the ovary is marked, *d*. On the style are numerous rows of hairs.

Fig. 631. Stamen of Borage (*Borago officinalis*). The anther lobes, *s*, are pointed, the filament is appendiculate, *i.e.*, is furnished with an appendage, *a*, in the form of a long slightly-curved process.

Fig. 632. Flower of Asclepias, shewing the united stamens surrounding the pistil. The stamens are furnished with remarkable hollow and horn-like appendages, *a*, which form a staminal crown. The petals and sepals, *p*, are reflexed.

Fig. 633. One of the stamens of Asclepias removed, shewing the filament, *f*, and anther, *a*, containing pollen masses, and the peculiar processes, *p*, which form an appendage to the stamen.

Fig. 634. Male flower of a species of Sedge (*Carex*). It consists of a glume or scale supporting three stamens, with slender thread-like filaments, and innate anthers.

Fig. 635. Flower of a kind of Club-rush (*Scirpus*). The glumaceous perianth has been removed, and there are seen six hypogynous toothed bristles, three stamens with innate anthers, and a single pistil with three stigmas at the summit of the style.

Fig. 636. Two stamens of Meadow-saffron (*Colchicum autumnale*), one, *a*, with the anther unmoved, the other, *b*, with the anther so placed as to show its versatile character, the filament being attached by a point.

302. The anther presents a groove or depression between its lobes, indicating the place where the septum or partition is situated (Figs. 628 and 638). Each anther lobe also presents a line or furrow running from top to bottom, and placed more or less laterally (Figs. 637 and 639). This is called the *suture*, or line of dehiscence, and marks the place where the anther opens to discharge the pollen. (Fig. 596, p. 221, and Fig. 640). The suture corresponds to the edge of the leaf, and in innate anthers it is lateral, while in others its position is more or less distinctly on the *face* of the anther (Fig. 571, p. 215), or on the side opposite to the attachment of the filament. At the suture the epidermal tissue is thin, and the endothecium is wanting.

303. The face of the anther is usually directed towards the centre of the flower, in which case the anther is called *introrse*, as in Magnolia, Nymphæa (Fig. 629, p. 230), and the Vine (Fig. 571, p. 215);

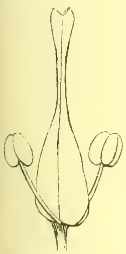


Fig. 638.

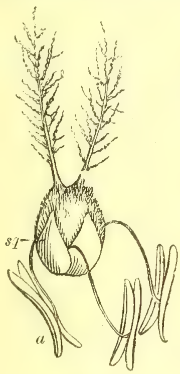


Fig. 637.

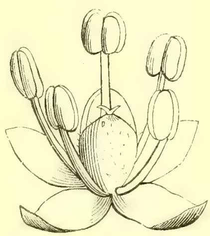


Fig. 639.

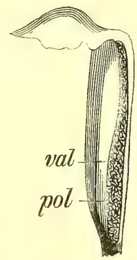


Fig. 640.

at other times it is directed towards the circumference of the flower, and the anther is *extrorse*, as in the Meadow-saffron (Fig. 641), in the Iris, and in the Tulip-tree (Fig. 259, p. 116). The mode of opening or of dehiscence varies in different anthers. Sometimes the lobes split along the whole face, either in the centre or at the side, longitudinally (Fig. 414, p. 174, and Fig. 640), at other times transversely (Fig. 642). Sometimes the slit only takes place at the apex, so as to present two holes or pores, as in Rhododendron and Solanum

Fig. 637. Grain of Wheat (*Triticum*), with its glumes and glumellulæ removed. Two scales or lodiculæ, *sq*, are seen at the base of the ovary. There are three stamens with thread-like filaments and versatile anthers, *a*, and two feathery styles at the summit of the ovary.

Fig. 638. Naked flower of the Ash (*Fraxinus excelsior*), shewing two stamens and one pistil. The anther has a groove on its surface indicating the separation between its two lobes.

Fig. 639. Flower of Goosefoot (*Chenopodium*), with a single perianth (monochlamydeous, or mono-perianthous), of five pieces, and five stamens shewing the two lobes of each anther, and the mark along the edges where the suture or line of dehiscence exists. The anthers open towards the pistil, which is in the centre. They are called antheræ introrsæ, or anticæ.

Fig. 640. Stamen of Fir (*Pinus*), shewing the line of longitudinal dehiscence, with the valve, *val*, and the pollen, *pol*, in the interior.

(Fig. 643), or four pores, as in Poranthera, or two tubes, as in the Heath (Fig. 644), or so as to form a separable lid, as in Gamboge. In Mayaca, the anther terminates in a tube one-third the length and diameter of the anther itself, and the pollen is discharged at the apex of the tube. In the Barberry (Fig. 592, p. 220, and Figs. 645 and 646), each lobe of the anther opens by a single valve, which is rolled upwards; and the same thing occurs in many Lauraceæ (Fig. 647), in which, however, there are frequently four valves, that is, two to each lobe, corresponding to the antherine cavities.

Fig. 641.

304. The union of the anther lobes is effected either by a continuation of the filament (Fig. 645), or by a mass of cellular tissue with spiral vessels, called the *connective* (Fig. 571, p. 215). This extends to a greater or less height between the lobes, and is sometimes so narrow as to be inconspicuous, as in Euphorbia. Sometimes it reaches beyond them in the form of a cellular expansion, as in Magnolia and Asarum, or of a long feathery appendage, as in Oleander (Fig. 648, *f*); while at other times it proceeds backwards in the form of a spur, as in the Violet (Figs. 649 and 650, *c*), and in the Heath (Fig. 644). In the Lime-tree it separates the two antherine lobes distinctly (Fig. 651, *a*). It divides into two branches occasionally, each bearing an anther lobe, as in Sage (Fig. 606, p. 222), and then it is *distractile*. The anther lobes are sometimes separated by the connective, so as to become horizontal, as in Stachys, and then their dehiscence appears to be transverse. The anther lobes present various forms, such as round (Fig. 639, p. 231), globose (Fig. 628, p. 229), elliptical (Fig. 636, p. 230), pointed (Fig. 631, p. 230, and Fig. 644), flexuose, as in the Gourd tribe (Fig. 652), and forked, as in Acalypha.

305. The *Pollen* is contained in the anther, and presents the appearance of a minute, usually yellow powder, which, when examined by the microscope, is found to consist of cellules (Fig. 653) of different forms, varying from $\frac{1}{300}$ to $\frac{1}{700}$ of an inch in diameter. Pollen-grains, when fully formed, are usually spherical (Fig. 662, p. 236), oval (Fig. 660, p. 236), or trian-

Fig. 641. Flower of Meadow-saffron (*Colchicum autumnale*), cut vertically. The perianth is double and coloured. Its tube, *t*, is very long. The stamens are attached to the tube, and the anthers open on the outside extrorsely. They are called antheræ extrorsæ, or posticæ.

gular (Fig. 664, p. 236). In Bladder-Senna they are of a square form, in Virginian Spiderwort cylindrical, and in the Hazel polyhedral. In Podostemon the pollen is of an oblong shape, with an hour-glass contraction in the middle; while in Zostera it is a beautiful microscopic object, consisting of long slender threads.

306. Pollen-grains are developed in the large cells seen in the early state of the anther (Figs. 598 and 599, *cm*, p. 221). Each of these cells is called a parent or mother cell (Fig. 654, *cm*). Its contents divide first into two, and then into four parts, each of which becomes covered with cellulose, so as to constitute independent cells or pollen-grains (Fig. 654, *p*). These grains either burst through the parent cell and become free, or they remain united in fours or some multiple of four, as in many species of Acacia; or in large masses, such as those

Fig. 642.

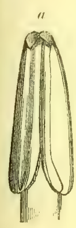


Fig. 643.

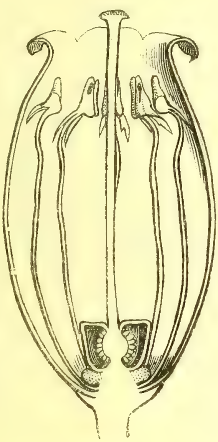


Fig. 644.

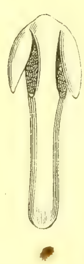


Fig. 645.

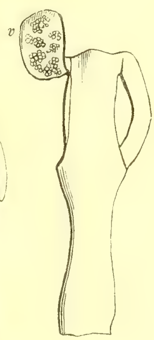


Fig. 646.

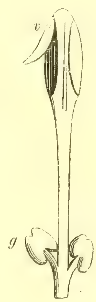


Fig. 647.

Fig. 648.

seen in Orchids (Figs. 655 and 656), and in Asclepias (Fig. 657), where they constitute *pollinia*. The remains of the partially destroyed mother cells sometimes remain in the form of threads.

Fig. 642. Stamen of Lady's Mantle (*Alchemilla*), with the anther opening transversely. It is called transversely-dehiscent.

Fig. 643. Stamen of a species of Nightshade (*Solanum*), showing the divergence of the anther lobes at the base, and the dehiscence by pores at the apex, *a*.

Fig. 644. Flower of Heath (*Erica*) cut vertically. The corolla is urceolate or urn-like; the stamens are eight in number; the anthers open in a porous manner by tubes at the apex, and from each connective two spur-like processes arise.

Fig. 645. Adnate anther of Barberry (*Berberis vulgaris*). The lobes of the anther open by hinged valves.

Fig. 646. The stamen of the Barberry (*Berberis vulgaris*), showing one of the valves of the anther, *v*, curved upwards, bearing the pollen on its inner surface.

Fig. 647. One of the stamens of the Sweet Bay (*Laurus nobilis*), in which the anthers open by recurved valves, *v*. These are generally four in number. At the lower part of the filament two anther-like stalked glands, *g*, are seen. These are probably an abortive state of the stamens.

Fig. 648. Stamen of Rose Bay (*Nerium Oleander*), with sagittate anther lobes, *a*, and a long feathery process, *f*, proceeding upwards from the connective.

307. Each pollen-grain has usually two coverings, the outer called *extine*, being a firm membrane marked frequently with bands, reticulations, or rough points (Fig. 658); the inner, denominated *intine*, being thin and capable of extension. The intine alone is present in Zostera, and some consider this covering as that first formed, the outer being a secretion from it. In the ripe pollen of the Fir (Fig. 659), the distension of the intine is such as to separate the extine into two hemispherical parts. Movements have been observed in the pollen grains of Cereus speciosissimus and some other plants, according to Dr. Horn. The motions have been attributed to minute papillose processes or cilia.

308. In the interior of pollen-grains a minute granular matter exists called *fovilla*, mixed with starch and oily matter. The fovilla granules vary from $\frac{1}{4000}$ to $\frac{1}{30000}$ of an inch in diameter. These display motions which are looked upon by some as molecular, or such

Fig. 653.

Fig. 651.

Fig. 649.

Fig. 650.

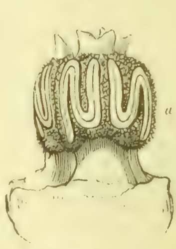


Fig. 652.

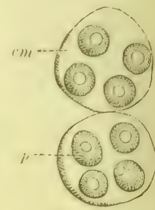


Fig. 654.

as are seen under the microscope among minute particles suspended in fluid, while by others they are regarded as analogous to the phytozoic movements seen in the antheridia of Cryptogamic plants.*

Fig. 649. The stamens and pistil of the Pansy (*Viola tricolor*). The five stamens have short filaments, and their anthers, *a*, are united into a tube round the pistil. Two of the stamens have spur-like processes, *c*, proceeding backwards into the corolline spur. The hooded stigma, *s*, is seen at the top of the pistil.

Fig. 650. Two stamens of Pansy (*Viola tricolor*), recurved, with their two anther lobes, and the process, *p*, extending beyond them. One of the stamens has been deprived of its spur, the other shows its spur, *c*.

Fig. 651. Stamen of the Lime-tree (*Tilia*). The two anther lobes, *a*, are separated by the connective at the end of the filament, *f*. Each lobe opens by longitudinal dehiscence.

Fig. 652. Stamens from the male flower of Melon (*Cucumis Melo*), with wavy or sinuous anther lobes, *a*. The anthers are said to be anfractuose.

Fig. 653. Pollen grains of Melon (*Cucumis Melo*), in various stages of development. No. 1, the grains in a young state, and free; No. 2, the grains farther advanced, and nearly ripe; No. 3, a pollen grain in a ripe state, fully developed.

Fig. 654. Parent cells, *cm*, from the anthers of the Melon, each containing four grains of pollen, *p*. The parent cell divides first into two by a merismatic process, and then each of these parts subdivides into two, thus forming four cells. The grains of pollen are represented with nuclei in their interior.

* See Annales des Sciences Nat. vol. xii. p. 40.

309. The surface of pollen-grains is often marked by grooves or folds (Figs. 660 and 661), and by rounded markings. At these parts the extine is either deficient, or separates like a lid, as in the Passion-flower. When the pollen is moistened in water its grains absorb it and become enlarged, and the intine bursts at one or more points, sending out the fovilla (Fig. 662). When the pollen is scattered on the pistil, and is moistened on one side by the fluid of the stigma (Fig. 663, *stig*), the intine, in place of bursting, protrudes in the form of a tube called a pollen-tube (Figs. 663, *tp*, 664, *t*, and 665, *b*). The number of tubes protruded in different kinds of pollen-grains varies. Amici says that the two pollinia (Fig. 656) of Orchis Morio contain each about 200 secondary small masses (Fig. 665, *a*), composed of grains united in fours, and that each of these small masses present 300 openings capable of emitting tubes.*

310. *Transformations of Stamens.*—Changes take place in the stamens by suppression and degenerations of various kinds. When-

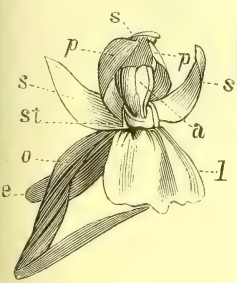


Fig. 655.

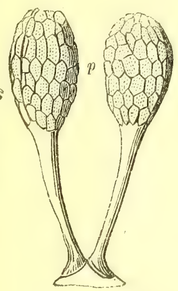


Fig. 656.

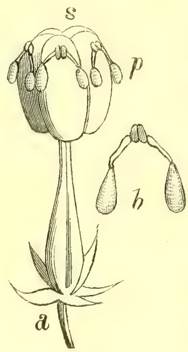


Fig. 657.

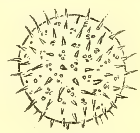


Fig. 658.

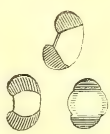


Fig. 659.

ever the stamens are below the number of the parts of the calyx, we may suspect that there has been some suppression. In many irregular flowers, such as Figwort and Dead-nettle, four stamens only occur, although the parts of the calyx and corolla are five. This depends on the suppression of one stamen, and, in the case of Figwort, we

Fig. 655. Flower of Orchis, consisting of sepals, *s s s*, petals, *p p*, and labellum, *l*, with its spur, *e*; the ovary, *o*, stigma, *st*, and anther, *a*, containing pollinia or pollen-masses.

Fig. 656. Pollinia, or pollen-masses, separated from the point above the stigma, with their retinacula or viscid matter attaching them at the base. The pollen-masses, *p*, are supported on stalks or caudicles. These masses are easily detached by the agency of insects.

Fig. 657. Pistil of Asclepias, *a*, with pollen-masses, *p*, adhering to the stigma, *s*. Pollen-masses, *b*, separated, united by a gland-like body.

Fig. 658. Round ripe pollen of Hollyhock (*Alcea*), with its extine covered with prominent points.

Fig. 659. Pollen of Fir (*Pinus*), in which, by the increase of the intine, the extine is separated into two hemispherical portions, marked by the dark spaces at each end of the grains.

* For fuller details regarding pollen, see Mohl, sur la structure et les formes des graines de Pollen, Annales des Sciences, 2d series iii. 148; Fritzsche de Plantarum Polline, Berolin. 1833, and ueber der Pollen, Petersburg, 1837; Hassall on the Structure of the Pollen Granule, in Annals of Nat. History; viii. 92; ix. 93, 544.

find a rudimentary stamen in the form of a staminodium, as shown in Figure 666, where a dark scale is seen attached to the corolla on the upper side. Again, in allied plants, such as Pentstemon, the fifth stamen is produced. In Labiate plants also, allied to the Dead-nettle, the fifth stamen sometimes appears in the form of a thread, terminated by an anther-like body, which, however, is barren. The stamens are suppressed in the case of pistilliferous flowers (Fig. 575, p. 216, and Fig. 579, p. 216). Sometimes they appear in such flowers in an altered and abortive state (Fig. 584, p. 217). The suppression of an outer row of stamens is often indicated by those remaining being opposite the petals (Fig. 458, p. 189). In flowers with numerous

Fig. 660.

Fig. 662.

Fig. 661.

Fig. 664.

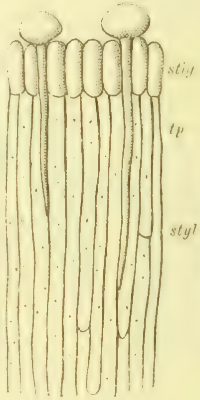


Fig. 663.

Fig. 666.

Fig. 665.

stamens, such as Poppies, Roses, and Crowfoots, there are always some of the stamens abortive, for we do not find two flowers in which the number is the same. It seems to be a law in vegetable organo-

Fig. 660. Elliptical pollen of Milk-wort (*Polygala*), viewed lengthwise. Its surface, or extine, *e*, is marked with grooves or slits, *f*, where the intine protrudes.

Fig. 661. The pollen of Polygala, viewed from above, shewing the extine, *e*, with the slits, *f*, for the protrusion of the intine.

Fig. 662. Ripe rounded pollen of Cherry (*Cerasus*), discharging its fovilla through a tubular opening formed by the intine. There are other two points at which the intine is seen protruding.

Fig. 663. Vertical section of the upper part of the pistil of Frogsmouth (*Antirrhinum majus*). Two pollen grains are seen lying on the stigma, *stig*, these send out tubes, *tp*, which pierce the stigma, and penetrate the tissue of the style, *styl*, until they reach the ovules or young seeds.

Fig. 664. Triangular pollen of Evening Primrose (*Œnothera*), with one pollen tube, *t*, protruded. This tube is formed by the intine which is also seen projecting at the other angles.

Fig. 665. Small pollen mass, *a*, of early purple Orchis (*Orchis mascula*). The grains are often united in four, or multiples of four. Pollen tube, *b*, arising from a pollen grain.

Fig. 666. Flower of Figwort (*Scrophularia*). The corolla is subglobose, with two short lips, the upper two-lobed with a scale or abortive stamen (staminodium) attached to it. The lower lip three-lobed, the two lateral lobes straight, and the middle one decurved. There are four developed stamens which are didynamous.

graphy that the number of the floral organs is less constant the greater it is. Instances of Bell-heath and Purple Snap-dragon have been mentioned in which the stamens were entirely abortive.

311. Stamens in some plants have a great tendency to be changed into petals, especially in cultivation. In plants belonging to the

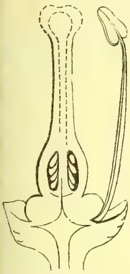


Fig. 669.

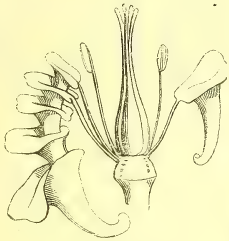


Fig. 670.

Fig. 667.

Fig. 668.

Water Lily tribe, such as the White Water Lily (Fig. 629, p. 230), the Yellow Water Lily (Fig. 671), and in the Lotus (Fig. 667), this tendency is very evident. In Roses this transformation may be easily

Fig. 667. The Lotus Water-Lily (*Nymphæa Lotus*), one of those plants in which there is a great tendency in the stamens to pass into petals. The leaves are beautifully reticulated. The plant is supposed to be the *Shushan* and *Shushannah* of the Old Testament, translated Lily (1 Kings vii. 19, 22, 26. 2 Chron. iv. 5. Cant. ii. 1, 2, 16; iv. 5; v. 13; vi. 3. Hos. xiv. 5).

Fig. 668. Flowering branch of Rue (*Ruta*), showing at *a*, the pistil dividing into separate parts, with a large circular disk at its base marked with dots. The petals are hooded at their extremities. It is the *Peganon* of the New Testament, translated Rue in Luke xi. 42.

Fig. 669. Pistil and receptacle of the Orange (*Citrus Aurantium*), cut vertically, showing the prominent part of the ring-like disk between the stamen and the ovary.

Fig. 670. Flower of Columbine (*Aquilegia vulgaris*), showing the conversion of stamens into folded petals, which are developed so as to form a series of horn-like tubes inserted within each other.

traced (Fig. 429, p. 181), as well as in all double flowers. In the case of Columbine the change is effected in such a way that the horned petals enclose each other (Fig. 670). Occasionally the petals are replaced by stamens. This kind of metamorphosis is much rarer than the opposite one. In Monandra fistulosa the lower lip is sometimes prolonged into a filament bearing an anther, and the petals of Shepherd's Purse have been observed antheriferous (anther-bearing.)

312. When the anther is abortive the filament sometimes produces hairs in its place. In the case of Canna, where only one anther lobe is perfected, the filament becomes petaloid. It is probable that the peculiar gland-like scales of Parnassia are only an altered state of the stamens (Fig. 570, p. 214). Goeppert noticed a specimen of Papaver officinale in which the anthers were converted into carpels. The conversion of the carpels into stamens is rare. Gay saw one of the styles of Colchicum antheriferous, and the other two prolonged into thread-like forms. Berkeley mentions a case of a

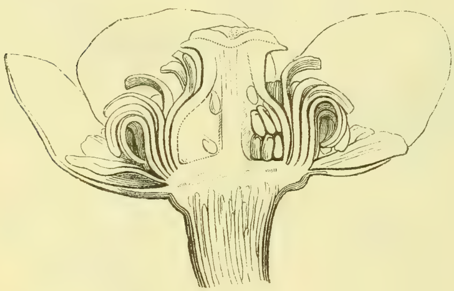


Fig. 671.

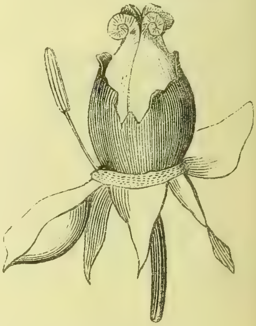


Fig. 672.

white seeded Gourd, in which the pollen was replaced by ovules, many of them apparently perfect.*

313. The organ which botanists call the *Disk*, seems to be in many cases an alteration of some of the staminal whorls. This is more especially true of such cases as Gloxinia and Gesnera, where the scales alternate with the developed row of stamens, and where the fifth stamen assumes the form of a scale. The Disk may be said to consist essentially of processes arising from the thalamus between the developed stamens and pistil. In the Orange (Fig. 669) the disk is in the form of a ring surrounding the base of the pistil; so also in Rue (Fig. 668), where it is very large and conspicuous. In the Vine (Fig. 571, p. 215), the disk-scales are evident. In the White Water

Fig. 671. Vertical section of the flower of the Yellow Water-Lily (*Nuphar luteum*), in which the stamens have a tendency to assume the form of petals. They are indefinite, and are attached below the pistil which occupies the centre.

Fig. 672. Flower of Tree Pæony (*Moutan officinalis*), deprived of its corolla, and showing the disk in the form of a fleshy expansion covering the ovary.

* See Gardener's Chronicle, Aug. 9, 1851.

Lily the disk is a large cellular prolongation covering the ovaries (Fig. 629, *d*, p. 230). In the Tree Pæony (Fig. 672) it forms a dark red expansion which covers the follicles. In umbelliferous plants (Fig. 347, p. 148), the remains of the disk are seen at the upper part of the fruit.

314. Recapitulation of the general facts relative to the stamens:—

1. The Stamens are the third whorl of the complete flower, and are arranged in one or more alternating rows. They constitute the Andrœcium, or male organs.
2. They consist essentially of metamorphosed leaves, and follow the same law of development and arrangement that leaves do. In double flowers they are converted into petals.
3. In Monœcious, Diœcious, and Polygamous plants, some flowers have stamens without the pistil, and are called Staminiferous, Staminate, or male.
4. The stamens arise normally from the thalamus, but they undergo changes by adhesion to the calyx, corolla, and pistil.
5. They are attached to the thalamus, or, in other words, are Hypogynous in the plants included under the division of Thalamifloræ; to the calyx, or Perigynous, in Calycifloræ; to the corolla in Corollifloræ; and to the pistil in Gynandrous plants.
6. Each stamen consists usually of two parts—the Filament, and the Anther containing the fertilizing powder called Pollen.
7. The stamens are either free or united to each other. The union takes place by the filaments in Monadelphous, Diadelphous, and Polyadelphous plants; and by the anthers in Syngenesious plants.
8. Stamens exhibit, in many instances, variations in their relative lengths, and, in the case of Didynamous and Tetradynamous plants, these variations are in definite proportions.
9. Alterations take place in the stamens by abortion and degeneration of parts, by irregular growth and adhesion, and by chorisis.
10. The organ called the Disk is frequently an undeveloped condition of a Staminal row.
11. The Pollen consists of cells contained in the anther-case, and discharged by various kinds of longitudinal, transverse, valvular, and porous dehiscence.
12. In the development of pollen, the division into four is common, and the grains often continue united in fours or multiples of four.

B. *Gynœcium or Pistilline Organs.*

a. PISTIL BEFORE BECOMING THE FRUIT.

315. The pistil is the verticil which terminates the axis of growth, and is placed in the centre of the flower (Figs. 673 and 674). It is composed of leaves called *Carpels* or *Carpidia*, from their connection with the fruit. These leaves are folded, so that their lower surface is external, and they are well seen in the Cherry, with double flowers, in which the organs of reproduction are more or less completely altered. In this plant one or more leaves (Figs. 675 and 676) occupy the place of the pistil. In the monstrosity of the Rose, represented in Figure 426, p. 178, the pistil is changed into a series of alternate leaves. When there is a single carpel (Fig. 677), the pistil is *simple*, and the two terms (carpel and pistil) are synonymous; when there is more than

one carpel, the pistil is *compound* (Fig. 678). The carpels are either distinct or united; and it frequently happens, that by adhesion and obliteration, changes take place by which the number of the carpels is

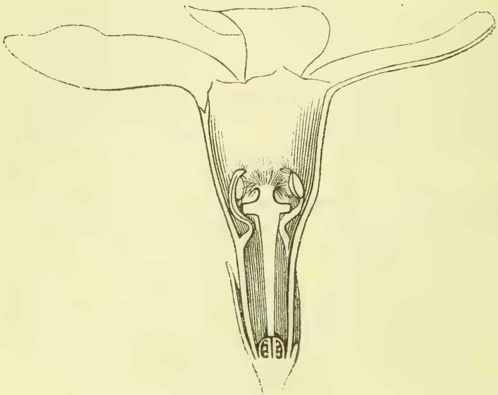


Fig. 673.

Fig. 674.

Fig. 675.

Fig. 676.

Fig. 677.

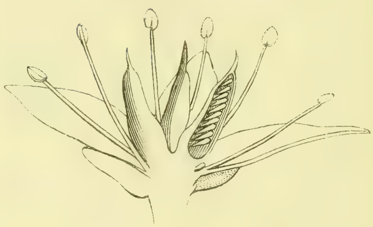


Fig. 678.

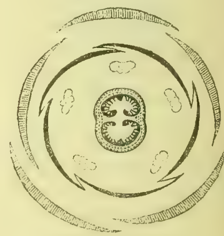


Fig. 679.

diminished, so that they do not equal the other whorls. It is rare to find the parts of the pistilline whorl symmetrical with the others. A flower,

Fig. 673. Flower of Periwinkle (*Vinca*), cut vertically, showing the gynœcium in the centre, consisting of ovary, with ovules at the lower part, ending in the style and stigma. The latter is contracted like an hour-glass in the middle, and has two projecting parts below like a cross. The stamens are seen attached to the corolla.

Fig. 674. Ideal section of a regular, symmetrical, pentamerous flower. There are five parts of the calyx, five of the corolla, five stamens, and five carpels in the centre, forming the pistil. The carpels contain ovules or young seeds.

Fig. 675. Expanded carpellary leaf from the double-flowering Cherry.

Fig. 676. Folded carpellary leaf of the double-flowering Cherry. In place of fruit the plant produces leaves.

Fig. 677. Pistil of Broom, consisting of ovary, *o*, style, *s*, and stigma, *t*, It is formed by a single carpel. The terms pistil and carpel are here synonymous.

Fig. 678. Flower of Stone-crop (*Sedum*), cut vertically, showing three of the carpels forming the pistil in the centre. The pistil is compound, and as it consists of separate carpels, it is apocarpous or dialycarpous.

Fig. 679. Diagram of the flower of Tobacco (*Nicotiana Tabacum*). There are five divisions of the calyx and corolla, five stamens, and a dimerous pistil. The pistil is formed by two carpels or carpidia united, and is called syncarpous. The flower is symmetrical and pentamerous, although the pistil does not correspond with the other whorls in number.

however, is still called symmetrical if the numbers of the three outer whorls are equal to, or multiples of each other (¶ 245). Thus, the flower of Solanaceæ is symmetrical, in which the calyx, corolla, and stamens are pentamerous, while the full-grown pistil is dimerous (Fig. 679).

316. A pistil is called *apocarpous* or *dialycarpous* when all the carpels are separate (Figs. 680 and 681) ; and *syncarpous* when they are combined into one (Fig. 682). The parts of a perfect pistil, as already noticed in ¶ 229, are the *ovary*, containing ovules or rudimentary seeds, the *style*, and the *stigma*. These terms are rather vaguely used, as applying either to the parts of a single carpellary leaf, or to the parts of a pistil formed of more than one carpel, and in which the ovaries, styles, and stigmas are united completely. In Figure 683, the lower portion is the ovary containing the ovule, *ov*, the style is marked *tc*, and the stigma *st*. The style is not always

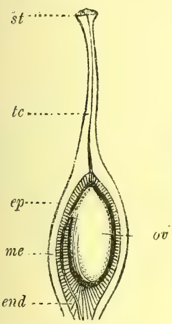


Fig. 683.

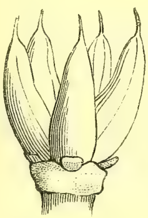


Fig. 680.

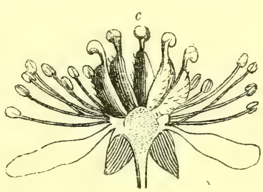


Fig. 681.

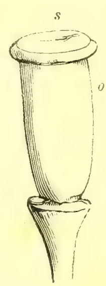


Fig. 682.

present, and, when absent, the stigma is sessile, as in the Poppy (Fig. 417, *sti*, p. 175).

317. The ovary of a simple pistil consists of the folded blade of a

Fig. 680. Pistil (gynœcium) of Stonecrop (*Sedum.*) It consists of five carpels, which are separate and distinct. Each carpel has its own ovary, style, and stigma. The pistil is apocarpous or dialycarpous. At the base of the carpels are seen scales which are probably separated from the stamens by chorisis. These scales are called the nectary. Below the pistil is the part of the receptacle to which the other whorls were attached.

Fig. 681. Vertical section of the flower of Meadow-sweet (*Spiræa*). The pistil is apocarpous, consisting of several distinct carpels, *c*, each with ovary, style, and stigma. The stamens are indefinite, and inserted into the calyx.

Fig. 682. Pistil of the Barberry (*Berberis vulgaris*). It is syncarpous, consisting of several carpels combined. The stigma, *s*, is peltate (shield-like), and nearly sessile. The combined ovaries, *o*, end in a very thick and short style. Below the pistil is the receptacle or thalamus which bears the floral whorls.

Fig. 683. Pistil of Apricot (*Prunus Armenaica*), cut vertically. The solitary ovule, *ov*, is contained in the ovary, which consists of three coats, the inner, *end*, which corresponds to the upper epidermis of the carpellary leaf, and which finally becomes the hard stone of the Apricot. The middle, *me*, corresponding to the mesophyllum or parenchyma of the carpellary leaf, and which ultimately becomes the fleshy part of the Apricot; and the outer, *ep*, corresponding to the lower epidermis of the carpellary leaf, and which finally constitutes the separable skin of the Apricot. The style is prolonged upwards, containing a canal, *tc*, and ending in the stigma, *st*, consisting of loose cellular tissue uncovered by epidermis.

single leaf (Fig. 688), and resembles it in structure. The outer surface of the ovary (Figs. 683 and 688, *ep*) represents the lower epidermis of the leaf, sometimes covered with hairs, and, when green, exhibiting stomata; the inner surface (Fig. 683, *end*, and 688, *en*) represents the upper epidermis; between these two surfaces are placed the parenchyma, and the vascular tissue consisting of woody, spiral, and dotted vessels of various kinds (Fig. 683, *me*). The midrib is on the outer or dorsal surface, and therefore is inferior, while the two edges of the leaf (Fig. 688, *pl*) are united at their inner part or *face* next the axis, and are superior.

318. The face of the ovary is called the *ventral suture*, while the back is called the *dorsal suture*. At the ventral suture there is a cellular growth called the *placenta* (Fig. 688, *pl*), to which the ovules, *ov*, are attached often by a distinct cord, *f*. As each margin of the folded leaf or carpel forms a placenta, this organ is essentially double, and it sometimes shows its formation by appearing as two lamellæ (Fig. 688, *pl*). Along the placenta the ovules are placed in one or


Fig. 684.

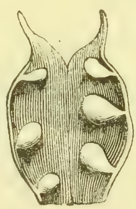


Fig. 685.


Fig. 686.

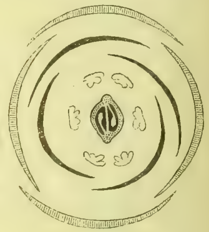


Fig. 687.

more rows (Fig. 685). Sometimes they occupy a small part of the placenta, as in cases where they are reduced to one (Fig. 683) or two. The parenchymatous tissue sometimes becomes hard, as in the nut; at other times it is much developed, and forms a succulent covering, as seen in fleshy fruits (Fig. 683, *me*).

319. When the style exists, it is a prolongation of the cells and vessels of the leaf upwards, and represents the narrow portion of an acuminate leaf, folded so as to form a canal (Fig. 683, *tc*), with loose

Fig. 684. Diagram of the flower of the Gentian (*Gentiana*), consisting of five parts of the calyx, five of the corolla, five stamens, and two divisions of the pistil, which are placed laterally, *i. e.*, to the right and left of the axis. The flower is regular, symmetrical, and pentamerous. The pistil bicarpellary.

Fig. 685. One of the carpels forming the pistil of Meadow-sweet (*Spiræa*). It is laid open to show the ovules attached to the placenta on the ventral suture. The placenta, style, and stigma, are shown to be double.

Fig. 686. Diagram of the Flower of Speedwell (*Veronica*). There are four unequal divisions of the calyx and corolla, so that the flower is irregular; two stamens and two divisions of the pistil, one of which is superior, and the other inferior. The flower is unsymmetrical.

Fig. 687. Diagramatic section of the flower of Wallflower (*Cheiranthus Cheiri*). There are four parts of the calyx and of the corolla, six stamens, which are tetradynamous (four long in pairs, and two short), and a bicarpellary pistil, with the carpels placed laterally, *i. e.*, to the right and left of the axis. The division in the pistil consists of a prolongation of the placentas from either side, and is called a replum or frame.

cells inside. It is terminated by the stigma (Fig. 683, *st*), which is a loose cellular portion divested of epidermis, and moistened with fluid, so as to detain the pollen-grains when scattered. The stigma is sometimes a mere point, at other times it extends along one or both sides of the style. It is to be considered as continuous with the placenta.

320. When the pistil is formed of a single carpel (Fig. 677, p. 240), it terminates the axis, and appears to be continuous with it. When the pistil is bicarpellary, that is, formed of two carpels (Fig. 690), they are placed opposite to each other, and if they unite, it is by their ventral sutures. The carpels, in such a case, are usually placed so that one is superior, that is, next the axis, and the other inferior, next the bract of the axillary flower, as in the Figwort order (Fig. 686). Sometimes, however, they are lateral, that is, to the right and left of the axis in a plane at right angles to the axis and

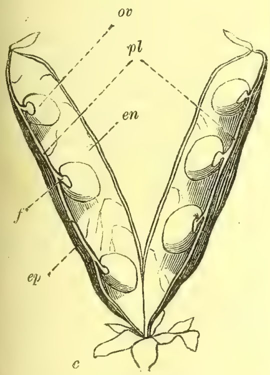


Fig. 688.

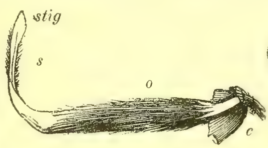


Fig. 689.

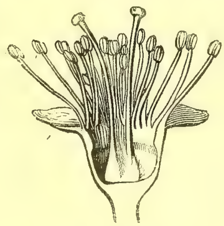


Fig. 690.

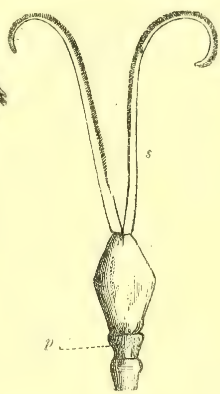


Fig. 691.

bract, as in the Gentian order (Fig. 684), and Cruciferæ (Fig. 687). When the carpels are more than two, they follow the usual laws of

Fig. 688. Pistil of the Pea (*Pisum sativum*), laid open. It consists of a single carpel containing numerous ovules, *ov*, which are attached to the placenta, *pl*, or ventral suture in two rows, by means of umbilical cords (funiculi), *f*. The wall of the carpel consists of three layers, the outer, *ep*, corresponding to the lower epidermis of the leaf, the inner, *en*, corresponding to the upper epidermis of the leaf. Between these two layers there is a small amount of cellular tissue like the parenchyma of the leaf. The parenchymatous portion is not so much developed as in Figure 683. The calyx, *c*, is persistent. The style and stigma are marked *s*.

Fig. 689. Pistil of a kind of Sweet-pea (*Lathyrus*), formed by a single carpel, consisting of ovary, *o*, with a style, *s*, and stigma, *stig*. It is monocarpellary. The calyx, *c*, is persistent. The flower is monogynous, because it contains one carpel, and one style and stigma.

Fig. 690. Flower of Cherry (*Cerasus communis*), cut vertically, showing the pistil composed of two separate carpels (bicarpellary); only one of the carpels comes to perfection in the fruit. The flower is said to be digynous in this condition. The stamens are indefinite, and attached to the calyx. The plant belongs to the division Calycifloræ, and some call it calycandrous, on account of numerous stamens being attached to the calyx.

Fig. 691. Syncarpous pistil of Carnation (*Dianthus Caryophyllus*), consisting of two united carpels, supported on a stalk or podocarp, *p*, called also a thecaphore or gynophore. The two ovaries are united, but the two styles, *s*, are separate, with recurved extremities. The flower is therefore said to be digynous.

alternation with the other parts of the flower (Fig. 674, p. 240). It is chiefly in apocarpous pistils that the alternation can be satisfactorily seen; for in syncarpous pistils, the adhesion which takes place often obscures the arrangement.

321. The number of carpels in an apocarpous pistil, or the number of separate styles in a syncarpous one (*i.e.*, one in which the ovaries are united), is indicated in the following way:—

A flower with a simple pistil or one style				is Monogynous (Figs. 683 and 689).
A flower with two separate carpels or two separate styles				is Digynous (Figs. 690 and 691).
A flower with three	"	"	"	is Trigynous.
A flower with four	"	"	"	is Tetragynous.
A flower with five	"	"	"	is Pentagynous (Fig. 692).
A flower with six	"	"	"	is Hexagynous (Fig. 693).
A flower with seven	"	"	"	is Heptagynous.
A flower with eight	"	"	"	is Octogynous.
A flower with nine	"	"	"	is Enneagynous.
A flower with ten	"	"	"	is Decagynous.
A flower with twelve	"	"	"	is Dodecagynous.
A flower with a greater number		"	"	is Polygynous (Figs. 694 and 695).

These differences are employed by Linnæus in forming some of his Orders.

322. In an Apocarpous pistil, the carpels may be arranged in one circle (Fig. 693), or in several (Fig. 694). In the latter case, the inner whorls alternate in succession with the outer. Sometimes they are placed on a flattened receptacle or thalamus, as in Marsh Marygold; at other times on an elevated one, as in the Crowfoot (Fig. 694), in the Strawberry (Fig. 695), and in the Tulip-tree; while at other times they are placed on a concave one, as in the Rose (Fig. 696).

323. In a Syncarpous pistil, various degrees of adhesion take place. The carpels may unite merely at their inner angles, leaving marked external divisions, as in the Rue (Fig. 668, p. 237); or the ovaries may be completely united while the styles are separate, as in Lychnis (Fig. 697) and Nigella (Fig. 698); or the whole may be consolidated into one, as in the Primrose (Fig. 699). In rare cases, the styles and stigmas are united into one body, while the ovaries are separate, as in Labiatæ (Fig. 701) and the Borage order (Fig. 700), as well as in Asclepias.

324. In syncarpous pistils, the number of carpels entering into their composition may be traced by observing the grooves or lobes of the ovary, by the number of styles and stigmas, and, when complete union takes place, by the venation, or by the divisions seen in the interior of the ovary. Thus, in the Lily, the syncarpous

pistil is composed of three carpels united, and, by cutting across the ovary (Fig. 702), we observe three loculi containing ovules. The carpels are generally united in such a way, that partitions or dissepiments (septa), more or less complete, are seen on making a transverse section. These are formed by the union of the margins or sides of the carpellary leaves, each septum being essentially double or composed of the laminæ of two contiguous carpels. This is seen in the figure of the pistil of Colchicum (Fig. 703), which is formed by three carpels; and on making a transverse section (Fig. 704), the formation of the septa is evident. The septa of collateral carpels are therefore vertical, and equal to the number of carpels. There can be no true septum in a single carpel (Fig. 688, p. 243), but spurious divisions (phragmata) may be formed, either in a transverse manner by cellular processes proceeding from the walls of the carpel, as in Cassia Fistula (Fig. 705) and Desmodium; or in a vertical manner, by projections from the dorsal suture, as in Flax (Fig. 706); or by

Fig. 692.

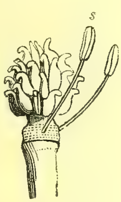
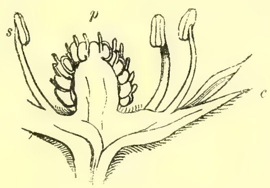


Fig. 694.



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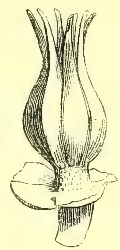

Fig. 693.

prolongations of the placenta, as in Cruciferæ, where a replum is produced (Figs. 707 and 708); or by a turning inwards of the ventral suture (Fig. 709), as in some species of Oxytropis, or of the dorsal suture, as in Astragalus (Fig. 710). In the Thorn Apple, the ovary, when cut transversely at the upper part, shows two cavities (Fig. 711); but when the section is made at the lower part of the ovary,

Fig. 692. Syncarpous Pistil of Flax (*Linum*). It consists of five carpels, united by their ovaries, while their styles and stigmas, *s*, are separate. Hence, the flower is pentagynous. On making a section of the compound ovary five loculaments are seen.

Fig. 693. Apocarpous pistil of Hellebore (*Helleborus*), consisting of six distinct carpels. The flower is hexagynous. Below the pistil is seen the receptacle or thalamus into which the other floral whorls are inserted. The plant belongs to the Thalamifloræ.

Fig. 694. Apocarpous compound pistil of Crowfoot (*Ranunculus*), consisting of numerous separate uni-ovular carpels, arranged in several rows on an elevated receptacle. The flower is polygynous. Each carpel consists of ovary, style, and stigma. Two of the stamens, *s*, are left to show their insertion below the pistil into the thalamus. The stamens are hypogynous, and the plant belongs to Thalamifloræ.

Fig. 695. Section of the flower of the Strawberry (*Fragaria vesca*), shewing the pistil in the centre, *p*, composed of numerous separate uni-ovular carpels, placed on an elevated portion of the receptacle, which ultimately becomes succulent, and constitutes what is commonly called the Fruit. Each carpel has a style and stigma. The flower is polygynous. Three of the stamens, *s*, are left to shew their insertion into the calyx, *c*. The stamens have introrse anthers dehiscing longitudinally. The plant belongs to Calycifloræ.

there are four cavities formed by a spurious vertical septum (Fig. 712).

325. When the partitions in the pistil extend to the axis, a transverse section shows a number of contiguous cavities or *loculaments* (loculi), with the placentas in the centre bearing ovules (Fig. 713).* A compound pistil of this sort composed of two carpels is two-celled (bilocular); of three, three-celled (trilocular), as seen in the Lily (Fig. 702), and Colchicum (Fig. 704); of four, four-celled (quadrilocular); of five, five-celled (quinquelocular), as in Campanula (Fig. 713); of many without distinct reference to number, many-celled (multilocular or plurilocular).

326. When the partitions do not extend to the centre, all the

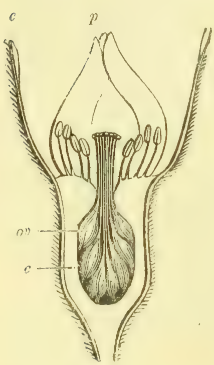

Fig. 696.

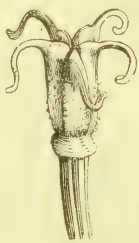

Fig. 698.

Fig. 699.

Fig. 700.

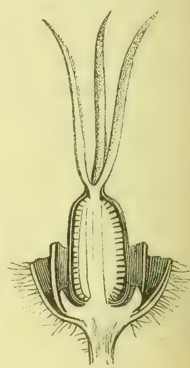

Fig. 697.

cells or loculi communicate, and hence such a compound pistil is really unilocular, or has one cavity, as in the Poppy (Fig. 717),

Fig. 696. Flower of the Rose (*Rosa*), cut vertically. The ovaries, *ov*, of the separate carpels are attached to a fleshy disk lining the calyx, *c*. The tube of the calyx is contracted at the upper part, and through the narrowed portion the styles pass. Each carpel has its ovary, style, and stigma, and contains a single ovule. The petals, *p*, as well as the stamens, are inserted into the calyx. The flower is polygynous. The plant belongs to Calycifloræ.

Fig. 697. Syncarpous pistil of Rose-campion (*Lychnis*), cut vertically. It is supported on a short stalk or gynophore. The ovaries are so united as to form one compound ovary, with one loculament. The ovules are attached to a free central placenta, owing apparently to a rupture of the dissepiments (septa). The styles are separate; three are seen in the figure. The flower is Pentagynous. The placenta in the centre of the compound ovary is very large.

Fig. 698. Compound syncarpous pistil of Nigella, consisting of five carpels partially united. The five styles and stigmata are free, and the flower is pentagynous. The divisions of the carpels are seen at the apex, and along the sides of the compound ovary.

Fig. 699. Compound syncarpous pistil of Primrose (*Primula*). The five carpels of which it is composed are completely consolidated so as to appear one. The ovaries, *o*, the styles, *t*, and stigmata, *s*, are united. The flower is called Monogynous, although in reality there are five parts of the pistil.

Fig. 700. The Pistil of Cerinthe, a plant of the Borage order. There are four carpels forming the pistil. The ovaries of the carpels are separate, while the styles and stigmas are united into one.

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* Some restrict the term placenta to the point where an ovule is attached, and give the name of placentary to the extended cellular body bearing more than one ovule. Several placentaries combined form what has been called the central placenta.

Reseda (Fig. 718), and Orchis (Fig. 719). In these unilocular syncarpous pistils there may be seen partitions proceeding to a greater or less extent into the cavity of the ovary, and bearing placentas on their edges (Fig. 715). Such placentas are called *parietal*, and their number indicates the number of united carpels. These placentas are sometimes nearly sessile on the walls of the ovary (Figs. 716 and 718); at other times they are supported on distinct parietal septa (Figs. 715 and 719). Such are called cases of parietal placentation, and are considered as showing the formation of *marginal* placentas, on the edges of carpellary leaves more or less completely folded inwards towards the axis. The ovules, in these instances, are analogous to buds on the margins of leaves, as seen in Bryophyllum (Fig. 720).

327. Cases occur in which the carpels are united so as to have

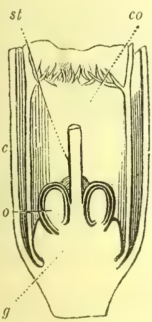


Fig. 701.

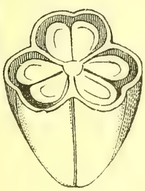


Fig. 702.

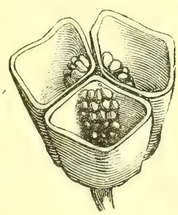


Fig. 704.

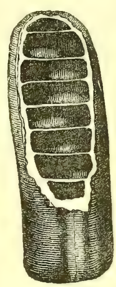


Fig. 705.

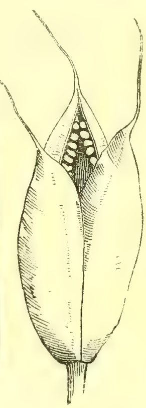


Fig. 703.

no apparent folding inwards of their edges, and in which the placentas are placed in the centre, quite separate from the walls of the ovary,

Fig. 701. Vertical section of part of the flower of Sage (*Salvia*), one of the Labiate plants. The calyx, *c*, corolla, *co*, the receptacle, *g*, the pistil in the centre, consisting of ovaries, *o*, and style, *st*. In this plant there are four carpels forming the pistil, two of which are seen in the figure. These carpels become separate, while the styles are united into one. The union of the carpels takes place by the styles, and not by the ovaries.

Fig. 702. Ovary or lower part of the pistil of the Lily (Lilium), cut transversely. There are three loculaments, indicating the union of three carpels, and the ovary is said to be trilocular. The divisions in the ovary, called septa or dissepiments, are formed by the sides of the carpellary leaves. Each septum is double, and the number of septa corresponds with the number of the carpels. The ovules are placed collaterally, in pairs, in each loculament, and are attached to a central placenta, formed by the union of the three ventral sutures.

Fig. 703. Pistil of Meadow-saffron (*Colchicum*), consisting of three carpels, which finally separate from each other at the apex, shewing the composition of the compound pistil. The dehiscence is called septicidal, because it takes place through the septa.

Fig. 704. The compound ovary of Meadow-saffron (*Colchicum*), cut transversely, shewing three loculaments, formed by the union of three carpels, which ultimately separate at the dissepiments. The ovules are attached to the placentæ in the centre.

Fig. 705. Pistil of Cassia Fistula (*Cathartocarpus Fistula*), cut vertically, showing the separate divisions in the legume. The divisions are spurious septa (phragmata), formed from the inner lining of the ovary. Each division contains a single seed, with pulp around it.

as in the Chickweed and Primrose families. This is called *central*

Fig. 707.

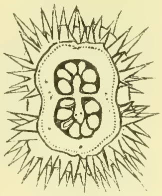


Fig. 711.

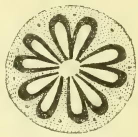


Fig. 706.

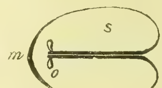
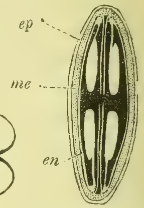


Fig. 709.



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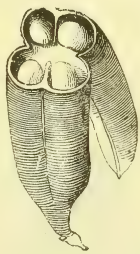


Fig. 710.

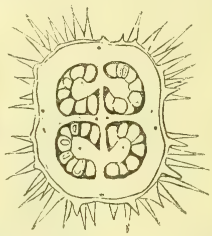


Fig. 712.

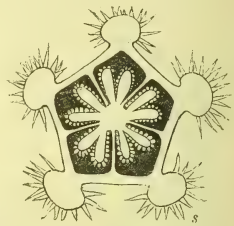


Fig. 713.

placentation (Figs. 721 and 722). It is by some considered as being

Fig. 706. Compound ovary of Flax (*Linum*), cut transversely, showing the five carpels of which the ovary is formed, and each of these carpels subdivided by foldings of the dorsal suture into two, thus making in all ten divisions. (See Fig. 692).

Fig. 707. Compound ovary (*Siliqua*) of Wallflower (*Cheiranthus*), consisting of at least two carpels united. One valve has been removed to show the partition or replum, *cl*, formed of a double layer from the placentæ, *cn*, on either side, to which the ovules, *ov*, are attached by means of funiculi. The ovules form a single row, one above the other, alternately attached to either side. The partition is spurious (phragma), as it is not formed by the edges of the carpels. The style and stigma, *s*, are at the upper part of the ovary.

Fig. 708. Transverse section of the pistil of the Wallflower (*Cheiranthus Cheiri*), showing the outer layer of the ovary, *ep*, the middle, *me*, and the inner, *en*. There are two divisions in the ovary, separated by a nearly complete phragma or spurious dissepiment, formed from the placentæ on either side, to which the ovules are seen attached by funiculi or umbilical cords.

Fig. 709. Diagram to illustrate the formation of a spurious septum in a carpel, by the folding inwards of the ventral suture. The midrib of the leaf, *m*, the inflected edges of the ventral suture, *s*, and the placenta, with the ovules, *o*. A unilocular ovary may thus become spuriously bilocular.

Fig. 710. Pistil of Milk-vetch (*Astragalus*), the ovary of which becomes spuriously two-celled (bilocular), by the folding inwards of the dorsal suture. The carpel is cut transversely across to show the partition and the ovules.

Fig. 711. Ovary of the Thorn-apple (*Datura Stramonium*), cut transversely at the upper part, showing two carpels united to form a compound ovary. The inner edges of each of the carpels, after meeting in the centre, turn outwards, and bear the ovules on their projecting portions.

Fig. 712. The ovary of the Thorn-apple (*Datura*), cut transversely at the lower portion, showing the mode in which the ventral sutures of each of the carpels turns outwards towards the midrib, whence a cellular prolongation proceeds, so as to divide the ovary into four in place of two loculaments. The partitions are spurious, and the ovary is spuriously quadrilocular, or tetrathecal.

Fig. 713. Ovary of Bell-flower (*Campanula*), cut transversely. The placenta is in the centre, consisting partly of a prolongation of the axis in the form of a column, and partly of the true placentaries, bearing numerous ovules, arranged collaterally in pairs. The ovary is quinquelocular, being formed by five carpels, which are attached to the calyx, *s*. The back of each of the carpels corresponds to the midrib, *s*, of a sepal.

produced by the disappearance of the septa, or by their rupture, at an early period of the growth of the ovary, so as to leave the placentas in the middle. This view is strengthened by seeing in some of the Chickweed tribe, septa in a very early stage of growth (Fig. 723, *c*), and imperfect remains of these partitions on the wall of the ovary, even in an advanced stage (Fig. 721). Berkeley, on examining a monstrous Carnation (a plant belonging to the Chickweed family), found that the placentation was at first marginal, and that, at an

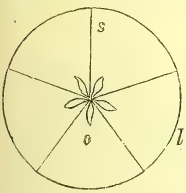


Fig. 714.

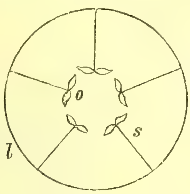


Fig. 715.

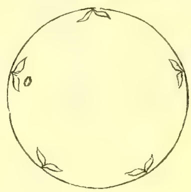


Fig. 716.

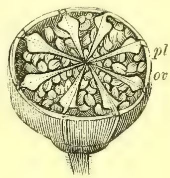


Fig. 717

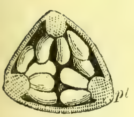


Fig. 718.

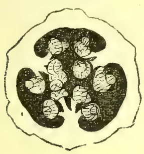


Fig. 719.

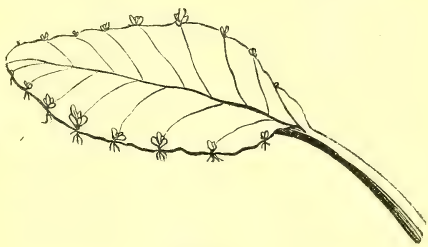


Fig. 720.

early period of growth, the placentas separated from the septa from the base upwards, forming a central solid mass below, but still bear-

Fig. 714. Diagramatic section of a quinquelocular or pentathecal ovary, composed of five carpels, the edges of which are folded inwards, and meet in the centre. The ovules, *o*, are attached to a central placenta, formed by the union of the five ventral sutures. The five partitions, septa, or dissepiments, *s*, are composed of the two sides of contiguous carpels.

Fig. 715. Diagramatic section of a quinquelocular ovary, in which the septa, *s*, proceed inwards for a certain length, bearing the placentas and ovules, *o*. In this case the ovary is unilocular, and the placentas are parietal.

Fig. 716. Diagramatic section of a quinquelocular ovary, in which the edges of the carpels bearing the placentas and ovules, *o*, are not folded inwards. The placentas are parietal, and the ovules appear sessile on the walls of the ovary. The compound ovary is unilocular, and edges of its carpels are applied to each other in a valvular manner.

Fig. 717. Ovary of the Poppy (*Papaver*), cut transversely, showing the parietal placentaries, *pl*, the whole surface of which is covered by ovules, *ov*. The ovary is unilocular. Spurious placental divisions extend in the young state towards the centre. As the pistil advances to maturity the placentas become shorter.

Fig. 718. Unilocular or monothecal ovary of Mignonette (*Reseda*), cut transversely, showing the ovules attached to three parietal placentas, *pl*.

Fig. 719. Unilocular or monothecal ovary of an Orchid (*Orchis*), cut transversely, showing three parietal placentas bearing ovules. The edges of the carpels are slightly folded inwards.

Fig. 720. Leaf of Bryophyllum calycinum, with buds at the crenatures of its margin. These buds may be considered as representing ovules attached to marginal placentas. When such a leaf is folded upwards so that its margins meet, the buds are then in the situation of the ovules in a single carpel.

ing evidence of their original formation by their connection with the stigmas above.

Fig. 721.

Fig. 722.

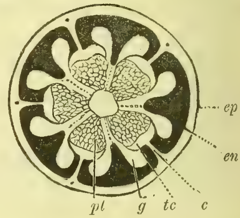


Fig. 723.

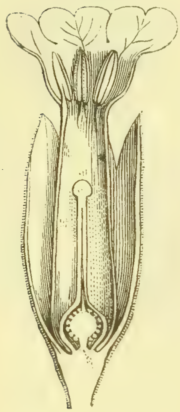


Fig. 724.

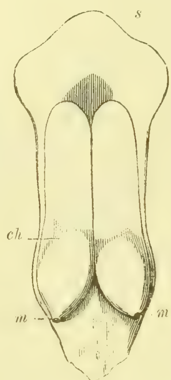


Fig. 725.

Fig. 726.

328. In some instances, however, especially in the Primrose tribe

Fig. 721. Diagramatic section of a compound unilocular ovary, formed by five carpels, the edges of which are very slightly folded inwards, as represented by short lines on the inner surface of the circle. The ovules, *o*, are in the centre, and not attached to the walls of the ovary. Such a case is supposed to be produced by the septa being ruptured and absorbed, so as to leave the placentas with the ovules in the centre. It may represent what takes place in the Chickweed order. Some consider the placenta in this case as being formed from the axis.

Fig. 722. Diagramatic section of a compound unilocular ovary, in which there are no indications of partitions. The ovules, *o*, are attached to a free central placenta, which has no connection with the walls of the ovary. This may represent what occurs in the Primrose order. In this case the placenta is said to be a truly axile, and not marginal formation.

Fig. 723. Young ovary of Rose-campion (*Lychnis*), cut transversely. In the centre is the axis, with five rays proceeding from it, dividing the placentas, *pl*, which are in connection with the conducting tissue, *tc*, of the styles, and which bear the ovules, *g*. In this young state there are five septa, *c*, extending from the walls of the ovary to the placenta. These partitions are finally ruptured, so that the placenta becomes free in the centre. The outer wall of the ovary is marked, *ep*, the inner, *en*. Some consider the placenta in this case as axile.

Fig. 724. Section of the flower of a Primrose (*Primula*), showing the pistil laid open. The round ovary is seen at the base of the style, containing numerous ovules attached to a free central placenta. The stigma is capitate. The stamens are attached to the upper part of the tube of the corolla, and opposite to its segments.

Fig. 725. One of the scales of a Fir-cone, bearing at its base two winged ovules. The base of the ovules or the chalaza is marked *ch*, the apex or micropyle, *m m*. The scale is looked upon as a modified bract, and the ovules are said to be naked, *i. e.*, not contained in a true carpel with ovary and stigma. The plant is gymnospermous, having naked ovules.

Fig. 726. False Sago plant (*Cycas revoluta*). It is one of the plants which produce naked ovules. It belongs to the natural order Cycadaceæ. A fine specimen, with ovules attached, is to be seen in the Museum at the Botanic Garden, presented by Dr. Gilbert M'Nab.

(Fig. 724), no vestiges of septa are found, and no marginal ovules at any period of growth (Fig. 722). Hence this kind of central placen-

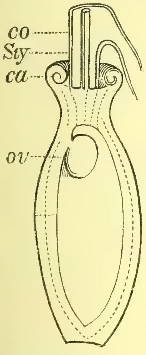


Fig. 727.

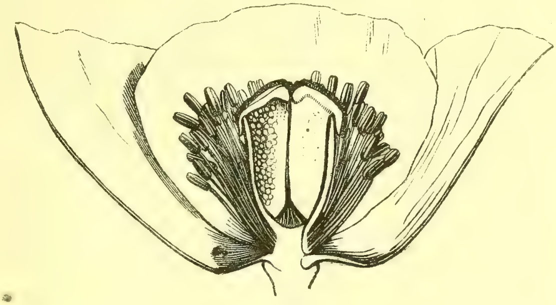


Fig. 729.

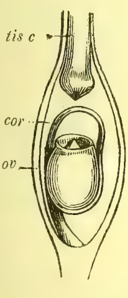


Fig. 728.

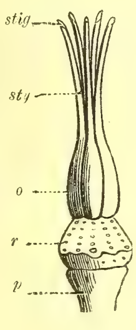


Fig. 730.

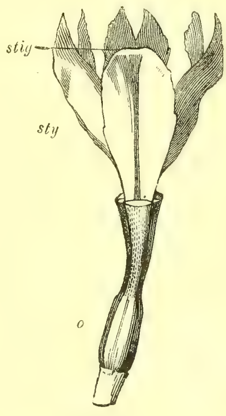


Fig. 732.

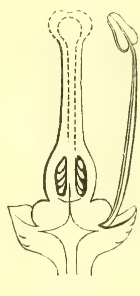


Fig. 731.

tation is supposed to be produced by a prolongation of the axis, and it

Fig. 727. Pistil of Red Valerian (*Centranthus ruber*), cut vertically, showing a single suspended ovule, *ov*, attached to the placenta near the summit of the ovary. The calyx, *ca*, is attached to the ovary, and its limb consists of incurved hairs; *sty* the style, and *co* part of the corolla.

Fig. 728. The ovary of the Sea-Pink (*Armeria*), cut vertically, showing the ovule, *ov*, with its coverings suspended by a cord or funiculus, *cor*, which rises from the basilar placenta. The conducting tissue of the style, *tis c*, passes for a certain way into the ovary.

Fig. 729. Vertical section of the flower of the Poppy (*Papaver*), showing numerous ovules attached over the surface of the placentary. The stigma is sessile on the top of the ovary. The stamens are numerous (indefinite) and hypogynous.

Fig. 730. Pistil of Columbine (*Aquilegia vulgaris*), situated on the receptacle, *r*, which is at the summit of the peduncle, *p*. The pistil is formed of five separate carpels, arranged in a circle on the receptacle. Each carpel consists of ovary, *o*, style, *sty*, and stigma, *stig*. The pistil is apocarpous.

Fig. 731. Pistil of Orange (*Citrus Aurantium*), situated above the calyx, and having a circular disk at its base. The pistil is superior, and it consists of a compound ovary, style, and stigma.

Fig. 732. Gynœcium of the Flower-de-Luce (*Iris*), consisting of an ovary, *o*, adherent to the perianth, and a style, *sty*, which divides into three petaloid segments bearing stigmas, *stig*. The ovary is inferior, and the perianth superior.

is therefore denominated *axile*—the leaves of the gynœcium being looked upon as united in a valvate manner, and as being verticillate round the placentary axis, which bears ovules like leaf-buds. Those who adhere to the view of all placentas being formed on the margins of leaves, have endeavoured to account for cases of *free central* placentation like those of the Primrose, by considering the placenta as formed by chorisis from the edge of carpellary leaves, or by placentas produced only at the base of the carpel, and, after uniting together in the centre, becoming elongated and enlarged. On the other hand, some advocates of axile placentation not only apply this view to such cases as those of the Primrose, but to all cases of placentation whatever; and, in the case of parietal placentas, think that the axis divides into a number of cellular prolongations, which become attached to the edges of the carpellary leaves.

329. Schleiden, who supports the view of axile placentation in all cases,* looks on the ovules as buds from the placental axis, or what he calls the spermophore. In the case of Coniferous plants, he says,


Fig. 734.


Fig. 733.


Fig. 735.

Fig. 736.

Fig. 737.

that the scales of the cone are not bracts (¶ 206), but carpellary leaves (Fig. 725), and that the axis of the cone is the placenta giving off ovules or buds at different parts which are quite free from the carpels. He considers the cone, therefore, as supplying an argument in favour of his view of placentation. In the Yew, he views the ovule as the terminal bud of the axis. In the case of cone-bearing

Fig. 733. Pistil of Madder (*Rubia*), with the calyx tube adherent to the ovary, and its limb appearing as a rim round the top of the ovary. There are two styles and stigmas. The ovary is inferior, and the calyx limb superior.

Fig. 734. Pistil and calyx of Saxifrage (*Saxifraga*), cut vertically, showing the calyx partially adherent to the ovary. The ovary is half-inferior, and the calyx half-superior. The compound ovary consists of two carpels containing numerous ovules.

Fig. 735. Pistil of the Elder (*Sambucus*), with the ovary partially adherent to the tube of the calyx, and surmounted by three sessile stigmas. The ovary is said to be half-inferior, and the calyx half-superior.

Fig. 736. One of the carpels forming the pistil of the Strawberry (*Fragaria vesca*). The carpel contains one seed, and it has a lateral style, *s*. The style arises from the true organic apex, which is so turned round as to appear on the side of the carpel.

Fig. 737. Uni-ovular carpel of Lady's-mantle (*Alchemilla*), with the style, *s*, arising from the apparent base. It is called a basilar style, although it arises from the organic apex which is here turned round. The stigma at the summit of the style is capitate.

* See Schleiden's Principles of Botany, translated by Lankester, p. 382.

plants such as the Fir (Fig. 172, p. 72), as well as in the Cycas family (Fig. 726), the ovules are generally called naked, because they are not considered by authors as being enclosed within a true pistil furnished with a stigma. The scales of Conifers, which are either dry, as in the common Fir, or succulent, as in the Juniper (Fig. 273, p. 121), are thus looked upon by some as bracts, and by others as expanded carpellary leaves, each producing a placenta at its base, to which the ovules are attached. The plants are usually called *naked-seeded* (Gymnospermous).

330. Marginal placentas are formed either by the edges of a single carpel (Fig. 688, p. 243), or by the edges of two contiguous carpels. The former takes place in apocarpous pistils (Fig. 680, p. 241), and in syncarpous pistils with complete septa (Fig 704, p. 247); the latter in syncarpous pistils with parietal placentas (Fig. 719, p. 249). The placenta does not always bear ovules throughout its whole extent. Sometimes it is *ovuliferous* (ovule-bearing) only at or near

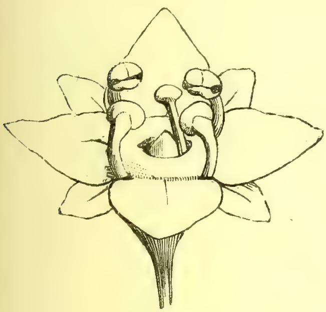


Fig. 738.

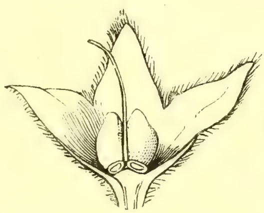


Fig. 739.

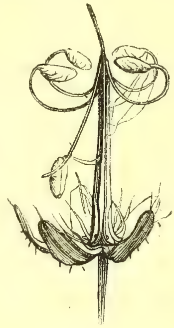


Fig. 740.

its summit (Fig. 727), or in its middle or at its base (Fig. 728). In such placentas, the ovules are sometimes reduced to one, as in the Common Sea Pink (Fig. 728), and in Composite plants (Fig. 542, p. 208). The placenta, in some instances, extends from the margin of the carpellary leaves over the whole inner surface of the ovary, as in the Flowering Rush, in the White Water Lily, and in the Poppy (Fig. 729). The spreading of the placenta over the surface may give rise to the appearance of ovules proceeding from the dorsal suture, especially when that is the only part of it which bears ovules.

Fig. 738. Tetramerous flower of Lady's-mantle (*Alchemilla*). The pistil in the centre shows a style which does not arise from the apparent summit of the ovary, the point of which is seen projecting beyond the hard ring at the throat of the calyx. There are four parts of the calyx, and four of corolla, and four stamens.

Fig. 739. Calyx and pistil of the Comfrey (*Symphytum*), cut vertically. The pistil consists of four carpels, the ovaries of which are free, while the compound style appears to arise from the axis in consequence of being basilar. Each ovary contains a single ovule. Two ovaries have been removed.

Fig. 740. Pistil of Crane's-bill (*Geranium*), consisting of five carpels, attached by their styles to a long beak-like prolongation of the axis. The styles ultimately separate from the axis, as represented in the figure, and the ovaries curl upwards.

331. The carpellary leaves forming the pistil or Gynœcial verticil are usually sessile (Fig. 741), but cases occur in which they appear to be stalked, so as to raise the ovary. Such an occurrence may be considered as depending either on a prolongation of the axis supporting the pistil, as seen occasionally in certain monstrosities of Rose (Fig. 426, p. 178) and of Geum, or on the union of the petioles of carpellary leaves. In the Passion-flower, there is a distinct stalk or gynophore bearing the pistil. The same thing takes place in some of the Caper tribe (¶ 231), as well as in Lychnis (Fig. 697, p. 246) and in the Pink (Fig. 691, p. 243), where the stalk is short and thick.

332. When the pistil is free in the centre of the flower, it is called *superior*, and the other verticils are inferior or hypogynous (Fig. 731). It is often united to the calyx and the other whorls. When the adhesion between the ovary and calyx or perianth is complete, as in the Gooseberry, Currant, Madder (Fig. 733), and Iris (Fig. 732), the ovary is said to be inferior. In such instances, the petals and stamens, which are attached to the calyx, appear to arise from the summit of the ovary, and are called *epigynous*. Between these two conditions, there are intermediate stages of adhesion, as in Saxifrage (Fig. 734) and Elder (Fig. 735), where the ovary becomes half-inferior.

333. In certain cases, it has been supposed that the axis forms part of the walls of the ovary by spreading out in a concave manner, in the same way as the expanded axis of Eschscholtzia seems to form part of the calyx. In the Rose, the axis becomes united to the tube of the calyx (Fig 425, p. 178), and is prolonged so as to form a hollow cavity or disk, on the inside of which numerous separate carpels are placed.

334. The style is the prolonged apex of the carpellary leaf, and is not an essential part of the pistil. In some cases it seems to be a process from the placenta, as shown by Lindley in Babingtonia. It may, therefore, consist merely of cellular tissue, with spiral vessels, or it may also have woody tubes, and other vessels of the midrib and blade of the leaf entering into its composition. A canal traverses it (Fig. 683, *tc*), containing loose cells, called *conducting tissue*, which is continuous with the placenta. The style (Fig. 741, *s*) is situated at the proper apex of the leaf (*apicilar*), but, by changes in the direction of the apex, it frequently happens that the style appears to be *lateral*, as in the Strawberry (Fig. 736), or even *basilar*, *i.e.*, from the apparent base, as in Lady's-mantle (Figs. 737 and 738). In syncarpous pistils, the styles are frequently united, so as to appear single (Figs. 699, p. 246, and Fig. 741). When the carpels are placed round an enlarged axis, so that their apices are united to the summit of it, the styles, when united, appear to come from the axis of the plant, as in many of the Borage order (Fig. 739), and in the Sage (Fig. 701, p. 247). The carpels are called in such cases *gynobasic*. In the Geranium the styles are united to the prolonged axis or beak, from which they separate when the fruit is ripe (Fig. 740).

335. The style in its form is generally rounded, but at times it becomes flat, like a petal, as in Indian-shot. In the Bell-flower there are peculiar hairs on the style (Fig. 742), apparently connected with the application of pollen. The style in the pistil of Clematis is also hairy, so as to render the fruit *caudate* or tailed (Fig. 743). A style, apparently simple (Fig. 739), may be formed of several united. Frequently the divisions of such a style extend downwards for a certain length, showing the parts of which it is composed, and thus indicating the number of carpels (Fig. 692, p. 245, and Figs. 744, 745, and 746). But there are cases in which the style, proceeding from a carpel, actually splits into two parts, becoming *forked*, as in Euphorbia (Fig. 747, *s*).

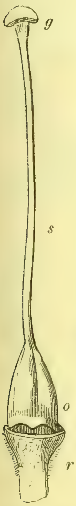


Fig. 741.

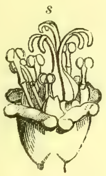
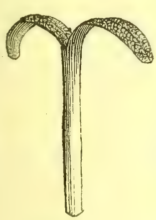


Fig. 747.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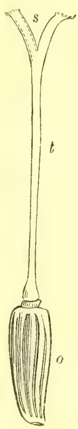

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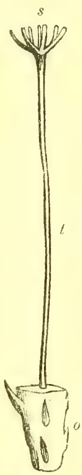


Fig. 746.

Fig. 742.

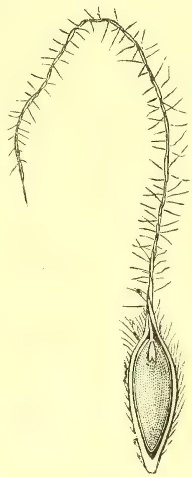


Fig. 743.

This splitting is accounted for by the circumstance that the style is in reality double, formed of two sides of the leaf (Fig. 685, p. 242).

Fig. 741. Syncarpous pistil of Tobacco (*Nicotiana Tabacum*), consisting of two united carpels. The pistil exhibits the compound ovary, *o*, the long style, *s*, and the capitate stigma, *g*. The end of the peduncle is marked, *r*.

Fig. 742. Pistil of Bell-flower (*Campanula*), consisting of a compound ovary, *o*, adherent to the calyx, a compound style, *s*, with hairs on its surface to collect the pollen, and a five divided stigma at its apex.

Fig. 743. One of the carpels forming the pistil of Traveller's-joy (*Clematis*). The ovary contains a single ovule, and the style is feathery. The carpel has been called caudate.

Fig. 744. Style of a ligulate flower of Milfoil (*Achillea*), it splits into two at its apex, bearing a stigma on each division.

Fig. 745. The pistil of Ox-eye (*Chrysanthemum*), consisting of ovary, *o*, adherent to the tube of the calyx, and surmounted by the obsolete limb of the calyx, the style, *t*, splitting at its apex, *s*, so as to bear two stigmatic surfaces. There are hairs on the divisions of the style, and tufts of hairs at the stigmas.

Fig. 746. Pistil of a species of Indian-fig (*Cactus*), consisting of a compound ovary, *o*, adherent to the calyx, a long style, *t*, which divides at the apex, into several parts bearing stigmas, *s*.

Fig. 747. Involucre of a species of Spurge (*Euphorbia*), containing numerous male, and one female flower. The latter consists of a trilocular ovary, surmounted by three forked styles, *s*.

336. The stigma is a part of the pistil, composed of loose cells, which secrete a viscid fluid, and which are uncovered by epidermis. This organ is either sessile on the summit of the ovary, as in the Tulip and Poppy (Fig. 417, p. 175), or it is placed at the apex (Fig. 741, *g*), or on the side of the style. It may be said to be continuous with the placenta, differing from it in not bearing ovules. This connection with the placenta is evidently seen in cases where it

Fig. 748.

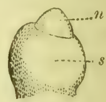


Fig. 754.

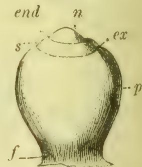
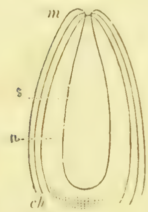


Fig. 755.



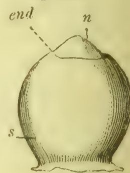


Fig. 750. Fig. 751. Fig. 752. Fig. 753. Fig. 749. Fig. 756.

can be traced along one or both sides of the style as far as the ovary. Being formed like the placenta, it is essentially double, and sometimes

Fig. 748. Vertical section of the flower of the Rock-rose (*Helianthemum*). The pistil is seen consisting of a compound ovary, containing numerous ovules, and surmounted by a short style, and a shield-like (peltate) stigma. The stamens are indefinite and hypogynous.

Fig. 749. Pistil of the Periwinkle (*Vinca*), consisting of ovary, *o*, style, *t*, and stigma, *s*, which is covered with hairs, and exhibits a peculiar hour-glass contraction in its middle, with a large circular rim below. At the base of the ovary is a peculiar disk, *d*.

Fig. 750. Pistil of the Pansy (*Viola tricolor*). It consists of ovary, style, and a peculiar hooded and hooked stigma, *s*, with a marked hole, as represented by the dark round spot.

Fig. 751. Young ovule of Celandine (*Chelidonium majus*) before its coverings are developed. It consists of the nucleus, *n*, which at this stage of growth is naked. The base of the nucleus, where the nourishing vessels enter, is marked *ch*. This point is called the chalaza.

Fig. 752. Orthotropous or Orthotropal ovule of Polygonum, showing the embryo sac, *s*, in the nucleus, *n*, the different ovular coverings, the base of the nucleus or chalaza, *ch*, and the apex of the ovule with its foramen, *m*.

Fig. 753. The ovule of the Mistleto (*Viscum album*). It consists of a naked nucleus, at the apex of which a depression appears, and ultimately a cavity, which is the sac of the embryo.

Fig. 754. The ovule of Celandine (*Chelidonium*), showing the nucleus, *n*, partially covered by the secundine, *s*.

Fig. 755. The ovule of Polygonum, with its nucleus, *n*, covered by the inner coat, *s*, or the secundine, and the outer coat, *p*, or the primine. The opening in the secundine, *end*, is called the endostome, that in the primine, *ex*, is the exostome. The point of the nucleus is seen projecting at the foramen. The end by which the ovule is attached to the placenta is marked, *f*.

Fig. 756. Ovule of the Walnut (*Juglans regia*), with a single coat, *s*, covering the nucleus, *n*, The foramen is marked *end*.

shows a division on one side, as in Drosera and some Euphorbias (Fig. 747, *s*). The half of one stigma occasionally unites to the half of that next it, thus giving rise to a peculiar abnormality in the relation of the parts.

337. Stigmas in a syncarpous pistil are either united (Fig. 699, *s*, p. 246) or free (Fig. 692, *s*, p. 245). In the latter case, their lobes or lamellæ indicate the number of carpels (Figs. 744, 745, and 746, *s*). The united stigmas sometimes become large and orbicular, as in Rock-rose (Fig. 748), or capitate, as in Primrose (Fig. 699, *s*, p. 246), or they radiate along a shield-like body, as in the Poppy (Fig. 417, *sti*, p. 175). In the Periwinkle (Fig. 749), the stigma is covered with hairs, and exhibits a marked contraction in the middle like an hour-glass, with a broad rim below. In the Nettle (Fig. 575, *s*, p. 216), the stigma is covered with hairs radiating from a point, and is called penicillate. In the Violet (Fig. 750, *s*), the stigma has a hooded and hooked appearance.

338. The name of stigma is sometimes erroneously given to parts of the style. Thus the upper petaloid portions of the style of the Iris (Fig. 732, *sty*, p. 251) have been called stigmata, a term which ought to be restricted to the little slits at their apex (Fig. 732, *stig*, p. 251). So also the umbrella-like stigma of Sarracenia is in reality an expansion of the styles with the stigmata at their edges. In some stigmata, as those of Mimulus, the two lamellæ are irritable, and close when touched. In Orchids (Fig. 616, p. 228), the stigma is sessile on the common column (gynostemium), and appears as a viscid space immediately below the anther lobes.

339. *Transformations of the Pistil* are of frequent occurrence. They depend, generally, on abortion of a certain number of carpels and adhesions of various kinds. In the apocarpous pistils of Aconite, Nigella, Larkspur, and Pæony, we find on the same plant pistils composed of two, three, four, five, and six carpels. In some of the Brambles, Moquin-Tandon has seen all the carpels except one disappear, thus making the fruit resemble that of the Plum. In the case of Leguminous plants, there is usually only a single carpel, although the flower is pentamerous; this state has been traced to abortion of carpels, and the view is confirmed by finding plants in the same natural order with more than one carpel. Thus, in the genus Diphaca there are two, so also in Cæsalpinia digyna, while in Affonsea there are five. The pistil of the Almond, Cherry (Fig. 690, p. 243), Plum, and Peach, primarily consists of two carpels, one of which usually becomes abortive. Pistils of a succulent nature, such as those of the Sloe and Bird-cherry, sometimes assume the form of a pod, like that of the Pea. Occasionally stamens are changed into carpels, as in Papaver bracteatum, according to Turpin; and at other times, as in Colchicum according to Gay, the carpels are transformed into stamens, and bear pollen.

340. *The Ovule* is the rudiment of the future seed (Fig. 683, *ov*, p.

241), and in its early state it appears as a minute cellular projection or mammilla of the placenta. It is analagous to a bud produced by the edge of a leaf, as in Bryophyllum (Fig. 720, p. 249), or to a bud formed on a branch in cases where the placenta is axile. The cells multiply until the ovule assumes a more or less enlarged ovate form, constituting what has been called the *nucleus*, or the central cellular mass of the ovule (Fig. 751). The term nucleus must not be confounded with the nucleus of a cell (Fig. 42, p. 22, and ¶ 58).

341. The ovular nucleus alters in the progress of growth, so as to be prepared for the development of the embryo-plant in its interior. At the apex of the nucleus an absorption or obliteration of cells takes place, by which a hollow cavity is formed, which becomes lined with a thin cellular membrane (epithelium), and forms the sac in which the rudiments of the embryo first appear (Fig. 752, *s*). This *embryo-sac* is surrounded by a cellular layer derived from the nucleus (Fig. 752, *n*), to which the name of *tercine* has been given. In some instances the nuclear cells or tercine appear to be the only coverings of the sac, as in the Mistleto (Fig. 753). In most cases, however, other cellular layers are formed, which first appear in the shape of annular appendages at the base, and then gradually spread over the central mass. These ovular coverings are usually two, one next the nucleus, and first formed (Fig. 754, *s*), called the *secundine*, and the other on the outside (Fig. 755, *p*), called the *primine*. These two coats or coverings of the ovule are sometimes incorporated so as to appear one (Fig. 756).

342. At the base of the ovule, these coverings and the nucleus are intimately united at one point by a cellular and vascular process, called the *chalaza* (Fig. 757, *ch*), where the nourishing vessels enter from the placenta. At the apex of the ovule they leave an opening called the *foramen* or *micropyle*, through which the influence of the pollen is afterwards conveyed. This foramen extends through both ovular coats, the opening in the outer (Fig. 755, *ex*) being the *exostome* (outer mouth), and that in the inner (Fig. 755, *end*) being the *endostome* (inner mouth). The foramen indicates the organic apex of the ovule, while the part connected with the placenta by means of the stalk (Fig. 755, *f*) called the *funiculus* or *podosperm*, is the base or *hilum*.

343. The relation which the hilum, the micropyle, and the chalaza bear to each other varies in different ovules. In an *orthotropous* or straight ovule (straight as regards its axis), the chalaza is at the hilum, and the micropyle at the opposite extremity (Fig. 752). In such an ovule the chalaza, *ch*, is at the base, and the micropyle, *m*, at the apex, and no curvature or inversion takes place either in the nucleus or in its coverings. In a *campylotropous* or curved ovule, the chalaza is still at the hilum, but the whole ovule is bent upon itself, so that the micropyle or apex approaches the hilum. This is shewn in Figure 758, which exhibits a vertical section of the ovule of Wallflower; the nucleus, *n*, is curved on itself, and so is the primine, *p*,

and secundine, *s*; the chalaza, *ch*, is at the base of the ovule, and the foramen or apex is close to it. In an *anatropous* or inverted ovule (Fig. 759), an inversion of the nucleus, *n*, takes place, so that its base, *ch*, is removed to the opposite side from the hilum, *h*, or base of the ovule, and the micropyle, *f*, is so placed as to be close to the hilum. In this case the chalaza, *ch*, is at the apparent apex of the ovule, and its connection with the placenta is kept up by a cord, *r*, called the *raphe*, consisting of cellular tissue and of spiral vessels.

344. Some represent the anatropous ovule as simply an inverted orthotropous one, with an elongated funiculus, in the form of the raphe, adherent along the side. It is probable, however, that the raphe is

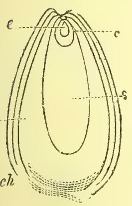


Fig. 757.

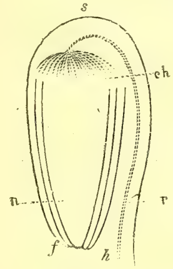


Fig. 759.

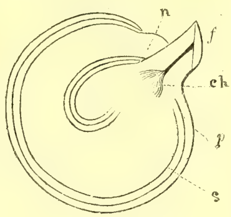


Fig. 758.

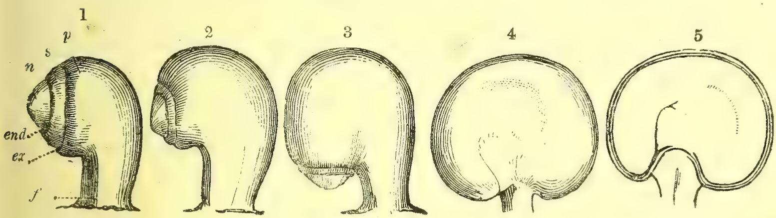


Fig. 760.

also in part formed by cells derived from the primine and secundine. This view is confirmed by the fact that the hilum in an anatropous ovule is not seen at the part where the raphe ends (Fig. 759, *s*), but at the part where it joins the placenta (Fig. 759, *h*). This

Fig. 757. Orthotropous or Orthotropal ovule of Polygonum, showing the coats of the ovule on the outside, the nucleus, *n*, the embryo-sac, *s*, containing a vesicle, *c*, in which the rudimentary embryo, *e*, is seen close to the foramen or micropyle. The chalaza is marked *ch*.

Fig. 753. Campylotropous or Campylotropal ovule of Wallflower (*Cheiranthus*), showing, *f*, the funiculus which attaches the ovule to the placenta, *p*, the primine, *s*, the secundine, *n*, the nucleus, *ch*, the chalaza. The ovule is curved upon itself, so that the foramen is near the funiculus.

Fig. 759. Anatropous or Anatropal ovule of Dandelion (*Leontodon Taraxacum*), showing the coats of the ovule surrounding the nucleus, *n*, which is inverted, so that its base, *ch*, where the chalaza exists, is removed from the base or hilum of the ovule, *h*, while the foramen, *f*, is near the base. The connection between the base of the ovule and the base of the nucleus at *s* is kept up by means of the raphe, *r*.

Fig. 760. Various stages of the development of the Campylotropous ovule of Mallow (*Malva*). The funiculus, *f*, the primine, *p*, the secundine, *s*, the nucleus, *n*, the exostome, *ex*, the endostome, *end*. In 1 the ovule is becoming slightly curved, in 2 more so, in 3 the curvature is decided, so that the foramen is near the hilum, in 4 and 5 the curvature and union of the parts is complete.

is, consequently, the true base of the ovule. When the hilum is placed midway between the micropyle and the chalaza, the ovule becomes *heterotropal*, and in such cases it frequently happens that the funiculus proceeds at right angles from the ovule, so that the latter becomes horizontal. Such ovules are considered by some as produced by a partial adhesion of the funiculus to the upper part of one side of the ovule.

345. Anatropous ovules are very common in plants. They appear to be formed with the view of allowing the pollen tubes to reach the foramen easily, as will be explained under Embryogeny. Campylotropous ovules are by no means uncommon. They are met with in Cruciferous and Caryophyllaceous plants, in Mignonette, and in the Bean. The orthotropous form is rare as a permanent condition of the ovule; it is met with in a few natural orders, such as the Buckwheat and Rock-rose tribes.

346. Many look upon the orthotropous form as being the earliest state of all ovules, and refer the other forms to changes produced during growth. The campylotropous ovule of the Mallow is traced in Figure 760 through its various phases, from its slight curvation, 1 and 2, through its more complete curvation, 3, until, by adhesion and other alterations, it assumes the forms shown in 4 and 5. So also the anatropous ovule of the Celandine is seen in an orthotropous state in Figures 751 and 754; the nucleus then begins to turn round, as seen in Figure 762, 1, and ultimately it assumes the forms exhibited in Figure 762, 2 and 3, the latter being its perfect state.

347. Ovules vary in number. Sometimes there is a *solitary* ovule in each ovary (Fig. 727, p. 251) or in each loculament, at other times there are several (Fig. 763). When the number is not great, and is uniform, the ovules are said to be *definite*, when very numerous they are *indefinite*. They are att[illegible]d in [illegible] ways to the placenta, and their posi[illegible] ovary varies. When the placenta at the base of the ovary is the only part ovuliferous, then the ovule is *erect*, as in Polygonum (Fig. 761). When the ovuliferous part is above the base, and the ovules proceed obliquely upwards, they are *ascending*, as in the Pellitory, and if they are developed equally on either side of the attachment, they are *horizontal* or *peltate*, as in Crassula. When the ovuliferous part of the placenta is at the apex of the ovary, the ovules are *pendulous*, as in Valerian (Fig. 764), in the Ash (Fig. 765), and in the Mare's-tail; when below the apex, they are *suspended*, as in the Apricot (Fig. 683, p. 241), in the Red Valerian (Fig. 727, p. 251), and in the Mezereon. In the Common

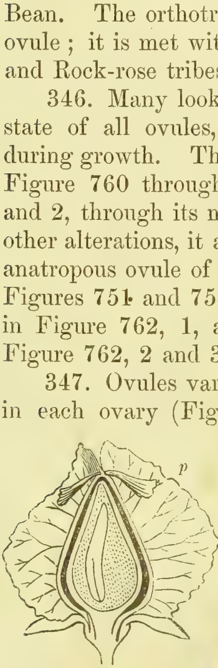


Fig. 761.

Fig. 761. Erect ovule of a species of Dock (*Rumex*). The ovary is attached to the enlarged pericarp, *p*, the placenta is at the base of the ovary, and hence the solitary ovule is erect. The ovule contains the embryo plant, which is inverted.

Thrift (Fig. 728, p. 251), and in Sumach, a funiculus extends from the placenta to the apex of the ovary, and curves downwards, *cor*, so as to suspend the ovule. When an ovary is multi-ovular (contains many ovules), the ovules may be all attached in the same way, and be placed either collaterally (Fig. 718, p. 249), or one above the other (Fig. 763); or they may be attached in different ways, so that some are erect

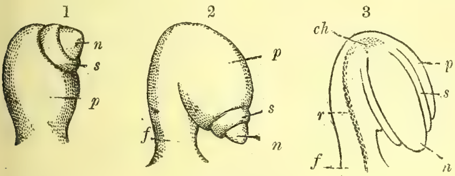


Fig. 762.

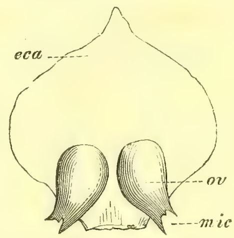


Fig. 766.

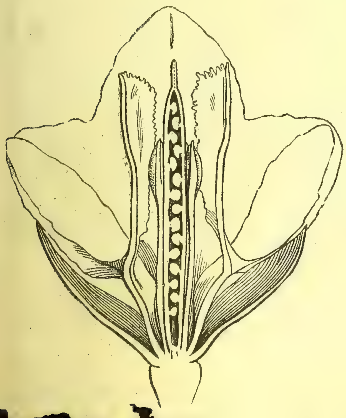


Fig. 763.

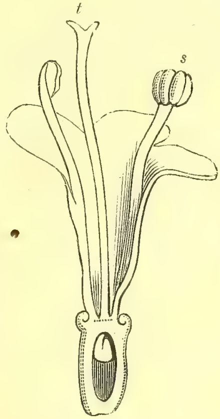


Fig. 764.

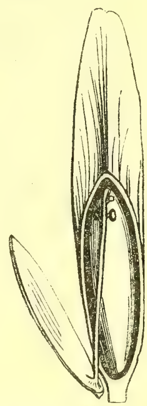


Fig. 765.

and others pendulous. These terms apply only to the position of the ovule as respects the ovary, and they have reference alike to orthotro-

Fig. 762. Stages in the development of the anatropous ovule of Celandine (*Chelidonium*). The first two stages are seen in Figures 751 and 754, at page 256, the remaining stages are represented in the present Figure, from 1 to 3. The primine, *p*, secundine, *s*, nucleus, *n*, funiculus or umbilical cord, *f*, the chalaza, *ch*, the raphe, *r*. At 1 the ovule is seen with the nucleus slightly turned, at 2 it is much more inverted, and at 3 the subversion is complete. The connection between the base of the nucleus, *ch*, and the base of the ovule, *f*, is kept up by the raphe, *r*.

Fig. 763. Vertical section of the flower of Hypecoum. The ovary contains numerous ovules, placed one above the other, and attached alternately to either side.

Fig. 764. Flower of Valerian (*Valeriana*), cut vertically, showing the solitary pendulous ovule in the ovary. The placenta is at the apex of the ovary. The stamen, *s*, the style, *t*.

Fig. 765. Samaroid or winged ovary of Ash (*Fraxinus*), with a solitary anatropous ovule pendulous from its apex. Part of the ovary is removed, to show the cord extending to the apex, where the ovule is attached.

Fig. 766. Pistillate flower of a Fir (*Pinus*), consisting of a scale, *eca*, which is a hardened bract, and two ovules, *ov*, attached to its base. The apex of the ovules is indicated by the foramen, *mic*. Some look upon the scale as an expanded carpellary leaf. The ovules are called naked, because they are not contained in a true ovary, with a stigma attached to it.

pous, campylotropous, and anatropous ovules. Thus, an anatropous ovule may be either erect or pendulous as regards its position in the ovary. The same terms apply to the seed in its relation to the seed-vessel.

348. The position of the raphe in anatropous ovules has been examined by Mr. Clarke, who gives the following arrangement :—

1. Pendulous ovules, with the raphe next the placenta, which is the ordinary position of anatropal ovules.
2. Pendulous ovules, with the raphe turned away from the placenta, as seen in many Endogens, also in Crowfoots and Peppers.
3. Pendulous ovules, with the raphe lateral, as seen in the Malpighia and Goosefoot orders, and in several genera.
4. Erect ovules, with the raphe next the placenta, which is the ordinary occurrence in erect anatropal ovules.
5. Erect ovules, with the raphe turned away from the placenta, as seen in Composite plants, in Penæa and Calytrix.
6. Erect ovules, with the raphe lateral, which are very general in Exogens.

349. Some ovules are not contained in a true pistil, *i. e.*, in a carpel consisting of true ovary and stigma. These ovules are met with in the Cycas and Cone-bearing orders. In the former (Fig. 37, p. 21, and Fig. 89, p. 38), the ovules are arranged on the edges of metamorphosed leaves, and the pollen from the male flowers is applied directly to them, without the intervention of a stigma.* In the latter, the ovules (Fig. 766, *ov*) are covered by scales, *eca*, which are hardened bracts or floral leaves covering the female flowers. In this case also the pollen is applied to the micropyle, *mic*, of the ovules, without the intervention of a stigma.

350. Recapitulation of the general facts stated relative to the pistil before it becomes the fruit :—

1. The pistil is the central part of the flower, and consists of one or more folded metamorphosed leaves, called Carpels, which constitute the Gynœcium or female organ.
2. These carpels are developed in the same way as leaves, and they agree with the latter in structure and arrangement.
3. In monœcious, diœcious, and polygamous plants, some flowers produce a pistil without stamens, and they are called Pistilliferous, Pistillate, or female.
4. The pistil is normally in the centre of the flower, and free or superior, all the other whorls being placed around it and below it, so as to be hypogynous.
5. The pistil is often, however, united to the other whorls, more especially to the calyx; it then becomes adherent or inferior, while the other whorls are more or less epigynous.
6. A Carpel is a leaf folded upwards towards the axis, and consists of an ovary containing ovules, and of a stigma which is either sessile or supported on a style. The terms ovary, style, and stigma, are applied either to the parts of a single carpel, or to the completely united parts of a compound (syncarpous) pistil.
7. The stigma and style always mark the organic apex of the ovary, even although they may be placed in a lateral or basal position as regards the apparent summit.
8. The dorsal suture of a carpel corresponds to the midrib of the leaf, the ventral suture bearing the placenta and ovules to the united margins of the folded leaf.

* A beautiful specimen of Cycas revoluta, with its metamorphosed fruit-bearing leaves, and ovules, has been presented to the Museum of the Edinburgh Botanic Garden by Dr. Gilbert M'Nab.

9. Placentation is of two kinds, marginal, *i. e.*, a development of cellular tissue along the ventral suture, or axile, *i. e.*, a prolongation from the axis.
10. Placentas are either central or parietal; and, when axile in their formation, they are often free in the centre, surrounded by carpellary leaves.
11. The individual carpels of which a pistil is originally formed, either continue separate, so as to form an Apocarpous pistil, or they are united, more or less, so as to form a Syncarpous pistil.
12. In an Apocarpous pistil the number of carpels forming it is evident; in a Syncarpous pistil their number is determined by counting the stigmas or styles when these are separate, or the number of loculaments and septa in the united ovaries.
13. Septa are formed by the united margins or laminæ of carpellary leaves, and are therefore vertical; each septum being double.
14. The pistil is more liable to change in the progress of growth than any of the other whorls. Its transformations depend chiefly on abortion or suppression of parts, degeneration, adhesion, rupture or absorption of septa, folding inwards of the ventral or dorsal sutures, and development of the placenta so as to form spurious partitions.
15. Ovules may be considered as cellular buds on the margins of carpellary leaves, or on the floral axis. In the one view they are marginal, in the other axile. They are attached to the placenta usually by means of a funiculus.
16. Ovules are composed of a nucleus and two evident coverings called primine and secundine, perforated at a point, called the Foramen or Micropyle, which is the true organic apex of the ovule.
17. Ovules are nourished by vessels from the placenta entering at the Hilum or base of the ovule, and proceeding to the base of the nucleus either directly or in the form of a Raphe. The base of the nucleus where the vessels enter being the Chalaza.
18. Ovules are either straight or curved, and are divided into Orthotropal, Campylotropal, and Anatropal, the last being the most common permanent form.
19. In practical Botany it is of importance to attend to the position of the hilum, foramen, chalaza, and raphe of the ovules; as well as to the position of the ovules in the ovary, whether erect or pendulous.
20. Ovules are usually contained in an ovary, and plants having such ovules are Angiospermous. Sometimes ovules are not in a true ovary, and are called naked, as in Gymnospermous plants.

b. PISTIL AFTER BECOMING THE FRUIT.

351. *The Fruit* is, properly speaking, the pistil arrived at maturity, containing the ripe seeds, in which the embryo plant is developed (Fig. 767). The simplest form of fruit is that formed by a single carpel, enclosing one or more seeds (Figs. 768 and 769). It often happens that changes take place by which some parts of the carpel are rendered succulent, and then, in place of a dry fruit, there is produced a fleshy one. This is well seen in the case of the Peach (Fig. 770), in which the outer epidermal covering of the carpel forms what is called the *skin*, the parenchymatous cells of the mesophyllum constitute the *flesh*, and the inner epidermis of the carpellary leaf is changed into the *stone;* the kernel being the ripe seed containing the embryo plant. In the Coco-nut, in place of fleshy cells, woody fibrous ones are produced; the outer layer of the husk representing the external epidermis of the ovarian carpel, the fibrous portion being the parenchyma of the carpel, and the hard shell being the inner epidermis of the carpel enclosing the seed and the embryo.

352. As in the case of the pistil, so in the fruit, the carpels composing it may be distinct or united. When the fruit consists of a single ripe carpel, or of several separate and distinct carpels, it is said to be *apocarpous* or *dialycarpous*, as in the Pea (Fig. 769), and the Carob-tree (Fig. 771, *b*), where there is a single carpel, and in the Ranunculus (Fig. 694, p. 245), and Columbine (Fig. 772), in which there are several separate mature carpels. When the mature carpels are combined, as in the Poppy (Fig. 417, p. 175), and in the Epilobium (Fig. 773), the fruit is *syncarpous*. Sometimes the mature pistils of several flowers are incorporated into one hard or succulent mass, as in the Cone (Fig. 353, p. 150), in the Mulberry (Fig. 774), and in the Fig (Fig. 366, p. 154, and Fig. 775), and in these instances, what is commonly called the fruit, consists, in reality, of a great number of fruits united together. Such fruits are called *collective* or *multiple*.

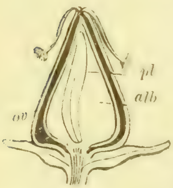


Fig. 767.

Fig. 768.

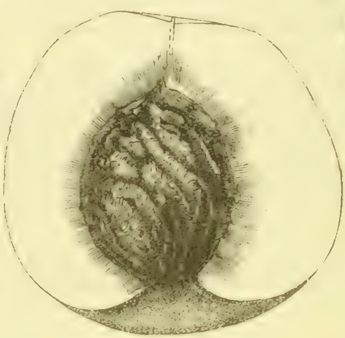


Fig. 770.

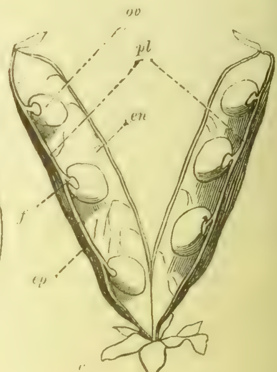


Fig. 769.

353. The fruit may be formed not merely by the pistil, but also by other parts of the flower united to it, more or less completely.

Fig. 767. Fruit of a species of Dock (*Rumex*), cut vertically. It is a monospermous indehiscent dry fruit, called an Achene, or Achænium. The outer part, *ov*, is the pericarp or seed-vessel containing the seed, with its coverings. The seed contains nourishing matter, called albumen or perisperm, *alb*, and the embryo plant, *pl*, with its cotyledons pointing downwards, and its radicle upwards. The seed is orthotropal, and the embryo is inverted. At the upper part of the pericarp two of the styles and stigmas are seen curving downwards. At the base, part of the perianth is represented.

Fig. 768. Achænium of Crowfoot (*Ranunculus*). A single-seeded seed-vessel, with the pericarp applied closely to the seed. Such fruits resemble seeds in appearance; the style and stigma, *s*, aid in distinguishing them.

Fig. 769. Legume of the Pea (*Pisum sativum*), consisting of a single carpel arrived at maturity, and containing numerous seeds (polyspermous). The pericarp consists of epicarp, or exocarp, *ep*, and endocarp, *en*. The seeds, *ov*, are attached to the placenta, *pl*, by means of the cord or funiculus, *f*. The Legume opens by the ventral and dorsal suture. The placenta, *pl*, is double, and runs along each edge of the ventral suture. At the apex of the pod the remains of the style and stigma are seen, and at the base the calyx.

Fig. 770. Fruit of the Peach (*Amygdalus persica*), consisting of the outer skin or epicarp, the flesh or mesocarp, and the stone or endocarp, enclosing the kernel or seed.

Thus, in the Apple, Pear, Medlar (Fig. 776), Gooseberry, Currant (Fig. 777), and Melon (Fig. 490, p. 197), the calyx is combined with the pistil; in the Hazel-nut (Fig. 351, p. 149), the Acorn (Fig. 350, p. 149, and Fig. 778), and Chestnut, bracts form the husk, the cup, and the burr; in the Rose (Fig. 503, p. 199), the receptacle is enlarged, and covers the pistil. Occasionally the fruit seems to consist not merely of a number of rows of transformed leaves, but of a transformed branch in addition. A good illustration of this occurs in the Chinese

Fig. 771.

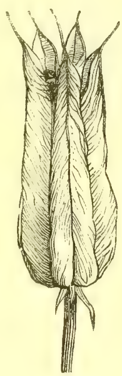


Fig. 772.

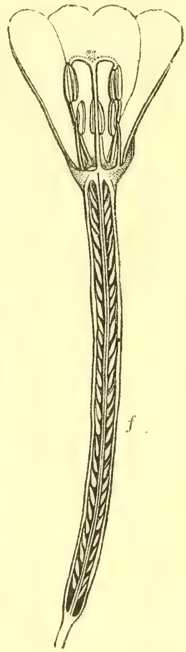


Fig. 773.

tree, called Hovenia, whose fruit consists of a swollen fleshy fruit-stalk, which is succulent enough to be eatable, and of a hard dry un-

Fig. 771. Flowering branch, *a*, and fruit, *b*, of the Carob-tree (*Ceratonia Siliqua*). The leaves are pinnate. The fruit is a Legume, dehiscing by the ventral and dorsal suture, and containing numerous seeds. The fruit is formed by a single mature carpel. The tree is called in Greek *Keratia* or *Keratonia*. In Luke xv. 16, the word *Keratim* occurs, which has been translated husks. These husks appear to have been the fruit of this tree. Some have thought, apparently erroneously, that the pods of this tree supplied food to John the Baptist, and hence the tree has been called St. John's Bread, and Locust-tree. The dried pods are at the present day used as food for horses and cattle.

Fig. 772. Apocarpous fruit of Columbine (*Aquilegia vulgaris*), consisting of five separate mature carpels, with styles and stigmas.

Fig. 773. Syncarpous fruit, *f*, of Willow-herb (*Epilobium*), consisting of four carpels united together, forming a quadrilocular fruit, with numerous comose (hairy) seeds. The seed-vessel is adherent to the tube of the calyx, and the limb of the latter is superior, while the fruit is inferior. The stamens and petals are attached to the calyx (Calycifloræ). The style and stigma are seen in the centre of the flower.

eatable capsule, formed in the usual way from modified leaves. In the Pear-tree peculiar transformations sometimes take place, by which the end of a branch has a tendency to become fruit.* Some suppose the hep of the Rose to be the hollow end of the axis or branch, with leaves above it.

354. By ascertaining the anatomy and structure of the pistil, we are led to a knowledge of the nature of the fruit, and we are enabled to see the changes which take place during growth. These changes depend on increase of the parenchyma, adhesion of one part to another, obliteration of loculaments or of ovules, and the development of additional processes or partitions from the placenta, and from other parts of the pistil. Thus, the Coco-nut in its young state, is formed by

Fig. 774.

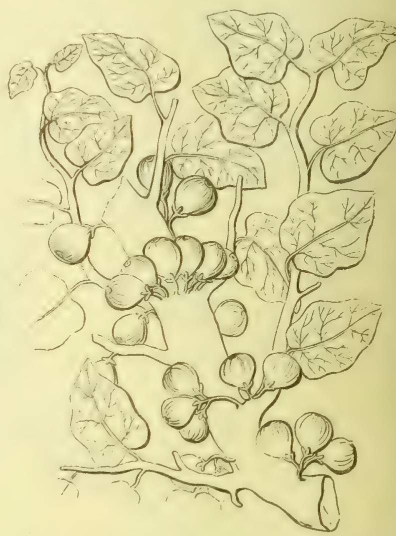


Fig. 775.

three carpels, each containing a single ovule, while in its mature condition there is only one loculament and one seed. In this case the partitions between the carpels are obliterated, and one ovule is developed at the expense of the other two. These changes may be

Fig. 774. Fruiting branch of the Black Mulberry (*Morus nigra*). The fruit is anthocarpous, or collective, consisting of the ovaries and envelopes of numerous flowers, united into one succulent mass. It is quite different in structure from the Raspberry. The leaves are reticulated, cordate, and serrate. The tree seems to be the *Sykaminos* of the Greeks, translated Sycamine-tree in Luke xvii. 6.

Fig. 775. Fruiting branch of the Sycamore-Fig (*Ficus Sycomorus*). The fruit is anthocarpous, or collective, consisting of a fleshy hollow receptacle, on which numerous flowers are arranged. These flowers are seen on cutting open the fruit vertically. What are called seeds in the Fig are in reality single-seeded fruits. The plant is the *Shikmoth* or *Shikmim* of the Bible, translated Sycamore (1 Kings x. 27; 1 Chron. xxvii. 28; 2 Chron. i. 15; Ps. lxxviii. 47; Is. ix. 10; Amos vii. 14; and Luke xix. 4).

* See Gardener's Chronicle, February 15, 1851.

traced on careful examination; and even in the ripe fruit indications of them are seen in the markings on the shell. In the Hazel-nut and in the Acorn (Fig. 779), the young pistil is formed of three carpels, with two ovules in each, as seen in the Figure, but in the progress of development changes are induced by which the fruit becomes one-celled and one-seeded. In these cases a trilocular sex-ovular pistil becomes a unilocular and monospermic fruit. In the Ash (Fig. 765, p. 261), the Elm, the Beech, and the Horse-chestnut, similar changes are produced in the pistil by the abortion of ovules, and the obliteration of divisions. In the Thorn-apple the pistil is formed of two carpels, separated by a septum (Fig. 711, p. 248), while the fruit exhibits four loculaments (Fig. 712, p. 248), produced by prolongations from the placentas, forming a spurious septum in each carpel. Changes of a similar kind occur in the fruit of Petræa, and in some

Fig. 777.

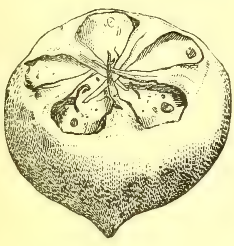


Fig. 776.

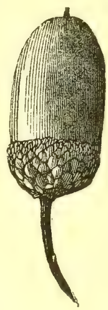


Fig. 778.

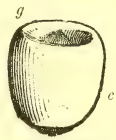


Fig. 780.

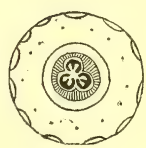


Fig. 779.

pods, such as the Cassia Fistula (Fig. 705, p. 247) and Astragalus (Fig. 710, p. 248).

355. It sometimes happens that the receptacle or peduncle becomes succulent, and is called the fruit in ordinary language. Thus, in the Strawberry (Fig. 781), the true fruit consists of small single-seeded

Fig. 776. Fruit of the Medlar (*Mespilus germanica*), consisting of five carpels, united together by means of a fleshy mass, and adherent to the calyx, which forms part of the fruit. The withered limb of the calyx is seen at the upper part of the syncarpous fruit or pome. The seeds are contained in stony coverings, called nucules, and hence the fruit has sometimes been called a nuculanium.

Fig. 777. Raceme or cluster of red Currants (*Ribes rubrum*). Each fruit is a berry (bacca), with the calyx adherent to it. The remains of the limb of the calyx are seen at the top of the berry. The seeds are immersed in a pulpy mass, and are attached at first to parietal placentas.

Fig. 778. Acorn, or fruit of the Oak (*Quercus*), consisting of the ovary containing a single seed, and surrounded by a series of bracts which form the cup or cupula.

Fig. 779. Transverse section of the Acorn (glans), showing the three carpels with two ovules in each, of which it is originally composed. Two of the carpels and five of the ovules are obliterated during the progress of growth, so that the mature fruit is unilocular and monospermal. Surrounding the ovary the mass of bracts are seen.

Fig. 780. Fruit of the Yew (*Taxus baccata*) consisting of a single seed, *g*, surrounded by a cup, *c*, which is formed by succulent bracts united.

(monospermic), dry seed-vessels (commonly called seeds), scattered over a succulent convex receptacle ; in the Rose, the true fruit consists of similar seed-vessels arranged on a fleshy concave receptacle (Fig. 504, p. 199) ; and in the Fig (Fig. 782), the true fruit consists of monospermic seed-vessels produced by separate flowers, and scattered over the inner surface of a concave succulent receptacle (Fig. 366, p. 154). In the Cashew, the nut or true fruit, is borne on a coloured succulent stalk, which enlarges during ripening.

356. In the interior of some fruits a pulpy substance is produced, apparently as a secretion from the inner lining of the ovary. This kind of pulpy matter is met with in the Gooseberry, Currant, Grape, Orange, and pod of Cassia Fistula. Occasionally the organs adjacent to the pistil become the succulent parts of the fruit. In Strawberry-

Fig. 781.

Fig. 783.

Fig. 782.

Blite, the calyx surrounding the pistil, and separate from it, becomes red and juicy ; in Gualtheria procumbens, the free calyx, after flowering, becomes red and succulent, surrounding the true fruit which is dry. In the Yew, the bracts enveloping the seed (Fig. 782, *c*), become succulent.

Fig. 781. The fruit of the Strawberry (*Fragaria vesca*), consisting of the enlarged succulent receptacle, or growing point, bearing on its surface numerous single-seeded carpels or achenes. Each achene has a style and stigma, and is thus at once distinguished from a seed. The calyx is seen at the base of the receptacle.

Fig. 782. Fruiting branch of the Fig-tree (*Ficus Carica*) with its palmately-lobed leaves. The fruit consists of the hollow succulent receptacle or general peduncle, enclosing numerous flowers which produce achenes. It is the *Teenah* of Scripture (Gen. iii. 7 ; Deut. viii. 8 ; 2 Kings xx. 7 ; Psalm cv. 33, &c.)

Fig. 783. Fruiting branch of the Bread-fruit tree (*Artocarpus incisa*), with its large pinnatifid leaves. The fruit, *b*, is anthocarpous, and consists of numerous female flowers united together so as to form a succulent mass. It is often seedless. The male flowers, *a*, are arranged in a spike.

357. The fruit, generally speaking, consists of the seed-vessel or *Pericarp*, and the *Seed*. It cannot be said to be perfect unless the

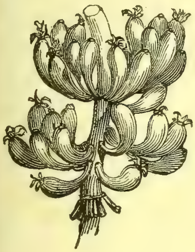


Fig. 784.

Fig. 786.

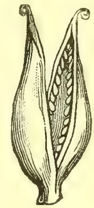


Fig. 790.

Fig. 787.

Fig. 789.

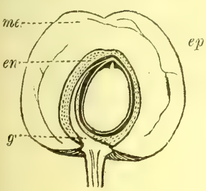


Fig. 785.

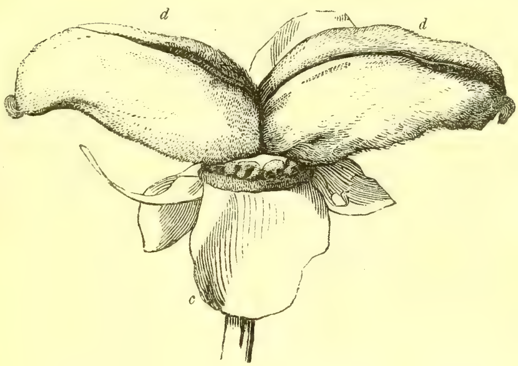


Fig. 788.

seed and embryo are produced. In many cultivated fruits, however, the seeds are abortive. Thus, in the case of the Bread-fruit (Fig.

Fig. 784. Cluster of fruit of the Banana (*Musa sapientum*). The fruit is baccate, and is adherent to the perianth, the remains of which are seen at the top of each fruit. The best Bananas are usually seedless.

Fig. 785. Drupe of the Cherry (*Cerasus*), cut vertically, showing the skin, or epicarp, *ep*, the flesh, or mesocarp, *me*, and the stone, putamen, or endocarp, *en*, enclosing the seed, *g*, with the embryo.

Fig. 786. The fruit of the Date-Palm (*Phœnix dactylifera*). 1, A cluster of Dates, with the spathe which originally enclosed them. 2, A collection of flowers of the Date-Palm. 3, A Date which is a drupaceous fruit. 4, Vertical section of a Date, showing epicarp, or the outer skin, mesocarp, or the fleshy portion, and endocarp, or the thin papery-like covering of the kernel or seed. The plant is the *Tamar* of the Bible (Exod. xv. 27; Psalm xcii. 12, &c.)

Fig. 787. Fruit of Fumitory (*Fumaria*). It is a single-seeded, indehiscent fruit, called an achene.

Fig. 788. Fruit of the Pæony (*Pæonia*), consisting of two carpels, *d d*, dehiscing by their ventral suture, and denominated Follicles. Each follicle contains several seeds arranged along the ventral suture. The parts of the calyx, *c*, are below the fruit.

Fig. 789. Fruit of the Figwort (*Scrophularia*), dehiscing by two valves, in a septicidal manner.

Fig. 790. Fruit of the Gentian (*Gentiana*), dehiscing by two valves in a septicidal manner. The seeds are arranged along each margin of the placenta.

783), Banana (Fig. 784), and Pine-apple, the best fruit is seedless, and such is often true of the Orange and the Grape. The Pericarp, in its simplest state, represents the carpellary leaf, and, like it, can be separated into three parts; the outer epidermal covering called *Epicarp*, or *Exocarp* (Fig. 785, *ep*); the middle parenchymatous portion, called *Mesocarp*, *me*, and when succulent, *Sarcocarp;* and the inner epidermal covering, *en*, called *Endocarp*, and when hard and stony, *Putamen*. These three coverings are well seen in the Peach (Fig. 770, p. 264), and in the Date (Fig. 786, 4). In their original structure these parts correspond with the leaf, but changes take place during ripening, by which some cells are hardened and others become succulent, and thus the resemblance to the leaf is much obscured. That succulent fruits, such as the Peach, Apricot, and Cherry, are to be regarded as altered carpellary leaves, is shown in the case of the

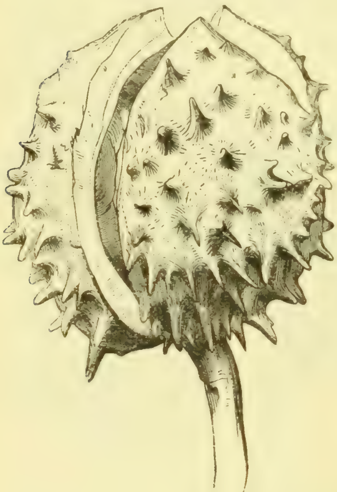


Fig. 791.

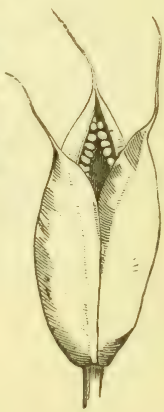


Fig. 792.

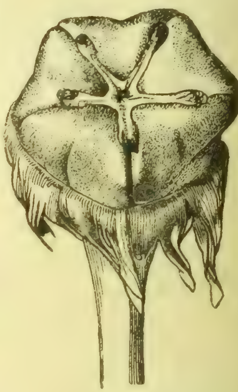


Fig. 793.

double Cherry, where true leaves occupy the place of the fruit (Figs. 675 and 676, p. 240). Mr. Wyville Thomson mentions instances of the common Sloe and Bird-Cherry producing red coloured follicular pods.*

Fig. 791. Fruit of the Horse-chestnut (*Æsculus Hippocastanum*), dehiscing by three valves, which separate from each other in a loculicidal manner. The parts are normally seven, but several carpels are abortive, and only one seed comes to perfection.

Fig. 792. Fruit or capsule of the Meadow-saffron (*Colchicum autumnale*), dehiscing by three valves in a septicidal manner. The fruit is thus resolved into its three component carpels, with their styles and stigmas.

Fig. 793. Fruit or capsule of a species of Fig-Marygold (*Mesembryanthemum*), dehiscing by five valves at the apex, in a septicidal manner. When the seed-vessels of some Fig-Marygolds are moistened in water the valves separate and spread outwards. This depends on endosmose taking place, which causes curvation in an outward direction.

* Specimens of these curious monstrosities have been presented by Mr. Thomson to the Museum of the Edinburgh Botanic Garden.

In many fruits, as in the Nut, the different pericarpial layers are so blended that it is not easy to mark their separation.

358. Some fruits fall without opening or dehiscing, the seeds being liberated during the process of decay; such fruits are *indehiscent* (Fig. 787). Other fruits open or dehisce in various ways, so as to scatter the seeds, and are called *dehiscent* (Fig. 788). The dehiscence takes place either in a vertical or in a transverse direction; the former is the usual mode. Vertical dehiscence takes place through the sutures, or by the separation of the parts of which a syncarpous fruit is composed. The separate parts are called *valves*. These valves are well seen in the Horse-chestnut (Fig. 791). In fruits formed by a single carpel, the dehiscence occurs either at the ventral or dorsal suture, or both. In the follicles of the Pæony (Fig. 788), the Columbine (Fig. 772, p. 265), and the Marsh Marygold, the dehiscence is ventral; in Magnolia grandiflora, the dehiscence is sometimes dorsal; while in the pod of the Pea (Fig. 769, p. 264) and of the Bean, it is both ventral and dorsal.

359. When the fruit consists of several carpels united, or is syncarpous, the dehiscence takes place either by a separation of the constituent carpels through the dissepiments, and in that case is *septicidal*, as in Figwort (Fig. 789) and Gentian (Fig. 790), where there are two valves, in Meadow-saffron (Fig. 792), where there are three valves, and in the Fig-Marygold (Fig. 793) and the Rhododendron, where there are five or more valves; or the dehiscence takes place by the dorsal suture of each carpel, and in that case is *loculicidal*, as in the Iris (Fig. 794), the Pansy (Fig. 795), the Lily, and the Horse-chestnut (Fig. 791).

360. There are modifications of these kinds of dehiscence. Thus, in the septicidal form the valves, on separating, sometimes carry the placentas with them, as in Gentian (Fig. 790), and Colchicum (Fig. 792); at other times, the placentas or placentaries are left attached to the central axis or columella, as in Rhododendron. In the case of Hura and Euphorbias (Fig. 796), each carpel, or coccus as it is called, separates from the columella, carrying with it an enclosed seed. In the loculicidal dehiscence the dissepiments may remain attached to the middle of each of the valves, and separate along with them, or the septa may adhere to the axis, and allow the valves to fall off without them, as in the Thorn-apple (Fig. 797) and Purple Convolvulus. The latter kind of loculicidal dehiscence is called *septifragal* (breaking off from the septa). In some cases the dehiscence is at first loculicidal, and afterwards the carpels separate from each other in a septicidal manner. This union of the two kinds of dehiscence is seen in some Spurges, in the Castor-oil fruit (Fig. 798), and in the Purging Flax. These various kinds of dehiscence are illustrated in diagrams 799, 800, and 801, which represent a dehiscent penta-carpellary fruit. In Figure 799, the dehiscence is septicidal; the five carpels, *l*, separate by dividing through their septa, *s*, and thus the fruit is split into its

component parts, the placentas either being attached to the edges of the valves, or remaining united in the centre to the columella. In

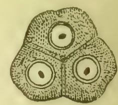


Fig. 796.

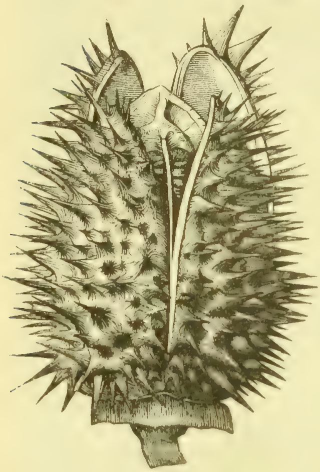


Fig. 797.

Fig. 798.

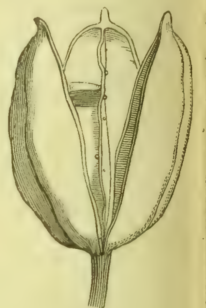


Fig. 794.

Fig. 795.

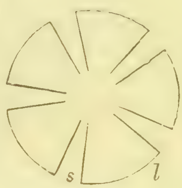


Fig. 799.

Fig. 800.

Fig. 801.

Figure 800, the dehiscence is loculicidal; the carpels, *l*, split at their

Fig. 794. The seed-vessel or capsule of the Flower de Luce (*Iris*), opening in a loculicidal manner. The three valves bear the septa in the centre. and the opening takes place through the back of the loculaments. Each valve is formed by the halves of contiguous carpels.

Fig. 795. The capsule of the Pansy (*Viola tricolor*), opening by three valves in a loculicidal manner. The placentas and seeds are placed on the middle of the valves.

Fig. 796. Transverse section of the tricoccous fruit of the Spurge (*Euphorbia*). It is formed by three single-seeded carpels called cocci, which, when ripe, separate from each other in an elastic manner, each carpel enclosing a single seed. The fruit is sometimes called a Regma.

Fig. 797. Fruit or capsule of the Thorn-Apple (*Datura Stramonium*), dehiscing by four valves, which separate in a septifragal manner, leaving the dissepiments in the centre. The valves are spiny, and hence the common name of the plant.

Fig. 798. Fruit of the Castor-oil plant (*Ricinus communis*), consisting of three carpels united together, which, when ripe, split in a loculicidal manner, and also separate from each other. Thus there is a combination of loculicidal and septicidal dehiscence. Each carpel encloses a single seed.

Fig. 799. Diagram to illustrate the septicidal dehiscence in a pentalocular capsule. The loculaments, *l*, correspond to the number of the carpels, which separate by splitting through the septa, *s*.

Fig. 800. Diagram to illustrate loculicidal dehiscence. The loculaments, *l*, split at the back, and the valves separate, bearing the septa, *s*, in their centres.

Fig. 801. Diagram to illustrate septifragal dehiscence, in which the dehiscence takes place through the back of the loculaments, *l*, and the valves separate from the septa, *s*, which are left attached to the placentas in the centre.

dorsal suture, *i. e.*, through the back of the loculaments, and the septa, *s*, remain attached to the middle of the valves, the placentas being usually attached to the ruptured septa. In Figure 801, the dehiscence is the variety of loculicidal called septifragal; the carpels, *l*, split at their dorsal sutures, but the septa, *s*, in place of being attached to the middle of the valves, are left united to the axis with the placentas.

361. In Orchis, the placentas, as represented in Figure 719, page 249, are parietal, and the seed-vessel opens by three valves (Fig. 802, *v*), which are placentiferous in their middle, but the midribs of the three carpels remain united at their base and summit, and the withered floral envelopes, *e*, are seen attached at the apex. In the

Fig. 802.

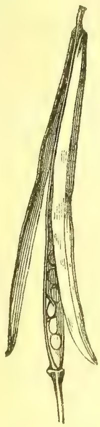


Fig. 803.

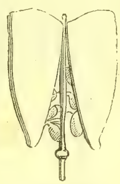


Fig. 805.

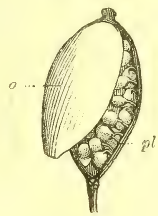


Fig. 804.

Fig. 806.

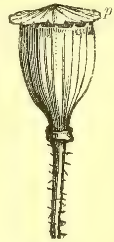


Fig. 808.

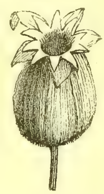


Fig. 807.

pod of cruciferous plants, such as Wallflower (Fig. 803), Whitlow-grass (Fig. 804), and Shepherd's-purse (Fig. 805), as well as in the

Fig. 802. Seed-vessel of an Orchid (*Orchis*), opening by three valves, *v v*, which bear the placentas and seeds in their middle. The midribs of the carpels remain united at the base and apex, and the withered floral envelopes, *e*, are seen attached at the apex.

Fig. 803. Siliqua or seed-vessel of Wallflower (*Cheiranthus Cheiri*), opening by two valves, which separate from the base upwards, leaving the seeds attached to the placentas in the middle, with a replum between.

Fig. 804. Silicula of Whitlow-grass (*Draba*), opening by two flat valves, *o*, from below upwards, leaving the parietal placentas, *pl*, in the centre, united by a membrane or replum. The seeds are attached to the placentas on either side of the seed-vessel. The partition of the seed-vessel is broad, and hence the name latiseptæ.

Fig. 805. Silicula of Shepherd's-purse (*Capsella Bursa-pastoris*), opening by two folded boat-shaped valves, which split from below upwards, leaving the narrow parietal placentas in the centre united by a frame or replum. The seeds are attached to the placentas on either side. The partition of the seed-vessel is narrow, and hence the name angustiseptæ.

Fig. 806. Seed-vessel of Celandine (*Chelidonium majus*), opening by two valves, which split from below upwards. The seeds are attached to the placentas, which are left in the centre. The seed-vessel is denominated a siliquiform or pod-like capsule.

Fig. 807. Seed-vessel or capsule of Campion (*Lychnis*), opening by ten teeth at the apex. The placenta is free central. The calyx is seen surrounding the seed-vessel, but not adherent.

Fig. 808. Capsule of Poppy (*Papaver*), opening by pores, *p*, under the broad peltate stigma.

pod-like fruit of Celandine (Figs. 806 and 809), two valves separate from the base upwards, leaving the parietal placentas united together

Fig. 810.

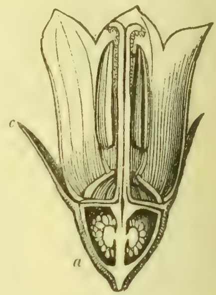


Fig. 812.

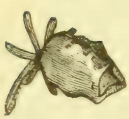


Fig. 811.

Fig. 809.

Fig. 813.

by a cellular frame or replum, which is either entire or perforated. In vertical dehiscence the splitting sometimes takes place only at the

Fig. 809. Flowering stalk, *a*, of Celandine (*Chelidonium majus*). The flowers are cymose in their inflorescence. Stalk, *b*, bearing leaf, *c*, and fruit, *d*. The latter is an elongated capsule. The juice of the plant is of an orange colour.

Fig. 810. Capsule of Frogsmouth (*Antirrhinum majus*), opening by rupturing at the apex. There are usually two orifices, one corresponding to the upper carpel, and the other to the lower. The style and stigma, *s*, are seen projecting from the fruit.

Fig. 811. Seed-vessel of Mignonette (*Reseda odorata*), opening at the apex so as to leave the seeds exposed. This opening takes place in the early stage of the growth of the fruit. The orifice is large. The seeds are said to be seminude.

Fig. 812. Flower of Bell-flower (*Campanula*), with the seed-vessel, *a*, united to the calyx, *c*. The seed-vessel opens laterally by slits through the ovary and calyx.

Fig. 813. Seed-vessel of Henbane (*Hyoscyamus niger*), opening by circumscissile dehiscence. The upper part of the seed-vessel comes off in the form of a lid, and the capsule has been on this account called Pyxis or Pyxidium. The transverse line of dehiscence may be considered as corresponding to the articulations of jointed carpellary leaves like those of the orange—the lower part representing the united petioles, and the lid the united laminæ.

apex of the fruit, so that the seed-vessel opens by teeth, as in Campion (Fig. 807), and Mouse-ear Chickweed, or by pores, as in the Poppy (Fig. 808), or by rupturing, as in Frogsmouth (Fig. 810), or by one large orifice, as in Mignonette (Fig. 811). In the Bell-flower (Fig. 812), the seed-vessel dehisces in a loculicidal manner laterally, or near the base.

362. Transverse dehiscence is of rare occurrence. It is seen in Henbane (Fig. 813), Pimpernel (Fig. 814), Purslane (Fig. 815), and

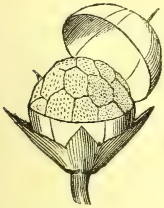


Fig. 814.

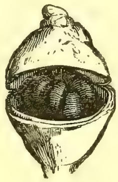


Fig. 815.

Fig. 816.

in various species of Monkey-pot (Fig. 816), in which the upper part of the fruit separates like a lid. This is called *circumscissile* dehiscence, and seems to indicate that the seed-vessel in these cases is formed by jointed leaves which separate at the articulations—the united petioles forming the lower part of the fruit, and the united laminæ constituting the lid.

Different kinds of Fruit, and explanation of Carpological Terms.

363. A classification of fruits ought properly to be founded on a consideration of their original formation, and of their anatomical structure in the early state. This is often puzzling to the student, inasmuch as it requires that he should trace the fruit during its different stages of development. By so doing, however, he is enabled to observe the various changes which take place by absorption, obliteration, adhesion, and division of parts, and he is in a condition to explain many apparent anomalies. Thus, in the Coco-nut, he sees that there are at first three loculaments and three ovules, but as the fruit ripens, two of each of them disappear, and finally only one remains. The three ridges, however, which remain on the endocarp, are at once explained by a reference to the early condition of the nut. Such is the case with many fruits, the structure of which

Fig. 814. Seed-vessel of the Scarlet Pimpernel (*Anagallis arvensis*), opening by transverse or circumscissile dehiscence. The capsule is called a Pyxis or Pyxidium.

Fig. 815. Seed-vessel of Purslane (*Portulaca*), opening by transverse dehiscence so as to constitute a Pyxidium or operculate capsule.

Fig. 816. Fruit (pyxidium) of the Monkey-pot (*Lecythis ollaria*), opening by a lid. The dehiscence is transverse or circumscissile, and the capsule is operculate or lidded. The seeds resemble the Brazil nuts, and are relished by monkeys, which are often entrapped when taking the nuts from the interior of the capsule.

would be obscure without a knowledge of the morphological alterations which have taken place. The names applied to fruits have a reference chiefly to their fully developed condition.

364. Without attempting to give a rigorous and minute definition of Carpological terms, which have been multiplied to a cumbrous extent, we shall merely explain some of those which are most frequently employed, arranging them according as they refer to fruits formed by a single separate flower, and which are called *Simple;* or to fruits formed by a combination of numerous flowers, and which are called *Collective*, *Multiple*, or *Anthocarpous*.

365. *Simple Fruits* may consist either of a single mature carpel, or of numerous separate carpels, arranged in one or more rows in a circular manner, on flat, convex or concave receptacles. They may be formed not only of the pistil but of the other parts of the flower united to it, and they may either be dehiscent or indehiscent, dry or succulent.

366. A *Follicle* is a fruit formed by a single mature carpel dehiscing by the ventral suture (Fig. 817). The fruit may consist of a

Fig. 817.

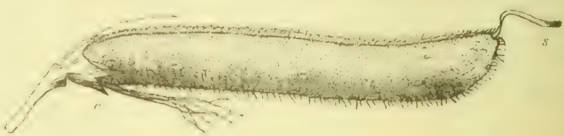


Fig. 818.

single follicle, as is seen occasionally in the Pæony; more commonly it is formed by two (Fig. 788, p. 269) or more separate follicles arranged in a circular or spiral manner, as in the Marsh Marygold, Columbine (Fig. 772, p. 265), Larkspur, Aconite, Hellebore (Fig. 693, p. 245), Spiræa (Fig. 681, p. 241), Asclepias, and the Tulip-tree. In some anomalous follicular fruits the opening takes place by the dorsal suture.

367. A *Legume*. This is commonly known by the name of *pod*, and is well seen in the case of the Pea, Bean, Lathyrus (Fig. 818), Tephrosia (Fig. 819), Acacia (Fig. 76, p. 33), Lentil (Fig. 251, p. 115), and Carob-bean (Fig. 771, p. 265). It consists of a single mature carpel dehiscing both by the ventral and by the dorsal suture (Fig. 769, p. 264), so as to separate into two halves. This kind of fruit is characteristic of the Pea order, which has hence been called

Fig. 817. Follicle of Columbine (*Aquilegia vulgaris*), consisting of a single polyspermal carpel, opening by the ventral suture.

Fig. 818. Legume or pod of a kind of Vetch (*Lathyrus*), consisting of a single polyspermal carpel dehiscing by the ventral and dorsal sutures. The seeds are attached along the ventral suture. At the base of the fruit are seen the calyx, *c*, and the remains of the stamens; and at its apex the style and stigma, *s*.

Leguminous. There are some anomalous legumes met with. In the Cassia or Cathartocarpus Fistula (Fig. 820), the legume has the markings of the sutures, but they are firmly united, and do not open so as to scatter the seeds; moreover, there are transverse partitions of a spurious nature from the inner walls dividing the pod into single-seeded cells containing a pulpy secretion in their interior. Indehiscent legumes containing one or more seeds, are met with in species of Dalbergia, Arachis, and Pterocarpus.

368. In some species of Acacia and Sainfoin (Fig. 821), in Bird's-foot, and in Sophora tomentosa, the legume is also indehiscent, and divisions between each of the seeds are formed by transverse foldings, embracing the whole thickness of the pod. This fruit is called a lomentaceous legume or a *lomentum.* It is sometimes called a moniliform pod. When mature, it separates into pieces, each of which contains a single seed. Some moniliform pods, as in Acacia arabica, are dehiscent. In some legumes, a spurious division is formed in a vertical manner by a prolongation from the placenta, or by a folding inwards


Fig. 819.

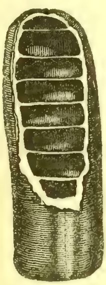


Fig. 820.


Fig. 821.

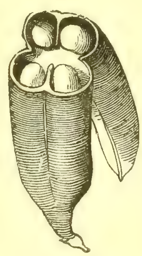


Fig. 822.


Fig. 823.

of the dorsal suture (Fig. 822). In Lucerne, the legume is curiously twisted, and becomes cochleate (Fig. 823); in Scorpiurus, it is revolute and somewhat spiral; and in Colutea, it has a leafy and inflated aspect (Fig. 824), whence the plant has received the name of Bladder-Senna.* In some legumes, the outer portion or the exocarp (epicarp)

Fig. 819. Legume of a species of Tephrosia, frequently found in adulterated senna. It dehisces by the ventral and dorsal suture, and the seeds are attached to the former.

Fig. 820. Peculiar indehiscent and partitioned legume of a kind of Cassia (*Cassia* or *Cathartocarpus Fistula*). The sutures are marked along the sides of the pod; but they do not open. The seeds are in separate cavities, immersed in pulp, which is a secretion from the endocarp, or inner lining of the pod.

Fig. 821. Lomentum or lomentaceous legume of a species of Sainfoin (*Hedysarum*). Each seed is contained in a separate cavity by the folding inwards of the walls of the legume at equal intervals; and the legume, when ripe, separates transversely into single-seeded portions.

Fig. 822. Legume of Milk-vetch (*Astragalus*), which is spuriously bilocular by the folding inwards of the dorsal suture. The legume is opened transversely to show the partition.

Fig. 823. Spiral or cochleate legume of Lucerne (*Medicago*). It is coiled up in a helicoid or cochlear manner, and when the convolutions are very close and appressed, it is difficult to determine its leguminous character.

* For a full account of the different kinds of Legumes, with figures, see Ralph's Icones Carpologicæ, Part i. Leguminosæ.

separates from the endocarp, which still remains covering the seeds. Such pods are seen in some species of Entada, and they are called spuriously dehiscent. The number of seeds in the legume varies. Some legumes are monospermal, as Gleditschia monosperma, Gourliæa, Voupa, Dipterix odorata, Geoffroya superba, Erythrina monosperma, and Copaifera officinalis. Others are dispermal or trispermal, as some species of Bauhinia, Dalbergia, Pterocarpus, and Arachis; again, in Cassia Fistula, the seeds often amount to nearly 100. In some inde-

Fig. 824.

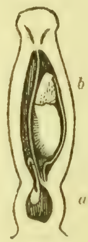


Fig. 829.

Fig. 826.

Fig. 827.

Fig. 828.

Fig. 825.

hiscent monospermal legumes, as Detarium, the coverings become succulent, so that they are really drupaceous, thus establishing a

Fig. 824. Inflated or Bladdery legume of the Bladder-senna (*Colutea arborescens*). The legume retains its leafy appearance, and its walls are not applied closely to the seeds.

Fig. 825. Siliqua of Wallflower (*Cheiranthus Cheiri*), composed of two, or, as some say, four carpels united. It opens by two valves which separate from below upwards. The placentas are parietal, and are left united by a cellular frame or replum, when the valves separate. The seeds are attached along each margin of the siliqua. The style, *sty*, and the stigma, *stig*, remain attached to the fruit.

Fig. 826. Fruiting branch of the Shepherd's-purse (*Capsella Bursa-pastoris*). The fruit is a silicula, or short pod, composed of two or four carpels, opening by two valves, which separate from below upwards. The placentas are left in the middle, united by a spurious dissepiment or replum.

Fig. 827. Silicula of the Scurvy-grass (*Cochlearia officinalis*), opening by two convex valves which separate from below upwards. The spurious septum or phragma is broad (latiseptæ).

Fig. 828. Silicula or pouch of Shepherd's-purse (*Capsella*), opening by two folded valves, which separate from below upwards. The phragma is narrow (angustiseptæ).

Fig. 829. Peculiar indehiscent siliqua of the Sea-Kale (*Crambe maritima*), in which the lower part of the pod, *a*, is seedless, and appears as a stalk, while the beak or upper joint of the pod, *b*, contains one or two seeds.

connection between the Leguminous and Rosaceous plants. In other indehiscent monospermal legumes, as Amphynemium, there is a membranous wing, so that the fruit resembles some varieties of samara.

369. A *Siliqua* is another kind of pod, formed (according to most authors) by the union of two carpellary leaves with parietal placentas, and dehiscing by two valves which separate from below upwards (Fig. 803, p. 273). It is well seen in the common Wallflower (Fig. 825) and in other Cruciferous plants (Fig. 374, p. 157). The two valves separate from the placentas, leaving them united by a cellular prolongation or replum (Fig. 707, p. 248), which divides the seed-vessel vertically into two loculaments. This replum is sometimes partially absorbed (Fig. 708, p. 248), and the siliqua is then unilocular (monothecal).

370. A broad and short siliqua (Figs. 804 and 805, p. 273, and Fig. 827) has received the name of *silicula.* In it, (the silicle) the carpellary leaves are either united together, so that the septum is in the broadest diameter of the pod (latiseptæ), as in Thlaspi, Draba (Fig. 804, p. 273), and Scurvy-grass (Fig. 827); or the carpels are folded so that their dorsal suture is prominent, and the replum is narrow or linear (angustiseptæ), as in the Shepherd's-purse (Figs. 826 and 828).

371. In the Siliqua, the style (when present) and the stigma remain adherent (Fig. 825, *sty*, *stig*). A siliqua may be divided transversely like a lomentum into single-seeded loculaments, as in Raphanus maritimus. Such a siliqua is indehiscent. In the Sea-Kale (Fig. 829), there is a jointed siliqua, the upper joint (beak) of which contains one or two seeds, while the lower is abortive and appears like a fruit-stalk. In Woad, the silicle becomes by abortion one-seeded, and by the absence of the replum unilocular. Occasionally a siliqua exhibits divisions on its inner walls which are not seen externally. Some look upon the siliqua as originally formed of four carpels, two of which are abortive; in this way the tendency to tetramerous symmetry is traced in the pistil.*

372. A *Capsule* is a dry syncarpous fruit dehiscing either vertically by valves, teeth, or pores, or transversely by a lid. It is composed of several carpels united, and it may exhibit all the kinds of dehiscence to which reference has already been made (¶ 358). In Caryophyllaceous plants, the dehiscence of the capsule often takes place by short valvular teeth (Fig. 807, p. 273), in the Mahogany fruit by complete valves which separate from below upwards, in Colchicum (Fig. 792, p. 270), and in Cotton (Fig. 101, p. 44) by valves separating from above downwards, in the Poppy (Fig. 808, p. 273) by pores below the stigma, in Frogsmouth (Fig. 810, p. 274) by rupturing at the apex, in Mignonette by becoming patent at the apex (Fig. 811, p. 274), in Campanula (Fig. 812, p. 274) by irregular

* Martins, Teratologie Vegetale, 50.

openings near the base, in Henbane (Fig. 813, p. 274) by a lid, in which case the capsule sometimes receives the name of pyxidium, in Spurges (Fig. 796, p. 272) by the sudden separation of elastic cocci or carpels, each containing one seed (Fig. 830), and in the Balsam (Fig. 831) by the separation of five elastic valves which coil upwards in the manner represented in Figure 832.

373. An *Achœnium* or *achene* is a dry indehiscent one-seeded (monospermous) fruit, as in Fumitory (Fig. 833) and Crowfoot (Fig. 768, p. 264). It is formed of a single carpel which is closely applied to the seed. At first sight it is difficult to distinguish this kind of seed-vessel from a seed, and hence Linnæus termed some achene-bearing plants naked-seeded (gymnospermia). The presence of the style and stigma, as in the Nettle (Fig. 834) and in the fruit of Carex (Fig. 835), aids in the determination. It is common to find several separate achenes forming the fruit. In Buttercups, the achenes are aggregated on a convex receptacle (Fig. 694, p. 245), in the Straw-

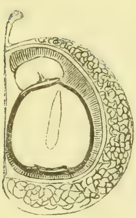


Fig. 830.


Fig. 831.

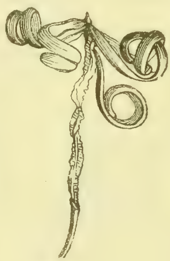


Fig. 832.


Fig. 833.

Fig. 834.

berry they are placed on a convex succulent receptacle (Fig. 695, p. 245), and in the Rose on a concave receptacle (Fig. 696, p. 246). In all these cases, the presence of styles and stigmata enables the student to ascertain that what are commonly called seeds are in reality fruits. The styles are sometimes remarkably elongated and feathery, as in Traveller's-joy (Fig. 836, *s*) and in the Pasque-flower Anemone.

Fig. 830. A Coccus or single carpel of Spurge (*Euphorbia*), separated from the other two, and cut longitudinally. It contains a single albuminous seed, with the embryo in the centre. At the upper part of the seed a kidney-shaped body is seen, which is a kind of aril proceeding from the edges of the micropyle.

Fig. 831. The ripe fruit of the Balsam (*Impatiens noli-me-tangere*), consisting of a five-valved capsule, which opens with great force when touched. Hence the name, Touch-me-not.

Fig. 832. The capsule of the Balsam (*Impatiens*), opening by five recurved elastic valves, so as to scatter the seeds.

Fig. 833. The fruit of the Fumitory (*Fumaria*). It is indehiscent and monospermal, and has received the name of Achænium or achene.

Fig. 834. Achene of the common Nettle (*Urtica*), surrounded by the perigone, and with the penicillate stigma, *s*, at the apex. The achene has hairs on its surface.

374. In the instances already noticed, the numerous achenes are the produce of a single flower, but cases occur, such as the Fig (Fig. 366, p. 154) and Dorstenia (Fig. 367, p. 154), in which they are each the produce of a separate flower. In the Borage and Mint orders, the two or four achenes forming the ripe fruit (Figs. 837 and 838) are at first united, and even when matured, there is a common style which is attached to the apparent base of each achene. Such cases may be considered as resembling two or four-celled capsules dehiscing in a septicidal manner, each division enclosing a single seed, as in Hura and Spurges.

375. Cases also occur in which the achænia are united to the tube

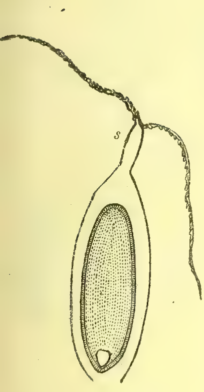


Fig. 835.

Fig. 836.

Fig. 838.

Fig. 837.

Fig. 839.

of the calyx. Thus in Composite plants, such as the Thistle and Dandelion (Figs. 364 and 365, p. 154), and in Groundsel (Fig. 839),

Fig. 835. Achene of a species of Sedge (*Carex*), cut vertically, showing the pericarp, with the style and stigmas, *s*, and the single albuminous seed in the interior, with the small embryo at the base of the albumen.

Fig. 836. Caudate Achænium of the Traveller's-joy (*Clematis*), cut vertically. It is an indehiscent one-seeded seed-vessel, with a long twisted feathery style, *s*, attached to it like a tail. The embryo is seen at the apex of the seed with the albumen surrounding it.

Fig. 837. Calyx and fruit of Comfrey (*Symphytum*), cut vertically. The fruit is divided by the folding of the ovary into four single-seeded portions or achænia, two of which are seen in the figure, and the style appears to arise from the base of the carpels. Linnæus erroneously called these plants naked-seeded.

Fig. 838. Fruit of one of the Borage tribe (*Cerinthe*), divided into four achænia, with the style in the centre, proceeding from the apparent base of the carpels. Linnæus by mistake called these achænia four naked seeds.

Fig. 839. Tubular flower of a species of Groundsel (*Senecio*), showing the single-seeded indehiscent seed-vessel or achænium, *a*, at the base. The tube of the calyx is adherent to it, and the limb of the calyx appears in the form of pappus, *c*, surrounding the gamopetalous corolla. The united anthers and bifid style, *s*, are seen in the centre of the flower. Some call the fruit of Composite plants such as this a Cypsela, considering it as formed originally of two monospermous carpels, one of which is abortive.

what are called seeds are in reality single-seeded fruits, each produced by a separate flower, with the tube of the calyx united to it, and the limb of the calyx appearing as a rim or as a hairy appendage, called pappus (¶ 263). The fruit in these plants seems to be originally formed of two carpels, as indicated by the divisions of the style and by the stigmata, but only one of the carpels comes to maturity.

376. In Umbel-bearing plants, such as Hemlock, Fool's-parsley (Fig. 379, p. 159), and Cummin (Fig. 347, p. 148), two achænia, invested by the tube of the calyx, are united by their faces, so as to form a compound fruit called a *cremocarp*, with a division or *commissure* between them (Figs. 840 and 841). This fruit, when ripe, shows its composition by separating into two achenes (called here, mericarps and hemicarps), which are suspended by a slender central stalk or axis, called a *carpophore* (Fig. 842). The outer surface of these mericarps is marked by ridges and furrows, and there are often peculiar vittæ or receptacles of oil (¶ 60) present in the pericarp.

377. It sometimes happens that the pericarp is not closely applied

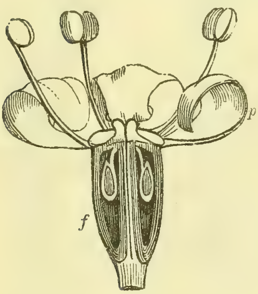


Fig. 840.

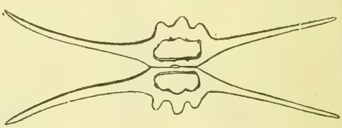


Fig. 841.

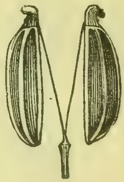


Fig. 842.

to the seed, but surrounds it like a bladder, and in that case, the achene has received the name of *utricle*. This variety of achene is seen in the Goosefoot order and in the Knawel. The achene and utricle are often surrounded closely by the calyx or perianth without being adherent, as in the Dock (Figs. 843 and 844) and in Carex.

378. A *Caryopsis* is a dry indehiscent monospermous seed-vessel resembling an achænium, but differing in the complete adhesion and

Fig. 840. Flower of Fennel (*Fœniculum vulgare*), one of the Umbelliferæ cut vertically, showing the fruit, *f*, composed of two single-seeded carpels, or achenes, united, so as to form a cremocarp. The pendulous seeds are seen in the carpels or mericarps. The two styles are seen at the apex of the fruit, with their dilated bases formed by an epigynous disk. The points (apicula) of the petals, *p*, are turned inwards. The calyx tube is adherent to the fruit, and the limb of the calyx is often obsolete. The fruit is therefore inferior.

Fig. 841. Transverse section of the fruit of another umbelliferous plant (*Angelica*). It is a cremocarp, formed by two hemicarps or achenes. Prominent ridges with depressions are seen on the surface of the fruit. The lateral ridges spread into broad wings, marked by the elongated processes in the figure.

Fig. 842. The fruit of the Fennel (*Fœniculum vulgare*) arrived at maturity. It separates into two cocci or achænia, each of which is marked with obtuse prominent ridges on the surface, and is suspended from the summit of a process of the axis (columella), called a carpophore.

incorporation which exists between the pericarpial covering and the seed. It is seen in the common cultivated grains, as Wheat (Figs. 845, 846, and 847), in Oats (Fig. 848), and in general in all Grasses. In these plants, the pericarp cannot be separated from the seed. Hence the grains of Wheat, Maize, Barley, Rye, and Oats, are in common language called seeds. It is only by examining them in the early state, and noticing the styles (Fig. 845), that we can determine their real nature. In the caryopsis, it is believed that there were

Fig. 843.

Fig. 844.

Fig. 845.

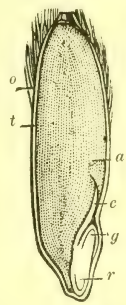


Fig. 848.

Fig. 846.

Fig. 847.

originally, at least, two carpels, as indicated by the styles, one of which is abortive.

379. A *Nut* is a dry unilocular one-seeded indehiscent fruit with a hard covering. In its early state, it is usually composed of two or

Fig. 843. Flowering branch of a species of Dock (*Rumex Patientia*), in which the achene is surrounded closely by the inner divisions of the perianth. The flowers are produced in cymose clusters.

Fig. 844. The fruit of a Dock (*Rumex*), cut vertically, showing the wing-like processes outside, *c*, which are the parts of the perianth enclosing the fruit or achene, with its albuminous seed and eccentric embryo.

Fig. 845. Young fruit or caryopsis of Wheat (*Triticum*), showing the scales outside, *sq*, the three stamens, and the feathery styles at the summit.

Fig. 846. Caryopsis or grain of Wheat (*Triticum*), seen on its outer face, with the embryo lying at lower part on one side.

Fig. 847. Caryopsis or grain of Wheat (*Triticum*), seen on its inner face, with a groove on the surface.

Fig. 848. Caryopsis, or single-seeded grain of Oats (*Avena*). The fruit and seed are incorporated. The pericarp, *o*, bears the styles and stigmas, and encloses the seed, *t*, with its albumen, or perisperm, *a*, and its embryo, consisting of the cotyledon, *c*, the gemmule, *g*, and the root, *r*.

more carpels, with one or more ovules in each; but, in the progress of growth, all disappear except one. It is illustrated by the Hazel-nut (Fig. 351, p. 149), the Chestnut, the Acorn (Fig. 257, p. 116, Fig. 350, p. 149, and Fig. 778, p. 267), and the Coco-nut. In many cases it is surrounded by a series of bracts forming an involucre, seen in the husk of the Nut, the cup of the Acorn, and the burr of the Chestnut. Some restrict the term nut (glans) entirely to such cases. The pericarp of the nut has its parts frequently so united as to be indistinguishable. In the Coco-nut, however, the pericarp can be separated into an epicarp or outer covering, a fibrous mesocarp, and a stony endocarp, marked with three ridges, and three depressions, one of which is perforated. The epicarp of the nut of the Sago-Palm is scaly.

380. A *Samara* is a nut or achænium, in which the pericarp is extended in the form of a winged margin or apex. There are origi-

Fig. 849.

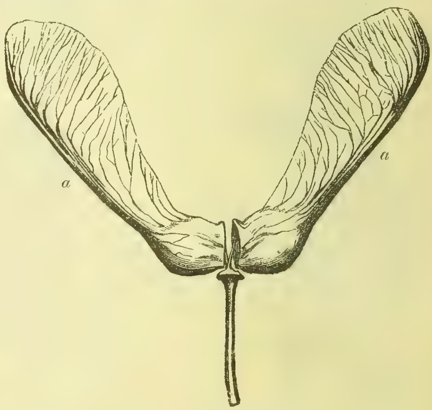


Fig. 850.

nally two carpels united, but one of them is frequently abortive. This samaroid fruit occurs in the Maple and Sycamore (Figs. 849 and 850), the Ash (Fig. 851), and the Elm. The samara of the Sycamore opens by splitting into two in a septicidal manner, as seen in Figure 850.

381. A *Drupe* is the general name given to what are called stone-fruits, such as the Peach (Fig. 770, p. 264, and Fig. 852), the Plum, the Cherry (Fig. 785, p. 269), the Apricot, the Date (Fig. 786, 3 and 4, p. 269), the Olive (Fig. 853), and Coffee (Fig. 854). It is a one-celled, one or two-seeded indehiscent fruit, having a fleshy mesocarp, which is hence denominated sarcocarp. In the Peach, the epicarp is the separable skin, the sarcocarp is the flesh which is eaten, and the endocarp is the hard shell or putamen, which can be split into two

Fig. 849. Branch of the Sugar-Maple (*Acer saccharinum*), bearing a cluster of samaroid fruit.

Fig. 850. Samara of the Maple (*Acer*), consisting of two achænia or nuts, with winged appendages, *a a*, at the back of the carpels. The two winged fruits separate from each other when ripe.

parts. In the Walnut (Figs. 855, 856, and 857), the putamen is divided in a marked manner into two, and from its interior bony par-

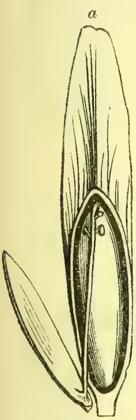


Fig. 851.

Fig. 855.

Fig. 853.

Fig. 852.

Fig. 854.

titions extend, so as to form lobes in the seed or kernel. Some fruits, such as the Almond (Figs. 858 and 859), are called drupes or drupa-

Fig. 851. Samara of the Ash (*Fraxinus excelsior*) laid open, showing the single pendulous seed. There were originally two carpels and two ovules, but one of each is abortive. The fruit has a winged appendage, *a*.

Fig. 852. Flowering and fruiting branches of the Peach (*Amygdalus persica*). The flowers, 1, have numerous stamens attached to the calyx. The fruit, 2, is a Drupe, consisting of epicarp, mesocarp or sarcocarp, and endocarp or putamen, enclosing the kernel or seed.

Fig. 853. Drupes of the Olive-tree (*Olea Europæa*). The fruit contains much oil, which is procured by expression. The plant is the *Zait* or *Sait* of the Bible (Gen. viii. 11; Deut. vi. 11; viii. 8; 1 Kings vi. 23, &c.)

Fig. 854. Branch of the Coffee-tree (*Coffea arabica*), bearing flowers and fruit. The latter are Drupes, having a succulent mesocarp. The seeds have horny albumen and a small embryo.

Fig. 855. Fruiting branch of the Walnut tree (*Juglans regia*). The fruit is a Drupe. The tree seems to be the *Egoz* of Scripture, translated *nuts* in the Song of Solomon vi. 11.

ceous, in which the sarcocarp is not succulent. Many call the Coco-

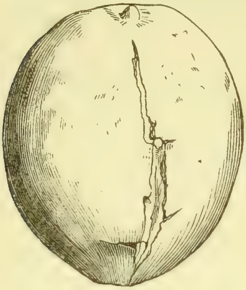


Fig. 856

Fig. 860.

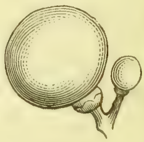


Fig. 861.

Fig. 857.

Fig. 858.

Fig. 859.

nut a drupe, with a fibrous mesocarp. There seems to be, in reality,

Fig. 856. The Walnut (*Juglans*), a drupaceous fruit sometimes called Tryma.

Fig. 857. The Walnut with the epicarp and mesocarp removed. The hard endocarp encloses the seed. From the inner surface of the two-valved endocarp hard processes extend inwards, which divide the kernel into numerous convoluted portions.

Fig. 858. The Almond-tree (*Amygdalus communis*), the fruit of which is a Drupe with a tough mesocarp. The Hebrew word *Shaked* is generally translated Almond (Gen. xliii. 11; Exod. xxv. 33, 34; xxxvii. 19; Numb. xvii. 8). The word *Luz*, which occurs in Genesis xxx. 37, and is there translated Hazel, appears to be the name of the Almond-tree, while *shaked* is the name of the fruit.

Fig. 859. Flowering branch, 1, and fruiting branch, 2, of the Almond (*Amygdalus communis*). The plant belongs to the drupaceous section of Rosaceæ. The stamens are numerous, attached to the calyx, and the fruit is a peculiar drupe with a tough leathery mesocarp. The endocarp is the shell of the almond, and the kernel is the seed.

Fig. 860. Fruit of the Gooseberry (*Ribes Grossularia*), cut vertically, showing the seeds attached to parietal placentas, and immersed in pulpy matter, which is formed partly from the endocarp and partly from the testa of the seed. The fruit is called a Bacca. The calyx is adherent to it.

Fig. 861. Baccate fruit of the Vine (*Vitis vinifera*), called Uva or grape. The seeds are attached to a central placenta, and are immersed in pulp which is a secretion for the inner lining of the pericarp. The calyx does not form part of the fruit.

in such cases, a transition from the drupe to the nut. The aggregation of several drupes forms the fruit of the Raspberry, the Bramble, and the Quassia plant (Fig. 316, p. 135).

382. A *Berry* or *Bacca*, is the name given to all indehiscent syncarpous fruits, the seeds of which are immersed in a pulpy or fleshy mass. Such fruits are collectively called baccate or berried. In the true berry, such as the Gooseberry and Currant (Fig. 777, p. 267), the calyx adheres to the fruit, and the placentas are parietal (Fig. 860), while in the grape (uva) the ovary alone is present (Fig. 861), and the placentas are central. Instances of baccate fruits are seen in

Fig. 862.

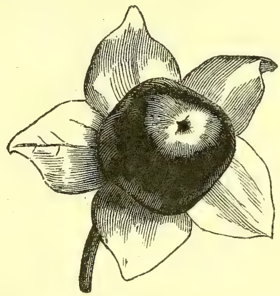


Fig. 863.

Fig. 864.

Solanaceous plants, such as the Potato, Egg-plant, Mandrake (Fig. 862), Belladonna (Fig. 863), and Winter Cherry (Fig. 501, p. 199), as well as in the Mistleto (Fig. 864).

383. In the Pomegranate there is a peculiar succulent berried fruit,

Fig. 862. Plant and berried fruit of the Mandrake (*Atropa Mandragora*). The plant, 1, has a very large root, with a thick cluster of leaves concealing the flowers. The fruit, 2, is succulent, and not adherent to the calyx. The plant is doubtfully supposed to be the Hebrew *Dudaim* mentioned in Genesis xxx. 14-16; and in the Song of Solomon, vii. 13.

Fig. 863. Berried fruit of Deadly Nightshade (*Atropa Belladonna*). The calyx does not form part of the fruit. The mesocarp becomes succulent. The berry is of a beautiful shining black colour.

Fig. 864. Baccate fruit of the Mistleto (*Viscum album*). The matter surrounding the seeds is very viscid and tenacious, and has been used for bird-lime.

called a *balausta*, in which the pulpy cells are arranged in two rows, some of which are in the centre round the axis, and others are placed outside, all being adherent to the calyx. In Figure 865, there is represented a transverse section of the lower portion of the Pomegranate in the young state, showing three carpels; and in Figure 866, a similar section of the upper portion, showing five carpels. Hance says that the lower cells arise from a central row of carpels, the cohering apices of which form the septum between the two chambers of the fruit, the ovules arising from the two united margins of the same carpellary leaf, and being directed towards the circumference of the ovary; while the upper cells are formed by an outer series of longer carpels alternating with the others, the cohering summits constituting the whole, or, at all events, the external portion of the style, and the ovules are borne on the entire inner surface of the carpidia, as in the Water-Lily—the cells being also frequently divided by spurious septa arising from the midrib. The peculiar appearances are traced to the existence of two rows of carpels, and the contraction caused by

Fig. 865.

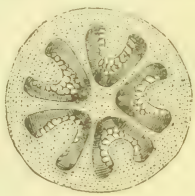


Fig. 866.

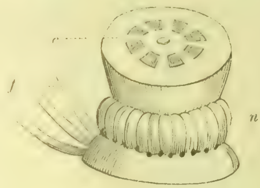


Fig. 867.

the calyx. In the Orange there is a modification of the berry, called *hesperidium*, in which there is a separable rind not formed by the calyx, consisting of epicarp and mesocarp, and pulpy separable cells formed by the endocarp (Figs. 867 and 868).

384. A *Pepo*. This is a fruit allied to the berry, occurring in the Cucumber (Fig. 869), Gourd, Melon (Fig. 327, p. 139, and Fig. 870), and Colocynth (Fig. 871). It consists of three carpels united, covered by a firm rind, which is partly formed by the calyx. The placentas are by some considered as parietal, and as sending processes inwards, by others they are looked upon as central, and as sending processes outwards, which reach the walls of the fruit and then curve backwards, bearing the seeds. The processes proceeding from the

Fig. 865. Transverse section of the lower part of the berried fruit of the Pomegranate (*Punica Granatum*), showing three carpellary divisions, with ovules situated on projecting central placentas, and looking towards the circumference of the fruit.

Fig. 866. Transverse section of the upper part of the berried fruit of the Pomegranate (*Punica Granatum*), showing five carpellary divisions, with the ovules attached to placentas projecting inwards, and looking towards the centre. The Pomegranate is a peculiar baccate fruit, with an adherent calyx, and it has received the name of Balausta. There are two rows of carpels in it, the arrangement of which becomes complicated during growth.

Fig. 867. Young fruit of the Orange (*Citrus Aurantium*) cut transversely, showing numerous central pulpy cells, with partitions, *c*, between them. The fruit is surrounded by an annular disk, *n*, below which are seen the remains of the stamens, *f*.

axis to the walls are usually obliterated, according to the latter view, giving rise to the appearance of the placentas being parietal. The fruit thus becomes one-celled. A transverse section of the Melon is given in Fig. 874, in which *pl* indicates the placentas, *cl* the septa, and *s* the processes connecting the curved placentas with the centre. In the Plantain and Banana (Figs. 873 and 875), the fruit is allied to the pepo, consisting of three carpels, with parietal placentas, the perianth being adherent to the ovary, and the seeds immersed in a pulpy mass when ripe. These plants rarely ripen seed when the fruit is of good quality. In the fruit of the Papaw-tree (Fig. 872), which

Fig. 870.

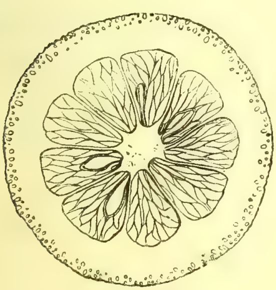


Fig. 868.

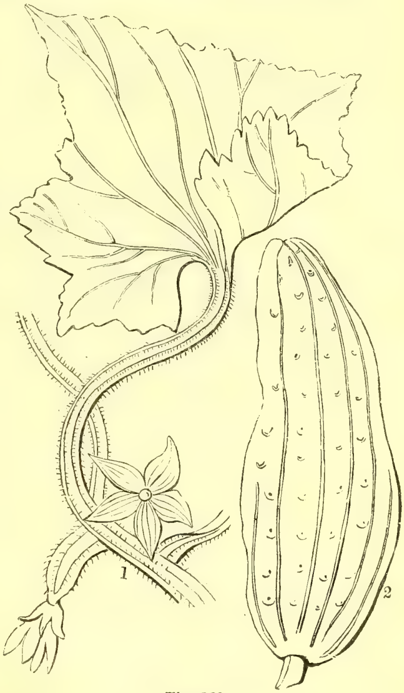


Fig. 869.

resembles the pepo, the placentas are distinctly parietal, but the rind is not formed by the calyx.

Fig. 868. Fruit of the Orange (*Citrus Aurantium*), cut transversely, showing the outer separable rind composed of epicarp and mesocarp, and the separable pulpy cells in the centre formed by the endocarp. The seeds are immersed in pulp in the endocarpial cells. The fruit is a peculiar kind of berry called Hesperidium. The calyx does not enter into its composition.

Fig. 869. Flowering stem, 1, and fruit, 2, of the Cucumber (*Cucumis sativus*). On the flowering branch the upper flower is male, the lower pendulous one female. The fruit is a peculiar bacca called a Pepo. Its rind is formed partly by the calyx, and it consists of three carpels, with parietal placentas according to some, and central placentas according to others. The Hebrew word *Kishuim* is translated cucumbers (Numbers xi. 5; Is. i. 8).

Fig. 870. The fruit of the Water-Melon (*Cucurbita Citrullus*). It is called a Pepo or Peponida, and resembles the Cucumber in structure. The fruit seems to be one of those included under the Hebrew word *Abattachim*, and translated Melons (Numbers xi. 5).

385. A *Pome* is a fleshy syncarpous fruit, composed of two or more scaly, or horny, or bony carpels, covered by a pulpy mass, which is incorporated with the calyx. The outer fleshy portion may be considered either as the combined epicarp and mesocarp, or it may be reckoned the receptacle enlarged, as in the Rose, and united to the calyx. This kind of fruit is seen in the Apple (Fig. 876), the Pear, the Quince, and the Medlar (Fig. 776, p. 267). There are frequently five carpels united, as seen in Figure 876. The cartilaginous cells enclosing the seeds of the Apple, and the bony coverings (nucules) of the seeds of the Medlar, may be reckoned either as the endocarp, or as the entire pericarp, according to the view taken of the formation of the pulpy exterior. In Apples we see little white downy lines running across the inner surface of the carpels; these, according to Berkeley, are formed by an hypertrophy, or increased growth of the cellular tissue.*

386. *Multiple or Collective Fruits* are formed by several flowers

Fig. 871.

Fig. 872.

Fig. 873.

united, and the name anthocarpous is also applied, because they consist usually of the bracts and floral envelopes combined with the ovaries. They are either indehiscent or dehiscent, succulent or dry.

387. A *Cone* is a form of collective fruit, composed of scales or bracts covering one or more naked seeds (Fig. 877). Some consider these scales as carpels spread out, but from the absence of style and

Fig. 871. Fruit of the Colocynth (*Cucumis Colocynthis* or *Citrullus Colocynthis*). It is called Coloquintida or Bitter apple. It is a Pepo or Peponida resembling the Cucumber in structure. It is the *Hunzal* of the Arabs, and it is one of the plants supposed to be included in the Hebrew word *Pakyoth*, translated Wild Gourds (2 Kings iv. 38–40). The Hebrew word *Pekaim*, translated *Knops* in 1 Kings vi. 18, and vii. 24, is supposed to refer to the form of the fruit of the Wild Gourd.

Fig. 872. Papaw-tree (*Carica Papaya*), bearing a cluster of fruit near the top of the stem. The fruit resembles a Pepo, but the calyx does not form part of it. The placentas are numerous and parietal.

Fig. 873. Fruit of the Banana (*Musa sapientum*). It is a succulent fruit allied to the Pepo. It is adherent to the calyx, and consists of three carpels with parietal placentas. The seeds are often abortive, especially when the fruit is good, as an article of diet.

* See Gardener's Chronicle, December 1851.

stigma (Fig. 725, p. 250, and Fig. 766, p. 261), they seem more properly referable to floral leaves or bracts. The cone gives name to the natural order Coniferæ, or Cone-bearers, such as the Fir (Fig. 172, p. 72), Spruce, and Larch, the Cypress (Figs. 879 and 881), the Araucaria and Altingia (Fig. 59, p. 26). In the Juniper the scales of the cone are succulent (Fig. 880 and Fig. 273, p. 121), and the fruit has sometimes received the name of *galbulus*. In the Yew (Fig. 780, p. 267), the bracts enveloping the naked seed also become succulent.

388. In the Fig (Fig. 775, p. 266, and Fig. 782, p. 268) a multiple fruit occurs, consisting of numerous flowers enclosed in a hollow receptacle. What are called the seeds of the Fig, are in reality monospermous seed-vessels (achenes), with styles and stigmata. In the Mulberry (Fig. 878), Bread-fruit (Fig. 783, p. 268), Jack-

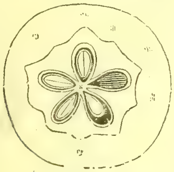


Fig. 876.

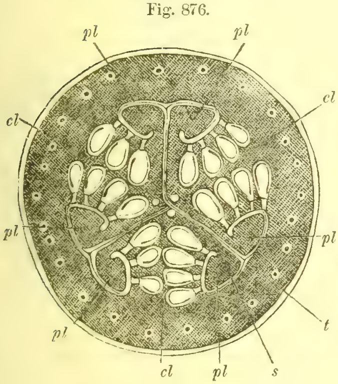


Fig. 874.

Fig. 875.

fruit, and Pine-apple (Fig. 882), the ovaries and floral envelopes of several flowers are all united into one fleshy mass, placed on a more or less convex or elongated receptacle. The crown of the Pine-apple may be regarded as a series of empty bracts terminating the

Fig. 874. Transverse section of the fruit of the Melon (*Cucumis Melo*), showing the placentas, *pl*, with the seeds attached to them. The three carpels forming the pepo are separated by partitions, *cl*. From the centre, processes, *s*, go to the circumference, *t*, ending in curved placentaries bearing the ovules. These placentas by some are considered as parietal, formed on the walls of the fruit, by others they are looked upon as the curved terminations of the central processes, *s*.

Fig. 875. Plant of Banana (*Musa sapientum*), with a fruit-bearing stalk hanging down from the upper part of the herbaceous stem.

Fig. 876. Section of the fruit of the Apple (*Pyrus Malus*), consisting of an epicarp and mesocarp partly formed by the calyx. A cartilaginous endocarp forming five cavities in the centre with seeds. The fruit is called a Pome. In the Medlar the endocarp is stony.

axis. In plants belonging to the same tribe, such as Bromelia Pinguin, the different flowers are separate, and do not unite into one mass when in fruit,—thus illustrating the composition of the Pine-apple. The succulent portion of the Mulberry is connected with the floral envelopes of several flowers; hence it is quite different from the Bramble, in which the succulent part is connected with the pericarp, and the fruit is formed by a single flower. In Figure 883, a section of the Mulberry fruit is given, showing the different flowers by which it is formed; and in Figure 884 is represented a separate female flower, with its ovary, styles, and stigmas. In the strobili of the Hop (Fig. 885), the bracts covering the flowers are membranous in place of being succulent.

389. *Transformations in Fruits.*—The same causes which produce

Fig. 880.

Fig. 877.

Fig. 878.

Fig. 879.

alterations in the other parts of the flower, give rise to anomalous appearances in the fruit. The carpels, in place of bearing seeds, are sometimes changed into leaves, with lobes at their margin. In a monstrosity of a kind of Larkspur, Brongniart has shown the conversion of the seed-vessel

Fig. 877. Anthocarpous fruit of a Pine (*Pinus*), consisting of numerous hard scales covering winged seeds. These scales are bracts or floral leaves. The fruit is called a cone. It may be said to be a hardened female spike in the form of a collective fruit.

Fig. 878. Fruiting branch of black Mulberry (*Morus nigra*), which appears to be the *Sykaminos* or Sycamine-tree of the New Testament (Luke xvii. 6). The fruit is anthocarpous or collective and succulent. It consists of numerous flowers united together into a succulent mass. It is called a Sorosis.

Fig. 879. Anthocarpous or collective fruit of the Cypress (*Cupressus sempervirens*). It is a depressed cone formed by hardened scales covering naked seeds.

Fig. 880. Anthocarpous fruit of Juniper (*Juniperus communis*). It is a cone composed of succulent scales, which are united together into one mass, and cover the female flowers. The fruit is sometimes called a galbulus. Many think that, under the Hebrew terms *Eres* or *Æres* and *Berosh* several coniferæ were included, and especially some species of Juniper. The Juniper is the *Abhul* of the Arabs.

and seeds into leaves.* Similar changes have also been noticed by him in the fruit and seeds of the Rape, Soap-wort, and Scarlet Pimpernel. The production of leaves from the upper part of the fruit has been noticed in the case of the Pear (Fig. 430, p. 181). In the genus Citrus, to which the Orange and Lemon belong, it is very common to meet with a separation of the carpels, so as to produce what are called horned oranges and fingered citrons. In this case a syncarpous fruit has a tendency to become apocarpous. The same thing is observed in some species of the genus Nigella. In the Orange we occasionally find a supernumerary row of carpels produced, as shown in Figure 886, *el*, and these, when the fruit is completely formed, give rise to the appearance of oranges enclosed within the original one, as shown in Figure 887. The Navel Orange of Pernambuco is of this nature.

390. It sometimes happens that, by the union of flowers, double

Fig. 881.

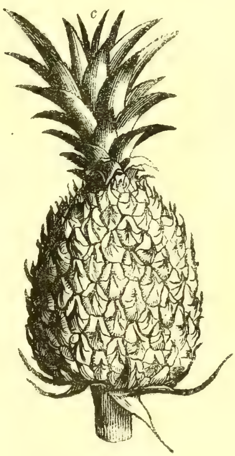


Fig. 882.

fruits are produced. The adhesion of two flowers does not necessarily imply sterility in the fruit. The ovary may be fertilized, and may come to perfection. In such a case, if the two pistils are adherent like the other parts of the flowers, then a double fruit is produced. Occasionally, however, a double fruit is produced, not by the incorporation of two

Fig. 881. Cypress-tree (*Cupressus sempervirens*), one of the cone-bearing plants yielding a collective fruit. The tree is by some considered as included under the term *Berosh*, which is translated Fir in many parts of Scripture (2 Sam. vi. 5; 1 Kings v. 8; 2 Kings ix. 23; Is. xiv. 8, &c.) The word *Tirzah* in Isaiah xliv. 14 has been translated Cypress, but there is no proof of this being the plant meant. Some think that Tirzah means the Evergreen Oak (Quercus Ilex). Some suppose that the *Etz Gopher* or Gopher-wood of the Bible (Gen. vi. 14) was the wood of the Cypress, or of some of the cone-bearing order.

Fig. 882. Fruit of the Pine-apple (*Ananassa sativa*), consisting of numerous flowers and bracts united together so as to form a collective or anthocarpous fruit. The crown of the Pine-apple, *c*, consists of a series of empty bracts prolonged beyond the fruit.

* Brongniart, Monstruosités Vegetales. Archives du Museum, tom. iv. 43.

flowers, but by the abnormal development of a second carpel in the flower. In this way double Cherries are frequently formed. The state

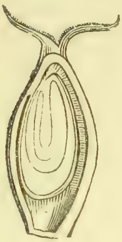


Fig. 884.

Fig. 883.

Fig. 885.

Fig. 886.

Fig. 887.

of the peduncle will often lead to a satisfactory conclusion as to the

Fig. 883. Vertical section of the fruit of the Mulberry (*Morus nigra*), showing the various flowers of which it is composed, and which are all arranged on a common axis.

Fig. 884. One of the female flowers of the Mulberry (*Morus nigra*) separated, showing the seed, the embryo, and the styles.

Fig. 885. Fruit of the Hop (*Humulus Lupulus*), consisting of membranous scales covering female flowers. The fruit is called a Strobilus.

Fig. 886. An abnormal state of the Orange (*Citrus Aurantium*), in which supernumerary rows of carpels are produced, apparently from altered stamens; *p*, the peduncle which usually terminates the axis and bears the floral verticils, is prolonged beyond the calyx, *c*, and the annular disk, *n*, in the form of a distinct internode, *m*, bearing a circular group of stamens changed into carpels, *el*, with styles and stigmata. Within and above these there is another row of stamens changed into carpels, *es*, surrounding the central pistil, *pc*. In this instance all the carpels were sterile.

Fig. 887. Another monstrosity of the Orange, in which there are twenty external divisions, *ce*, representing carpels which, in place of uniting at the top, leave an opening, whence proceed twenty projections, *ci*, which form a crown to the fruit. These projections are a series of abortive carpels. Such fruits are called proliferous.

nature of double fruits. In the first-mentioned cases, the peduncle often shows a groove which marks the union of two; in the latter instance there is no such groove. Double Plums are sometimes produced by the development of an additional carpel, and double Oranges, Apples, and Cucumbers, are often the result of the adhesion of two flowers. Koenig mentions a Strawberry plant which produced eight strawberries on one stalk; and Turpin notices a Pine-apple with seven fruits united, the crowns of which remained free. Occasionally the multiplication of fruits may be traced to chorisis or splitting of parts. The production of leaves from fruits is by no means uncommon in the Pear, as already noticed, and in the cones of Pines, Spruces, and Larches, in which the axis becomes prolonged beyond the fruit.* Fruits producing leaves are usually more or less completely abortive, and they are called *frondiparous.*

391. The following may be given as a general arrangement of Fruits:—

I. Apocarpous Fruits formed by one or more separate carpels.

1. Monospermal, containing one seed.

a. Dry and Indehiscent.

Achene or Achænium in Composite flowers; Caryopsis in Grasses; Nut in the Hazel, and in the Coco-nut Palm; Scaly Nut in Sagus; Aggregate Achenes or Achænia, numerous in Ranunculus and Rose, four in the Borage and Mint order. In some Achenes the pericarp is loose and separate from the seed, and they are called Utricles. Occasionally the calyx or perianth is closely applied to the Achene, as in Rumex. Some Legumes are dry, monospermal, and indehiscent, as Dipterix.

b. Succulent and Indehiscent.

Drupe in Cherry and Peach, and in Detarium; Aggregate Drupes form the Etærio of the Raspberry; Drupe with partitioned endocarp in the Tryma of the Walnut.

c. Dry and Dehiscent.

Some forms of Legume in which one seed only is developed, as in Copaifera, Cæsalpinia paniculata, and Geoffroya superba.

2. Polyspermal, containing usually more than one seed.

a. Dry and Dehiscent.

Follicle in Pæony; Legume in the Pea, and in Leguminous plants in general.

b. Dry and Indehiscent.

Some varieties of Legume, as in Cassia Fistula, and in Lomentum-bearing plants, such as Sophora tomentosa.

II. Syncarpous Fruits formed by two or more carpels united by their ovaries.

1. Monospermal, by abortion of one or more carpels or ovules.

To this head are referred many of the fruits included under the monospermal section of Apocarpous fruits, such as the Caryopsis of Grasses, the Nut, also the Samara of the Ash and Elm, and some varieties of Siliqua and Silicula, as in Sea-Kale and Woad.

* See De Candolle's Organographie, pl. 36, fig. 3, and pl. 43, fig. 4.

2. Polyspermal.

a. Dry and Dehiscent.

Capsule in Cotton, Mahogany, Poppy, Pyxis or Pyxidium in Henbane, Siliqua in Wallflower, Silicula in Shepherd's-purse; Ceratium in Celandine, Regma in Euphorbiaceous plants, Diplotegia in Campanula.

b. Dry and Indehiscent.

Cremocarp of Umbelliferous plants, and Samara of Sycamore and Maples, in which the two carpels separate from each other, but do not truly dehisce.

c. Succulent and Indehiscent.

(1) *Baccate Fruits with Adherent Calyx.*

The Bacca in Gooseberry, Pepo in Melon and Banana, Balausta in Pomegranate. Under this may be included also the Cynarrhodum in the Rose, the hep of which is formed by the succulent calyx enclosing the achenes.

(2) *Baccate Fruits with the Calyx not Adherent.*

The Uva in the Grape, the fruit of Solanaceous plants such as the Potato, the Papaw fruit, the Hesperidium in the Orange, the Pome in the Apple and Pear, and the Nuculanium (a variety of Pome) in the Medlar.

III. Anthocarpous Fruits formed by the union of several flowers.

1. Succulent hollow receptacle enclosing monospermal ovaries produced by separate flowers, as in the Syconus of the Fig.
2. Scaly spike of female flowers combined into one multiple fruit.
   a. Scales hard and seeds naked in the Cone of the Fir.
   b. Scales membranous, seeds in a seed-vessel, as in the Strobilus of the Hop.
3. Succulent spike of female flowers, as in the Sorosis of the Mulberry and Bread-fruit.

392. *The Seed.*—When the ovule arrives at maturity it constitutes the seed, which is contained in a seed-vessel in the plants which are called *Angiospermous;* while, in *Gymnosperms*, such as Coniferæ (Fig. 766, p. 261), and Cycadaceæ, it is naked, or, in other words, has no true pericarpial covering. By far the larger number of flowering plants belong to the former division. It sometimes happens in Angiosperms, that the seed-vessel is ruptured at an early period of growth, so that the seeds become more or less fully exposed during their development; this occurs in Mignonette (Fig. 811, p. 274), where the capsule opens at the apex, and in Cuphea, where the placenta bursts through the ovary and floral envelopes, and appears as an erect process bearing the young seeds.

393. The seed (Fig. 888) consists of a nucleus, *c*, usually covered by two cellular integuments, *e* and *te*, which are sometimes included under the general name of *spermoderm*. The outer integument is denominated the *episperm*, *exosperm*, or more commonly the *testa* (Fig. 888, *te*). It corresponds to the primine of the ovule (Fig. 755, *p*, p. 256). It is frequently formed by a union of both primine

and secundine. It varies in its texture, being sometimes thin and membranaceous, at other times thick and hard. It presents various colours, being brown, white, red, black, and mottled. Its surface sometimes presents ridges and furrows, as in Larkspur (Fig. 889), reticulations, as in the Water Cress (Fig. 890), alveolar depressions, as in the Poppy (Fig. 891), and tubercular eminences, as in Chickweed (Fig. 892). Occasionally, the seminal integument is furnished with appen-

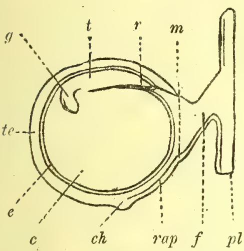


Fig. 888.

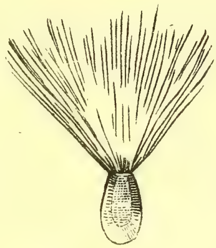


Fig. 895.

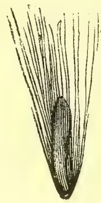
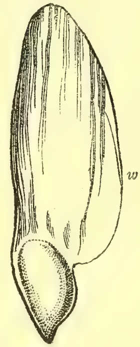


Fig. 896.



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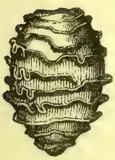


Fig. 889.

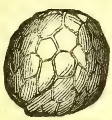


Fig. 890.

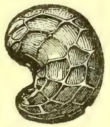


Fig. 891.

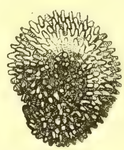


Fig. 892.

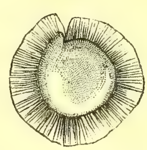


Fig. 894.

dages in the form of wings, as in Pine seeds (Fig. 893) and Bignonia, or with a margin, as in Sandwort (Fig. 894); and at other times it

Fig. 888. The seed of the Pea (*Pisum*), deprived of one-half of its integument or spermoderm. The outer covering, called epicarp, exocarp, and testa, is marked *te*, the inner, called endocarp, *e*. Within these integuments is the nucleus, consisting of cotyledons or seed-lobes, *c*, containing nourishing matter, the gemmule, or young leaf-bud, *g*, the radicle, or young root, *r*, the tigelle or stalk between root and bud, *t*. The seed is attached to the placenta, *pl*, by a cord or funiculus, *f*. The nourishing vessels, *rap*, enter the nucleus at the chalaza, *ch*, and the root of the embryo points to the micropyle or foramen, *m*.

Fig. 889. Obovate seed of the Larkspur (*Delphinium*), the spermoderm or testa of which presents wavy ridges and furrows.

Fig. 890. Round seed of the Water-Cress (*Nasturtium*), with a reticulated testa or exosperm.

Fig. 891. Kidney-shaped seed of the Poppy (*Papaver*), with alveolar depressions on its surface. The testa is said to be alveolar or pitted.

Fig. 892. Rounded seed of Chickweed (*Stellaria*), having tubercular eminences on the surface of the episperm or exosperm.

Fig. 893. Seed of Fir (*Pinus*), with a membranous appendage, *w*, to the testa, called a wing. The seed is said to be winged.

Fig. 894. Seed of Sandwort (*Arenaria*), with a margin or border round it. The seed is called marginate or bordered.

Fig. 895. Seed of Asclepias, with a cluster of hairs arising from the edges of the micropyle, and by some considered as a hairy aril. These hairs are for the purpose of scattering the seed.

Fig. 896. Hairy or comose seed of the Willow (*Salix*). The hairs arise from the short funiculus, and surround the seed.

is provided with hairs, as in the Cotton plant (Fig. 101, p. 44), Asclepias (Fig. 895), and the Willow (Fig. 896). It is of importance to distinguish between such hairs and the pappus of Composite plants (Fig. 495, p. 198), and of Valerian (Fig. 497, p. 198), which is in reality an abortive calycine limb attached to the fruit. We have already stated that the presence of the style or stigma distinguishes single-seeded fruits from seeds.

394. The seed of some Polemoniaceous plants has a covering, consisting of small cells or hairs containing spiral fibres inside. These hairs are closely applied to the surface of the episperm, and are confined by a mucilaginous coating. When placed in water, the mucilage dissolves, and the hairs are liberated, so as to spread out in all directions. The walls of the cells are also usually ruptured, so as to allow the spiral fibres to uncoil, and form a beautiful object under the microscope. The same kind of structure occurs in the pericarpial covering of some Labiate plants, such as Salvia, and of some Composite plants, such as Senecio (¶ 39). The spreading out of these fibrous cells is apparently intended for the purpose of fixing the seed in the moist soil, into which they are carried by the wind. Sometimes the secundine of the ovule assumes a succulent consistence in the seed, and forms a lining to the episperm.

395. The *Endopleura* or *tegmen* is the inner seminal envelope or integument. In general, it is formed from the tercine or the membrane of the nucleus, and it is sometimes united with the embryo-sac (Fig. 757, *s*, p. 259). In some cases, as in the Water-lily, Ginger, and Pepper, this sac remains as a distinct covering of the young plant under the name of the vitellus. The endopleura is often incorporated with the testa, and scarcely separable from it. It is composed usually of a thin layer of cellular tissue, and when the nucleus is sinuous, as in the Walnut (Fig. 897), it follows its windings, so as to enter between the lobes.

396. The spermoderm, or general seminal integument, has certain markings corresponding to those mentioned in the ovule. Thus, we observe the micropyle or small opening in the coats which extends to the nucleus (Fig. 888, *m*), the chalaza (Fig. 888, *ch*) or the fibro-vascular connection between the nucleus and the coats, and the base or hilum by which the seed is connected with the funiculus (Fig. 888, *f*). These bear the same relation to each other as they do in the ovule. Thus, in an orthotropous seed, the hilum and chalaza are united, and the micropyle is at the opposite end or apex; in a campylotropous seed, the hilum and chalaza are united, and the micropyle is slightly removed from the hilum; while in an anatropous seed, the nucleus is inverted—its base and the chalaza being removed from the hilum, and the micropyle being close to the hilum. The seed of the Orange is anatropous, and the brown chalaza, *c*, is seen in Figure 898 as an expansion at one end, while the raphe connecting the hilum and chalaza is seen in Figure 899 running as a border, *r*, along one side of the seed.

397. The micropyle is smaller and less distinct in the full grown seed than it was in the ovule. It indicates the place where the radicular extremity of the embryo is situated (Fig. 906, *r*, p. 302). Its situation in the Bean and Pea, when they begin to sprout, is marked by a little lid-like process which is pushed upwards. The chalaza is more or less evident in different seeds. It is conspicuous in anatropous seeds, such as the Orange (Fig. 898), where the raphe (Fig. 899, *r*) or vascular connection between it and the placenta exists. The raphe forms a cord usually along the inner side of the seed, and may be considered as a prolongation from the funiculus, along with a covering

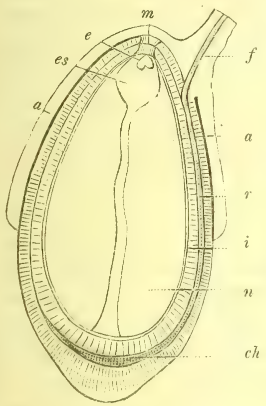


Fig. 900.

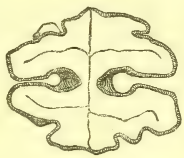


Fig. 897.

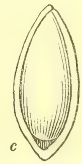
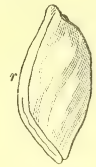


Fig. 898.



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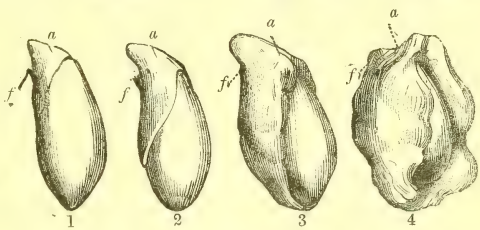


Fig. 901.

derived from the integument of the seed.* The scar or hilum is of different sizes and colours, and indicates the base of the seed or the

Fig. 897. Seed or kernel of the Walnut (*Juglans*) cut transversely, showing the divisions which correspond to hard processes of the endocarp or shell. The seed is four-lobed at its apex and base, and is exalbuminous. The integuments follow the windings of the cotyledons, which resemble the convolutions of the brain. The cotyledons are fleshy and oily.

Fig. 898. Anatropal seed of the Orange (*Citrus Aurantium*) opened to show the chalaza, *c*, which forms a brown spot at one end.

Fig. 899. Entire anatropal seed of the Orange (*Citrus*), with its rugose or wrinkled testa, and the raphe or internal funiculus, *r*, ramifying in the thickness of the testa on one side.

Fig. 900. Young anatropal seed of the White Water-lily (*Nymphæa alba*), cut vertically. It is attached to the placenta by the funiculus or umbilical cord, *f*, cellular prolongations from which form an aril, *a a*. The vessels of the cord are prolonged to the base of the nucleus, *n*, by means of the raphe, *r*, composed of cells and spiral vessels. The base of the nucleus is indicated by the chalaza, *ch*, while the apex is at the micropyle, *m*. The covering of the seed composed of episperm and endopleura, or, in other words, of exosperm and endosperm, is marked *i*. The nucleus, *n*, is composed of albumen or perisperm, surrounded by its covering, and enclosing the embryo-sac, *es*, which remains in the ripe seed in the form of a vitellus. The embryo, *e*, with its suspensor, is contained n the sac, the radicle pointing to the micropyle, *m*.

Fig. 901. Successive stages in the development of the arillode, the false or micropylar aril, of the Spindle-tree (*Euonymus*). The foramen or micropyle, *f*, is the part whence the arillode, *a*, proceeds. It passes through different stages, from 1, where it covers only a small part of the seed, to 2 and 3, where the covering is extended, until it reaches 4, where the seed is almost entirely enveloped by it.

* A full description of these parts has already been given when treating of the ovule, p. 258.

place where it is attached to the placenta. This attachment is either direct, or is accomplished by the intervention of a stalk or cord called the funiculus, which in Magnolias becomes much elongated. In the Bean the scar is of a black colour; in other cases it is white or brown. It sometimes extends over a large portion of the seed, as in the Horse Chestnut.

398. On the outside of the integument of the seed there is sometimes an additional partial covering of a cellular nature which is developed after the ovule is fertilized, and which has received the name of *aril* (arillus). It proceeds from the placenta or top of the funiculus in some instances, while in others it arises from the foramen of the seed. In the former case it is called a true or funicular aril, while in the latter it is called a false or micropylar aril, or sometimes *arillode*. In the Passion-flower and Water-lily (Fig. 900, *a*), a funicular aril exists, while in the Spindle-tree, Nutmeg, Spurge (Fig. 830, p. 280), and Milk-wort, a micropylar aril is seen. In Figure 901, a representation is given of the development of the arillode, *a*, in the Spindle-tree, *f* being the foramen or micropyle from which this seminal covering arises. It finally spreads as a beautiful scarlet envelope of the seed. In the Nutmeg, the arillode is laciniated and of a fine scarlet colour, constituting the mace. Some consider the hairs of the seed of Asclepias (Fig. 895, p. 297) as a form of micropylar aril. Certain cellular processes are occasionally seen at the base, apex, or sides of the seed. They have received the names of *caruncles* and *strophioles*. In Milk-wort they occur at the base, in the Castor-oil seed at the apex, and in Blood-root and Asarabacca they constitute a lateral crest arising from the raphe. Some have included all these under the name aril, applying the terms raphian and chalazal according to their position.

399. The different parts of a seed are represented in Figure 900, *n* being the nucleus or central portion, composed of nourishing matter enclosing the embryo-sac, *es*, with the embryo-plant, *e*, the radicle of which points to the micropyle, *m*; *f*, the funiculus, *ch*, the chalaza, *r*, the vessels running from the placenta to the base of the nucleus, *i*, the integuments or spermoderm, and *a a*, the funicular aril.

400. The nucleus or kernel of the seed (Fig. 900, *n*) is the fully developed central portion of the ovule. It is much altered in general by the deposition of starchy, azotised, and ligneous matter, and by the development of the embryo. It consists either of the embryo alone, as in Wallflower (Fig. 902), or of the embryo, along with a separate deposit of nourishing matter called the *albumen* or *perisperm*, as in Palms (Fig. 903). This albumen consists of starchy, ligneous, oily, saline, and nitrogenous substances contained in cells of various consistence. It is, therefore, not merely what chemists call vegetable albumen ; and hence it is better to give it the name of perisperm or endosperm.

401. A seed is said to be *albuminous* or perispermic when it has a separate store of albumen distinct from the embryo, as in the Coco-nut (Fig. 904), Wheat (Fig. 846, p. 283), and Aconite (Fig. 905); and *exalbuminous* or aperispermic when the nutritious matter is incorporated with the lobes of the embryo, as in Cruciferous plants (Fig. 902), in the Bean, the Pea (Fig. 888, p. 297), Almond, and Maple. In the last mentioned cases, the lobes or cotyledons (¶ 75) of the embryo are thick and fleshy, in consequence of the nourishing matter which they have absorbed, and the embryo occupies the entire cavity of the seed.

402. The perisperm varies in its consistence according to the nature of the deposit and the state of the cells. In the Vegetable-Ivory Palm, the cells are thickened by ligneous deposits, and the perisperm is of a horny consistence, so also in Coffee (Fig. 854, p. 285). In the Cereal grains, as Wheat (Fig. 846, p. 283), it is mealy and farinaceous; in the Poppy it is oily; in the Coco-nut (Fig. 904, *p*) it is cartilaginous; in the Mallow, mucilaginous. When cut, the perisperm may present a uniform appearance, as in Castor-Oil, or

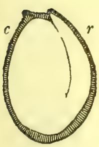


Fig. 902.

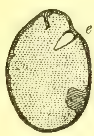


Fig. 903.

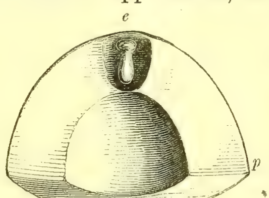


Fig. 904.

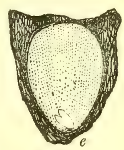


Fig. 905.

it may have a mottled or *ruminated* appearance, as in the Nutmeg and Betel-nut. The latter depends on some unaltered cells of the endopleura or of the embryo-sac ramifying through the substance and forming convolutions. The proportion which the perisperm bears to the embryo varies much. Sometimes, as in the Coco-nut (Fig. 904), in the Date and in Monkshood (Fig. 905), the embryo is very small, while the albumen is abundant; at other times, as in the Nettle (Fig. 906), the embryo is large and the albumen small. The deposit of

Fig. 902. Seed of Wallflower (*Cheiranthus*) cut vertically. The seed is exalbuminous or aperispermic—all the nourishing matter being incorporated with the cotyledons, *c*. On removing the integument which is marked by the dark lines, the embryo alone is found in the interior. The radicle, *r*, is folded on the edges of the cotyledons, which are accumbent; the plant belongs to the division of cruciferæ, called Pleurorhizeæ.

Fig. 903. The seed of a Palm, cut vertically, showing copious horny albumen, and a small embryo, *e*, at one side. The seed is albuminous or perispermic, having a store of nutriment separate from the embryo.

Fig. 904. Section of a part of the seed of the Coco-nut (*Cocos nucifera*), showing the abundant cartilaginous albumen or perisperm, *p*, and the small embryo, *e*, in a cavity at one end of the seed, close to the part of the endocarp which is perforated, and remote from the hilum or base of the seed.

Fig. 905. The seed of the Monkshood (*Aconitum*), with its covering or spermoderm, its copious albumen, and a small embryo, *e*, at one extremity. The seed is albuminous, and the embryo is slightly transverse in its position.

albumen takes place within the integuments of the seed. It either occupies the space between the endopleura and the embryo-sac (Fig. 900, *n*, p. 299), when it is called *exospermic*, as in the Water-lily (Fig. 907) and other plants which have a distinct vitellus, or it is deposited within the sac, and then is *endospermic*; or it occupies both positions at once, and then may be called by the general name of perisperm.

403. *The Embryo* is the young plant contained in the seed. It is the part to the production and nourishment of which all parts of the flower contribute. It is contained originally in a cavity called the embryo-sac (Fig. 900, *es*), and appears at first as a small vesicle or cell (Fig. 900, *e*), attached to the sac by a cellular process called a suspensor, which is often very long, as in Cruciferous plants (Fig. 910). The suspensor (Fig. 910, *s*) sometimes presents a peculiar enlarged nucleated cell, *c*, at the extremity opposite to the embryo, *e*. The embryo-sac is sometimes separated from the endopleura by a quantity of perisperm (Fig. 900, *n*), at other times it is incorporated with it. The embryo-sac exhibits peculiar tubular prolongations from its base and apex in some instances, as in the Eyebright.*

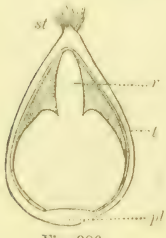


Fig. 906.


Fig. 907.

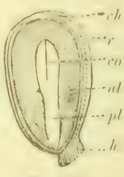


Fig. 908.

Fig. 909.

404. The Embryo in its structure exhibits cells and spiral vessels. It consists of a general axis, one part of which is concerned in the

Fig. 906. Vertical section of the achene of the Nettle (*Urtica*), containing the single seed, with its integuments or testa, *t*. All outside *t* belongs to the fruit, which bears the penicillate stigma, *st*. The seed is erect, being attached by its base to the placenta, and its apex or foramen being at the opposite extremity. The embryo is consequently inverted, as its radicle or base, *r*, points to the foramen, while its apex or the cotyledons are at the base of the seed. The radicle is called superior as it points in this case to the summit of the seed-vessel. There is only a small quantity of separate albumen, the embryo occupying nearly the whole interior of the seed.

Fig. 907. The seed of the White Water-lily (*Nymphæa alba*), cut vertically, showing the integuments, the albumen and the embryo-sac, and the embryo. The greater part of the albumen or perisperm is outside the embryo-sac, but there is some also within it, and called endospermic. The remains of the embryo-sac form the vitellus containing the embryo.

Fig. 908. The seed of the Pansy (*Viola tricolor*) cut vertically. The embryo, *pl*, is axial, in the midst of fleshy albumen, *al*. The seed is anatropal, and the embryo is orthotropal, the cotyledons, *co*, point to the base of the nucleus or chalaza, *ch*, while the radicle, or the other extremity of the embryo, points to the foramen, close to the hilum, *h*. The hilum or base of the seed, and the chalaza or base of the nucleus, are united by means of the raphe, *r*.

Fig. 909. Anatropal seed of Barberry (*Berberis*), with its erect or orthotropal embryo. The cotyledons of the embryo show venation, as indicated by the lines on them. The radicle or narrow end of the embryo points to the micropyle, close to the hilum or base of the seed, *h*, The embryo is in the midst of albumen.

* See Tulasne, Etudes d' Embryogenie Vegetale, Annales des Sciences Nat. 3d ser. Bot. xii. 21, 321.

production of the root (Fig. 908, *pl*), and another in the formation of the stem (Fig. 908, *co*). The radicle or root-portion of the axis always points to the micropyle of the seed. Hence, in orthotropal seeds (Fig. 906), the embryo is said to be inverted, because its radicle points to the apex of the seed where the micropyle is situated, while in anatropal seeds (Fig. 909) it is erect. The axial portion of the embryo is provided with foliaceous or fleshy organs called seed-leaves, or *cotyledons* (Fig. 908, *co*), which serve a temporary purpose in nutrition. Their venation is seen in Figure 909. From the upper part of the axis, the stem called the *plumule* rises, bearing the ordinary, or *primordial* leaves of the plant. These separate parts are well seen

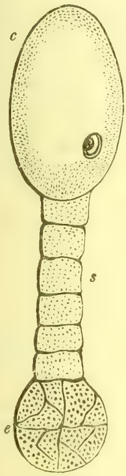


Fig. 910.

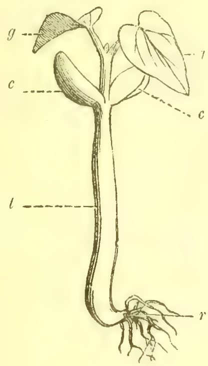


Fig. 911.

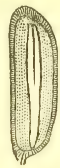


Fig. 913.

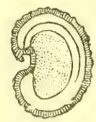


Fig 915.

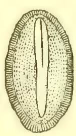


Fig. 912.

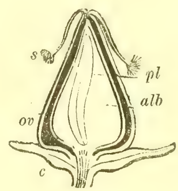


Fig. 914.

when the young plant has begun to grow, as in Figure 911, where *t* is the general axis, with the roots *r* at the base, the cotyledons, *c c*,

Fig. 910. The embryo of the Whitlow-grass (*Draba verna*), with its suspensor. The embryo, *e*, consists of a globular mass of cells which shows the original four divisions, each of which divides into two, till, by successive cell-multiplication, the embryo is formed. The suspensor consists of a series of cells, *s*, ending a large terminal nucleated cell, *c*, at the micropyle. This cell is three times the diameter of the embryo at the same period, and seems to serve the purpose of nutrition.

Fig. 911. Embryo of the Haricot (*Phaseolus vulgaris*) sprouting, showing the radicular portion, *r*, giving off roots, the two cotyledons or seed-leaves, *c c*, with the portion of the axis, *t*, between the root and cotyledons. The axis or plumule arises from between the cotyledons bearing the first ordinary, or primordial leaves, *g g*. The embryo is dicotyledonous, and the cotyledons epigeal, appearing above ground during sprouting.

Fig. 912. Seed of the Scarlet Pimpernel (*Anagallis arvensis*), cut vertically, showing the embryo with its two cotyledons and radicle in the axis of albumen. The embryo is said to be axile or axial.

Fig. 913. Axial embryo of the Barberry (*Berberis*), shown in a vertical section of the seed.

Fig. 914. Fruit (Achene) of the Dock (*Rumex*), cut vertically, showing the embryo, *pl*, at one side of the albumen, *alb*. The embryo is said to be abaxial or eccentric, and it is slightly curved. The covering of the fruit is marked *ov*; the stigmas and styles, *s*, are attached to it. All within the pericarpial covering is the seed. The remains of the perianth or calyx are marked *c*.

Fig. 915. Seed of the Red Campion (*Lychnis*), cut vertically, showing the peripherical embryo, with its two cotyledons and its radicle. The embryo is curved round the albumen, so that its cotyledons and radicle both come near the hilum. The embryo is sometimes called amphitropal.

above, and the plumule with the primordial leaves coming from between the cotyledons.

405. The Embryo is sometimes placed in the centre of the albumen, or in the axis of the seed, and in a straight direction (Figs. 912 and 913), it is then *axile* or *axial;* when not in the centre of the seed it is *abaxile* or *eccentric* (Fig. 914). In place of being straight it is often curved in various ways. This may depend on the curvature of the seed itself, as in the Snake-nut, and in Campylotropous seeds (Fig. 888, p. 297); or the seed may be straight, and the embryo alone curved. In the Chickweed order (Fig. 915), and in the Marvel of Peru (Fig. 916), the embryo is curved round the albumen, becoming *peripherical.* In other cases, as the Thorn-apple (Fig. 917), it is curved in a similar way within the albumen. In Grasses it is situated at the base of the seed, and outside the albumen (Figs. 846 and 848, p. 283). In the Poppy, the embryo is in the axis, but is *curved* or *arcuate* (Fig. 918), in Geranium, the cotyledons are twisted and doubled, in Convolvulus, they are corrugated, and in the Potato and in Bunias (Fig. 919), they are spiral. In some Cruciferous plants, the cotyledons are bent like a leaf folded laterally on its midrib, and they are then called *conduplicate*, and marked o≫; in other Cruciferous plants, they are flat, and the radicle is either bent along their edges, as in Wallflower (Fig. 920), and marked o =; or lies on the back of one of them, as in Rocket (Fig. 921), and marked o ||. In the former case, the cotyledons are *accumbent*, in the latter, *incumbent.* Some authors speak of the position of the embryo, not merely in reference to the seed, but also in reference to the fruit. This is apt to lead to confusion. A superior or ascending radicle is the name given by them when it points to the apex of the fruit (Fig. 906, p. 302, and Fig. 914), while an inferior or descending radicle points to the base

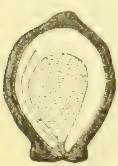


Fig. 916.

Fig. 917.

Fig. 918.

Fig. 919.

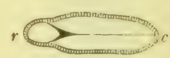


Fig. 920.

Fig. 916. The seed of the Marvel of Peru (*Mirabilis*), cut vertically, showing the amphitropal or peripherical embryo, surrounding the albumen. The cotyledons and radicle are close to the hilum.

Fig. 917. Curved embryo of the Thorn-apple (*Datura*), with its twisted radicle. In this case the embryo does not surround the albumen, but is curved within it. The cotyledons and radicle point to the hilum.

Fig. 918. Vertical section of the seed of the Poppy (*Papaver*), showing the embryo in the axis of the albumen, but slightly curved or arcuate (like a bow).

Fig. 919. Vertical section of the seed of Bunias, with its spiral embryo. The cotyledons, *c*, are rolled upon the radicle, *r*, in a spiral manner; hence the name Spirolobeæ.

Fig. 920. Transverse section of the seed of the Wallflower (*Cheiranthus*). The radicle, *r*, is folded on the edges of the cotyledons, *c*, which are said to be accumbent. The radicle is lateral hence the name Pleurorhizeæ.

of the fruit; a centripetal radicle points to the centre or axis of the fruit, while a centrifugal one points in the opposite way.

406. In some plants, the embryo is entirely cellular and has no cotyledons. They are denominated *Acotyledonous.* They correspond to Cryptogamic or flowerless plants. The embryo, in such cases, is called a *spore* (Fig. 922). It gives off roots and stems from different parts of its surface, and not from any fixed points. It may either be regarded as an ovule remaining in a cellular state, or as a simple cellular embryo. It will be noticed when treating of the organs of Cryptogamic plants.

407. Plants which possess cotyledons in their embryo (Fig. 923)

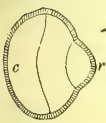


Fig. 921.

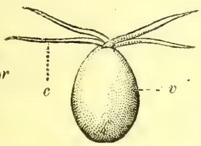


Fig. 922.

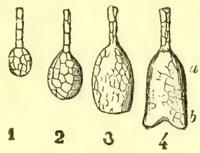
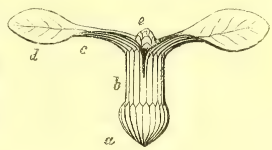


Fig. 924.



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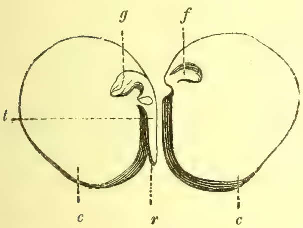


Fig. 923.

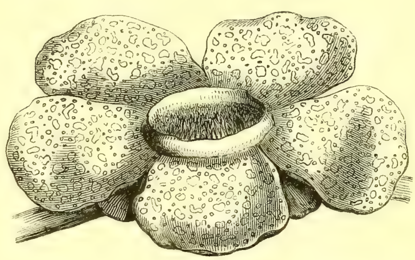


Fig. 926.

are called *Cotyledonous*, and they are divided into those having two cotyledons, and which are called *Dicotyledonous*, and those having one,

Fig. 921. Transverse section of the seed of the Dames-Violet (*Hesperis*). The radicle, *r*, is folded on the back of the cotyledons, *c*, which are said to be incumbent. The radicle is dorsal; hence the name Notorhizeæ.

Fig. 922. Cellular spore, *v*, of Vaucheria, which may be considered a cellular embryo without cotyledons (acotyledonous). There are no definite points whence the root and stem proceed. The spore in the present instance is furnished with filamentous processes, *c*, called cilia.

Fig. 923. Embryo of the Pea (*Pisum*) laid open to show its different parts. This embryo occupies the whole interior of the seed. It consists of two fleshy cotyledons, *c c*, the axis, *t*, with the radicular extremity, *r*, and the plumular end, *g*, often called the gemmule. The depression in one cotyledon, where the plumule lay, is marked *f*. The embryo is dicotyledonous, and the cotyledons are hypogeal, remaining below ground when the plant sprouts or germinates.

Fig. 924. A dicotyledonous embryo, in different stages of development, within the seed. At 1 it appears as a globular cellular mass at the extremity of a cellular cord or suspensor; at 2 it becomes more ovoid; enlarges still more at 3; and at 4 it presents two distinct portions, *a*, the radicle attached to the suspensor, and *b* the two cotyledons.

Fig. 925. Ideal representation of a dicotyledonous embryo or bifoliar phyton, with its radicular extremity, *a*, its two cotyledons, *d c*, with their sheathing bases embracing the axis, *b*, and the primary bud, *e*. A dicotyledonous plant may be considered as composed of a series of such bifoliar phytons.

Fig. 926. Flower of Rafflesia, a parasitic plant found in Java. The flower is three feet in diameter, and its cup can contain nearly twelve pints of fluid. Its seeds resemble the spores of Cryptogamic plants. Its embryo has no cotyledons. Hence Lindley calls it a Sporogen.

called *Monocotyledonous.* The former correspond with the Exogenous division of Phanerogamous or flowering plants, the latter with the Endogenous. A dicotyledonous embryo at first appears in the form of a cell (Fig. 900, *e*, p. 299), the production of which in the embryo-sac depends on the application of the pollen to the stigma. This cell is nucleated, and developes others in succession (Fig. 910, *e*) until the embryo assumes the appearance of a congeries of cells suspended by a cellular filament (suspensor), as shown in Figure 924, 1. The globular cellular mass becomes afterwards more elongated, and passes through the stages 2 and 3 of Figure 924 until it assumes the appearance seen at 4, having an oblong or cylindrical form, with one extremity, *a*, undivided, and the other, *b*, lobed or notched. The undivided portion is the radicle (young root), and it may be considered as part of the rudimentary axis, from one end of which the roots are given off, and from the other the primary bud or plumule. The split portion of the embryo is composed of two lobes or cotyledons, formed at one node, and placed opposite to each other.

408. The cotyledons vary in their consistence, being sometimes leafy, at other times fleshy (Fig. 923). They are sometimes so large as to form the great bulk of the seed, as in the Bean, Pea (Fig. 888, p. 297), and the Almond. They form the first bud of the axis, which may thus be said to consist of a radicular and cotyledonary portion—their point of union being the *collar*, *neck*, or crown. The part interposed between the neck and the cotyledons, which is often very short, is sometimes called the *cauliculus* or *tigellus.* The dicotyledonous embryo then is composed of two leaves or two unifoliar *phytons*, as they are called, united together so as to form one axis. The sheathing lower part of the cotyledons helps to form the caulicule ; and from the axil of the cotyledons, or from the axis between them, is produced the plumular or gemmular bud (Fig. 923, *g*) which forms the stem and leaves. This embryo may be represented by the ideal Figure 925, in which *b* is the axis or tigellus, *a*, the radicular portion, connected with the soil and darkness, *d*, the two cotyledons, united at their lower part so as to form the tigellus, and *e*, the primary bud or plumule, connected with air and light. The embryo may be called a bifoliar phyton.

409. Although this is the usual state of the embryo in Exogens, nevertheless, there are a few exceptions. In some Exogens without leaves, as the Dodder (Fig. 128, p. 54) and Rafflesia (Fig. 926), the cotyledons are also suppressed. The embryo of these plants (Fig. 927) has a resemblance to the spore of Acrogens. In Cone-bearing plants, as the Pine, Spruce, Fir, and Cedar, the cotyledons are split by collateral chorisis, so as to be divided into several (Fig. 928), and this has given rise to the term *polycotyledonous* applied to them. The cotyledons of the Geranium and Lime-tree (Fig. 929) are divided into lobes. Accidental divisions are also seen in the cotyledons of the Sycamore and Rue. In Schizopetalon and some other

Cruciferæ, the cotyledons are usually bipartite, so as to appear to be four.*

410. A monocotyledonous differs from a dicotyledonous embryo in

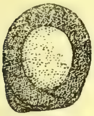


Fig. 927.

Fig. 928.

Fig. 929.

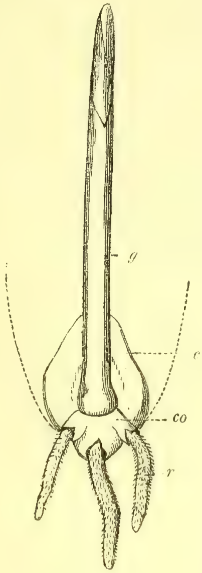


Fig. 930.

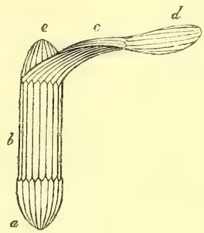


Fig. 932.

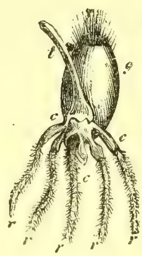


Fig. 931.

having only one cotyledon or seed-leaf (Fig. 930, *c*). It is composed

Fig. 927. Acotyledonous embryo of the Dodder (*Cuscuta*). There is a simple thread-like curved axis, but no cotyledons.

Fig. 928. Polycotyledonous embryo of the Pine (*Pinus*) beginning to sprout. The axis, *t*, shows its radicular portion, *r*, and cotyledonary portion, *c*. The cotyledons, *c*, appear to be numerous, but this is considered as being produced by the chorisis or division of two. Within the cotyledons the primordial leaves are seen, constituting the plumule or first bud of the plant.

Fig. 929. Embryo of the Lime-tree (*Tilia*), with its radicle, *r*, and its palmately five-lobed cotyledons, *c*.

Fig. 930. Monocotyledonous embryo of the Oat (*Avena*) sprouting. The radicular extremity of the axis gives off a number of rootlets, *r*, which pass through sheaths, *co*, the single cotyledon is marked *c*, the young stem *g*. The edges of the grain (caryopsis) are marked by the dotted lines.

Fig. 931. Grain (caryopsis) of Wheat (*Triticum*) sprouting. The embryo occupies the lower part of the grain, *g*. The radicular portion of the axis gives off roots, *r r*, which pass through sheaths, *c c*, while the primary bud or plumule, *t*, rises with its single sheathing cotyledon or seed-lobe. The embryo is monocotyledonous. The great mass of the grain is made up of farinaceous albumen or perisperm.

Fig. 932. Ideal representation of a Monocotyledonous or unifoliar phyton. The axis, *b*, has a radicular extremity, *a*, and a plumular bud, *e*. The cotyledon, *d c*, has a sheathing base embracing the axis, and giving off the plumular bud, *e*, from its axil. A monocotyledonous plant may be considered as composed of a series of such phytons.

* See Duchartre, Memoires sur les embryons qui ont été décrits comme polycotylés. Ann. des Sc. Nat. 3 ser. Bot. x. 207.

of an axis (Fig. 931) having a radicular portion, *r*, and a cotyledonary portion, *t*, and it may be represented by a single leaf or a unifoliar *phyton*. In Figure 932 is given an ideal representation of a monocotyledonous embryo, with its tigellus or axis, *b*, having a radicular portion, *a*, one cotyledon, *d c*, with a sheathing base, and a bud in its axil, *e*, which rises as the stem. When this embryo is examined in the seed, it frequently exhibits no marked divisions—the cotyledon being coiled round the axis like a sheath, and embracing the plumule so as to conceal it. This is the case with the embryo of the Coco-nut (Fig. 904, p. 301). In some cases, as in the Cuckow-pint (Fig. 158, p. 67), there is an evident slit on one side of the cotyledon, indicating the point where the plumule protrudes when sprouting. Sometimes a monocotyledonous embryo has more than one cotyledon. In that case, the second cotyledon alternates with the first, being produced at a second node, which is separated from the first by an internode.

411. *Transformations in Seeds.*—Changes take place in seeds by abortion, degeneration, and union. There are few plants in which all the ovules become perfect seeds. Many are suppressed during the progress of growth, so that frequently one seed is developed at the expense of several ovules. Sometimes the seeds are converted into leaves. Brongniart has noticed this in a specimen of the Chinese Primrose, in which the anomalous seeds attached to the central placenta resembled the leaves of the plant in their form, while, at the same time, the parts of the calyx and corolla were slightly modified.* He has also described and figured the foliar transformation of ovules and seeds in Delphinium elatum, Brassica Napus, Soapwort, and Scarlet Pimpernel.† Turpin has observed the seeds of Columbine, of Dutch Clover, and of the Carrot, transformed into leaves. Monstrosities sometimes occur by the union of seeds.

412. There is usually a single embryo in each seed, but cases occur in which a plurality of embryos is produced. This is a very common occurrence in the Orange, Cycas, and Cone-bearing orders. In the case of the two latter orders, the suspensor often ramifies so as to produce numerous separate embryos on its branches. These embryos are frequently abortive. In the seed of the Fir there are certain cellular bodies, called corpuscles by Brown, which give origin to filaments by which the embryos are suspended. These may be said to resemble the large cell at the upper part of the suspensor in some Cruciferous plants (Fig. 910, *c*, p. 303). Accidental union of embryos also takes place. De Candolle observed double embryos in the Cress, and in species of Spurge and of Mustard. The appearance of three or four cotyledons in the seeds of some species of Solanum and in the Haricot, has been traced to a union of embryos, and not to a chorisis of two cotyledons.

* Annales des Sciences Nat. 2d ser. i. 310.

† See Brongniart sur Monstruosités Végétales, in Archives du Museum, iv. 43.

413. Recapitulation of the chief facts relative to the Fruit, Seed, and Embryo :—

1. The Fruit consists either of the ovary alone arrived at maturity, or of the ovary combined with the bracts, calyx, or other floral envelopes.
2. The Fruit may be formed by the parts of a single flower, and then it is Simple or monanthous; or by the parts of several flowers united, and then it is called Multiple, collective, anthocarpous, or polyanthous.
3. The parts of a mature ovary are the Pericarp or Integuments, and the Seed with the Embryo.
4. The Pericarp consists of an outer covering called Epicarp or Exocarp, of an inner called Endocarp or, if stony, Putamen, and occasionally of a distinct middle coat called Mesocarp or, if fleshy, Sarcocarp. In some instances, a special covering exists in the form of an aril, which is either funicular or micropylar.
5. Changes take place in the ovary while becoming the fruit, by obliteration of parts, by the growth of cellular tissue, and by foldings and partitions of different kinds. In order to know fully the structure of the ripe fruit, reference must be made to the ovary in its young condition.
6. Fruits, when formed of one carpel, are called monocarpellary; and when of more than one, they are polycarpellary. Sometimes the terms bicarpellary, tricarpellary, tetracarpellary, and pentacarpellary, are used to indicate fruits formed by two, three, four, and five carpels.
7. A monocarpellary fruit, and polycarpellary fruits with distinct and separate carpels, are called Apocarpous. Fruits in which the carpels are united by their ovaries, or by their ovaries and styles, or by their ovaries, styles, and stigmas, are called Syncarpous.
8. The number of carpels in a Syncarpous fruit is indicated usually by the number of partitions in the ovary, or by the number of styles and stigmas.
9. When the partitions (septa) extend to the centre, the number of loculaments will in general point out the number of carpels in a Syncarpous fruit.
10. A Fruit is unilocular, bilocular, trilocular, quadrilocular, quinquelocular, or plurilocular, according as it has one, two, three, four, five, or many separate cavities in its ovary. A unilocular fruit, however, may be composed of several carpels, the partitions between which are parietal only.
11. Fruits are either Dehiscent or Indehiscent. In the former case, they fall to the ground without opening; in the latter, they open to scatter the seeds.
12. Monocarpellary Fruits dehisce usually by their ventral or dorsal suture. Polycarpellary Fruits dehisce in a septicidal, loculicidal, septifragal, circumscissile or opercular, and porous manner. The parts which separate are called valves.
13. Fruits are either Dry or Succulent. In the former, the parts of the pericarp are often confounded together, while in the latter, they are frequently separable.
14. Fruits containing one seed are monospermic, those containing two are dispermic, many, polyspermic.
15. Monospermic dry Fruits are often indehiscent, and are apt to be confounded with seeds, and may be distinguished by the presence of the stigma.
16. When Seeds are contained in an ovary, as is usually the case, the plants are called Angiospermous; when the seeds are not contained in a true ovary with a style or stigma, then the plants are called Gymnospermous.
17. The seed is attached to the placenta by the funiculus. The organic base of the seed is the hilum, while the organic apex is the micropyle.
18. Like ovules, seeds are orthotropous, campylotropous, or anatropous. In the last, the presence of a distinct chalaza and raphe indicates their nature.
19. The Integuments of the seed are called Spermoderm, and consist usually of two parts—the Episperm, Testa, or Exosperm, and the Endopleura or Tegmen. Occasionally, a middle coat or mesosperm is present, which, when fleshy, receives the names of Sarcosperm or Sarcoderm.

20. The Seed contains the embryo either alone, or with a supply of nourishing matter called Perisperm or albumen. In the former case, the seed is exalbuminous, in the latter, albuminous.
21. Seeds usually contain one embryo, and are said to be monembryonous; but instances occur in which several embryos exist in a seed, and it is then said to be polyembryonous.
22. The sac of the Embryo sometimes continues distinct in the seed in the form of a vitellus, and the albumen is either deposited outside the sac (perisperm), or inside the sac (endosperm), or in both situations at once.
23. The Embryo consists of an axis, the lower extremity of which is the radicular portion or radicle; the upper extremity is the cotyledonary portion. From the axil of the cotyledon or cotyledons the first bud, called plumule or gemmule, proceeds.
24. The Radicle or base of the embryo points to the micropyle. In orthotropal seeds the embryo is inverted, in anatropal seeds it is erect.
25. The chalazal end of an anatropal seed corresponds to the cotyledonary extremity of the embryo; the funicular end of an anatropal seed to the radicle of the embryo.
26. The Embryo occupies different positions in the seed, being either in the centre, or at the side or at the base of the albumen. It is also either straight, or curved or twisted in different ways.
27. An embryo with two cotyledons is Dicotyledonous, and is met with in Exogens; an embryo with one cotyledon is Monocotyledonous, and occurs in Endogens; while an embryo without cotyledons is Acotyledonous, and is found in Cryptogams.
28. A Monocotyledonous Embryo is composed of a unifoliar phyton; a Dicotyledonous embryo is composed of a bifoliar phyton; while an Acotyledonous embryo is a cellular leafless phyton.

CHAPTER IV.

NUTRITIVE AND REPRODUCTIVE ORGANS OF FLOWERLESS PLANTS.

I. GENERAL REMARKS ON THESE ORGANS.

414. Although allusion has been cursorily made to these organs in the foregoing pages, still it seems necessary to give a fuller and more connected view of them. As regards elementary tissues, Flowerless or Cryptogamic plants are composed either entirely of cells, as occurs in Sea-weeds and Mushrooms; or of cells and vessels united, as seen in Ferns, Mosses, and their allies. The vascular tissue consists chiefly of pleurenchyma (Fig. 45, p. 23) with closed spirals, annular (Fig. 66, p. 28), and scalariform vessels (Fig. 68, p. 29). In the simplest plants, as Protococcus (Fig. 933), the cell performs all the functions necessary for the nourishment and reproduction of the plant. In the more complicated Flowerless plants, there are some organs specially adapted for nutrition or vegetation, and others for reproduction. Between the Protococcus, a simple cell with thin transparent and colourless walls, and the Tree-fern (Fig. 934) and Pepperwort, with stems and leaves, there is a wide difference. Nevertheless, they are united by intermediate forms. The permanent organization of some Cryptogamics low in the scale is only the temporary condition of higher tribes.

415. In Ferns, Pepperworts, and the higher Cryptogams, there are roots, conspicuous stems, and leaves, for the purposes of nutrition, and certain special organs destined for reproduction. As these tribes produce a foliaceous axis or corm, they are denominated *Cormogens* or *Cormophytes* (Fig. 934), and when their stems are woody, they present the acrogenous structure as described in paragraph 136. In the lower Cryptogamics there are no true roots, nor stems, nor leaves, and their nutritive and reproductive organs are frequently assimilated. These tribes, from having no foliaceous axis, but simply a cellular expansion, have been called *Thallogens* or *Thallophytes* (Fig. 935).

416. In the lowest plants, a few simple cells, either separate or combined, perform the part of nutritive organs. In the case of the Protococcus, the plant of Red and Green snow (Fig. 933), a rounded cell constitutes the whole plant; in Oscillatorias, the cell is elongated; in many Confervas, a congeries of cells is united in a single row; and

in certain Algæ (Fig. 936) and Moulds, the cellular filaments or threads

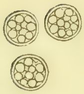


Fig. 933.

Fig. 934.

Fig. 935.

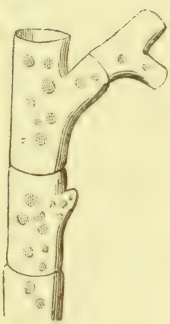


Fig. 936.

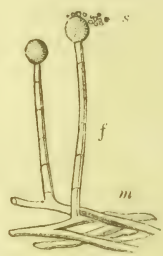


Fig. 937.

give off branches. The vegetative system of Fungi consists of

Fig. 933. Green-snow plants (*Protococcus viridis*), consisting of single cells, which perform all the functions of nutrition and reproduction. The parent cells contain numerous cellules, which are discharged when the outer general covering gives way. Each of the cellules so separated gives rise to a distinct plant, and they may be considered either as spores or as cellular buds.

Fig. 934. A Tree-fern (*Alsophila Perrottetiana*), with a conspicuous acrogenous stem, bearing a cluster of leaves (fronds) at the apex. The stem is hollow, and bears the scars of fallen leaves on its exterior. At the base of the stem there is a thickening, *ra*, due to the formation of adventitious roots, which descend from the points where the leaves were attached.

Fig. 935. Iceland Moss (*Cetraria islandica*), a species of Lichen, with a flattened cellular expansion (thallus), bearing fructification in the form of apothecia. The plant is thallogenous.

Fig. 936. Branching cellular filament of a Conferva (*Chætophora*), composed of cylindrical cells placed end to end, and containing green matter (endochrome).

Fig. 937. Mould plant (*Mucor*), composed of a mycelium or spawn, *m*, whence arise septate filaments, *f*, ending in a large round cell, *s*, containing spores, which are discharged by the bursting of the bag enclosing them.

colourless filaments (Fig. 937, *m*) called *mycelium*, the cells of which contain no *endochrome* or coloured particles. These filaments are either in the form of continuous canals, or they have partitions, so as to appear in the form of septate tubes. In Lichens and many Sea-weeds, the nutritive organs consist of a series of cells united, so as to produce a flat expansion or *thallus* (Fig. 935). This thallus varies in colour. It is red, for instance, in some Sea-weeds, and green in others. The structure of the thallus is either homogeneous, as in the lower Algæ, or heterogeneous, as in the higher Algæ. In the latter case, there may be distinguished different cellular strata called external or cortical, internal or medullary, and intermediate or subcortical. In Ferns, Pepperworts, Club-mosses, and Mosses, the union of cellular and vascular tissue gives rise to a more complex form of organization, resembling very closely that of Phanerogams. The nutritive organs of Cryptogams produce frequently peculiar buds, *gemmæ* or *innovations*, as they are called, which are capable of being detached from the

Fig. 938.

Fig. 939.

Fig. 940.

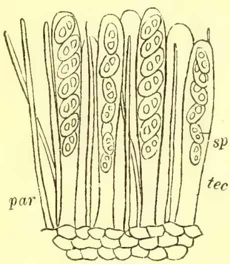


Fig. 942.

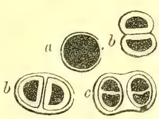


Fig. 941.

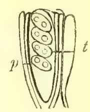


Fig. 943.

plant, and of forming new individuals. The integumentary covering of Cryptogams is sometimes only of a cuticular nature without stomata, as in Algæ, while at other times it is epidermal and bears stomata, as in Ferns, Mosses, and Liverworts.

417. While the nutritive organs of Cryptogamic plants thus bear

Fig. 938. Round spore of a Fern (*Pteris longifolia*). It has a double covering. The outer layer is marked with three lines.

Fig. 939. Elliptical spore of the Brittle Bladder-fern (*Cystopteris fragilis*). The outer covering is marked with pointed projections.

Fig. 940. Sporidium of a Lichen, containing two cells within a common covering. Some think that these two cells conjugate and give rise to a mass of spores. The sporidium, when complete, often contains numerous small cellules or germinating spores. A sporidium with two cells, such as represented in the figure, is sometimes called a bispore.

Fig. 941. One of the lower Algæ (*Palmella cruenta*), consisting of a cell, *a*, with mucilaginous contents, which divides, first into two, *b b*, and then into four, *c*. Each of the four divisions is capable of propagating the plant when they are discharged from the mother-cell. This is one of the simplest known plants, being composed of a single cell, which performs the functions of nutrition and of reproduction.

Fig. 942. Vertical section of the fructification of a Fungus (*Peziza*). It consists of thecæ or bags, *tec*, each containing eight nucleated cells (Sporidia). Along with the thecæ are filaments called paraphyses, *par*.

Fig. 943. Theca or ascus, *t*, of a Lichen, with nucleated cells (Sporidia) in its interior. Along with it are paraphyses, *p*.

a greater or less resemblance to those of Phanerogams, the case is very different with the reproductive organs. Cryptogams have no flowers and no true seeds; they are propagated by cellular bodies denominated *Spores* (Figs. 938 and 939), which are cells capable of sprouting and forming new plants, and which some have called cellular embryos without cotyledons, or leafless phytons. The plants are consequently Acotyledonous (¶ 406). The origin of these spores is very obscure, but they appear to be formed through the medium of certain cellular organs of a reproductive nature.

418. The term spore should be confined to the ultimate germinating cell of Cryptogamics. It is frequently, however, applied to the cell in which the true spores are formed. Hence spores have been called simple or compound, according as they are formed by one or by several cells. The term *Sporidium* is applied to the compound spore of Lichens. Thus, in Figure 940, there is a sporidium containing two cells, while in Figure 941 there is a mother-cell, which divides first into two and then into four germinating cells. When the cells are numer-

Fig. 944.

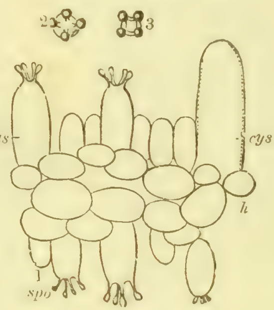


Fig. 945.

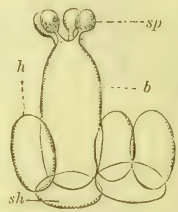


Fig. 946.

ous they are either placed end to end, so as to be in the form of a septate or partitioned sporidium, or they are accumulated into a mass, called a cellular sporidium. The latter is often the advanced stage of the former, as seen in Lichens. In simple spores, the walls are either simple, as in Botrytis, or double, as in Ferns.

419. Spores are developed either in the interior of the cell which

Fig. 944. Clavate cellular filament of an Alga (*Vaucheria ovoidea*). The terminal portion becomes separated from the rest by a partition. In this portion the single spore, *s*, is developed, which is discharged through an opening, as seen in the figure. The spore has cilia, by means of which it moves about for some time in water after being separated from the parent cell. The lower part of the filament contains green endochrome. The spore is of a very dark green colour.

Fig. 945. Portion of the lamella or gill of a Mushroom (*Agaricus campestris*), cut transversely, showing the two lateral surfaces on which the spores are placed. The spores are arranged in fours, *spo*, 1, 2, 3, and supported on cells called basidia, *bas*. The spores being on the outside of a cell are called exospores, and the plant is basidiosporous. There are also peculiar granular bodies contained in sacs called cystidia, *cys*. The cells forming the hymenium and subhymenium are marked *h*.

Fig. 946. Portion of the lamella or gill of the Mushroom (*Agaricus campestris*), cut transversely, showing one of the lateral surfaces. The Hymenium, *h*, has a layer of cells below it called the subhymenium, *sh*; the four spores, *sp*, are on the outside of a cell called basidium, *b*, and the spores are on stalks (sterigmata).

gives origin to them, or on the outside of it. In the former case, they are called *Endospores*, in the latter, *Exospores* or *Gymnospores*. In Protococcus (Fig. 933, p. 312) and in Mucor, the fructification consists of numerous spores in the interior of a mother-sac, more or less spherical. In Palmella (Fig. 941), the mother-cell contains two or four spores. In Pezizas (Fig. 942) and Lichens (Fig. 943), the sporidia (or cells containing spores) are usually four, six, or eight in number. In Vaucheria, only one spore is produced in the mother-cell (Fig. 944, *s*), while in Lavers, Fuci, Liverworts, Mosses, and Ferns, the endochrome or coloured matter filling the mother-cells divides into four parts, each of which becomes a spore, thus resembling the production of pollen-grains in Phanerogams (¶ 306). The large cell, containing one, four, six, eight, or numerous spores or sporidia, receives the name of *Theca* (Fig. 942, *tec*).

420. The exospores or naked spores in the Yeast plant, and in Moulds such as Aspergillus and Penicillium, consist of elongated filaments which are formed by a series of cells placed end to end. When ripe, the cellules separate. In Botrytis and Isaria, a single spore only constitutes the exospore, while in Cantharellus there are two, and in Agarics four (Fig. 945, 2, 3). Leveillé called the mother-cell, on the exterior of which one, two, four, or many spores are formed, a *basidium* (Fig. 945, *bas*). In Agarics, the basidia bearing four spores at their extremity are in general united together so as to form a tissue called *hymenium* (Fig. 946, *h*). In Lichens, Sphærias, and Pezizas, the thecæ containing four, six, or eight spores or sporidia placed one above the other are often separated by filaments called *paraphyses* (Fig. 942, *par*), and the united thecæ and paraphyses constitute the hymenium.

421. The hymenium or the spore-bearing surface is placed on the tissue forming the cortical or medullary layers (strata) of the plant. These strata, sometimes called generically the *excipulum*, may be flat, as in Usnea, and then called *apothecium*, or hollow, as in Peziza, and then called *receptacle;* or they may form a closed cavity with an opening (ostiolum) only at one part, and then they are called a *conceptacle* or *perithecium*. Conceptacles, when united together, are sometimes surrounded by a general covering to which the name of *peridium* has been given. The mass of conceptacles, whether free or united, and enveloped in this peridium, have been sometimes denominated *gleba*. The peridium is sometimes formed of two membranes, as in Geaster, the outer one of which splits so as to allow the inner to appear, and the latter in its turn opens at a fixed point to discharge the spores.

422. In Ferns and Mosses, the hollow cavities containing the spores receive the name of *sporangia* or spore-cases. They are situated either at the extremity of the axis (Fig. 947, *s*) or in the axil of leaves, or on the back of leaves (Figs. 948 and 950). In Mosses, certain cells occupying the centre of the sporangium are sterile, and unite to form a central column denominated *columella*. In Salvinia,

the spores are fixed to a kind of placenta by a cord, and the membrane enclosing them has been called a *sporocarp* (Fig. 951).

423. In some instances, certain minute cells are produced called *sporules*. They are met with in some of the rose-coloured Sea-weeds

Fig. 948.

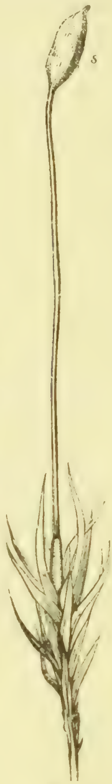


Fig. 947.

Fig. 949.

and in Marchantia (Fig. 949, *g*). They are capable of reproducing the plant, and are looked upon by some authors as forms of buds or

Fig. 947. Fruiting stalk of Hair-moss (*Polytrichum*). The leaves are awl-shaped (subulate), and arranged alternately. The seta or stalk rises from leaves called perichætial. The stalk has a sheath at its base; at its apex is the sporangium, *s*, or spore-case, which is an urn-shaped sporiferous (spore-bearing) bag, having a lid or operculum at its summit. This fruit-bearing stalk arose from a cell of the pistillidium after impregnation, and it is considered as an instance of alternation of generations. The fructification, as seen in the figure, is the second generation, and differs totally from the first.

Fig. 948. Frond (fructiferous leaf) of a Fern (*Niphobolus*), showing sori, or round clusters of sporangia at the ends of veins. As these sori are on the back of the frond, the Fern is called dorsiferous.

Fig. 949. Portion of the thallus, *t*, of Liverwort (*Marchantia polymorpha*). From the thallus arises a stalk, *s*, bearing a peltate receptacle, *r*, containing antheridia in its substance. At another part of the thallus is a cup-like body, *g*, containing small rounded cells, called by some sporules, and by others germs, buds, or bulbils. They produce new plants when separated from the parent. They do not seem to be developed by a process of reproduction, and thus they resemble buds; but they differ from the latter in being produced in a special organism.

bulbils. They differ from the latter, however, in being produced in special organisms. They appear to occupy an intermediate position between buds and spores, resembling the former in not being developed by a process of reproduction, and the latter in being contained in special organs.

424. Spores are generally regarded as being produced by the agency of certain organs equivalent to the stamens and pistils of

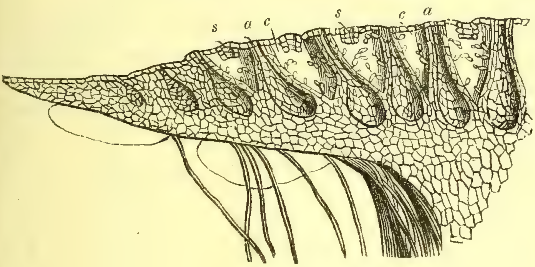
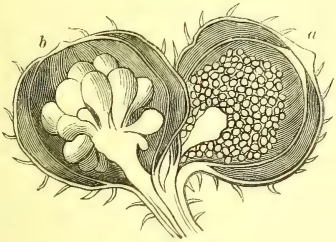


Fig. 952.



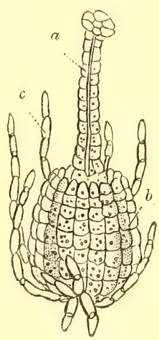


Fig. 950. Fig. 951. Fig. 953. Fig. 954.

Phanerogams. These organs have been demonstrated more or less completely in all the orders of Cryptogamic plants, and they have

Fig. 950. Mature sporangium of the Male Fern (Lastrea Filix-mas). It is supported on a stalk, *p*, some of the cells of which form an elastic ring or annulus, *a*, round the spore-case. The spore-case opens at the side to discharge the spores.

Fig. 951. Sporocarp or involucre of Salvinia, showing large pear-shaped spores in one cavity, *b*, attached to a placenta, and smaller spores (probably antheridia), in another cavity, *a*.

Fig. 952. Vertical section of a portion of the peltate receptacle of Liverwort (*Marchantia*), showing the antheridia, *a a*, or flask-like sacs containing phytozoary cells. Between the antheridia there are air cavities, *c c*, communicating with stomata, *s s*.

Fig. 953. Pistillidium of Liverwort (*Marchantia*), surrounded by its cellular covering, *b*, and by septate filaments called paraphyses, *c*; and surmounted by a style-like calyptra, *a*.

Fig. 954. Plant of Hair-moss (*Polytrichum*), bearing at its summit antheridia, *a*, which are covered by altered leaves. This moss is called diœcious, inasmuch as antheridia and pistillidia are on separate plants.

received the names of *antheridia* (Fig. 952, *a*), and *pistillidia* or *archegonia* (Fig. 953), the former representing the stamens or the male, the latter the pistil or the female. The antheridia were early noticed by Hedwig in the case of Mosses, and their presence has of late years been detected in nearly all the Cryptogamic tribes. In all Cryptogams with distinct stems and leaves, as Ferns, Horsetails, Club-mosses, Pepperworts or Rhizocarps, Mosses, and Liverworts, bodies called antheridia and pistillidia have been demonstrated. In Mosses (Figs. 947 and 954) and in Liverworts (Figs. 949 and 955), they occur on the fully developed plants. In Ferns and Horsetails, they are seen on a cellular structure of a leafy character, called the *pro-embryo* or *pro-thallus* (Fig. 956) developed from the spores. In some Mosses, the antheridia and pistillidia occur on different plants (Figs. 947 and 954), which are hence called diœcious. The union of the two appears to be required for the perfection of the spore or cellular embryo.

425. In antheridia, there have been detected moving filaments to which the name of *phytozoa* or *spermatozoids* has been given (Figs. 957 and 958). These filaments do not germinate. Phytozoa have been detected in Charas, Liverworts, Mosses, Sea-weeds, and Fungi. In the first three, the phytozoa are in the form of small vermiform filaments swollen at one extremity, and having two very long and slender threads at the other (Fig. 959). Each phytozoon is formed in a special cell, is rolled upon itself in a spiral manner (Fig. 958, 2), and escapes either by a pore or by a dissolution of the wall of the cell. In Sea-weeds (Fig. 960), the phytozoa have the threads projecting from either extremity of an obovate body. In the thecæ and sporangia, also, of many Cryptogamics, certain moving spores have been observed, furnished with vibratile threads or cilia (Figs. 961, 962, 963, and 964). These spores have been denominated *zoospores* or *sporozoids*. Their motions seem to be connected with vibratile processes which vary in number, and which proceed from different parts of the spore. In Figure 962 there are two filaments at one end of the spore, in Figure 961 four, and in Figure 963 many; while in Figure 964 the filaments surround the spore completely. These spores move about in fluid until they begin to sprout, at which time the motions cease and the cilia disappear.

426. It would appear from recent researches that many spores, when sprouting, produce organs which resemble the permanent state of other Cryptogams lower in the scale. Thus Mosses, when germinating, exhibit elongated greenish filaments in every respect analogous to Confervæ. Ferns in their infancy resemble completely the adult Liverworts, having a green flat pro-embryo like the thallus of the latter (Fig. 956). The pro-embryo or pro-thallus afterwards gives rise to the proper stem and frond of the Fern. The membranous thallus is a permanent state of the Liverworts, but a transition state of Ferns. The higher Cryptogams would thus appear to pass through

a pro-embryonic or pro-thalloid state, and it is often in this condition that the antheridia and archegonia are seen, which are considered the organs of reproduction. These organs, when existing on the pro-thallus, do not at once give origin to a germinating spore, but produce a cellular body from which, at a future period, the fructiferous

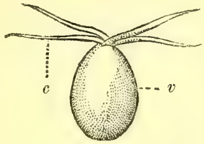


Fig. 961.

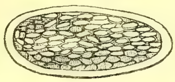


Fig. 957.

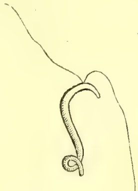


Fig. 959.

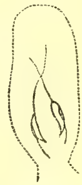


Fig. 960.

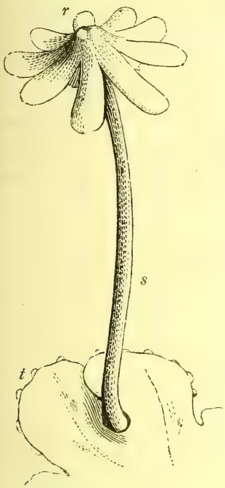


Fig. 955.

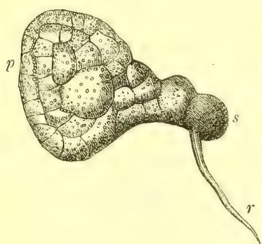


Fig. 956.

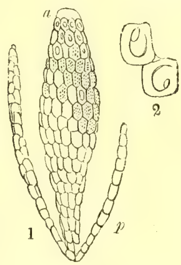


Fig. 958.

or fruit-bearing frond arises. There seems to be an alternation of generation in these instances. In the first stage, a thalloid expansion

Fig. 955. Part of the thallus, *t*, of Liverwort (*Marchantia*), bearing a stalk, *s*, which ends in a divided receptacle, *r*, on the under surface of which sacs containing spores and elaters are produced. This is considered a female plant, bearing pistillidia only, while, in Figure 949, a male plant is represented. Hence, the plant is said to be diœcious.

Fig. 956. Spore, *s*, of a Fern (*Pteris longifolia*) sprouting, giving off a root-like process, *r*, and a flat cellular expansion, *p*, called the pro-thallus or pro-embryo. On this expansion antheridia and pistillidia are said to occur. A cell of the latter is afterwards developed into a frond bearing sporangia and spores. It is said to be an instance of alternation of generations. The pistillidian body is sometimes called the ovule, and the developed cell is called the sac of the embryo.

Fig. 957. Antheridium of a Sea-weed (*Fucus serratus*), containing numerous phytozoa or spermatozoids in its cellules.

Fig. 958. Antheridium, 1, *a*, of the Hair-moss (*Polytrichum*), consisting of cellules, 2, containing phytozoa coiled up in their interior. The phytozoa have a thickened extremity, whence proceeds a tapering tail-like process. Along with the antheridium are two septate filaments or paraphyses, *p*, which are probably abortive antheridia.

Fig. 959. Phytozoon or spermatozoid, from the antheridium of Chara. It has two long vibratile processes at one extremity, and to these its movements are referred.

Fig. 960. Antheridium of a Sea-weed (*Fucus serratus*), still containing two of the phytozoa, which consist of a swollen portion, with filaments proceeding from either extremity. The phytozoa exhibit movements.

Fig. 961. Moving spore (Zoospore or Sporozoid) of an Alga (*Chætophora*), consisting of a cell, *v*, with four cilia or vibratile processes, *c*, at one extremity.

is what the spore produces. This is the first phase of existence. The pro-thallus then gives rise to the next stage, in which sporangia are produced with spores in their interior; this constitutes the second phase of existence. These phenomena have been particularly observed in Ferns by Suminski, Wigand, and De Mercklin.*

427. In reviewing what has been recently done in this interesting department of Cryptogamic botany, Henfrey gives the following statements:—The antheridia of Mosses (Fig. 958), Liverworts (Fig. 952, *a*), Ferns, and Horsetails, agree with what authors called the *small spores* in Quillwort, Pillwort, and Salvinia, in producing cellules containing phytozoa or spiral moving filaments. These antheridia constitute one of the sexual organs. The pistillidia of Mosses and Liverworts (Fig. 953) agree with the so-called *ovules* or peculiar spores of Ferns, Horsetails, Club-mosses (Fig. 965), Quillworts, and Rhizocarps (Fig. 966), in general structure and in the presence of a large cell, called the embryo-sac by some, from which the new form of structure originates. These pistillidia constitute the second sexual organ.

428. In Mosses and Liverworts the antheridia and pistillidia may be considered equivalent to the stamens and pistils, the sporangium being the fruit; or we may, with Hofmeister, regard it as an alternation of generations—the pistillidium being considered an ovule

Fig. 962.

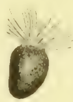


Fig. 963.

Fig. 964.

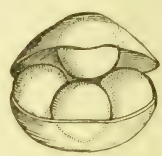


Fig. 965.

Fig. 966.

producing a new individual (viz., the sporangium) of a totally different character from that developed from the spore (viz., the leafy moss-plant, in the usual acceptation of the term). In Ferns and Horsetails, the spores produce a frondose structure of a definite form (pro-embryo or pro-thallus), upon which are developed antheridia and pistillidia, or ovules of some authors. This seems to be one generation completed; and the new development from the so-called ovule appears as a totally distinct form, producing stem and leaves, which have

Fig. 962. Zoospore of an Alga (*Conferva glomerata*), with two moving cilia at one end.

Fig. 963. Zoospore of an Alga, with a tuft of cilia at one end.

Fig. 964. Zoospore of an Alga (*Vaucheria*) surrounded by moving cilia.

Fig. 965. Larger spores of Club-moss (*Lycopodium*), inclosed in an involucre. It is sometimes called an oophoridium in consequence of containing germinating bodies (ovules). It is considered as representing the female organ. The involucre opens transversely to discharge the spores.

Fig. 966. Ovule or spore-case of Pepperwort (*Marsilea*), containing a single germinating spore. There is a little projection or mammilla at the summit, whence the roots and leaves proceed during germination.

* Leszczyc-Suminski Zur Entwickelungs-geschichte der Farrnkräuter, Berlin, 1848; and also Ann. des Sc. Nat. 3d Ser. Bot. xi. 114. Wigand, Zur Entwickelungs-geschichte der Farrnkräuter, Botan. Zeitung, 1849; also Ann. des Sc. Nat. 3d Ser. Bot. xi. 126. See also Mercklin, Beobachtungen an dem Prothallium der Farrnkräuter, 1850.

a distinct individual form and structure, and produce the spores after a long period upon temporary parts of this structure (*i.e.*, on the leaves), and by no means cease to exist when these are matured. This is then a real alternation of generations. Hofmeister compares the whole permanent plant of the Fern or Horse-tail to the sporangium of a Moss or Liverwort. The pistillidia of Mosses and Liverworts are considered by him the analogues of the so-called ovules of higher Cryptogams, while the sporangium is considered as the analogue of the perfect plant of Ferns, and the leafy stem as the analogue of the pro-embryo of Ferns.*

II. NUTRITIVE AND REPRODUCTIVE ORGANS OF DIFFERENT ORDERS OF CRYPTOGAMIC PLANTS.

1. Organs of Ferns and their Allies.

429. *Ferns* or *Filices* are composed of cellular and vascular tissue. They have roots, leaves, an acrogenous stem, and an acotyledonous embryo. The stem or *caudex* either rises conspicuously into the air, as in the case of Tree-ferns with their elegant foliage (Fig. 967), or it appears as a rhizome running along the surface of the earth or under ground, as seen in the native Ferns of Britain (Figs. 968 and 969). The stem contains vascular bundles consisting of woody, dotted, annular, closed spiral, and scalariform vessels (Fig. 970). The last are characteristic of Fern structure. These vascular bundles are arranged in a peculiar manner, as shown in Figures 971 and 972. In the former figure, which represents the section of a Tree-fern stem, the woody tissue or pleurenchyma, *f*, is of a dark colour, and surrounds the other vessels, *v*, which are of a pale colour; the parenchyma is distributed partly in the centre, *m*, and partly at the circumference, *p*, and the bases of the leaves, *e*, form an external covering. The appearance presented by the vascular bundles, *f*, of the Male Fern is shown in Figure 972. In the case of the common Brake (Pteris aquilina), the arrangement of the vascular bundles, when the stem is cut, gives an appearance resembling a double eagle, and hence the specific name.

430. The trunk of Tree-ferns is hollow when fully formed, gene-

* For fuller details on the subject, see Henfrey's Report on Cryptogamic Reproduction, in the Transactions of the British Association for 1851; and for a complete Treatise on the organs of Cryptogamic plants consult Payer, Botanique Cryptogamique, Paris, 1850. See also Mohl, einige Bemerkungen uber die Entwickelung und den Bau der Sporen der Cryptogamischen Gewachse; Hofmeister, Untersuchungen der Keimung, Entfaltung und Fruchtbildung höherer Kryptogamen, Leipzig, 1851.

rally simple, sometimes dichotomous, having on the outside leaf-scars which display the markings of the vascular bundles (Fig. 973 and Fig. 204, p. 93). The external surface of the stem, especially at the lower part, is often covered by adventitious or abnormal roots (Fig. 934, *ra*, p. 312). The stem is formed by the union of the bases of the leaves, which carry up the growing point with them, and in this way the

Fig. 967.

stem increases by additions to its summit, or is acrogenous (¶ 136). In consequence of this mode of growth there is little increase in diameter.

431. The leaves which are called *fronds* are produced at the summit of the stem (Fig. 967), and they form a very graceful crown or coma. In the young state, they are rolled up in a circinate

Fig. 967. Tree-fern with its slender cylindrical trunk, and crown of elegant drooping fronds, on which the fructification is produced. This stem is acrogenous, increasing by additions to its summit.

manner, so as to resemble a crosier (Figs. 974 and 968, *f*). They consist of veins and parenchyma, the former being usually of equal thickness throughout, and divided in a forked (furcate) or reticulated manner. The epidermis has stomata, but they are not very numerous. The fronds bear the fructification. In some instances, they

Fig. 968.

produce bulbils or gemmæ, which, when separated from the plant, take root and give rise to new individuals; such Ferns are called *bulbiferous* or *gemmiparous*.

Fig. 968. A species of Spleenwort (*Asplenium*). 1, Shows the rhizome, *r*, covered with the bases of the leaves (fronds), and giving off roots; some fronds in bud, *f*, rolled up in a circinate manner, others expanded, *g*, bearing the fructification 2 a portion of a frond separated to show the linear sori or clusters of sporangia.

432. The Venation of Ferns supplies important characters in classification, as has been particularly shown by Mr. John Smith of Kew. The veins, according to him, are either produced equally on

Fig. 969.

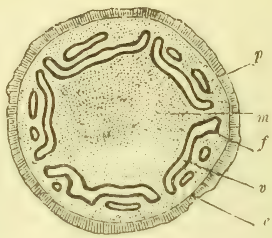


Fig. 971.

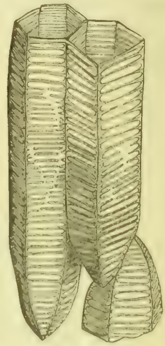


Fig. 970.

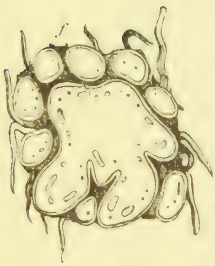


Fig. 972.

Fig. 974.

Fig. 973.

both sides of a midrib, or they radiate from near the base, the midrib being evanescent (Fig. 975). Sometimes the primary veins proceed-

Fig. 969. Short-fruited Spleenwort or Lady-fern (*Athyrium Filix-fœmina*). 1, The entire fern with its short rhizome, and its delicate fronds, which, in the young state, are rolled up in a circinate manner; 2, one of the pinnæ, with its pinnules, bearing the oblong slightly-curved sori (clusters of sporangia) on their back. The fern is dorsiferous.

Fig. 970. Scalariform vessels taken from a Tree-fern. They have a prismatic form, and are marked by bars like the steps of a ladder.

Fig. 971. Transverse section of the stem of a Tree-fern (*Cyathea*), showing the arrangement of the cellular tissue and vascular bundles. The cellular tissue of the centre, *m*; that of the circumference, *p*; vascular bundles, *f v*, consisting of dark-coloured woody fibres, *f*, and paler vessels, *v*, chiefly scalariform and closed spiral; the outer cortical portion formed by the bases of the leaves, *c*.

Fig. 972. Transverse section of the Rhizome of the Blunt Shield-fern, often called the male Shield-fern (*Lastrea Filix-mas*), showing the bundles of vascular tissue, *f*, scattered among the parenchyma, and the bases of the leaves which form the stem.

Fig. 973. Bifurcating (forked or dichotomous) trunk (caudex) of a Tree-fern (*Alsophila Perrottetiana*), showing the scars (cicatrices) left by the fallen fronds. These scars exhibit the arrangement of the vascular bundles. The whole stem divides into two equal portions.

Fig. 974. Diagram to illustrate the circinate vernation of the fronds of Ferns. The entire fronds and the pinnæ are rolled up from apex to base like a crosier.

ing from the midrib are simple, at other times forked, the bifurcating branches running nearly parallel (Fig. 976). Sometimes the veins coming from the midrib give off in their turn secondary veins, either simple or forked (Fig. 977). In these bipinnate forms of venation, the secondary veins occasionally unite at their apices, so as to form a sort of intermediate vein more or less complete, and parallel to the

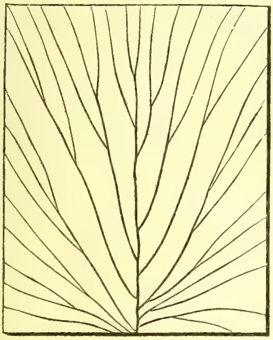


Fig. 975.

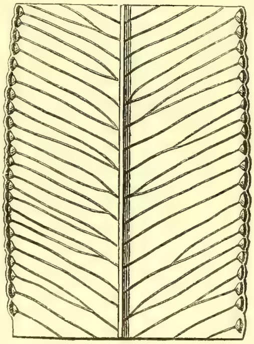


Fig. 976.

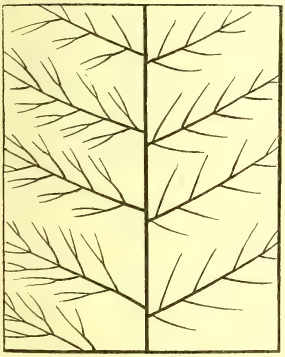


Fig. 977.

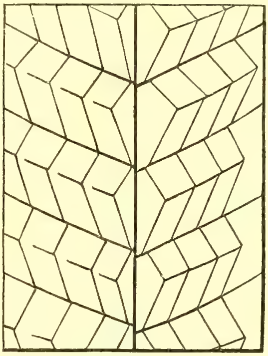


Fig. 978.

primary ones (Figs. 978 and 979). The secondary and tertiary veins sometimes anastomose, so as to form an angular net-work or reticulation (Fig. 980). The veins coming off from the midrib in Figure

Fig. 975. Venation of Ferns, in which the primary veins come off from the midrib, near its base, and the midrib itself becomes evanescent. The veins divide in a forked manner, and hence the venation is called furcate or bifurcate.

Fig. 976. Venation of Ferns, in which the primary veins come off from the midrib throughout. Some of the veins are simple, others are forked. They end in fructification in the margin of the frond.

Fig. 977. Venation of Ferns, in which the primary veins come off alternately from the midrib, and in their turn give off simple or forked secondary veins in an alternate manner.

Fig. 978. Venation of Ferns, in which the midrib gives off alternate primary veins, and these in their turn give rise to secondary veins, the extremities of which unite midway between the primary veins, so as to form an intermediate vein, either continuous or interrupted.

981 unite in a peculiar way, so as to form a sort of angular arch from various parts of which anastomosing veinlets proceed, giving rise to reticulated venation. In Figure 982, the primary veins give off secondary ones, some of which (at the base) are free and simple,

Fig. 979.

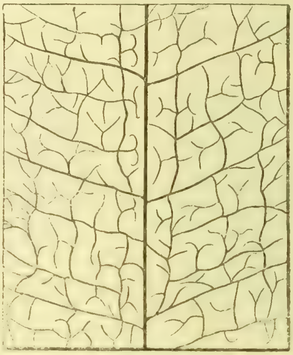


Fig. 980.

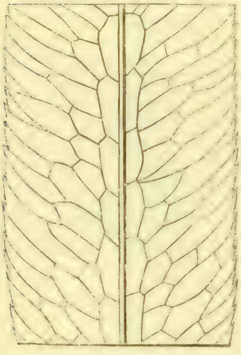


Fig. 981.

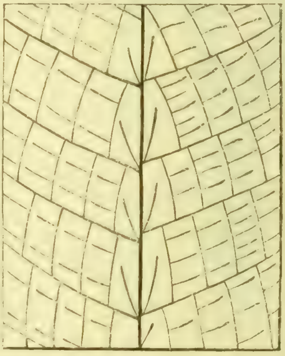


Fig. 982.

while others unite with the veins above and below, and form a sort of arch from which other interrupted veins parallel to the primary veins proceed.*

Fig. 979. Venation of Ferns, in which the midrib gives origin to alternate primary veins, which in their turn give off secondary veins. The secondary veins from contiguous primary veins unite in a common intermediate vein, which does not extend to the midrib.

Fig. 980. Venation of Ferns, in which the midrib gives off primary veins, which in their turn give origin to secondary veins, and then tertiary veins, so as to form a sort of net-work or reticulation.

Fig. 981. Venation of Ferns, in which the midrib gives rise to short primary veins, which divide into secondary veins, so as to form an anastomosis or net-work of vessels. The veins end in a serrated manner.

Fig. 982. Venation of Ferns, in which the midrib gives off alternate primary veins, which give origin to secondary veins, some of which at the base remain simple, while others subdivide and unite to form a kind of rectangular net-work.

* For further remarks on the venation of Ferns, see Smith on the arrangement and definition of the genera of Ferns, in Hooker's Journal of Botany, iv. 38.

433. The fructification in its fully developed state appears as *sporangia*,* situated on the veins on the back, or on the margins of the leaves (Fig. 948, p. 316, and Figs. 968 and 969, 2), containing spores. The spore-cases are arranged in clusters (sori) of a round (Fig. 983) or elongated form (Fig. 968, 2), and they are either naked or covered by a layer of the epidermis, which forms an involucre or *indusium* (Figs. 983 and 984). This indusium presents various forms, and is pushed off during growth in different ways, according to its mode of attachment to the leaf. In Figure 983, it is attached by the middle; in Figure 984, by the sinus or termination of the fissure. The clusters of sporangia are sometimes confluent, and form a continuous line bursting through the epidermis. The edges of the fronds are sometimes folded over the sori. It sometimes happens that the sporangia, in place of being in clusters on the back of the frond, as in the *dorsiferous* fructification, appear in the form of a simple or branched

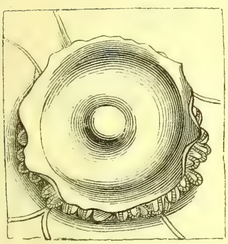


Fig. 983.

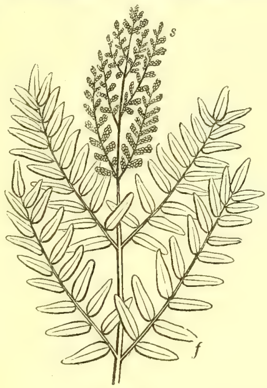


Fig. 985.

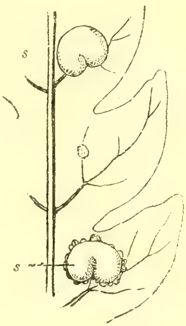


Fig. 984.

spike. In such cases the midrib and veins of the frond constitute the rachis and branches, and the spore-cases and spores are developed at the expense of the parenchyma of the leaf. Thus, in the Royal Fern (Fig. 985), the frond, *f*, is seen presenting the usual foliaceous or leaf-like appearance, and the fructification, *s*, is in the form of sessile or unstalked sporangia, arranged on a fructiferous branching rachis (Fig. 986), and opening by a vertical fissure at the apex. It sometimes

Fig. 983. Sorus or cluster of Sporangia of a Fern (*Aspidium trifoliatum*). The Sporangia are covered by an indusium or involucre, derived from the epidermis of the frond. The involucre is round (orbicular), and attached by its centre in an umbilical manner. The annulate sporangia are seen at the lower edge of the involucre.

Fig. 984. Portion of the frond of the male Shield-fern (*Lastrea Filix-mas*), showing two sori, *s s*, or clusters of sporangia covered with a reniform involucre or indusium attached by the sinus.

Fig. 985. Frond of the Royal Fern (*Osmunda regalis*), bearing divided pinnæ, *f*. The frond is bipinnate. At the extremity of the frond the pinnæ are altered so as to bear fructification, consisting of sporangia, arranged in a spike-like manner on a number of short axes. The pinnules, in place of bearing parenchyma, are changed into spore-bearing cells. The morphological changes are often easily traced in specimens in which the pinnæ are partly parenchymatous, and partly sporangiferous.

* The terms theca and capsule are used by many authors as synonymous with sporangium. Some restrict the term sporangium to the mother-cells in which the spores are developed.

happens that a pinna of Osmunda is partly parenchymatous and partly sporangiferous. A spiked arrangement of sporangia is seen in Moonwort and Adders-tongue. In Hymenophyllum and allied genera, the stalked sporangia are covered by a cup-like process or involucre formed by the frond.

434. The sporangia commence as cellular buds from the parenchyma. Some of the cells constitute the stalk when present (Figs. 987, *p*, and 950, p. 317), others form the sporangium, *s*, in the interior of which spores are formed. It frequently happens that the cells outside the sporangium form an *annulus* or ring (Fig. 987), which is either vertical, and attached by its base, as in Polypody, or horizontal and free, as in Hymenophyllum. The cells composing the ring have walls which vary in thickness on the inner and outer side, and by their unequal contraction finally rupture the delicate sporangium, so as to allow the spores to escape. The ring is very obscure and imperfect

Fig. 986.

Fig. 988.

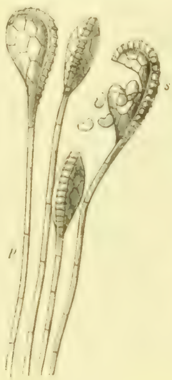


Fig. 987.

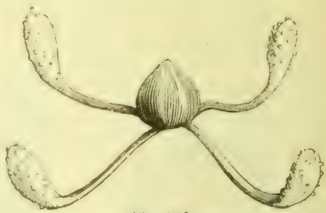


Fig. 991.

Fig. 989.

Fig. 990.

in some Ferns, as Osmunda, and it is awanting in Moonwort and Adders-tongue, and in many other Ferns. Hence, some Ferns are called *annulate* (having a ring), others *exannulate* (not having a ring).

Fig. 986. Cluster of sporangia of the Royal Fern (*Osmunda regalis*). The sub-globose sporangia are clustered on the margin of an altered pinna; they have an obscure ring or annulus, are striated, and open by two regular valves.

Fig. 987. Sporangia of a Fern (*Marginaria verrucosa*). They are supported on septate cellular stalks (pedicels), *p*, a continuation of which, in the form of an elastic cellular ring, surrounds the spore-case, *s*. The fern is called annulate, or ringed, on this account. The sporangium, *s*, opens on one side, so as to scatter the spores, and the elasticity of the ring aids in the rupture.

Fig. 988. Spore of a Fern (*Polypodium aureum*), having two cellular coverings, the outer of which is marked by dots, and a linear depression.

Fig. 989. Polygonal scale, *s*, of a species of Horse-tail (*Equisetum*), bearing membranous sacs, *t*, which open on their inner surface to discharge spores.

Fig. 990. Spore of a Horse-tail (*Equisetum*), surrounded by two filaments with club-shaped extremities. The filaments in this state are coiled round the spore.

Fig. 991. Spore of the Horse-tail, with the hygrometric filaments expanded, showing the two club-shaped extremities of each of them. This is their appearance when dry. When moistened or breathed upon they coil round the spore, as in Figure 990. They are interesting objects under the microscope, exhibiting movements according to their state of dryness or moisture.

435. The spores (Fig. 938, p. 313) are covered by a double membrane, and the outer layer is marked with points, as shown in Figures 939, p. 313, and Fig. 988. These spores germinate, and give rise to a peculiar parenchymatous expansion, called the *pro-thallus* or *pro-embryo* (Fig. 956, p. 319), on which peculiar reproductive cells have been discovered by Suminski. Some of these cells contain moving spiral filaments

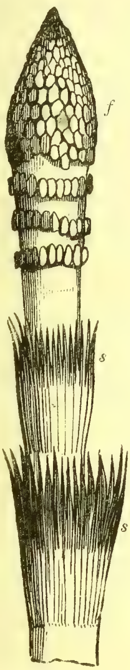


Fig. 992.

Fig. 993.

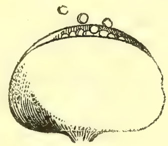


Fig. 995.

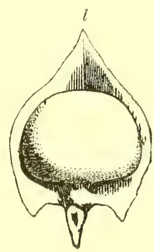


Fig. 994.

(phytozoa), and are looked upon as antheridia; others of a larger size and oval form contain a mother-cell or embryo-sac, which, after im-

Fig. 992. Fructification of a species of Horse-tail (*Equisetum Telmateia*). The stalk is surrounded by a series of membranous sheaths, *s s*, which are fringed by numerous sharp processes or teeth. The fructification, *f*, is at the extremity of the frond, in the form of a pyramidal mass of polygonal scales, bearing spores on their under surface. The fructification in some species is on the same branch with the leaves, while in others, as in the figure, it is on a separate branch.

Fig. 993. Fructification of a Club-moss (*Lycopodium clavatum*). The branch is covered with minute pointed leaves, *l*; from it proceeds a stalk bearing at its extremity two spikes, *f*, consisting of modified leaves, with fructification.

Fig. 994. Fructification of Club-moss (*Lycopodium*), situated in the axil of a leaf, *l*. It consists of a case containing minute cellular bodies, which are discharged in the form of powder.

Fig. 995. One of the cases separated from the axil of the Club-moss leaf, opening by two valves, and discharging the minute Lycopode powder.

pregnation, is supposed to produce the frond bearing sporangia. These stages of growth have already been noticed (¶ 425) as instances of alternation of generations. These views have been adopted by many able physiologists of the present day.*

436. *Horse-tails, or Equisetaceæ.*—The plants of this Cryptogamic order exhibit cells, vessels, epidermis, and stomata. The epidermis is siliceous and striated; the stomata have been shown in some of the species of Equisetum to consist of four cells, two of which are pectinate, presenting on their inner surface numerous projecting processes like the teeth of a comb. They occur in a longitudinal series, and are well seen in Equisetum hyemale, or Dutch Rushes, after the action of nitric acid. The plants have roots, rhizomes, or under-ground stems, and aerial branches, but no true leaves. The rhizomes sometimes extend to the depth of many feet. The stalks sent up from the rhizomes, are hollow and jointed, the articulations being separable, and surrounded by toothed sheaths (Fig. 992, *s*). In the outer cylindrical portion of the stalks there are longitudinal tubes or fistulæ, which alternate with furrows on the exterior. The primary branches arising from the rhizome are sometimes simple, at other times branched—the branches being often verticillate.

437. The fructification in its advanced state consists of spore-cases enclosing spores, attached to the under surface of shield-like hexagonal scales, and collected into a common pyramidal head (Fig. 992, *f*). In Figure 989 is shown one of the stalked scales bearing spore-cases, which split longitudinally on their inner surface. The scale, *s*, has some resemblance to the bracts in the Cypress cones, and it bears on its under surface a circular row of membranous sacs elongated like teeth, *t*. The sacs open towards the centre of the scale, or that part to which the stalk is attached. Within these sacs there are mother-cells which produce each a single spore. This spore is provided with two elastic spiral appendages, which at first completely cover the wall of the mother-cell and enclose the spore (Fig. 990), but finally spread out so as to burst the walls of the sac (Fig. 991). The elastic club-shaped (clavate) filaments remain attached to the spore, and display hygrometric properties, coiling up when moisture is applied,

* Some who consider the organs of reproduction as existing on the pro-thallus, look upon the cellular body as composed of a series of true spores, only one of which (the central one) comes to perfection. This cell or embryo-sac is not detached from the pro-thallus, but germinates while attached to it, and gives rise to the frond, bearing certain leafy organs called sporangia, with a number of ***buds*** (the so-called spores) free in their interior. These buds are, according to them, mere extensions of the plant, not produced by impregnation; and, when separated from the frond, they germinate and form a pro-thallus bearing the true reproductive organs. What are usually called spores are by these botanists considered as equivalent to the gonidia or green germs of Lichens. These views, however, have not been adopted generally. For further remarks on the structure of Ferns, see Thuret, sur les Anthéridies des Fougères, in Ann. des. Sc. Nat. 3d ser. Bot. xi. 5. Nees Von Esenbeck ueber die Entwickelung der Farrnkräuter, Isis, 1829. Henderson on the germination of Ferns, Mag. of Zoology and Botany, i. 333. Meyer, ueber die Bedeutung der Organe der Farrnkräuter, Isis, 1829. Link, einige Bemerkungen uber den innern Bau der holzigen Farrnkräuter, Linnæa, 1820. Mohl de structura Caudicis Filicum in Mart. Plant. Crypt. Brazil; besides the Treatises of Suminski, Mercklin, and Wigand already referred to.

and spreading out when dry. If put in the field of a microscope of low power and breathed upon, the movements of coiling and uncoiling are well seen. The spiral fibres or *elaters*, by their elasticity, seem to aid in scattering the spores, and in placing them in circumstances favourable for growth.

438. The spore, when sprouting, produces a pro-embryo or prothallus, which at first appears as a green lobed leaf supported on a stalk, which serves as a root. The lobes of the pro-embryo extend and subdivide until a number of cellular septate tubes are produced, containing green matter. In this pro-embryonic state the Horse-tails resemble Confervæ. It is in this state that bodies resembling the antheridia of Ferns have been detected, as well as peculiar cells, which have been regarded as equivalent to the archegonium or the so-called ovule of the higher Cryptogamics. This latter body gives origin to the aerial stem of the plant which bears the fructification. There would appear to be, in this instance also, an alternation of generations similar to what Suminski has observed in Ferns. The branches which are sent up by the Horse-tail are sometimes barren, producing verticillate leaves only, without any spore-cases or spores. Mohl has observed the development of the spore-case of Equisetum. It appears first as a homogeneous cellular body, in the centre of which are gradually produced greenish granules, surrounded by a special membrane. The green matter is divided into four parts, or mother-cells, each containing a single spore.*

439. *Club-mosses or Lycopodiaceæ.*—These plants have creeping stems or corms, which produce leafy branches, having some resemblance in general appearance to Mosses. Structurally they consist of cells and vessels, the latter occurring in the form of woody and annular vessels, which occupy the axis or central part of the stems. Roots are given off from the primary stem, as well as from different parts of the branches. The leaves are small and sessile, imbricated (Fig. 993, *l*), or verticillate, and on their epidermis stomata exist in small quantity. The plants are interesting, as being allied apparently to fossil plants, such as Lepidodendrons (Fig. 309, p. 132).

440. The fully developed fructification occurs in the axil of leaves (Fig. 994), which are often collected together in the form of a spike (Fig. 993, *f*). The fructification is of two kinds, one being kidney-shaped, two valved cases (Fig. 995), which originate in cellular mammillæ, and ultimately appear as sacs containing cells, with four spore-like bodies in each. These are discharged in the form of yellow dust, known as Lycopode powder, and used, from its inflammable nature, in place of sulphur. Some consider these organs as antheridia containing a matter resembling pollen. The powdery substance has not been seen to germinate. The other kind of fructification con-

* See Mirbel, sur les Equisetum, Bulletin de la Soc. Philomathique. Agardh, Germination des Equisetum, in Memoires du Museum. Vaucher, Monographie des Presles, in Mem. de la Soc. D'Hist. Nat. de Geneve. Milde on the germination of Equiseta, in Linnæa for October 1851.

sists of a roundish and somewhat four-sided body, called by Müller *oophoridium*, containing four large spores in its interior, and opening by two valves (Fig. 965, p. 320). These large spores, called *ovules* by some, germinate and reproduce the plant.

441. While the first mentioned organ (Fig. 995) is considered by some as an antheridium containing grains like those of pollen, the latter

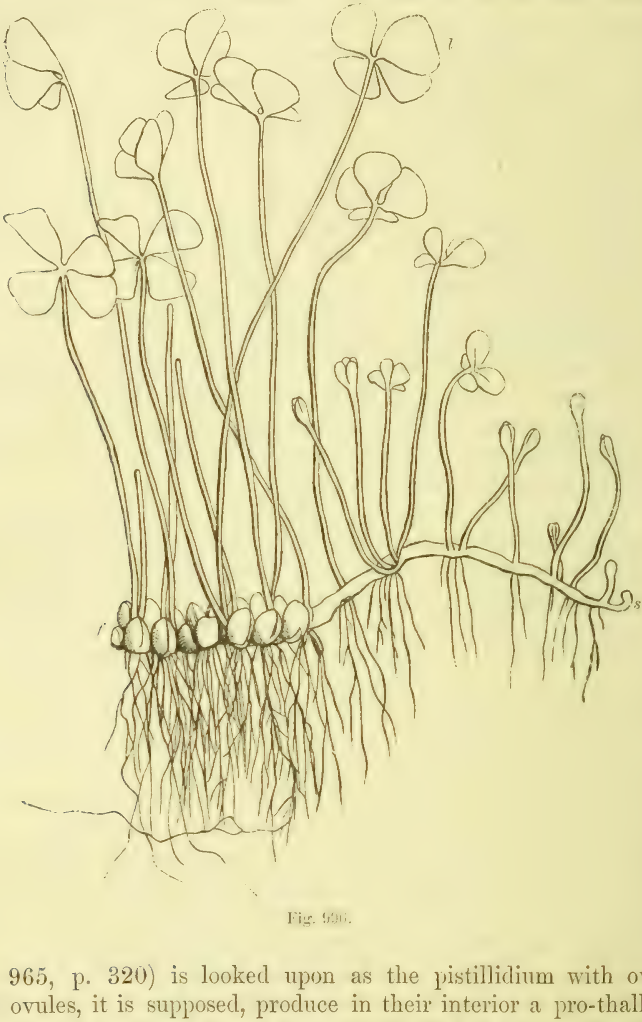


Fig. 996.

(Fig. 965, p. 320) is looked upon as the pistillidium with ovules. These ovules, it is supposed, produce in their interior a pro-thallus or pro-embryo of small size, from a large cell of which the proper fructifying

Fig. 996. Species of Pepperwort (*Marsilea Fabri*), with its creeping stem, *s*, bearing quadrifoliate stalked leaves, *l*, on one side, and roots on the other. The fructification, *f*, is at the base of the leaves, consisting of sporocarps, which open to allow of the escape of a peculiar receptacle seen in Figure 997.

stem is developed. In Quillwort, the two kinds of fructification are imbedded in the substance of the base of the leaf.*

442. *Pepperworts*, *Marsileaceæ*, or *Rhizocarpæ*.—These plants have creeping stems with leaves, which are divided into three or more cuneate portions, and have a circinate vernation. The leaves have stomata and veins. The stem increases by its extremity. It contains a central vascular bundle consisting of woody and scalariform vessels surrounded by parenchyma. One of the plants called Marsilea is represented in Figure 996, in which the rhizome bears roots on one side and long-stalked leaves on the other, the laminæ of the leaves, *l*, being divided into four parts. The fructification, *f*, is produced at the base of the leaf-stalks. It consists of *sporocarps* or ovoid sacs enclosing organs of reproduction.

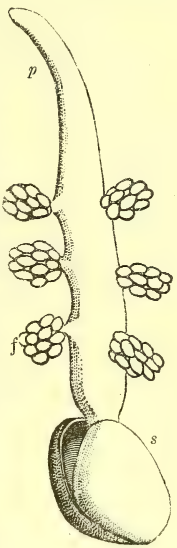


Fig. 997.

443. The sporocarp or, as some call it, involucre, is globular, and is borne on a jointed stalk; the terminal joint (receptacle of some) produces branching and anastomosing fibres which at first give the appearance of membranous partitions, and bear on their ultimate divisions horizontal spike-like masses, at first enveloped in a membrane, and composed of antheridia, and of sporangia or, as some call them, ovules. The latter are large and are placed at the upper part of a gelatinous kind of placenta, while the former are at the lower part. In each spore-case, there is a single spore which germinates by sending out roots and leaves at a little projecting point at the summit. The leaves, at first, are filiform, and then two and four lobed.†


Fig. 998.

444. In Figure 997 is represented the two-valved sporocarp, *s*, of Marsilea open, and giving out a cellular cord (called by some the midrib of the modified leaf forming the involucre), which at first was curved in a ring-like manner so as to unite the valves, and which finally is detached at one end, *p*, bearing the reproductive spike-like

Fig. 997. Fructification of a species of Pepperwort (*Marsilea Fabri*). The sporocarp, *s*, opens to give out a peculiar cellular cord or peduncle, *p*, which at first was curved in a ring-like manner. This cord bears spike-like fructification, *f*, consisting of antheridia and pistillidia enclosed in sacs, and attached to a common axis or placenta.

Fig. 998. Antheridium of a Pepperwort (*Marsilea Fabri*), an obovate sac, containing minute cells with phytozoa.

* For further remarks on the structure of the Club-mosses, see Müller's paper on the Development of Lycopodium in Botanische Zeitung for 1846, and in Annals of Natural History, xix. 27. Brongniart, Hist. des Vegetaux Fossiles. Delile, Examination de la Vegetation de l'Isoetes setacea. Mohl on Isoetes in Linnæa, xiv. 181.

† See Fabre and Dunal on Marsilea, in Ann. des Sciences Nat. 2 ser. vii. 227; ix. 115; xii. 255. Nägeli, sur la propagation des Rhizocarpées Ann. des Sc. Nat. 3 ser. ix. Valentin on Pilularia, Linnæan Transactions, xviii. 483. Savi, sulla Salvinia natans, 1820. Griffith on Salvinia and Azolla, Calcutta Journal, v.

masses, *f*, on its surface—these masses consisting of antheridia and pistillidia inclosed at first in sacs, and attached to mucilaginous placentas. In Figure 966, page 320, is shown the ovule or sporangium with a sort of projecting hood and a mammilla, whence roots and leaves proceed during sprouting; while in Figure 998 is seen the pyriform antheridium with the grains like pollen in its interior. Some call these grains *small spores* in contra-distinction to the large germinating spores.

445. In Pillwort, the reproductive bodies are in small rounded sacs at the base of the narrow leaves. These sacs are divided internally into four, and they dehisce by four valves. Certain gelatinous processes on the inner side of the walls of the sac bear two kinds of organs, one containing granular matter like pollen, and the other germinating bodies. These apparently are analagous to the antheridia and pistillidia of other Cryptogamics. The former are pyriform sacs containing pollen-like grains, the others are similar sacs containing cells arranged in fours, one of which is developed as the embryo-plant. In Salvinia, as shown in Figure 951, page 317, the antheridia and the ovules or pistillidia are in distinct involucres or sporocarps, supported on cellular columns.

2. Organs of Mosses and their Allies.

446. *Mosses* or *Musci.*—These plants have stems bearing minute cellular leaves. The stems consist of cells which in the periphery are polyhedral, while in the centre they are elongated. There is no pleurenchyma nor true vascular system. In many Mosses the stem terminates at a certain epoch, by bearing the organs of reproduction. Such stems are determinate, and the Mosses are called *acrocarpous* (fruit at the summit). In other cases the principal stem ends in a leaf-bud, and continues to elongate, the organs of reproduction appearing on lateral branches. Such stems are indeterminate, and the Mosses are called *pleurocarpous* (fruit at the side).

447. The leaves, when produced on the stem, are called *caulinary*; when they surround the reproductive organs they are called *perichætial* (around the seta). The latter are usually more approximated than the others, and form a sort of rosette, in the centre of which the reproductive organs are situated. The leaves are very thin in their texture, and are frequently composed of a single cellular layer. The cells usually contain chlorophylle, but sometimes, as in Sphagnum, they are colourless. The cells are either uniform in their size and appearance, or a certain number towards the centre are elongated, so as to form veins or ribs. The phyllotaxis of Mosses is usually $\frac{1}{2}$, $\frac{2}{5}$, or $\frac{3}{8}$. Buds, or what are called *innovations*, are often produced in the axil of the leaves. These buds, when detached, become new plants.

448. Occasionally the reproductive organs of Mosses have a peculiar leafy covering or *perigone*, formed by the adhesion of three or six small leaflets, which are quite distinct from the perichætial leaves.

The organs of reproduction are of two kinds: one, consisting of cylindrical, pear-shaped, or ellipsoidal stalked sacs, containing minute cells, with phytozoa or spermatozoids in their interior; the other being also stalked sacs, of a more or less spherical form, containing germinating

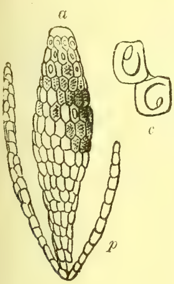


Fig. 1000.

Fig. 1001.

Fig. 999.

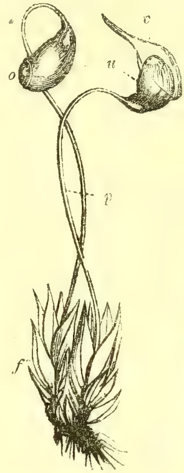


Fig. 1003.

Fig. 1002.

spores. The former constitute the antheridia, the latter the pistillidia or archegonia. These organs sometimes exist together on the same

Fig. 999. Antheridium-bearing plant of Hair-moss (*Polytrichum*). It consists of an axis bearing pointed leaves. At the apex of the axis, *a*, the leaves become altered in form and appearance, and cover cellular sacs with paraphyses. The former are antheridia, and are called the male organs. In this Moss the antheridia and pistillidia are on separate plants, hence it is called Diœcious.

Fig. 1000. The so-called male organs of the Hair-moss (*Polytrichum*). The antheridium, *a*, is a cellular bag containing minute quadrangular cells, *c*, each enclosing a spiral phytozoon or spermatozoid. Surrounding the perfect antheridium there are abortive filaments, *p*, called paraphyses.

Fig. 1001. Fructification of the Hair-moss (*Polytrichum*), consisting of an urn-like (urceolate) case or sporangium, *a*, supported on a stalk (seta), *s*, and covered by a calyptra, *c*, which has on its exterior silky hairs, and which splits irregularly at the base.

Fig. 1002. Fructification of the Extinguisher-moss (*Encalypta vulgaris*), consisting of an urceolate sporangium, *u*, supported on a seta, *s*, and covered by a transparent calyptra, *c*, under which is seen the lid or operculum, *o*. The calyptra is entire at the base, and is called mitriform.

Fig. 1003. Hygrometric Cord-Moss (*Funaria hygrometrica*), with its urn-like sporangia, *u*, supported on stalks, *p*, which arise from perichætial leaves, *f*. The sporangia are covered by a calyptra, *c*, which splits on one side. The operculum or lid, *o*, is seen in one of the sporangia from which the calyptra has fallen. The seta is twisted, and displays hygrometric properties.

plant; at other times they are on separate plants. In the former case the Mosses are monœcious, in the latter diœcious. When both these organs are not only on the same plant, but also surrounded by the same perigone, the term hermaphrodite has been applied by some.

449. The antheridia of Mosses are produced from little clusters of leaves, which differ from those of the stem (Fig. 999, *a*). They appear in the form of cellular, cylindrical, clavate bodies (Fig. 1000, *a*), containing at first a mucilaginous fluid, and finally very minute quadrilateral cellules, *c*, (sometimes called *zoothecæ*), in each of which a spiral phytozoon is seen. The antheridia dehisce by irregular openings at their apex, so as to discharge their contents (Fig. 1000, *a*). Along with the antheridia there are cellular jointed filaments (Fig. 1000, *p*) called *paraphyses*, which are considered to be an abortive state of these organs.

450. The archegonia, often mixed with paraphyses or abortive filaments, arise also from small clusters or rosettes of leaves (Fig. 1003, *f*), and appear in the form of spherical or obovate bodies having an outer envelope (epigone) and a central cellular nucleus. In the progress of growth, the central portion increases and rises upwards, and, at the same time, the epigone is ruptured near the base—one portion of it remaining below in the form of a small sheath (vaginula), the other being carried up on the fruit-bearing stalk in the form of a *calyptra* (Fig. 1001, *c*). This calyptra is sometimes split at one side (Fig. 1003, *c*) so as to become *dimidiate* (halved), and at other times it is either entire (Fig. 1002, *c*) or split equally all round the base, and it is then called *mitriform*. The nucleus or central portion, when fully developed, constitutes the *sporangium* or fructification. The sporangium is usually supported on a stalk or *seta* (Fig. 1003, *p*), formed by the lower cells of the nucleus. The seta is often twisted, and, from its hygrometric properties, it produces changes in the position of the sporangium, according to the state of dryness or moisture of the atmosphere. A species of Funaria or Cord-moss, receives the name of *hygrometrica*, on account of these properties. The seta varies in length: sometimes it is very short, as in Phascum; at other times long, as in Polytrichum (Fig. 947, p. 316).

451. The sporangium in its young state is a mass of cellular tissue, the cells of which are homogeneous, and contain green matter. When mature, it is an urn-like body (Fig. 1003 and 1004, *u*), with a cellular central axis called *columella*, and a cavity containing spores. In some instances the sporangium is indehiscent; in other cases it opens either by four lateral valves, as in the Split-moss (Andræa), or by means of a lid called an *operculum* (Figs. 1004, *o*, and 1005, *o*). The walls of the sporangium consist of three cellular layers, which may be looked upon as three urns contained within each other, the innermost, next the spores, being less deep than the others. The outer layer, prolonged upwards, forms the operculum or lid, which separates by transverse dehiscence. The two outer layers some-

times become much swollen at the base, where the sporangium joins the seta, and give rise to a cellular mass called an *apophysis*. Sometimes there is only a thickening at the union of the seta and urn (Fig. 1001, *a*); at other times there is a swelling at one side.

452. When the operculum is removed, the opening (stoma or mouth) of the sporangium is seen. This is sometimes entire, as in Mosses called naked-mouthed (gymnostomi); at other times it is surrounded by a *peristome*, formed by prolongations and divisions of the two inner parietal layers of the sporangium (Fig. 1006, *p*). The peristome consists of one or more rows of hygrometric cellular *teeth*,

Fig. 1004.

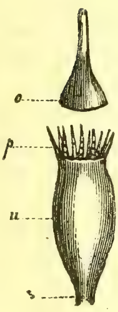


Fig. 1005.

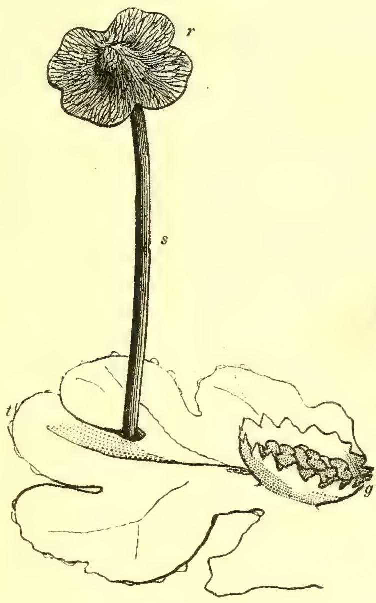


Fig. 1007.

Fig. 1006.

which are either four, or some multiple of that number. When there is one row of teeth, the Mosses are called *aploperistomi* (having a single peristome); when there are two rows, the Mosses are called *diploperistomi* (having a double peristome). The peristomatic processes

Fig. 1004. Sporangium, *u*, of Hair-moss (*Polytrichum*), deprived of its calyptra, and showing the operculum or lid, *o*, at the summit. The sporangium is supported on a seta, *s*.

Fig. 1005. Sporangium, *u*, of the Extinguisher-moss (*Encalypta*), with its seta, *s*, operculum or lid, *o*, which is removed so as to exhibit the peristome, *p*, with its sixteen processes or teeth.

Fig. 1006. Sporangium, *u*, of Hair-moss (*Polytrichum*), supported on its seta, *s*, and deprived of its calyptra and operculum. Surrounding the apex is the peristome, *p*, and closing the orifice is a membrane called the epiphragm, *e*.

Fig. 1007. A species of Liverwort (*Marchantia polymorpha*), with its green thallus, *t*, bearing a cup-like body, *g*, in which minute cells or free buds (sporules of some) are seen, and a stalked receptacle, *s r*. In the substance of the disk-like receptacle, *r*, cells are produced containing phytozoa These are considered antheridia.

(teeth) are sometimes twisted as in Tortula. In some Mosses the inner parietal layer appears as a membrane called *epiphragm* or *tympanum*, stretched across the mouth, from the walls of the sporangium to the columella (Fig. 1006, *e*). The lid is composed of a single cellular layer, and may be considered a continuation of the outer sporangial wall. It is generally, however, separated from the sporangium by two or three rows of cells, forming a ring or *annulus*. The inner lining of the sporangium encloses sporiferous mother-cells, the contents of which divide into four spores.

453. Some consider the sporangium as formed of a series of cellular leaves, arising from the top of the seta, and united together, the lid being formed by the laminæ, which are joined by an articulation to the petiole, in the same way as occurs in the Orange leaf. The teeth are regarded as instances of chorisis; while the calyptra is said to be a convolute leaf or bract, covering the spore-case in its young state. In some rare instances it is said that leaves are produced in place of spore-cases. Henfrey considers the pistillidia of Mosses as resembling the so-called ovules of Club-mosses and Rhizocarps—the pistillidia giving rise to sporangiferous individuals. There is thus a compound organism, in which a new individual, forming a second generation, developed after a process of fertilization, remains attached organically to its parent, from which it differs totally in all anatomical and physiological characters. It is an instance of alternation of generations. This, he says, is quite different from buds in Phanerogamia. It is not merely an extension by gemmation. The sporangia of Mosses are the result of a truly reproductive process, while the innovations are buds.

454. The spores of Mosses, when sprouting, give out filaments which ramify and anastomose. These filaments, being composed of cells placed end to end, and being filled with green matter, resemble Confervæ. After fifteen or twenty days, there are seen at numerous points, where the filaments cross, small leaves disposed regularly round a very short axis. In this process Mosses resemble fungi. In both the spores give origin to filaments, and from these filaments the characteristic organs of the plant arise. In the latter, however, the filamentous cells, called the mycelium, never contain green matter; while the filaments of Mosses always do. The mycelium of Fungi performs almost entirely the function of nutrition, and often remains during the life of the plant; while the filaments of Mosses perform only temporary functions, and are replaced by proper leaves, stems, and roots, which give origin to the reproductive organs.

455. *Liverworts or Hepaticæ.*—In these plants, the vegetative system (organs of nutrition) consists either of a simple membranous expansion, composed of united cells, containing green matter, or of an axis bearing cellular leaves. In Marchantia, this membranous expansion or *thallus* (Fig. 1007, *t*) is composed of several layers of cells. The upper and lower layers consist of colourless cells, and form a sort

of epidermis. The upper epidermal layer has stomata, while the lower gives off root-like filaments. The central layer of cells contains green matter, and between the cellules there are spaces which communicate with the stomata on the upper surface. Those Liverworts which have a thallus such as Marchantia, are called *membranous;* while those having stems and leaves, such as the Scale-mosses (Jungermanniæ), are *caulescent.* In the latter the leaves present various forms, such as oval, entire, bidentate, bifid, two-lobed, quadripartite, and laciniated.

456. The thallus of Marchantia differs from the foliaceous expansion of Lichens, in its mode of production. In the latter, the spore, when sprouting, gives out filaments like the mycelium of Fungi, whence the foliaceous receptacle is produced; while in the former the spore is at once developed as a cellular mass, of a more or less irregular form, in the same way as occurs in Sea-weeds. The thallus of Marchantia, besides producing organs of reproduction, bears cup-like bodies with toothed edges, containing little germs or bulbils (the sporules of some authors), which are not traced to a reproductive process, and differ from buds, in being contained in peculiar organisms. These *sporules*, *bulbils*, or *germs*, propagate the plant. They are seen in Fig. 1007, *g*, on the surface of the thallus. Besides these, there are innovations, or true buds, which are produced from the edges of the principal thallus in membranous Liverworts, and from the axil of the leaves in the caulescent Liverworts. These buds, when detached, give origin to new individuals.

457. In Hepaticæ, the reproductive organs consist of *zoothecæ* or *antheridia*, and *archegonia* or *pistillidia*, either on the same or on different plants. The antheridia are small cellular sacs of a globular, ovoid, or flask-like form. They have a single or double cellular covering, enclosing viscid matter, in which are developed four-sided cells, in each of which is a small filiform body, rolled up in a circular manner, and displaying rapid movements. These bodies, called *phytozoa*, are finally liberated, and unrol themselves, appearing as filaments swollen at one extremity, and gradually tapering to the other. In Marchantia (Fig. 1007), these antheridia occur in the upper side of an elevated disk or receptacle, *r*. When this disk is cut vertically, as shown in Figure 1008, they are seen at *a a*, as flask-like cellular sacs, separated by air cavities, *c c*, which communicate with stomata, *s s*. A magnified antheridium discharging its phytozoary cells, is given in Figure 1009. In some Hepaticæ these antheridia occur in the substance of the thallus, while in others (as in some Jungermanniæ) they appear in the axil of the leaves.

458. The archegonia or pistillidia of Hepaticæ are either situated in the substance of the thallus, as in Riccia, or they are raised upon stalks, as in Marchantia (Fig. 1010) and Jungermanniæ. In Marchantia these stalks bear radiated receptacles, *r*, on the under surface of which the sporangia are placed. These sporangia have a membranous

covering called *epigone* or *calyptra*, the upper end of which elongates like the neck of a bottle (Fig. 1011, *a*), so that the pistillidium resembles a pistil, with its ovary, style, and stigma. When the sporangium is raised on its stalk, the calyptra is ruptured irregularly; its

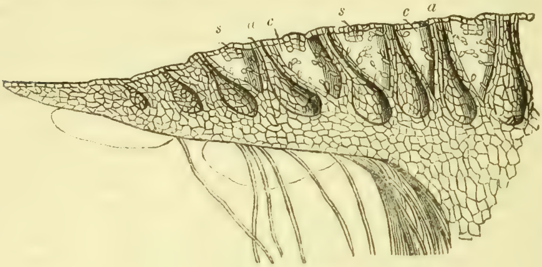


Fig. 1008.

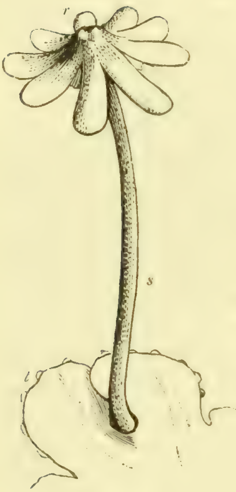


Fig. 1010.

Fig. 1009.

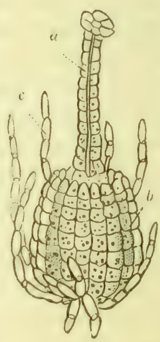


Fig. 1011.

Fig. 1012.

lower portion remaining in the form of a sheath round the base of the stalk. The pistillidium, thus formed by the central cellular spore-

Fig. 1008. Vertical section of the disk-like receptacle of Liverwort (*Marchantia*), showing the antheridia, *a a*, in its substance. These antheridia are flask-shaped sacs containing phytozoary cells. They communicate with the upper surface, and their contents are discharged through it. Between the antheridia there are air cavities, *c c*, connected with stomata, *s s*.

Fig. 1009. Antheridium of Liverwort (*Marchantia*) ruptured, and discharging its cellular contents.

Fig. 1010. A species of Liverwort (*Marchantia polymorpha*), with its thallus, *t*, bearing a stalked receptacle, *s r*. The receptacle, *r*, is divided into numerous segments, on the under side of which are sporangia containing spores and elaters.

Fig. 1011. Pistillidium of Liverwort (*Marchantia*). It is a cellular body surrounded by an involucre (perigone or calyx), *b*, and septate filaments (paraphyses), *c*, and it is provided with a styloid calyptra, *a*.

Fig. 1012. Spiral threads or elaters, *e*, of Liverwort (*Marchantia*), originally contained in the sporangia, and serving, by their elasticity, to scatter the sporidia, *s s*.

bearing sac and the epigone, is surrounded also by a cellular sac called the *perigone* (Fig. 1011, *b*), which begins in the form of a ring at the base, and ultimately forms a cup-like covering. Occasionally there are certain cellular filaments, or perichætial leaves, surrounding the perigone (Fig. 1011, *c*). In Marchantia the perigone encloses a single pistillidium; in Jungermannia it encloses several, but only one is developed.

459. The structure of the sporangium, or the sac containing the mother-cells of the spores, varies in different genera. In Anthoceros, the sporangia are elongated and open by two valves, and there is a central cellular columella. In Jungermannia, the sporangia are globular, and open by four spreading valves. There is no central column, but the inner wall displays cellules, called elaters, fixed by one extremity, and containing one or two spiral fibres which by their elasticity scatter the spores. In Riccia, the sporangia are globular, and there are neither elaters nor columella. In Marchantia, the sporangia consist at first of a mass of cellular tissue containing green matter. There are two sets of cells, one internal, being the spore-cells, and the other external. The latter display polyhedral and rounded cells along with slender fusiform tubes, the walls of which are marked by two spiral striæ, which ultimately appear as two cork-screw like threads (Fig. 1012). These threads or *elaters* are very hygrometric, and serve to scatter the spores. In the Hepaticæ, in general, the spores are developed in spheroidal mother-cells, the contents of which divide into four parts, each of which is a germinating spore. The spores become free by the destruction of the walls of the mother-cells.*

3. Organs of Lichens and their Allies.

460. *Lichens or Lichenes* are cellular plants growing on stones, on the surface of the earth, and on trees, and taking up nourishment by all points of their surface. They belong to the Thallogenous division of Cryptogamics, in which no vascular tissue is seen. Their vegetative system varies much in its form and appearance. Sometimes it appears as fine pulverulent matter in the form of a leprous or mealy crust; sometimes it is a foliaceous expansion, as in Parmelia (Fig. 1013) and in Iceland Moss (Fig. 1014); sometimes it is in the form of filaments, as in Archil (Fig. 1015), of horn-like processes, or of branching stalks, as in the Rein-deer Moss (Fig. 1016); and sometimes it is a gelatinous mass.

* For further particulars relative to the structure and development of the members of the Muscal alliance, consult Hedwig, Theoria Generationis et Fructificationis Plantarum Cryptogamicarum, and Fundamentum Historiæ Naturalis Muscorum Frondosorum. Cassebeer, ueber die Entwickelung der Laubmoose. Beninga de Evolutione Sporidiorum in Capsulis Muscorum. Bruch and Schimper, Bryologia Europæa. Lindenberg, Species Hepaticarum. Gottsche, Synopsis Hepaticarum. Mohl, sur le Developpement des Spores de l'Anthoceros Lævis, Ann. des Sc. Nat. 2d ser. xiii. 208. Valentine on Mosses, Linnæan Transactions, xvii. 465. Montagne, des Organes Males du Genre Targionia, Ann. des Sciences Nat. 2d ser. ix. 100. Hooker's British Jungermanniæ. Mirbel, Recherches Anatomiques et Physiologiques sur le Marchantia Polymorpha, in Nouv. Ann. du Museum, i. 93.

461. The vegetative system is sometimes called the *common receptacle*, at other times it is called *thallus*. The latter term is by some authors restricted to the vegetative system of Liverworts and Seaweeds—the foliaceous expansion of Lichens being considered by them as produced from anastomosing filaments, forming a sort of mycelium or spawn, which, after serving a temporary purpose, disappears. The vegetative system of Lichens consists of two kinds of cells, cylindrical and spherical. When the common receptacle (thallus) spreads on the surface of bodies, the cylindrical cells are on the lower surface, and the spherical on the upper. When the common receptacle is vertical, the spherical form the external portion, and the cylindrical the central.

462. There are two layers of tissue usually distinguished in Lichens, one called *cortical*, in which the cells are more or less rounded, the other medullary, in which there are both round and filiform cells. The spherical cells of the medullary layer (Fig. 1020, *g*) are generally filled with green matter, and, in certain circumstances,

Fig. 1013.

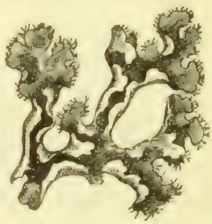


Fig. 1014.

Fig. 1015.

they become detached and form separate individuals. These green cells have received the name of *gonidia*. When they are being detached, the separation begins at the centre, so that the middle of the Lichen becomes pulverulent, while its circumference may remain foliaceous or crustaceous. By the continuation of this process it sometimes happens that the whole Lichen becomes a mass of greenish or yellowish powder. The gonidial cells seem to be the active vegetating part of the Lichens, and give rise to the other tissues. They may be considered as germs not produced by a process of impregnation.

463. The reproductive organs of Lichens consist of *thecæ* (sporangia of some), often accompanied with paraphyses. While these represent the archegonia or pistillidia, there is no good evidence of

Fig. 1013. A Lichen (*Parmelia*), with its cellular expansion (thallus), and its rounded apothecia, or spots of fructification.

Fig. 1014. Iceland Moss (*Cetraria islandica*), a species of Lichen, consisting of a foliaceous cellular expansion bearing the fructification.

Fig. 1015. Archil (*Roccella*), a species of Lichen used to furnish Litmus. It consists of thread-like cellular expansions, bearing fructification.

the existence of true antheridia. Itzigsohn has recently indicated the presence of antheridia containing spermatozoids, but his observations have not been confirmed by Tulasne and others.* The thecæ contain four, eight, twelve, or sixteen sporidia (Fig. 1017), which are cells with spores in their interior. The sporidium in its early state consists of two nucleated cells (Fig. 1018), which in the progress of growth become changed (probably by a process of conjugation), so that ultimately the mature sporidium contains numerous minute spores. In Figure 1017, *t*, there is represented a theca or *ascus*, as it is often called, with four sporidia in its interior, and surrounded by paraphyses or abortive filaments, *p*.

464. The thecæ and paraphyses are usually united together, so as to form a mass of fructification of a circular, cup-like, globular, or linear form. The fructification, when circular, is called *apothecium* and *patella* (Figs. 1019 and 1020, *a*), when linear, *lirella.* Sometimes

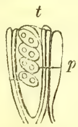


Fig. 1017.

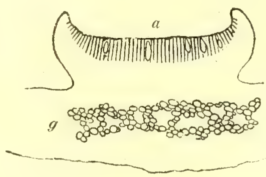


Fig. 1016. Fig. 1018. Fig. 1019. Fig. 1020.

the fructification is covered by a cortical layer of cells (perithecium), varying in colour, black, red, or pale, which ultimately gives way, either by a pore or by irregular dehiscence. This is seen in what are called *Angiocarpous* Lichens. In them there is a nucleus in the centre of the fructification, which consists of hyaline tubes or asci, each of

Fig. 1016. Rein-deer Moss (*Cladonia rangiferina*), a species of Lichen on which the rein-deer feeds. It consists of branching cellular filaments bearing the fructification. The Lichen has a coral-like aspect.

Fig. 1017. A theca, *t*, of a Lichen, containing four nucleated cells. These cells ultimately form the sporidia or sacs containing numerous minute spores. Round the theca are cellular filaments or paraphyses, *p*.

Fig. 1018. A cell taken from the theca or ascus of a Lichen. It contains two smaller cells in its interior, which some botanists consider as conjugating cells. The large cell ultimately constitutes the sporidium filled with minute spores. Some have called the sporidium in this condition a bispore or bilocular spore.

Fig. 1019. Portion of the cellular expansion (thallus) of a Lichen, bearing a rounded mass of fructification *a*, called apothecium.

Fig. 1020. Vertical section of an apothecium and thallus of a Lichen. Rounded free cells, *g*, of a green colour, and called gonidia, are seen in the centre of the thallus. These gonidia, which are called free buds by some, are capable of germinating and reproducing the plant. They constitute the active part of the Lichen, and are surrounded on each side by integumentary layers. Sometimes they burst through the surface of the thallus. The apothecium, *a*, consists of thecæ and paraphyses. Its upper surface is often coloured and covered by a perithecium.

* Comptes Rendus, March 24, 1851.

which contains eight *sporidia.* When mature, the sporidia and asci are ruptured, so as to discharge numerous minute spores through the pore or perforation at the apex of the perithecium. When the fructification bursts through the cortical layers, and appears externally, it is either completely distinct from the cortical layer, or a portion of the latter remains in the form of an elevated border. Sometimes the superficial cellular layer produces a stalk called *podetium*, on which the fructification is supported. The extremities of the paraphyses are often swollen and coloured, so as to give rise to the peculiar colour of the apothecia.*

4. Organs of Fungi and their Allies.

465. *Fungi* are cellular plants having neither leaves, nor stems, nor roots. The organs of nutrition or vegetation consist of whitish anastomosing filaments called *mycelium* or spawn (Fig. 1021, *m*), which spread like a network through the substances on which the Fungi grow. From this network proceed bodies resembling globes, circular disks, mitres, cups, and coralline branches, which bear the organs of reproduction. The mycelium is developed either under ground, or in the interior of the substance on which the plant grows. The filaments of the mycelium are composed of elongated colourless cells. This peculiar condition of Fungi has sometimes been mistaken for their perfect state, and hence the spawn has been described in some cases as a separate genus. It is necessary to watch the various phases of development in this order of plants in order to give a correct view of their organization and their characters.

466. The organs of reproduction are produced at different points of the mycelium, sometimes solitary, sometimes several together. They at first appear as small tubercles composed of very minute hexagonal cells. These tubercles increase and present different phenomena according to the nature of the plant to which they belong. Thus in Ægerita, the tubercle, after attaining its full development, is covered with filaments, each bearing a spore at its extremity; in Peziza, it is hollowed out into the form of a cup more or less deep, the interior of which is lined with thecæ or asci; in Agaricus, it produces a pileus or cap-like body borne on a long stalk which comes from the interior of the tubercle, and bears the fructification externally; in Lycoperdon it forms in its tissue numerous lacunæ, from the circumference of each of which are produced elongated cells bearing four spores on their surface.

467. The mycelium requires a certain amount of moisture and heat for the development of the reproductive tissue. Sometimes it remains

* For further particulars as to Lichens, consult Meyer, ueber die Entwickelung der Flechten. Fries, Lichenographia Europæa. Fée. Methode Lichenographique, and Essai sur les Cryptogames des Ecorces officinales. Eschweiler, systema Lichenum. Leighton, on the British species of Angiocarpous Lichens, printed by the Ray Society 1851.

long in a dormant state, with tubercles on its surface, and in this condition it presents some of those forms described as Sclerotium by botanists. The tubercles remain under ground, or under the epidermis of leaves, or the bark of trees, and in these situations they undergo certain changes. Under favourable circumstances the changes are very rapid, and the tissue bearing the reproductive organs springs up with amazing rapidity. This is well seen in the case of Mushrooms, Puff-balls, and Phallus. The mycelium itself spreads with great rapidity, as is familiarly seen in Mushroom spawn. It may be kept long

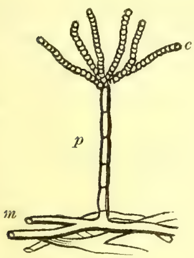


Fig. 1021.

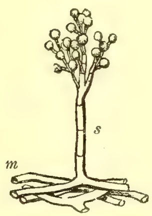


Fig. 1025.

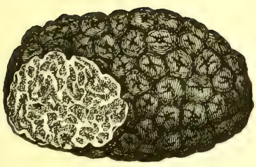
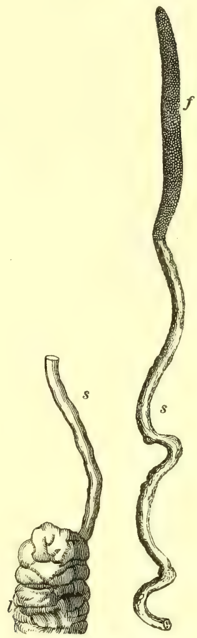


Fig. 1022.



Figs. 1023, 1024.

in a dry state, ready to develope the reproductive apparatus whenever heat and moisture are applied.

468. Some Fungi vegetate under the surface of the ground, and either produce their fructification there, as the Truffle (Fig. 1022), or above ground, as the Mushroom (Fig. 1031). A very large number,

Fig. 1021. A species of Mould (*Penicillium*), consisting of a mycelium or spawn, *m*, whence arises a fructiferous stalk, *p*, bearing several rows of cells, *c*, united in a bead-like (moniliform) manner. These minute cells are the germinating spores.

Fig. 1022. The Truffle (*Tuber cibarium*), a subterranean Fungus, with a black tuberculated or warty external covering, and a white cellular interior containing sporiferous cells.

Figs. 1023 and 1024. Specimen of a New Zealand Fungus (*Sphæria Robertsii*), growing from the head of a caterpillar (the larva of Hepialus virescens), *l*. The stalk, *s s*, bearing the fructification, *f*, in a spike-like form at its extremity. The growth of the Fungus destroys the caterpillar.

Fig. 1025. A species of Mould-fungus (*Botrytis*), consisting of a mycelium, *m*, bearing a septate cellular stalk, *s*, which branches at the apex, each division bearing a rounded spore.

however, are developed as parasites in the interior of living or dead organised bodies. Many of them give rise to diseases in plants. Some Fungi are produced in animal tissues, more especially in certain diseased conditions of the epidermal system or of the mucous membranes. Their presence in such cases seems to cause an alteration in the phenomena of disease. In Figures 1023 and 1024 is shown a species of Sphæria growing on the larva of a New Zealand insect called Hepialus virescens. Such fungoid growths often cause the destruction of the insect on which they grow, and, in the case of the silk-worm, they give rise to serious loss.

469. The organs of reproduction of Fungi are spores which are either naked or are contained in thecæ or asci, and which are mixed with certain filaments called antheridia. Little is known in regard to the latter. When spores are produced in the interior of distinct sacs, called *thecæ* or *cystidia* (Fig. 945, *cys*, p. 314), they are denominated

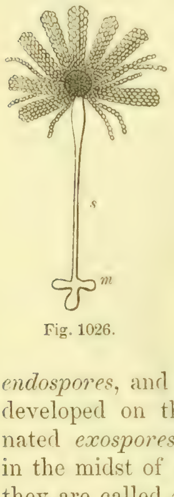


Fig. 1026.

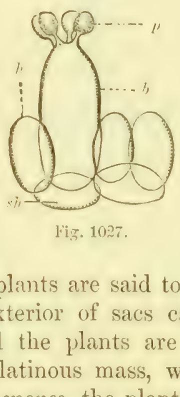


Fig. 1027.

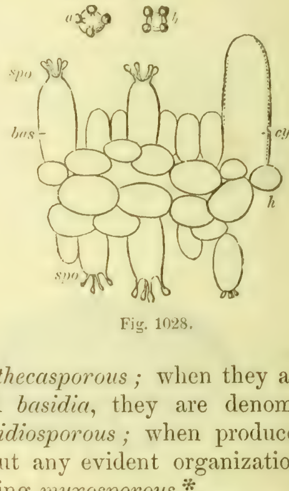


Fig. 1028.

endospores, and the plants are said to be *thecasporous;* when they are developed on the exterior of sacs called *basidia*, they are denominated *exospores*, and the plants are *basidiosporous;* when produced in the midst of a gelatinous mass, without any evident organization, they are called *myxospores*, the plants being *myxosporous.**

470. In Basidiosporous or Exosporous Fungi, there are different modes of spore-development. In the filamentous Fungi (Hyphomy-

Fig. 1026. Blue mould, a species of Fungus (*Aspergillus glaucus*), having a mycelium, *m*, whence arises a stalk, *s*, bearing numerous rows of sporiferous cells developed from a common centre, which is the swollen extremity of the stalk or floccus.

Fig. 1027. Part of the fructification of the Mushroom (*Agaricus campestris*). The cellular stratum, bearing the fructification or hymenium is marked *h*, and below it is the sub-hymenial layer, *sh*. A basidium or basidial cell, *b*, bears at its apex four spores, *sp*, which are supported on stalks or sterigmata. The Fungus is basidiosporous, and it has a naked hymenium.

Fig. 1028. Portion of a lamella or gill of the Mushroom (*Agaricus campestris*), cut transversely showing the two lateral surfaces bearing basidia, *bas*, with four spores, *spo*, at their apices, and cystidia, *cys*, or sacs containing minute cells. The hymenium is marked *h*. At *a* and *b* are represented the four spores.

* Berkeley thinks that in certain Fungi the asci are converted into spores. See Reports of Brit. Assoc. for 1851.

cetes), the terminal cell of a filament sometimes is transformed into a spore, as in Botrytis (Fig. 1025); at other times several of the terminating cells are transformed so as to produce a series of spores like a row of beads, as in Torula and Penicillium (Figs. 1021 and 1026). In the Agarics and Puff-balls, four small prominences appear on the basidium, which elongate and finally become four stalked spores (sporophores), as seen in Figures 1027, *sp*, and 1028, *spo*. In Thecasporous Fungi, the sac or cystidium is either a globular body containing a great number of spores (Fig. 1029, *s*) disposed without order, as in some of the Mucors (Ascophora mucedo); or it is of an ovoid or clavate form, containing four, six, or eight spores or sporidia placed one above the other, as in Peziza (Fig. 1030). This class of Fungi is included among the Lichens by Schleiden, who considers all true Fungi as having free naked spores, *i.e.*, as being basidiosporous.

471. The fructification is composed either of a single transparent

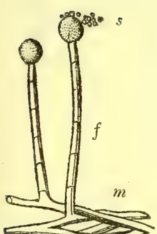


Fig. 1029.

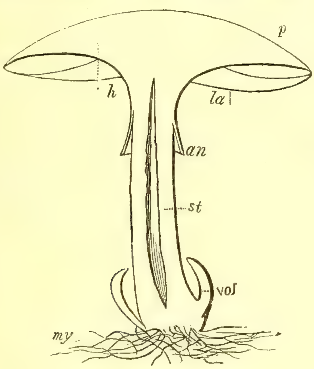


Fig. 1031.

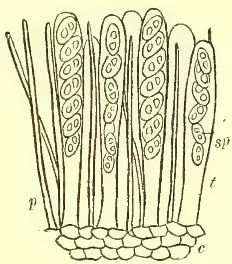


Fig. 1030.

colourless cell, of a rounded or spindle-like form, at the end of each filament (Fig. 1025); or it is composed of several cells united in a linear series (Figs. 1021 and 1026) or irregularly. The cystidia and basidia are either monosporous or tetrasporous (Figs. 1027 and 1028).*

Fig. 1029. A species of Mould (*Mucor*), showing the mycelium, *m*, bearing a fructiferous stalk, *f*, ending in a sac or cystidium, *s*, which encloses numerous very minute spores. The spores are discharged by the bursting of the sac.

Fig. 1030. Vertical section of the fructification of a Fungus (*Peziza*), showing the cellular stratum, *c*, bearing clavate spore-cases or thecæ, *t*, which contain nucleated cells, *sp*. These cells ultimately become sporidia, containing spores. Along with the thecæ are cellular filaments or paraphyses, *p*.

Fig. 1031. Vertical section of a Mushroom (*Agaricus campestris*); *my*, mycelium or spawn; *vol*, remains of volva or wrapper, which covers the fructification in the young state; *st*, stipe or stalk, which is hollow internally; *an*, annulus or ring, being the remains of the velum, veil, or cortina, which extended from the edge of the pileus to the stipe; *la*, lamellæ or gills of the hymenium, *h*; *p*, the pileus.

* The spores of Fungi are very minute. In the case of Moulds, millions of them are required to make a body the size of a pin-head. They float about in the air, and, owing to their minuteness, cannot be detected.

When either of these kinds of fructification are united into a mass along with paraphyses, they form what is called the *hymenium* (Fig. 1030). The hymenium is either naked, as in the Hymenomycetous Fungi, or it is enclosed in a membrane called *peridium*, as in Gasteromycetous Fungi. This membranous covering may be either single or double.

472. The hymenium bearing the organs of reproduction sometimes consists of vertical plates or laminæ radiating from a centre, as in the Agarics, or of tubes, as in Polyporus, or of solid columns, as in Hydnum. Sometimes it is covered by a membranous expansion called an *indusium*, which gives way in the progress of growth. Sometimes it is placed on the lower surface of a disk-like body called the *pileus* or cap, as in the Mushroom; at other times it is on the upper surface of the pileus, as in Helvella.

473. In the Mushroom (Fig. 1031) and other species of Agaricus, the following are the usual organs observed :—A mycelium or spawn, *my*, developed under ground, bearing tubercles which consist of the reproductive organs enclosed in a *volva* or wrapper. This volva, *vol*, is ruptured in the progress of development. The Agaric is then seen to be composed of a pileus, *p*, supported on a stalk, *st*, called a *stipe*. On the lower side of the pileus is the lamellar hymenium or gills, *la*, bearing spores. The hymenium was first covered by the veil or indusium, which finally gives way, leaving only a ring, *an*, round the stalk.*

5. Organs of Algæ and their Allies.

474. *Algæ* include a great number of plants which grow in the sea, in rivers, lakes, marshes, and hot springs. Their structure is such that they can only grow in water; when exposed to the air they wither and cease to grow. They have no true leaves and no proper stem, but consist of a thallus or cellular expansion which varies in colour—being brown, red, green, or yellow. In some of the larger Sea-weeds, as Durvillea utilis and Lessonia fuscescens, the thallus is supported on a thick stalk, which exhibits in its structure the appearance of concentric circles. These stalks, however, are composed entirely of cellular tissue arranged in a peculiar manner. There is no vascular system and no woody fibre in their composition. Some species have root-like processes by which they are attached to rocks. These are only intended for fixing them to a spot so as to allow the fronds to be properly exposed to the water, and they do not appear to act as special nutritive organs. The structure of Algæ is cellular, and

* For further details relative to Fungi, consult Berkeley on the Fructification of Fungi, Ann. Nat. Hist. i. 81, and Ann. des Sc. Nat. 2d ser. Bot. xii. 160. Montagne, Esquisse Organographique et Physiologique des Champignons. Leveillé, sur l'Hymenium des Champignons, Ann. des Sc. Nat. 2d ser. Bot. viii. 321; and Recherches sur les Uredinées, Ann. des. Sc. Nat. 2d ser. Bot. xi. 5. Tulasne, Fungi Hypogæi; also various papers by him in Ann. des Sc. Nat. 2d ser. Bot. xvi. 5, xvii. 5, xviii. 129, xix. 373, and 3d ser. Bot. i. 41, vii. 12. Dutrochet, sur les Champignons, in Ann. des Sc. Nat. 2d ser. Bot. i. 50, and Nouv. Ann. du Museum, iii. 76.

the cells vary much in form. Some of the cells are round or elliptical, others square, others elongated. The absorption of nourishment takes place throughout the whole substance of the thallus. On the surface of some Algæ, as the Charas, carbonate of lime is deposited, and sometimes, as in Corallines, the whole texture is so permeated by this substance, as to become of a hard and stony consistence.

475. In Algæ the reproductive organs vary in their appearance. They consist of spore-cases, which are often aggregated together in *conceptacles* (Fig. 1032, *p*), along with *antheridia* containing spermatozoids (Figs. 1033 and 1034). The spores are often united in fours in a mother-cell, forming a *tetraspore* (Fig. 1035, *t*). There are also present in many Algæ *zoospores* or *sporozoids*, which exhibit movements during a certain period of their existence, and are provided with filamentous vibratile processes (Fig. 1036). These moving spores have been particularly examined in Vaucheria ovoidea (Fig. 1037). This plant consists of an elongated cell, full of green matter, the extremity of which swells at a certain epoch, and exhibits a dark green mass, distinct from the rest of the green matter, and finally separated from it by a

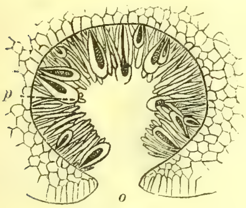


Fig. 1032.

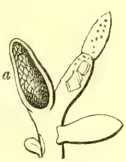


Fig. 1033.


Fig. 1034.

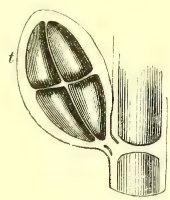


Fig. 1035.

partition. The dark green mass is covered with a membrane or epispore, and then forms a spore of an oval form. This spore finally escapes from the end of the elongated cellular filament; and then it moves about in the fluid, by means of vibratile *cilia*, as they are called. The motions continue for some hours, until the spore fixes itself, and begins to sprout. These zoospores occur also in other genera of Algæ. The number of cilia varies, being numerous in Vaucheria, four in Chætophora elegans, and two in Conferva glomerata (Fig. 1038, 1, 2, 3). The antheridia are simple or double sacs, borne on tubes or filaments (Fig. 1033, *a*), which line superficial cavities or conceptacles, either along with sporiferous sacs, or alone. The same sac contains a number of phytozoa, having an ovoid or bottle-like shape, with two cilia, one

Fig. 1032. Transverse section of a conceptacle of a Sea-weed (*Fucus vesiculosus*), showing the spores in their coverings, *p*, and paraphyses lining the cavity. The spores escape by an orifice, *o*.

Fig. 1033. Antheridium, *a*, or Zootheca of a Sea-weed (*Fucus serratus*), containing phytozoa. With the antheridium paraphyses are united in the same conceptacle.

Fig. 1034. Antheridium of a Sea-weed (*Fucus serratus*), still containing two phytozoa in the sac. To the broad part of the phytozoa two vibratile cilia are attached.

Fig. 1035. Tetraspore, *t*, of one of the rose-coloured Sea-weeds (*Callithamnion cruciatum*). It is a sac formed by the metamorphosis of the lowermost pinnule of the frond, and contains four germinating spores.

anterior and the other posterior (Fig. 1034), and having a fixed relation, as regards position, to a reddish granule situated towards the middle of the body.

476. In some of the lower plants of this order, such as Diatomaceæ (Fig. 1041), an evident division of cells takes place; and in this way the plants are propagated. In Protococcus, the plant of Red and Green Snow (Fig. 1039), and in Palmella, the plant of Gory Dew (Fig. 1040), and their allies, the whole plant separates into cells, which may be considered either as buds or spores. In these plants no special reproductive organs have been detected. In some of the Confervæ, as well as in Diatomaceæ, the union of cells takes place in a singular manner, so as to give rise to the formation of germinating spores (Fig. 1043).

477. *Brittleworts or Diatomaceæ.*—Among these are included some of the simplest forms of Algæ. They are usually composed of united rectangular fragments of a brittle nature, which separate at certain

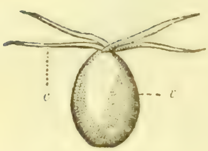


Fig. 1036.

Fig. 1037.

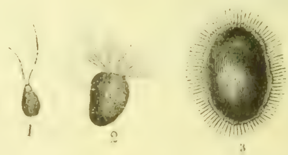


Fig. 1038.

Fig. 1039.

periods of growth, and form new individuals (Fig. 1041). The true Diatoms have a siliceous covering, so that they retain their form when dry, and are not destroyed by fire; while the division called Desmidieæ have no siliceous covering, and alter much on drying. In some of the plants of the order, the union of cells, called *conjugation*, has been observed, similar to what takes place in Confervæ. Many of the bodies included under this division of Algæ, were considered by

Fig. 1036. Zoospore or sporozoid of one of the Confervæ (*Chætophora*). The spore consists of a vesicle, *v*, to which are attached four cilia or vibratile filaments *c*, which move for a certain time after the spore is discharged.

Fig. 1037. A Confervaceous Alga (*Vaucheria ovoidea*), consisting of an elongated club-shaped cell, full of green endochrome. The enlarged extremity contains a dark green mass, *s*, separated by a partition from the rest of the coloured particles. This dark mass becomes surrounded by a covering or epispore, and finally escapes through an opening in the apex of the filament. The spore, *s*, is provided with cilia, as seen in the next figure. The spore moves in the fluid around the plant for some time.

Fig. 1038. Zoospores or Sporozoids of Algæ. They are cellular bodies, provided with cilia or vibratile filaments. 1. Zoospore of Conferva, with two cilia at one end. 2. Zoospore of Conferva, with a tuft of cilia at one end. 3. Zoospore of Vaucheria, surrounded by cilia.

Fig. 1039. Cells of an Alga found in Green Snow (*Protococcus viridis*). It consists of a cell which performs the functions of nutrition and reproduction. It divides into various germinating cells, equivalent to spores, or, as some would say, to cellular buds.

Ehrenberg as of an animal nature, and he has figured them as such The division of the parent cell into two halves, is observed in a marked degree in Diatoms; and these halves afterwards become detached, so as to form distinct individuals.*

478. *Confervas and their Allies.*—These are plants usually of a green colour, consisting of round or cylindrical cells united (Fig. 1042), so as to form a filamentous or a flattened thallus. In their simplest form they are seen in the Palmella (Fig. 1040), consisting of a single globose cell, dividing first into two, and afterwards into four cells, which finally burst the mother-cell, and escape. Each of these divisions, like the parent cell, has the power of vegetating, and of dividing, by a merismatic process, into four, so as to multiply the plant. In Vaucheria, as already noticed (Fig. 1037), the terminal cell is concerned in the production of a germinating cell or spore, which has peculiar motions. In Achlya prolifera the terminal cell

Fig. 1040.

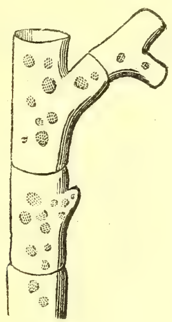


Fig. 1042.

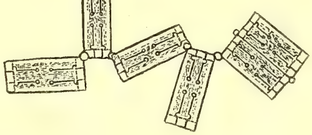


Fig. 1041.

discharges numerous moving spores. In Zygnema and other Confervas (Fig. 1042), the cells composing the filaments have the power of giving out lateral cellular processes, by means of which a union takes place, the result being the production of a spore, either in the tube between the filaments, or in one of the cells of the filaments. The cells in these plants appear to have different functions, and to correspond to the antheridia and pistillidia of the higher Cryptogams. In Figure 1043 two filaments of Zygnema are seen united by tubes, *p*; the contents of one cell, *c*, are seen passing into another

Fig. 1040. Cells of the plant of Gory Dew (*Palmella cruenta*). The plant consists of a cell, which divides into two and then into four parts, each of which is capable of propagating the plant.

Fig. 1041. Frustules of a Diatomaceous Alga (*Diatoma marinum*), separating from each other in a merismatic manner. The frustules of the plant vary from nearly square to six times as long as broad, and they present two striæ.

Fig. 1042. Branching cellular septate filament of a Confervaceous Alga (*Chætophora*). The cells contain endochrome.

* For valuable observations on these plants, see Ralfs on British Desmidieæ; also, on Diatomaceæ, in the Annals of Nat. Hist. vol. xi. Ehrenberg's Infusoria. Thwaites on Diatomaceæ, in Ann. of Nat. Hist. xx. 9, 343, and 2d ser. i. 161. Smith on Diatomaceæ, Ann. of Nat. Hist. 2d ser. vii. 1.

cell, *d;* and the result is the production of a germinating spore, *s.* In the two lower cells spiral phytozoa are seen. In Hydrodictyon, or Water-net, the cells are so united, as to leave spaces between them, and thus give rise to a net-like appearance.

479. *Rose-coloured Sea-weeds, or Florideæ.*—These Algæ are usually of a rose or purplish colour, and consist of variously-formed cells, arranged either in a single row, or in several rows, so as to form an articulated or an expanded flat and often divided thallus. The organs of reproduction are restricted to particular parts of the thallus, and consist of spore-cases, containing spores, frequently four in number (Fig. 1035), intermixed often with antheridia, or filaments containing spermatozoids, these organs being placed in the interior of conceptacles. The reproductive organs exist either in cavities of the thallus, or in

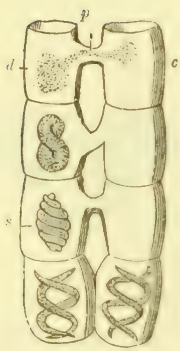


Fig. 1043.

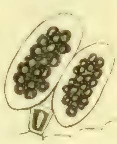


Fig. 1044.

Fig. 1045.

Fig. 1046.

distinct sacs produced on the surface of the thallus, or at the apex of some of its divisions. The occurrence of *tetraspores*, or mother-cells containing four spores, is general in this division of the Algal alliance. The antheridia, according to Decaisne and Thuret, consist of septate filaments, the terminal cell of which assumes a clavate form, and con-

Fig. 1043. Two filaments of a Confervaceous Alga (*Zygnema*), conjugating, *i. e.* uniting together by tubes, *p*, which pass between the different cells. The contents of two cells, *c d*, unite so as to form a germinating spore, *s*. In the lower two cells spiral filaments are seen.

Fig. 1044. Part of the fructification of a rose-coloured Alga (*Callithamnion tetragonum*). There are two sacs called favellæ, containing numerous angular spore-like bodies. These are said to reproduce the plant, and are by many considered as analogous to buds.

Fig. 1045. Part of the fructification of a rose-coloured Sea-weed (*Bonnemaisonia asparagoides*). It consists of an ovate sac called ceramidium, with a terminal pore, and containing a tuft of pear-shaped germinating cells or spores.

Fig. 1046. Thallus, *t t*, of the common Bladder Sea-weed (*Fucus vesiculosus*), showing the fructification, *fr*, at the extremities of the divisions. The fructification consists of a mass of conceptacles united together, so as to form a gleba or large tubercle. In the thallus there are bladders of air, *v*.

PART II.

PHYSIOLOGICAL BOTANY.

tains phytozoa. The latter become free by the dissolution of the walls of the cell. Besides the tetraspores, sacs (coccidia or ceramidia) of a rounded form exist, containing minute spore-like bodies (Figs. 1044 and 1045), which some call sporules. They appear to germinate, and differ from buds, in being contained in special sacs; some consider

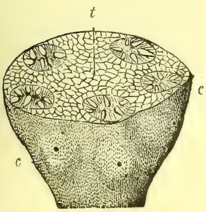


Fig. 1047.

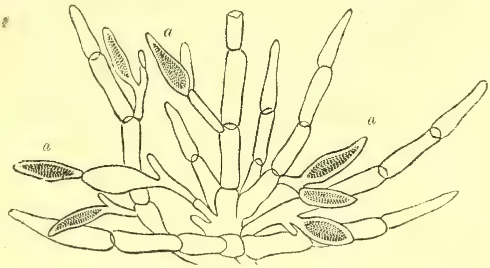


Fig. 1049.

Fig. 1051.

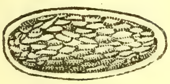


Fig. 1048.

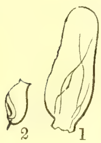


Fig. 1050.


Fig. 1053.

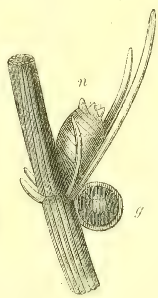


Fig. 1052.

these cellular bodies as bulbils, which separate from the parent plant; others look upon them as another kind of spore.

480. *Brown Sea-weeds, or Fucaceæ.*—These are usually brown or olive-coloured plants, growing chiefly in salt water. They consist of cells, which are united so as to form various kinds of thalli. Some-

Fig. 1047. Transverse section of the tubercle of the common Bladder Sea-weed (*Fucus vesiculosus*), showing numerous conceptacles, *c c*, in the midst of cellular tissue, *t*.

Fig. 1048. Antheridium of a Sea-weed (*Fucus serratus*), full of phytozoary cells.

Fig. 1049. Cellular septate filaments, with antheridia, *a a a*, from the conceptacle of a Sea-weed (*Fucus serratus*). The abortive filaments are called paraphyses. The antheridia are sometimes in the same conceptacle with sporiferous sacs; at other times they are in different conceptacles.

Fig. 1050. Antheridium, 1, of a Sea-weed (*Fucus serratus*), containing two phytozoa; 2, a phytozoon, separate, with the two thread-like processes, from either extremity, coiled up.

Fig. 1051. Fructiferous axis of Chara, bearing nucules (spore-cases), *n n*, and globules (antheridia), *g g*, at the points whence branches come off.

Fig. 1052. Axis of Chara, with branches, from the axil of which arises the nucule, *n*, and below the globule, *g*.

Fig. 1053. Globule of Chara, being a rounded body with eight radiating valves externally, and filaments containing phytozoary cells internally.

times the thallus is supported on a distinct stalk, formed of elongated cells; and in the frond there occur also thickened cellular lines, having the appearance of veins. The cells of the thallus are often agglutinated together by a gelatinous intercellular substance. The reproductive organs consist of spore-cases and antheridia, contained in conceptacles (Fig. 1032, *p*), which are aggregated together in receptacles, or large club-shaped expansions, at the extremity or margin of the thallus and its divisions (Figs. 1046 and 1047). The antheridia are sacs (Fig. 1048) borne on jointed filaments (Fig. 1049), and they contain moving phytozoa (Figs. 957, 960, and 1050). The occurrence of antheridia and spore-cases on the same or different plants, has given origin to the terms monœcious and diœcious, which are applied to Sea-weeds by Thuret and

Fig. 1054.

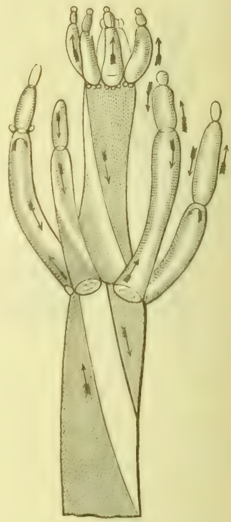


Fig. 1055.

Decaisne. When the spores germinate, certain filamentous processes are produced, which burst the outer covering or epispore.

481. *Charas or Characeæ.*—These plants are considered as allied to Algæ, although they present many marked peculiarities. They

Fig. 1054. A species of Chara (*Chara or Nitella flexilis*), consisting of cellular tubes, with verticillate cellular branches, the extremities of which are forked. The plant grows in fresh water, and is referred to the Algal alliance.

Fig. 1055. Part of the axis and branches of Chara, showing, by the arrangement of the arrows, the course of the intra-cellular circulation. There is a regular movement of fluids in the individual cells, as is indicated under the microscope by the motion of granules carried with the current. The subject will be considered under Rotation, or Intra-cellular movements.

consist of an axis formed by elongated tubular cells (Fig. 1054), either transparent, or encrusted with carbonate of lime. From the axis arise branch-like processes, arranged in a verticillate manner. In the interior of the tubes of these plants, distinct circulating motions are seen under the microscope. The currents proceed from one end of the tubular cell to the other, following an elongated spiral direction, and carrying with them granules. This is shown in Figure 1055, and will be specially noticed under PHYSIOLOGY. The reproductive organs of Charas are of two kinds (Fig. 1051, *g* and *n*), one called the *globule* (Fig. 1052, *g*), a spherical body, containing filaments with phytozoa, the other denominated the *nucule* (Fig. 1052, *n*), an oval body, containing a germinating cell or spore.

482. The nucule is produced on the axil of a branch, and consists

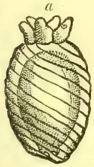


Fig. 1056.

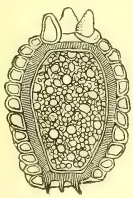


Fig. 1057.

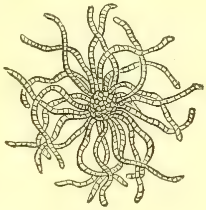


Fig. 1058.

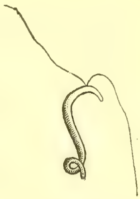


Fig. 1059.

of a large central cell or spore, surrounded by five cells, which are wound round it in a spiral manner (Figs. 1056 and 1057), and ending in five tooth-like processes at the apex. The spore is contained in a special covering. The globule is usually placed immediately below the nucule (Figs. 1051 and 1052, *g*), and consists of eight valves, enclosing a cavity in which the filamentous articulated phytozoary cells are contained. Each valve is composed of numerous cells, radiating from the centre of the valve, and exhibiting triangular processes at the edge of the valve, by means of which it dovetails into the adjacent valves (Fig. 1053). The cells in the interior of the valvular cavity are filled, like those on the flat portion of the valves, with red granules. On the apex of cells projecting from the centre of each valve, there are numerous filaments (Figs. 1058 and 1060), composed of cells con-

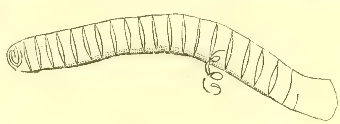


Fig. 1060.

Fig. 1056. Nucule of Chara entire, composed of five cells, wound round a large central cell in a spiral manner, and ending in five processes at the apex, *a*.

Fig. 1057. Nucule or sporangium of Chara cut vertically, showing the large central cell or spore which germinates.

Fig. 1058. Mass of septate filaments, attached to cells projecting from the centre of the valves of the globule. These filaments are composed of phytozoary cells.

Fig. 1059. Phytozoon of Chara, separated from a cell of the filament. Near one of the extremities two vibratile cilia arise.

Fig. 1060. Partitioned filament of Chara, consisting of a series of cellules containing phytozoa, one of which is seen escaping in the form of a spiral thread.

taining minute phytozoa, coiled up in a spiral manner. These escape from the cell, and exhibit spontaneous movements (Fig. 1059).*

483. Brief Recapitulation of the Organs of Cryptogamic Plants :—

1. Some Cryptogamic plants, such as Acrogens, consist of cells and vessels; others, such as Thallogens, consist of cells only. The former may be called Vascular Cryptogams, the latter Cellular Cryptogams.
2. Cryptogamic plants sometimes have conspicuous stems, as seen in the stipes and rhizomes of Ferns. Sometimes they present a flat cellular expansion or thallus as in the case of Lichens; while at other times they have an underground creeping cellular stem, as exhibited in the mycelium or spawn of Fungi.
3. Some Cryptogams have green leaves, with an epidermis and stomata; others are leafless, and are variously coloured.
4. The Organs of Reproduction are in general obscure, and consist usually of cellular sacs of two kinds—one being antheridia, containing phytozoa or spermatozoids, the other being pistillidia or archegonia.
5. In the fully developed state of the plant, the antheridia disappear, while the pistillidia are transformed into cellular sacs of various forms, containing spores.
6. Spores are germinating bodies, considered as formed by a process of reproduction, and as being analogous to cellular embryos. Spores are occasionally furnished with vibratile cilia.
7. Spores are developed in mother-cells, the contents of which often divide into four. Mother-cells, containing two, four, six, eight, or more spores, are called sporidia.
8. Cryptogamic plants are also propagated by buds or gemmæ, which are either attached to the leaves or fronds, or are contained in peculiar cup-shaped bodies.
9. In Ferns, the antheridia and pistillidia are supposed to exist on a pro-thallus or cellular expansion, produced by the spore when it germinates. A cell of the pistillidium (ovular body) afterwards gives rise to the spore-bearing leaves (fronds). The spores are contained in sporangia, with or without an elastic ring, developed on the back, on the side, or at the base of the leaves.
10. In Mosses, the antheridia and pistillidia are seen at certain stages of the plant-growth, and they are either on the same or on different plants. The fully developed fructification consists of spore-cases (sporangia), usually stalked, containing spores which are discharged by an opening either at the apex or side. The apicilar opening is often surrounded by peristomatic processes, which, as regards number, are either four or some multiple of four.
11. In Liverworts, the antheridia and pistillidia are usually on different parts of the plant; and they are frequently in the substance, or on the under surface, of disk-

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* For fuller details relative to the forms and structure of the members of the Algal alliance, consult Agardh, Dissertatio de Metamorphosi Algarum. Vaucher, Histoire des Conferves d'eau douce. Derbes et Solier, sur les Organes reproducteurs des Algues, in Ann. des Science Nat. 3d ser. Bot. xiv. 261. Thuret, Recherches sur les Zoospores des Algues, et des Anthéridies des Cryptogames, in Ann. des Sc. Nat. 3d ser. Bot. xiv. 214; also sur les organes locomoteurs des spores des Algues, in Ann. des Sc. Nat. 2d ser. Bot. xix. 266. Decaisne et Thuret, Recherches sur les Anthéridies et les spores de quelques Fucus, in Ann. des Sc. Nat. 3d ser. Bot. iii. 5. Solier, sur deux Algues Zoosporées, in Ann. des Sc. Nat. Bot. 3d ser. vii. 157. Unger, Recherches sur l'Achlya prolifera, in Ann. des Sc. Nat. 3d ser. Bot. ii. 5. Kutzing, Phycologia generalis, and Tabulæ Phycologicæ. Ralfs, on British Desmidieæ; also in Transactions of Botanical Soc. of Edinburgh, ii. Ralfs, on Diatomaceæ, in Annals of Nat. Hist. xi. 447. Thwaites, on Diatomaceæ, in Annals of Nat. Hist. xx. 9, 343, and 2d ser. i. 161. Smith, on Diatomaceæ. Ann. of Nat. Hist. 2d ser. vii. 1, and on the germination of the spores in Conjugatæ, Ann. Nat. Hist. 2d ser. viii. 480. Decaisne, sur les Corallines, in Ann. des Sc. Nat. 2d ser. xviii. 96. Agardh, sur le genre Chara, Ann. des. Sc. Nat. 1st ser. iv. 61. Amici, observations microscopiques sur le Caulinia fragilis, &c., Ann. des Sc. Nat. 1st ser. ii. 42, and in Ann de Chimie, xiii. 384; sur les metamorphoses et mouvement des corps reproducteurs de divers Conferves, Ann. des Sc. Nat. 1st ser. xiii. 428. Brongniart on Chara, Dict. Classique, iii. 474. Harvey, Phycologia.

shaped cellular stalked expansions. Along with the spores, spiral filaments, called elaters, are seen.

12. In Lichens, the antheridia and pistillidia have not been satisfactorily determined. The fructification consists of thecæ or asci, containing sporidia. There is also an internal green layer of germinating cells called gonidia.
13. In Fungi, the antheridia and pistillidia are obscure. The fructification is various; the spores being either contained in sacs or thecæ (cystidia), or being supported on stalks on the outer surface of cells called basidia. The sporiferous cells are attached to a cellular layer called hymenium, which presents various forms. The hymenium is either naked or enclosed in a cellular membranous covering.
14. In Algæ, antheridia and pistillidia have been detected in many instances, the former being sometimes in the same cavity with the latter, and at other times in different cavities. In some of the Algæ, certain cells, in the same or in separate filaments, seem to possess different properties, and produce spores by a process of conjugation or union. In the lowest Algæ, the cells of the plants divide in a merismatic manner, and produce new individuals.

PART II.

PHYSIOLOGICAL BOTANY.

CHAPTER I.

REMARKS ON THE GENERAL PHENOMENA OF PLANT LIFE.

484. The Physiological department of Botany, which is usually denominated Vegetable Physiology, embraces a consideration of plants in a state of activity, and performing certain functions which are intimately connected with their life and duration. These vital functions may be traced through all stages of growth, from the first cell of the embryo up to the fully developed plant. The study of the functions of the simple *plant-cell* aids much in the elucidation of all the phenomena of plant life. The cell of the Yeast plant (Fig. 1061), and of the Red and Green Snow plants (Figs. 1062, 1063), is capable of performing all the functions of nutrition and reproduction. It absorbs fluids through its walls, enlarges, elaborates secretions, and forms new cells which propagate the individual. Thus, a simple isolated cell grows or enlarges, is endowed with a certain plastic or formative vital power, by which new cells are produced, exhibits frequently movements in its interior, forms secretions, becomes often thickened by deposits on its walls, and ultimately dies. Here, then, in the cell, in all its stages of growth, formation of secretions, reproduction, and decay, is an epitome of vegetable life.

485. The cell, while carrying on these vital actions, sometimes continues to retain a more or less rounded form, as in the Red-snow plant (Fig. 1062); at other times it undergoes morphological changes, so as to assume a cylindrical, clavate (Fig. 1064), fusiform, sinuous, or starlike form. There is an active period of cell-life during which

the protoplasm or formative matter in the interior is capable of undergoing the changes to which allusion has been made. The formation of reproductive cellules within the cavity of the cell, or of deposits on its walls, frequently puts an end to its vital functions.

486. The same vital process which takes place in an isolated cell, occurs also in cells united together. In cellular plants, as Algæ (p. 348), and Fungi (p. 344), several cells are generally combined, so as to form one plant. The union takes place either in a single linear series, as in many Confervæ (Fig. 1065), or in a branching series, as in certain Moulds (Fig. 1066), or in several rows united laterally, so as to form a flat expansion, as in the thallus of Sea-weeds (Fig. 1067). Each cell of such plants performs its own special function, and the united cells are concerned in giving rise to combined vital phenomena. While there is individual cell-life, there is also the general life of the united cells, which, together, constitute the compound cellular plant. In such plants the functions of the different cells are specialized; some being concerned in the function of nutrition or vegetation, others in that of reproduction. In common Mould (Fig. 1068), there is observed a series of cells, *m*, forming the mycelium or spawn, which absorb nourishment, and produce stalks, *f*, by means of which nutriment is

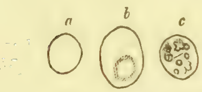

Fig. 1061.

Fig. 1062.

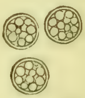

Fig. 1063.

conveyed, and these terminate in a globular collection of cells, *s*, concerned in reproduction, to which the name of spores or germs is given. Here the functions of nutrition and reproduction are localized, each being confined to a peculiar set of cells.

487. Proceeding from the lower forms of vegetation to the higher, we reach vascular plants, which, although cellular in their early stage of growth, present, when fully developed, marked morphological changes. In them the cells exhibit various forms—some being short and angular, others being lengthened so as to form tubes or vessels. When these vessels are thickened by ligneous deposits, they constitute woody tubes (Fig. 1069), which give strength and stability. The cavities of these tubes are frequently obliterated, as in the perfect heart wood of trees, and then their active life ceases. The production of fibres on the inner

Fig. 1061. Cells of the Yeast plant (*Torula cerevisiæ*) in different stages of growth; *a*, cell in an early state; *b*, cell with nucleus; *c*, cell with nucleoli. The simple cell performs all the functions of nutrition and reproduction.

Fig. 1062. Cells of the Red-snow plant (*Protococcus nivalis*), in different stages of growth and development; *a*, cell in the young state; *b*, cell fully formed, with cellules in its interior ready to be discharged, and to form independent plants; *c*, cell after its contents have been discharged. An isolated cell, in this instance, performs the functions of nutrition and reproduction.

Fig. 1063. Cells of the Green-snow plant (*Protococcus viridis*), in their state of full development, containing germs or cellules which when discharged produce new plants. The cells perform nutritive and reproductive functions.

walls of elongated tapering cells gives rise to the various kinds of fibro-vascular tissue (Figs. 1070, 1071, 1072). In vascular plants special cells are appropriated for secretions (p. 32), such as starch, gum, sugar, oils, and milky juices. We frequently find contiguous cells having very different contents. Thus, in the grain of the Cerealia, certain rows of cells contain nitrogenous compounds, while others contain starch; in the stems of grasses and Equiseta some cells are filled with silica, while adjoining cells contain scarcely a trace of this substance. The nutrition of the plant is carried on by one set of cells and vessels, while its reproduction, or the development of new cells, is confined to another set. Vascular plants are thus compound individuals, formed of cells in various morphological states. There is a

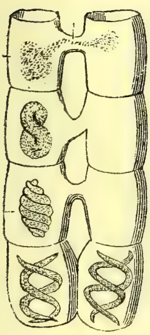
Fig. 1065.


Fig. 1064.

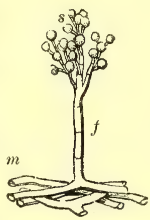

Fig. 1066.

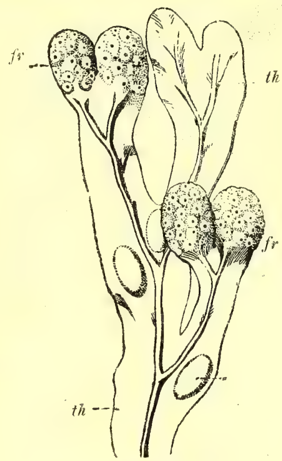

Fig. 1067.

specialization of the functions of cells and vessels, and all by their united action contribute to the general life of the compound plant.

488. Schacht* remarks that a plant is composed of one or more cells, and that it is only in the lowest species that the cells are of the same *value ;* in other words, are of the same chemical and physical nature, and of the same physiological importance. Even amongst the mushroom and sea-weed orders, it is only the lowest plants which have

Fig. 1064. Elongated club-shaped cell of *Vaucheria ovoidea*, discharging a cellular spore which has been formed in its interior.

Fig. 1065. Two filaments of a cellular plant (*Zygnema*), uniting together by means of tubes. The plant consists of a filament formed by a series of cells united in a single row. The different cells appear to have different functions.

Fig. 1066. A species of Mould-fungus (*Botrytis*), consisting of certain nutritive cells, *m*, forming the mycelium or spawn, a cellular stalk, *f*, which branches at the top and bears reproductive cells, *s*.

Fig. 1067. Thallus of the common Bladder sea-weed (*Fucus vesiculosus*), consisting of numerous cells united, some being nutritive, *th*, *th*, others reproductive, *fr*, *fr*.

* Schacht, die Pflanzen-Zelle, Berlin 1852; Schacht, La vie de la Plante, Annales des Sciences Naturelles, 3d serie, xvii. 292.

cells concerned alike in the processes of vegetation and reproduction. The higher plants of these orders, like the Lichens, are composed of cells of different *value*, in the sense in which we have defined (p. 361) that phrase. In plants of still higher organization, we meet with numerous cells totally different in a physical and chemical, as well as in a physiological point of view. The life of such plants depends on the regular action of these cells of unequal value, arranged and developed in a determinate manner, but varying with the plant. At the earliest period of its organization, every plant is composed of cells of the same value. Very soon, however, two

Fig. 1073.

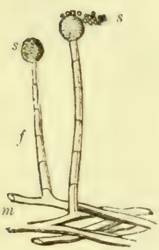

Fig. 1068.

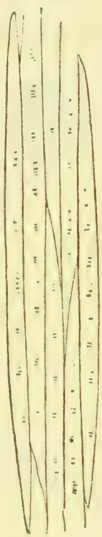

Fig. 1069.

Fig. 1071.

Fig. 1072.

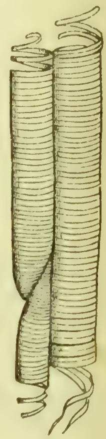

Fig. 1070.

different kinds of cells appear, one sort being concerned in the production of new cells, and called by Schacht the organizing tissue or cambium ; the other serving chiefly to form nutritive matter, such as starch, gum, sugar, chlorophyll, &c., and called the nourishing tissue or proper parenchyma. The former tissue occurs at the extremities of

Fig. 1068. A species of Mould (*Mucor*) showing the nutritive cells forming the mycelium or spawn, *m*, and those composing the stalk, *f*, which bears at its summit a globular cell, *s*, containing minute reproductive germs or spores. The cells at *m* and *f* are concerned in nutrition, those at *s* are connected with reproduction.

Fig. 1069. Woody tubes consisting of elongated cells having thick walls.

Fig. 1070. Spiral vessels consisting of elongated cells which assume a tubular and fusiform shape, and have a spiral fibre formed on the inside of their walls.

Fig. 1071. Elongated cell, forming a tube, with the fibres inside in the shape of rings.

Fig. 1072. Cells elongated and enlarged, so as to form pentagonal and hexagonal tubes with the fibres inside in the shape of lines or bars.

Fig. 1073. Embryo contained in the seed of the Barberry. The lower portion of the axis gives origin to the radicle or young root which protrudes at the micropyle. The upper portion afterwards appears as the ascending portion of the axis.

the bud and root, and also gives origin to the vascular bundles; it is an active tissue, rich in azotized matters. The latter is the tissue engaged in the formation of nutritive matters, such as starch, cellulose, lignine, oils, resins, colouring matters, and organic acids. It is rich in the hydrates of carbon, which are deposited on the walls, and in the interior of the cells. This tissue becomes elongated, so as to assume the form of woody and vascular tubes, the activity of which often ceases after a certain period. The life of vegetable cells is thus, according to Schacht, a chemico-physiological phenomenon; one cell absorbs and elaborates substances differently from others. The life of the higher species of plants results from the regular vital action of cells of unequal value, which are concerned in the formation of new organs and of new matters.

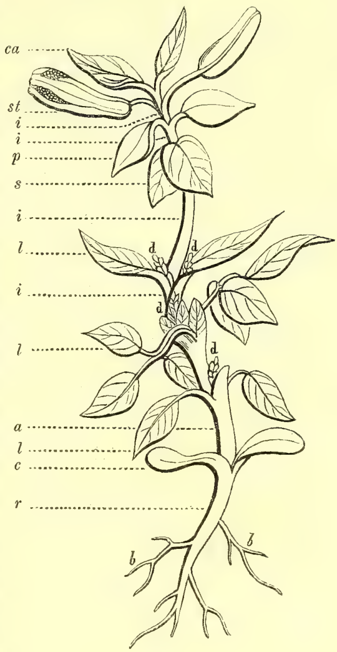

Fig. 1074.

489. In the growth of an ordinary vascular plant, we perceive, first, a swelling of the cellular embryo contained in the seed (Fig. 1073); the axis elongates — one portion of it, called descending, has active organizing cells connected with the formation of the root (Fig. 1074, *r*), and its fibrils, *b b;* another, called ascending, appears as a bud (gemmule), containing active organizing cells, which give rise to the stem (Fig. 1074, *a*), and its various internodes, *i i i i*, bearing, first, seed-leaves or cotyledons, *c*, then ordinary leaves, simple or compound, *l l l*, then flower-leaves, in the form of sepals, *s*, petals, *p*, stamens, *st*, and carpels, *ca*. In the axil of the leaves, that is, at the points where they come off from the axis, buds, *d d d d*, are produced capable of developing branches, and on the edges of the carpellary leaves, *ca*, or, at other times, at the extremity of the axis, cellular buds, called ovules, are formed. There is thus, as shewn in the ideal figure, a

Fig. 1074. An ideal representation of a flowering plant chiefly after Schleiden. There is a general axis from which proceeds the descending system, forming the root, *r*, with its fibrils, *b b*. From the same axis proceeds the ascending system, forming the stem, *a*, with its various internodes, *i i i i*. On the ascending axis leaves are produced, first in the form of cotyledons or seed-leaves, *c*, and then in the form of simple or compound leaves, *l l l*, in the axil of which buds, *d d d d*, are produced. In the progress of time the flower and organs of reproduction are developed, and these are formed upon the type of the leaf; the calycine leaves or sepals, *s*, the coralline leaves or petals, *p*, the staminal leaves or stamens, *st*, and the pistilline leaves or carpels, *ca*. The ovules are either produced on the edges of the carpels or at the extremity of the axis enclosed by the carpels. Both the nutritive and reproductive organs are formed upon a common type.

central axis, from which proceeds a radicular portion in a downward direction, and a tigellary portion upwards—the former being the system connected with the absorption of nutriment from the earth by means of fibrils, the latter being concerned with the exposure of the leaves and flowers to air and light, so as to form secretions and produce seed.

490. When the young plant begins to sprout or germinate, chemical changes take place, by which the insoluble starch of the seed is converted into soluble, gummy, and saccharine matter. The descending portion of the axis then appears in the form of the radicle, which protrudes from the foramen of the seed, and gives origin to fibrilliform roots. The roots absorb liquid nourishment from the soil, which is carried up as sap through the stem to the leaves, undergoing changes in its course. This conveyance of sap is not carried on by a series of anastomosing tubes, as in the case of animals, but by a series of closed cells or tubes of different forms, which are of unequal value, and which convey liquids of various kinds from one part to another. Some of the tubes, such as the spiral vessels and their modifications, usually convey air.

491. The active cambium cells are concerned in the formation of vascular bundles, and of the parenchyma or nutritious cells of the stem and root. A cylindrical layer of these active cells is formed in the young stem between the medullary and cortical parenchyma. In an ordinary tree, this layer, called by Schacht the *thickening-zone*, continues its functions during the life of the plant, forming internally new wood, and externally new bark. In Endogens and the higher Cryptogamous plants, this thickening zone is active but for a short period of time, and hence the stems of these plants, after increasing in diameter up to a certain point, grow subsequently only in height.

492. The leaves absorb liquids and gases, and elaborate secretions, which are afterwards employed in the processes of vegetation. The green parts of plants under the influence of light carry on a process of deoxidation,* decomposing carbonic acid, and setting free its oxygen, thus counteracting the effects produced on the atmosphere by the breathing of man and animals, and by other processes of combustion and oxidation. Sir Humphry Davy remarks—"Nature has linked together organic beings, and made them mutually dependent on each other for their existence, and all dependent on light. A privation of light would be destructive to organic existence; vegetation would cease; the supply of oxygen would be quickly cut off from animals; the atmosphere would become composed of carbonic acid; and perception and volition would exist no longer."†

493. At a certain period of a plant's life flowers are produced, containing the organs of reproduction. Their function is the formation

* This process ought, perhaps, in strict chemical language, rather to be called one of *decarbonization*, inasmuch as the plant retains the carbon for its own use.

† Davy's Works, vol. i. p. 106.

of the seed containing the embryo. The seeds are scattered in various ways, and, when placed in favourable circumstances, sprout and give origin to new plants. The duration of the life of plants varies. Some plants go through all their phases of existence in the course of a year, and are called *annual;* in others the vital functions extend over two years, and they are hence called *biennial;* while a third set, such as our forest trees, continue to live during many years, and are called *perennial.* Some plants flower only once in their life, and then die after producing fruit. In such instances the flowering and fruiting may take place at the end of one year, or it may be delayed for many years. The age which some trees attain is very great. The peculiarity of the organization of vegetables, and their unlimited power of increase by buds, present great difficulties in determining the duration of perennial plants. Each individual cell, and each single organ, has a definite termination of its life. The individual shoots go through their periods of existence independently, and only share the weakness which the older organs suffer from age, when these latter are no longer able to convey onward the necessary amount of nourishment to the young shoots. In such circumstances, the latter die, not from deficiency of innate vital powers, but from defect of nourishment or starvation. If an additional supply of food could be imparted, as by grafting the shoots on vigorous stems, then their life would be prolonged. The obstacle to the conveyance of the requisite quantity of nourishment to the young shoots, in proportion as the stem elongates year by year, will naturally put an end to the existence of perennial plants. Even in those trees which attain a great age, there is thus an internal cause which tends to their ultimate death, although that may be long delayed.

494. Plants, in the exercise of their various functions, form certain organic products which supply nourishment to a higher order of beings. The animal kingdom is, in truth, dependent for its existence and support on the vegetable world. Plants, under the influence of light and heat, bring together a certain number of elements derived from the atmosphere and soil, and subject them to processes by which they are combined into nutritious matter. One portion of this is consumed by plants themselves in maintaining their structure, and in developing the embryos which are to replace them, another portion serves for food to animals, and the remainder is either returned to the soil, so as to increase its fertility, or is buried in the earth, so as to form peat, coal, and other fossil fuels destined to benefit future generations of mankind.

495. The following tabular view by Dumas* and Boussingault points out the contrast and antagonism between the processes of animal and vegetable life, and shews the mode in which they are made mutually subservient to each other :—

* Dumas, Balance of Organic Nature. See also Alison on Vital Affinity, in Trans. Royal Soc. Edin. xx. 386.

AN ANIMAL is	A VEGETABLE is
An apparatus of combustion or oxidation.	An apparatus of reduction or deoxidation.
Possesses the faculty of locomotion.	Is fixed.
Burns carbon.	Reduces carbon.
,, hydrogen.	,, hydrogen.
,, ammonium.	,, ammonium.
Exhales or gives off carbonic acid.	Fixes carbonic acid.
,, water.	,, water.
,, oxide of ammonium.	,, oxide of ammonium.
,, azote.	,, azote.
Consumes oxygen.	Produces oxygen.
,, neutral azotized matters.	,, neutral azotized matters.
,, fatty matters.	,, fatty matters.
,, amylaceous matters, gum, and sugar.	,, amylaceous matters, gum, and sugar.
Produces heat.	Absorbs heat.
,, electricity.	Abstracts electricity.
Restores its elements to air and earth.	Derives its elements from air and earth.
Transforms organized into mineral matters.	Transforms mineral into organized matters.

496. The various functions of plants are under the control of vital forces, the nature of which is unknown to us. No doubt we can trace the operation in vegetables of certain chemical and physical laws, but these are regulated in their operation by the vital powers of the organism. Although we can trace the absorption of certain unorganized matters, and can ascertain by chemical means certain of the changes which they undergo in the course of their progress, still we have not been able to detect the mode in which these changes are produced by the vegetable tissues, nor the process by which the various vegetable products are secreted and deposited. When the chemist tells us that carbonic acid, water, and ammonia, form the organic tissues of plants, he does not pretend to explain the mode in which these materials are transformed by the physical and vital powers of the plant into the different organs. The chemist has done much, however, to advance the science of physiology, more especially as regards the nutrition of plants, and his researches have, in an especial manner, been productive of the happiest results in regard to the practice of agriculture. The knowledge of the composition of plants and of the soil has led to great improvements in culture, and to the judicious employment of manures of various kinds. Chemistry and Physiology must go hand in hand in the investigation of the functions of plant life.

497. Dr. Carpenter has recently hazarded the conjecture, that a living plant has not merely the power of withdrawing materials from

the unorganized world around it, but that it also can act on heat, light, and electricity, in such a way as to convert them into vital forces; and that the disintegration of the living structure, while it gives back solid and gaseous matters to the soil and air, also restores those imponderable agents to the universe.* In speaking of heat from this point of view, Dr. Carpenter states that he does not regard it as the vital principle or as identical with vital force; nor does he recognise the possibility that any action of heat upon unorganized elements can of itself develope an organized structure. There must be the pre-existence of a living organism, through which alone heat can be converted into vital force. "Starting," he says, "with the abstract nature of force as emanating from the Creator, we might say that this force, operating through unorganized matter, manifests itself in electricity, magnetism, light, heat, chemical affinity, and mechanical motion; but that, when directed through organized structures, it effects the operations of growth, development, chemico-vital transformation, and the like." "Plants form those organic compounds at the expense of which animal life (as well as their own) is sustained, by the decomposition of carbonic acid, water, and ammonia; and the *light*, by whose agency alone these compounds can be generated, may be considered as metamorphosed into the *chemico-vital affinity* by which their components are held together. The *heat* which plants receive, acting through their organized structures as *vital force*, serves to augment these structures to an almost unlimited extent, and thus to supply new instruments for the agency of light and for the production of organic compounds. Supposing that no animals existed to consume these organic compounds, they would be all restored to the unorganized condition by spontaneous decay, which would reproduce carbonic acid, water, and ammonia, from which they were generated. In this decay, however slow, the same amount of heat would be given off as in more rapid processes of combustion; and the faint luminosity which has been perceived in some vegetable substances in a state of eremacausis, makes it probable that the same is true of light. And though the process of decay may be prevented or modified, so that the whole or a part of the materials of vegetable structures are disposed of in other ways, yet whenever they return to the condition from which they were at first withdrawn, they not only give back to the inorganic world the materials out of which they were formed, but the light and heat to which their production was due. Thus, in making use of the stores of coal which have been prepared for his wants by the luxuriant flora of past ages, man is not only restoring to the atmosphere the carbonic acid, the water, and the ammonia, which it must have contained in the carboniferous period, but is artificially reproducing the light and heat which were then expended in the operations of vegetable growth. That the relative proportion of the light and heat thus restored should

* Carpenter on the mutual relation of vital and physical forces, Phil. Trans. for 1850, p. 727.

be the same as that which they originally bore to each other, is by no means necessary; since each (according to Professor Grove's views) is convertible into the other. In the few cases in which *motion* is affected by the vital force of plants, this may be considered as restoring to the inorganic universe a certain measure of the force which they have derived from it, in the form of light and heat."

498. Whatever may be said in regard to these speculations, there can be no doubt that heat and light are powerful agents in promoting the vital activity of plants. It is only in connection with a certain temperature that the various processes of vegetation can proceed, and light is required for deoxidation as well as for the development of nuclei, of chlorophyll, and of the other secretions which are concerned in plant-life.

CHAPTER II.

CHEMISTRY OF VEGETATION.

CONSTITUENTS OF PLANTS AND SOURCES WHENCE THEY ARE DERIVED.

499. It is impossible to study the functions of individual cells and vessels, or of the entire plant, without knowing their chemical composition, and the sources whence they derive the materials necessary for carrying on their vital processes. Hence, before proceeding to consider the plant in a state of activity, and as performing vital actions, it is necessary to give a general view of the chemistry of vegetation. This subject has engaged the attention of many distinguished chemists, among whom may be mentioned Saussure, Sprengel, Davy, Liebig, Dumas, Mulder, Boussingault, and Johnston. The subject has assumed importance in an agricultural point of view, and a knowledge of it is essential for carrying on farming operations in an enlightened manner. The theory of manures, and the practical application of them, is intimately connected with the knowledge of the composition of plants and of soils. Much has been done lately in the way of advancing scientific as well as practical agriculture, and the establishment of chemical departments by the Highland and the English Agricultural Societies bids fair to advance the farming of Britain.

500. One of the most beneficial aims of chemistry, Daubeny remarks, is to impart greater precision to known and familiar methods of culture, by pointing out the causes upon which their efficacy depends, and thus to enable the agriculturist to employ greater discrimination in their use; whilst another not less important practical end, is that of furnishing a clue to the discovery of new and economical sources for materials of acknowledged utility in husbandry, and of instructing us how to preserve in all their integrity the constituents on which their virtue depends. The diffusion of scientific information among farmers is valuable, not merely as regards the attainment of truth, but likewise in the exclusion of error. While it promotes the progress of agricultural knowledge in a right direction, it guards at the same time against the evils produced by fanciful hypotheses.

I. ORGANIC CONSTITUENTS OF PLANTS.

501. The materials of which the substance of plants is composed are of two kinds, *Organic* and *Inorganic.* The organic constituents form the great bulk of the tissues of plants; they are completely consumed when the plant is burnt; they are produced by living organs alone, and cannot be manufactured in the laboratory of the chemist. The inorganic constituents, on the other hand, form a small portion of the tissues; they are incombustible, and remain in the form of ash after the organic constituents have been consumed by fire; and they can be produced in the laboratory of the chemist. The former may be called the combustible materials produced by living plants; the latter, incombustible materials, found not only in plants, but also in the mineral kingdom. Both are derived originally from unorganized matter, and both enter into the composition of organized structures in a greater or less degree. The vegetable organic constituents are composed chiefly of Carbon (C), Oxygen (O), Hydrogen (H), Nitrogen (N).* The inorganic constituents are composed of metallic bases in combination with oxygen, acids, and metalloids. In the fresh plant there is always a large quantity of water (H O). This is removed by drying.† The quantity varies in different plants—succulent and fleshy species containing a larger proportion of water than those which are dry and hard. It has been found that 100 lbs. of the following crops, in their ordinary fresh state, lose by drying at 230° F., the following quantities of water, on an average:—

Peas lose of water . . .	8 lbs.	Potatoes	72 to 77 lbs.
Clover seed	11 lbs.	Apples and Pears .	83 to 84 lbs.
Wheat	14 lbs.	Red Beet	85 lbs.
Oats	15 lbs.	Strawberries and Gooseberries	90 lbs.
Rye	15 lbs.	Common Hornwort . . .	90 lbs.
Wheat-straw	26 lbs.	Seakale	92 lbs.
Oat-straw	28 lbs.	French Beans and Turnips	93 lbs.

502. After the plants have been dried so as to remove the water, an estimate can be made, by burning, of the relative proportion of organic and inorganic matter—the former being dissipated by the action of fire, and the latter remaining in the form of ashes. Boussingault gives the following tabular view of the quantity of Carbon, Hydrogen, Oxygen, Nitrogen, or the organic constituents, and of ash or the inorganic constituents:—

* Sulphur *(S)*, and Phosphorus *(P)*, also enter into the composition of some of the organic compounds of plants. See section entitled Azotized constituents.

† The results of Boussingault's experiments in regard to the watery contents of plants, are given in the 2d volume of his Economie rurale. See also Schleiden's Principles of Botany, translated by Lankester, Appendix, p. 560.

	Wheat.		Oats.		Yellow Peas.	Clover Seed.	Hay.	Turnips.	Potatoes.
	Grain.	Straw.	Grain.	Straw.					
Carbon	46.1	48.4	50.7	50.1	46.5	49.4	45.8	42.9	44.0
Hydrogen . . .	5.8	5.3	6.4	5.4	6.1	5.8	5.0	5.6	5.8
Oxygen	43.4	38.95	36.7	39.0	40.1	35.0	38.7	42.2	44.7
Nitrogen . . .	2.3	.35	2.2	.4	4.2	7.0	1.5	1.7	1.5
Ash	2.4	7.0	4.0	5.1	3.1	2.8	9.0	7.6	4.0
	100	100	100	100	100	100	100	100	100

This table shows that the quantity of ash is small, and that of the organic elements Carbon and Oxygen are the most abundant. The relative proportions of the different organic elements, it will be seen, vary in different plants, and in different parts of the same plant. Thus nitrogen is more abundant in the grain than in the straw of wheat and oats. It is also more abundant in yellow peas and in clover seed, than in the cereal grains and hay. Some of the organic vegetable compounds consist of Carbon, Oxygen, Hydrogen, and Nitrogen or Azote, and are hence called Nitrogenous or Azotized. Others are composed of Carbon, Oxygen, and Hydrogen, without the addition of Nitrogen, and are hence called Non-Nitrogenous or Unazotized. In considering these constituents, we shall make some remarks on the elements of which they are respectively formed.

1. NON-NITROGENOUS OR UNAZOTIZED CONSTITUENTS AND THEIR ELEMENTS.

503. The organic compounds, denominated unazotized, are important constituents of all plants. Some of them, such as cellulose, lignine, starch, gum, sugar, and oily matters, are universally diffused over the vegetable kingdom, and have already been noticed when the contents of cells were considered (pp. 31 to 34). Others, such as vegetable acids, bitter principles, and resins, are more limited in their distribution. All of these substances, except cellulose and starch, which are organized, and gum, which is amorphous, are crystalline when they can be got in a solid state. Those unazotized matters, which are still subject to the law of crystallization, do not take part in the formation of tissues. Starch and cellulose, on the other hand, are concerned in the development of the organized parts of plants, but in order to effect this, they require the addition of certain azotized products as well some inorganic matters. Cells and vessels cannot be formed without the presence of albuminous matter, which contains nitrogen and sulphur in its composition, and which cannot be produced without the presence of phosphates. The physico-vital energies of the plant effect the union of carbon, oxygen, and hydrogen, in different

proportions. These elements, existing in certain states of combination in the atmosphere, are within the reach of plants at all times.

504. *Carbon* enters largely into the composition of plants. It is said to form two-thirds of the weight of dried plants in general. This substance is familiar to us in the form of wood-charcoal, and in its purest state it is seen in the diamond. Charcoal is porous, and has the power of absorbing soluble gases in large quantity, of separating saline and other matters from solutions, and of taking away disagreeable odours. When combined with two equivalents of oxygen, carbon forms carbonic acid (CO_2), and it is in this condition that it is taken up by the leaves and other parts of plants. Some maintain that this carbonic acid is derived by plants entirely from the atmosphere, which contains about 1-1000th of its volume of the gas. The quantity contained in the air, although it appears small when compared with the whole bulk of the atmosphere, is nevertheless sufficient to supply all the carbon of plants. A room 40 feet long, 24 feet wide, and 16 feet high, will contain in its atmosphere 15 cubic feet of carbonic acid, equal to 28 ounces by weight of carbon. The leaves of plants have a great power of absorbing carbonic acid. Boussingault proved this by passing air containing the usual proportion of carbonic acid over a vine leaf. Even by coming for a few seconds into contact with the leaf, the air was deprived entirely of its carbonic acid. The carbonic acid in the atmosphere is derived from various sources. Amongst the most evident of these are — 1. The respiration and transpiration of man and animals. 2. The decomposition of dead animal and vegetable matter. 3. Various processes of combustion on the surface of the earth. 4. Volcanic action going on in the interior of the earth in different countries.

505. The function of respiration in animals consists in the giving out of carbonic acid, or, in other words, the oxidation of carbon, while the great function of vegetables is the elimination of oxygen or the deoxidation of carbonic acid. The two processes are antagonistic, and a balance is kept up between the carbonic acid given off by animals, &c., and the oxygen given out by plants. A grown person is said to give off 3½ lbs. of carbon in a day, and every pound of carbon burnt or oxidized yields more than 3½ lbs. of carbonic acid. While active volcanoes give out carbonic acid, there are also extinct ones which do so. The soil in the country on the Rhine, to the south of Bonn, gives out carbonic acid; and all the waters in that district are charged with it. The carbonic acid of coal arises from the decay of vegetable matter.

506. When plants decay they furnish to the soil a large supply of carbon in the form of *humus* or common vegetable mould. This cannot be taken up directly as food by plants, but it is acted on by air and moisture, and undergoes certain changes by which a portion of carbonic acid is probably formed. It also has the power of absorbing gases, such as ammonia, and sulphuretted hydrogen, as well as saline

substances, and of making them available for the use of plants. Humus is transformed into humic, geic, and apocrenic acids, and these combine with various matters in the soil so as to aid in the nutrition of plants. The carbonic acid in the soil, according to Liebig, is not the source whence plants derive their carbon. He thinks that it acts chiefly in dissolving the carbonates and phosphates of magnesia and lime in the soil, and in forming bicarbonates of potash and soda.

507. *Oxygen* is another organic element of plants. It is known to us in a gaseous state as forming 21 per cent. of the bulk of the atmosphere, and as supplying materials for respiration and combustion. When one atom of oxygen is combined with one of hydrogen, water is formed, and carbonic acid is the result of the union of one atom of oxygen with two of carbon. In its combinations with metals and metalloids, oxygen forms a large proportion of the solid materials of the globe. Johnston says, that "nearly one-half of the weight of solid rocks of the globe, of every solid substance around us, of the houses in which we live, of the stones on which we tread, and of the soils we cultivate, and much more than one-half by weight of the bodies of all living animals and plants, consist of this elementary body." All the oxygen in plants seems to be derived from carbonic acid and water. No vegetable contains more oxygen than can be accounted for by these two sources.

508. *Hydrogen* is another element of plants which is known to us in the state of a gas. It does not, however, occur free and in a simple state in nature. It exists in small quantity in animal and vegetable substances, forms 1-9th of the weight of pure water, and enters into the composition of coal. The hydrogen of plants is derived from water. As carbonic acid and water therefore exist at all times, more or less, in the atmosphere, it appears that the air is the source whence plants procure the *carbon*, *oxygen*, and *hydrogen*, which enter so largely into their composition. At the same time, it cannot be denied, that these elements also exist in the soil, and may be taken up by the roots of plants in the form of carbonic acid and water.

509. It will be seen, by the following tabular view, taken from an extended one given by Dr. Gregory,* that it is easy to derive the non-azotized vegetable products (*i.e.*, the products consisting of carbon, oxygen, and hydrogen), from carbonic acid (CO_2), and water (HO), by a process of deoxidation; and as this process is constantly going on in every plant, by means of which oxygen is given out, we may conjecture that it is in this way that the products are formed. In the Table it will be perceived, that there are seven groups, forming successive stages in the scale of deoxidation, at one end of which stand carbonic acid and water, and at the other the non-oxygenated volatile oils; and it is evident also, that the members of one group may be converted into those of the succeeding one by the removal of oxygen, with or without the addition of water :—

* Gregory's Handbook of Organic Chemistry, p. 460

SUBSTANCE FORMED. Name.	Formula.	Carbonic Acid used in Equivalents.	Water used in Equivalents.	Oxygen separated in Equivalents.
A. Soluble Vegetable Acids. The Oxygen given off is less than that of Carbonic Acid.				
1. Oxalic acid (dry)	$C_2\ H\ O_4$ ...	2	1	1
2. Gallic acid (cryst.)	$C_7\ H_3\ O_5$ ...	7	3	12
3. Tartaric acid (do.)	$C_8\ H_6\ O_{12}$ ...	8	6	10
4. Malic acid (do.)	$C_8\ H_6\ O_{10}$ ...	8	6	12
5. Citric acid (do.)	$C_{12}\ H_8\ O_{14}$ ...	12	8	18
6. Meconic acid (do.)	$C_{14}\ H_4\ O_{14}$ ...	14	4	18
In this group the Oxygen exceeds the Hydrogen.				
B. Mild Neutral Bodies. The Oxygen of the Carbonic Acid is given off.				
7. Starch	$C_{12}\ H_{10}\ O_{10}$ ...	12	10	24
8. Cane Sugar and Gum	$C_{12}\ H_{11}\ O_{11}$ ...	12	11	24
9. Grape Sugar, dry	$C_{12}\ H_{12}\ O_{12}$ ...	12	12	24
10. Cellulose	$C_{12}\ H_8\ O_8$ ...	12	8	24
In this group the Oxygen and Hydrogen are in the proportion to form water. They may be viewed theoretically as composed of Carbon plus *water.*				
C. Bitter, Acrid, and Coloured Principles. The Oxygen of the Carbonic Acid, and a part of that of the Water, is given off.				
11. Meconine	$C_{10}\ H_5\ O_4$ ...	10	5	21
12. Parietine	$C_{10}\ H_8\ O_3$ ...	10	8	25
13. Salicine	$C_{26}\ H_{18}\ O_{14}$ ...	26	18	56
14. Pectine	$C_{28}\ H_{20}\ O_{26}$ ...	28	20	50
In this group the Hydrogen exceeds the Oxygen.				
D. Fragrant Oxygenated Volatile Oils, and Volatile Acids related to them. Still more Oxygen is given off.				
15. Oil of Anise	$C_{16}\ H_8\ O_4$ ...	16	8	36
16. Oil of Cinnamon.........	$C_{18}\ H_8\ O_2$ ...	18	8	42
E. Oily and Fatty Volatile Acids. In these the greater part of the Oxygen is given off both from the Carbonic Acid and from the Water.				
17. Valerianic acid	$C_{10}\ H_{10}\ O_4$ ...	10	10	26
18. Œnanthylic acid	$C_{14}\ H_{14}\ O_4$ ...	14	14	38
19. Myristic acid............	$C_{28}\ H_{28}\ O_4$ ...	28	28	80
20. Bassic acid................	$C_{36}\ H_{36}\ O_4$ ...	36	36	104
21. Melissic acid	$C_{60}\ H_{60}\ O_4$ ...	60	60	176

SUBSTANCES FORMED.		Carbonic Acid used in Equivalents.	Water used in Equivalents.	Oxygen separated in Equivalents.
Name.	Formula.			
F. Resins and Camphors. In these very little Oxygen is left.				
22. Many resins	$C_{10} H_7 O$ ...	10	7	26
23. Camphor	$C_{10} H_8 O$ ...	10	8	27
24. Borneo Camphor	$C_{20} H_{18} O_2$ ...	20	18	56
25. Many resins	$C_{20} H_{14} O_2$ ...	20	14	52
G. Non-Oxygenated Volatile Oils. No Oxygen left.				
26. Oil of Lemons, &c.......	$C_5 H_4$	5	4	14
27. Oil of Turpentine, &c.	$C_{10} H_8$	10	8	28
28. Oil of Juniper, &c.......	$C_{15} H_{12}$	15	12	42

510. By examining the table, it will be seen that we can procure various vegetable products in succession from carbonic acid and water by a constant loss of oxygen. Beginning with oxalic acid, for instance, we procure it from two equivalents of carbonic acid and one of water, with the loss of one equivalent of oxygen :—

$$\begin{array}{lcl} \text{Thus two equivalents of Carbonic Acid} & = & C_2 \quad O_4 \\ \text{One equivalent of Water} & = & \quad H\ O \\ \hline & & C_2\ H\ O_5 \end{array}$$

and taking away one of oxygen, we have $C_2 H O_4$ an equivalent of oxalic acid, which exists in combination with lime and potash in many plants, such as Rhubarb, Rumex acetosa and Acetosella, Oxyria reniformis, and Oxalis Acetosella. By a still farther separation of oxygen, we account for the formation of tartaric acid in the grape and tamarind; malic acid in the apple and gooseberry; citric acid in the orange, lemon, lime, and red currant; gallic acid in the seeds of the mango; meconic acid in the opium poppy, and so on. As the loss of oxygen is greater, we pass from acids to neutral substances, such as cellulose, starch, gum, and sugar, which are very abundant products of plants (pp. 31 to 34). In them the oxygen given off is equal to that in the carbonic acid. These neutral substances seem to be steps in the scale between the acids and other vegetable products. Sugar may also be derived from any of the acids by addition of water and separation of oxygen. Thus, citric acid, $C_{12} H_8 O_{14} + 4 H O - O_6 = C_{12} H_{12} O_{12}$ or dry grape sugar. Again, cellulose, of which the membrane of cells and vessels is composed, may be derived from grape sugar by losing a certain proportion of water. By a still further deoxidation, we arrive at bitter, acrid, and coloured or colouring substances, as meconine in opium, salicine in Willows, and pectine in pulpy fruits ; next we reach fragrant oxygenated volatile oils, as oils of Cinnamon and Anise ; then volatile, oily, and fatty acids, as valerianic acid in Valerian and Viburnum Opulus, myristic acid in Nutmeg, bassic acid in the butter-tree of Africa, and melissic acids in plants yielding wax; then resins and camphors found in many coniferous plants, in the Camphora officinarum, and Dryabalanops Camphora; and, finally, to carbo-hydrogens, in which there is no oxygen, as oils of lemon, turpentine, and juniper.

2. NITROGENOUS OR AZOTIZED CONSTITUENTS, AND THEIR ELEMENTS.

511. Another class of substances found in the tissues of plants, and essential to the process of vegetation, consists of carbon, hydrogen, oxygen, and *nitrogen* (N), with the addition of *sulphur* (S), and alkaline or earthy phosphates. They are commonly called *Nitrogenous* or *Azotized* or *Azoto-sulphurized* substances.* Some authors include them under the general name of Mucus or Protoplasm. The constituents of these organic matters are known by the names of vegetable albumen, fibrine, and caseine. The general name of gluten is given to the glutinous part of wheat which remains after the starch and soluble constituents of the grain have been removed. This gluten consists usually of fibrine and albumen. Wheat contains from 8 to 24 per cent. of gluten ; barley 3 to 6 ; oats 2 to 5.

512. Nitrogen enters largely into the composition of the tissues of animals, and hence it must be supplied to them in their food. Without the presence of azotized compounds, no blood nor muscle can be formed. Hence the quantity of these compounds in plants, along with phosphates which form bone, indicates their blood-forming or sanguigenous value. Nitrogen is known to us as a gas forming 79 volumes per cent. of the atmosphere, and moderating the effect of oxygen on all oxidable bodies. Like hydrogen, it is sparingly soluble in water. It enters into combination with hydrogen, and forms ammonia, composed of 1 equivalent of nitrogen and 3 of hydrogen (NH_3). Ammonia is given off during the decay of animal tissues, in the form of a pungent vapour, which is readily absorbed by water, and also in combination with other substances, such as carbonic acid and sulphuretted hydrogen. The nitrogen of the air may also, as some think, combine with hydrogen in the soil, and form ammonia. The presence of ammonia in the atmosphere was determined by Saussure in 1806. M. Ville has recently stated that the nitrogen of the air is assimilated by plants, but his observations have not been confirmed.† Daubeny, for in-

* Liebig on the azotized nutritive principles of plants.—Annalen der Chemie und Pharmacie, Aug. 1841, translated in Taylor's Scientific Memoirs, vol. iii. 244.

† See Ville's remarks in Comptes Rendus for 1852.

stance, does not believe in the assimilation of the nitrogen of the air by plants.

513. The atomic composition of these azotized matters is by no means fully ascertained. The following, according to Gregory, is their approximative composition :—

	C.	H.	N.	S.	O.	Total Atoms.
Albumen .	216	169	27	2	68	482 besides phosphates.
Fibrine .	216	169	27	2	68	482 besides phosphates.
Caseine .	288	228	36	2	90	544 besides phosphates.

All these substances are sanguigenous or blood-forming, and they are all putrescible. Fibrine coagulates spontaneously, albumen coagulates by heat, and caseine by acids. Vegetable albumen is isomeric with the albumen of blood and the fibrine of muscles. The albumen of eggs differs in having three in place of two atoms of sulphur. Fibrine acts as a ferment, and converts starch into sugar ; in this state it has sometimes received the name of diastase, which, however, is not a distinct substance. Caseine also acts as a ferment and converts sugar into lactic acid. The emulsine of Almonds and the emulsive body in Mustard, appear to be varieties of caseine. Leguminous seeds, such as peas, grown in dark cellars, according to Liebig, contain much asparagine, a nitrogenous substance derived from malic acid and ammonia by the loss of hydrogen and oxygen—caseine in this case acting as a ferment. It appears that these nitrogenous matters are concerned both in germination and in the process of vegetation.

514. In order that this azotized matter may be formed, plants must have a supply of nitrogen as well as sulphur and phosphates. The two latter are derived from the soil, in the form of soluble compounds of sulphuric and phosphoric acids, while the former is derived, according to Liebig, not from the nitrogen of the air, but from the ammonia diffused through it. This ammonia constitutes only 1-10,000th of the bulk of the air at the utmost ; it is usually much less. Dr. Anderson says 100 lbs. of atmospheric air contain 77 lbs. of nitrogen, and not more than $\frac{1}{4}$ of a grain of ammonia. Still this has been shown to be sufficient for the supply of nitrogen to plants. Ammonia is returned to the air during the processes of putrefaction which go on in dead animals and plants, as well as in the excreta of the former, such as the urine. It is also yielded by transpiration. Thus ammonia is continually sent into the atmosphere, and by the constant movement of the air the supply is diffused. Ammonia is also absorbed by the soil, and may thus be rendered available for the use of plants. It is known also that in some instances volcanic action gives rise to the formation of ammonia.

515. Daubeny believes that the ammonia, as well as the carbonic acid which formed the food of the first plants, was produced, not by processes of animal decay, but by such as were proceeding within the globe prior to the creation of living beings, and that the disengage-

ment of both these compounds has been going on slowly and continually from the earliest period to the present time. While the evolution of carbonic acid indicates perhaps nothing more than the operation of subterranean heat, the escape of atmospheric air deprived of a portion of its oxygen seems to imply that the heat originates in internal combustion, by which oxygen is absorbed; and the disengagement of ammonia may lead us to presume that this combustion is connected with the decomposition of water, which alone can be supposed to supply the hydrogen necessary to form the ammonia with nitrogen. Volcanic action may, he says, cause nascent hydrogen under great pressure to be brought into contact with nitrogen, and thus produce ammonia. He considers the supply of these substances as due to the effect of volcanoes. The eminent fertility of the soil near Naples is to be attributed, he thinks, not merely to alkalies present in the volcanic material of which it is made up, but also to the slow disengagement of ammoniacal salts as well as carbonic acid from crevices in the mountain. These, by furnishing nitrogen and carbon, supersede in some degree the necessity for animal manure. The soil in this favoured spot, the Terra del Lavoro, no doubt also contains a portion of earthy phosphates, and thus may yield an uninterrupted succession of corn crops, repeated as often as the disintegration of the substratum permits, so long as the volcanic processes in progress beneath it continue to send forth volumes of the gases alluded to. The superior quality of the wheat grown in this part of Campania may, perhaps, be thought to confirm such a conjecture. It would appear that the flour of warm climates in general, contains more gluten than that of colder ones, perhaps because heat promotes the decomposition of organic matter, and consequently renders the supply of ammonia more abundant; and to this circumstance its superior fitness for the manufacture of macaroni is attributed.

516. Others think that part of the nitrogen of plants is derived from nitric acid and nitrates, and this view is gaining ground. Nitric acid is produced during thunder storms, and in the rain which falls during these storms this acid has been detected in small quantities. The nitric acid in these instances probably proceeds not only from a combination between the nitrogen and oxygen of the air, but also from a combination between the ammonia and oxygen. The minute quantity of nitric acid and nitrates in some springs may also supply nitrogen. The nitric acid in these instances appears to proceed from the decay of animal matter, and from the oxidation of ammonia. M. Barral has recently shown that nitric acid exists in considerable quantity in rain water. In the rain guages of the Paris Observatory he found that the monthly average quantity of nitric acid was 294 grains in a cubic metre,* while that of ammonia was only 55.7 grains. Rain water is thus shown to be an important source of nitrogen for plants.

517. All the azotized matters to which we have alluded are formed by a process of deoxidation from carbonic acid (CO_2), water (HO),

* A metre is equal to 3.2808992 feet.

hydrated ammonia (NH_3HO), nitric acid (NO_5), and sulphuric acid (SO_3). They all contain much less oxygen than is necessary to convert their hydrogen into water, their carbon into carbonic acid, and their sulphur into sulphuric acid. They are never found alone in plants, but generally two of them together. They cannot exist without the presence of phosphates. Hence the ashes of plants are in part derived from the sanguigenous matters, such as albumen and fibrine, which enter along with cellulose into the composition of the cell-walls.

518. The first nitrogenous compounds which are formed in the plant, according to Dr. Gregory, are amides, such as malamide (asparagine), which appears in great abundance in the first young shoots of the *Leguminosæ*, and in etiolated (blanched) plants, such as asparagus and peas or vetches grown in the dark. It is formed from malic acid and ammonia (malate of NH_3), by the separation of two equivalents of water. In the same way many other amides are, in all probability, also formed. The next class of nitrogenous substances are the alkaloids. We cannot yet trace the actual formation of these in the plant; but we have reason to think that they are formed in different ways. They may, however, be formed from carbonic acid, water, and ammonia, or nitric acid, by separation of oxygen. The next class of nitrogenous compounds is the oils containing nitrogen and sulphur, of which oil of mustard is the best known; and the last class is the sanguigenous bodies, vegetable albumen, fibrine, and caseine, which contain both nitrogen and sulphur as well as phosphates. Supposing these to be directly formed from the food of plants, they may be produced from carbonic acid, water, and ammonia, by separation of oxygen.

519. The latter bodies may also be formed from dry grape sugar, ammonia, and sulphuric acid. The following table by Gregory,* shows that the various azotized substances in plants may be formed, like the non-azotized, from the materials used for their food, by a constant process of deoxidation :—

SUBSTANCE FORMED.	FORMULA.	CO_2 used in Equivalents.	HO used in Equivalents.	NH_3 used in Equivalents.	O given off in Equivalents.
	AMIDES.				
Malamide (asparagine)...	$C_8\ N_2\ H_{10}\ O_8$	8	4	2	12
Amygdaline	$C_{40}\ N\ H_{27}\ O_{22}$	40	24	1	82
	BASES.				
Morphine	$C_{35}\ N\ H_{20}\ O_6$	35	17	1	81
Strychnine..................	$C_{44}\ N_2\ H_{22}\ O_4$	44	16	2	106
Quinine	$C_{20}\ N\ H_{12}\ O_6$	20	9	1	43
Caffeine	$C_{16}\ N_4\ H_{10}\ O_4$	16	0	6	28
Nicotine......................	$C_{10}\ N\ H_8$	10	8	1	28
Coniine	$C_{16}\ N\ H_{16}$	16	16	1	48

* See Gregory's Handbook of Organic Chemistry, p. 472.

These azotized or nitrogenized compounds contain nitrogen without sulphur, and they may be formed from acids or sugar acting on ammonia with deoxidation—the acids or sugar having been previously formed from carbonic acid and water by deoxidation. The next class of nitrogenous compounds is that of the oils containing nitrogen and sulphur, of which oil of mustard is the best known. To understand its formation, we must explain that of oil of garlic, which contains sulphur, but no nitrogen :—

SUBSTANCE FORMED.	FORMULA.	CO_2 used in Equivalents.	SO_3 used in Equivalents.	HO used in Equivalents.	NH_3 used in Equivalents.	O given off in Equivalents.
Oil of Garlic (sulphuret of Allyle)	$C_6\ H_5\ S$	6	1	5	...	20
Oil of Mustard (sulphocyanide of Allyle)	$C_8\ N\ H_5\ S_2$	8	2	2	1	24

The last and most complex of the nitrogenous bodies are the albuminous or sanguigenous compounds, vegetable albumen, fibrine, and caseine, which contain both nitrogen and sulphur. Their formulæ have already been given in an approximate manner. Supposing them to be directly derived from the food of plants, they may be formed thus :—

SUBSTANCE FORMED.	FORMULA.					CO_2 used in Equivalents.	HO used in Equivalents.	NH_3 used in Equivalents.	SO_3 used in Equivalents.	O given off in equivalents.
	C	H	N	S	O					
Albumen and Fibrine ...	216	169	27	2	68	216	88	27	2	454
Caseine	288	228	36	2	90	288	120	36	2	612

520. The value of plants, as food for man and animals, depends chiefly on the organic matter contained in them, and more especially on the amount of nitrogenous compounds, which, however, are always associated with the alkaline and earthy phosphates so indispensable to the growth of all animals. The following table of analyses by Dr. Lyon Playfair gives the amount of organic matter in different articles of vegetable food :—

ARTICLES OF FOOD.	Dry Organic Matter, or Real Food.	The Portions subtracted as *useless* are—	
		Water.	Ashes.
	Lbs.	*Lbs.*	*Lbs.*
100 lbs. of ordinary hay contain	76½	16	7½
„ Linseed cake	75½	17	7½
„ Peas	80½	16	3½
„ Beans	82½	14	3½
„ Wheat straw	79	18	3
„ Barleymeal	82½	15½	2
„ Oatmeal	89	9	2
„ Bran	81	14	5
„ Oats	79	18	3
„ Lentils	81	16	3
„ Potatoes	27	72	1
„ Red beet	10	89	1
„ Turnips	10	89	1
„ Swedes	14	85	1
„ White carrot	12	87	1
„ Mangold wurzel . .	10	89	1

Fromberg, taking into account the nitrogenous matter chiefly, gives the following comparative values of different articles of vegetable food:—

Beans	100	Rye	55
Peas	80	Barley	50
Oats	75	Potatoes	45
Wheat	70	Rice	35

521. Dr. Anderson has made experiments on the nutritive values of the most important kinds of food used for cattle. In these experiments the proportions of nitrogen and oil, which are by far the most valuable of the nutritious elements, have been selected as the means of comparison, as will be seen in the following table:—

In a Ton of	Nitrogen.	Oil.	In a Ton of	Nitrogen.	Oil.
Linseed, English	97 lbs.	777 lbs.	Peas	77 lbs.	29 lbs.
„ Foreign	76 „	715 „	Oats	60 „	— „
Oil Cake	103 „	224 „	Barley	42 „	— „
Poppy Cake . . .	110 „	129 „	Oat Dust	27 „	83 „
Rape Cake	105 „	223 „	Turnips	4¼ „	7 „
Beans	85 „	32 „	Distillery Draff . .	5½ oz.	— „

All these are what may be called oleaginous foods, but there are also others, in which the quantity of oil is deficient, but in which there is abundance of nitrogen and of starchy and saccharine matters. Beans and peas are the most important and valuable of these, and after them follow oats, barley, and the other grains.

522. Thus we have considered the most important elements which enter into the composition of the nitrogenous and non-nitrogenous organic constituents of plants. They can be derived from the atmosphere in the form of water, carbonic acid, nitric acid, and ammonia, and they may be termed the atmospheric food of plants. The soil, however, contributes in a certain degree to the formation of these organic matters, more especially by supplying sulphuric acid and phosphates. Boussingault, Wiegmann, and Polstorff, found that plants placed in a soil deprived completely of all organic matter, continued to grow for some time deriving their organic constituents from air and distilled water.

II. INORGANIC CONSTITUENTS OF PLANTS.

523. The *terrestrial* or *telluric food* of plants, as it is termed, consists chiefly of certain *inorganic* matters, the amount of which is ascertained by the ash left after burning. While the organic constituents of plants are destroyed by a high temperature, and undergo decay under the agency of moisture and warmth, the inorganic constituents are incombustible, and do not undergo the putrefactive process. There are at least 12 inorganic elements which enter into the composition of plants:—

Sulphur, S, as Sulphuric acid, SO_3.
Phosphorus, P, as Phosphoric acid, PO_5.
Silicium, Si, as Silicic acid, SiO_3.
Calcium, Ca, as Lime, CaO.
Magnesium, Mg, as Magnesia, MgO.
Potassium, K, as Potassa, KO.
Sodium, Na, as Soda, NaO.
Chlorine, Cl, in combination with metals.
Iodine, I, do. do.
Fluorine, F, do. do.
Iron, Fe, in combination with oxygen, Fe_2O_3.
Manganese, Mn, do. MnO.

Alumina (Al_2O_3), the sesquioxide of Aluminum, which has been noticed by some authors as another inorganic constituent of plants, seems to be an accidental ingredient, being sometimes present, and at other times absent. Mr. Stevenson Macadam has recently obtained indications of the presence of Bromine (Br.) in plants.*

524. The quantity of inorganic matter in plants is small when compared with the organic constituents. It is nevertheless essential to the life and vigour of plants. The cell-walls cannot be formed without inorganic matters, and some of them enter into the composition of the azotized substances formed by plants. Thus sulphur and salts of phosphoric acid are necessary for the formation of albumen, fibrine, and caseine. In some rare instances of plants forming mould, no ash has been detected.

525. The quantity of ash left by 100 parts of the following plants is thus given by Johnston :—

* Edinburgh New Philosophical Journal, vol. liii. p. 324.

	Grain.	Straw.		Grain.	Straw.
Wheat . .	1.2 to 2.0	3.5 to 18.5	Rye	1.0 to 2.4	2.4 to 5.6
Barley . . .	2.3 to 3.8	5.2 to 8.5	Indian Corn	1.3	2.3 to 6.5
Oats	1.6 to 2.8		Field Peas	2.5 to 3.0	4.3 to 6.2

	Wood.	Leaves.		Wood.	Leaves.
Larch . . .	0.33	6.0	Birch	0.34	5.0
Scotch Fir	0.14 to 0.19	2.0 to 3.0	Elm	1.88	11.8
Beech . . .	0.14 to 0.60	4.2 to 6.7	Ash	0. 4 to 0.6	
Poplar . .	1.97	9.2	Oak	0.21	4.5
Willow . .	0.45	8.2			

Thus the quantity of inorganic matter in the same weight of different crops varies. It will be seen, for instance, that the grain of barley yields more ash than wheat or rye. The quantity of inorganic matter also in different parts of the same plant varies, as seen in the grain and straw of cereal grains, and the wood and leaves of trees.

526. It would appear by the following statements by Johnston, that the nature of the soil has a marked influence on the amount of inorganic matter in the plant :—

A. Analyses of Oats grown in different soils, as respects the quantity of ash.

	Straw.	Grain.
On Aberdeen Granite, crushed .	9.57 per cent.	3.42
On Clay Slate, do. .	7.85 "	3.51
On Greenstone, do. .	7.88 "	2.25
On Limestone, do. .	10.18 "	3.88
On Chalk, do. .	9.36 "	3.16
On Gypsum, do. .	5.83 "	3.22
On Siliceous Pit Sand .	6.37 "	2.91
On Blue Tile Clay .	9.21 "	3.27
On Light Loam .	8.79 "	3.06

B. Analyses of Vine Twigs as grown in different soils, showing the comparative quantities of different inorganic matters.

	Soil of Primary Rocks.	Mountain Limestone.	Mica Slate.
Potash .	34.13	24.93	26.41
Soda .	8.03	7.31	8.79
Lime .	32.67	37.59	33.47
Magnesia .	4.66	7.12	9.16
Oxide of Iron .	0.16	0.24	0.19
Phosphoric Acid	16.35	19.55	16.87
Sulphuric Acid	2.16	2.37	2.44
Chlorine .	0.50	0.35	0.25
Silica .	1.45	0.62	2.48
	100.11	100.08	100.06

527. The following are given by Johnston as the mean of experiments by different chemists in regard to the inorganic constituents

of 100 parts of some of the cultivated plants and trees. Alumina is left in the list, although it may be considered as an accidental ingredient :—

A. Inorganic Matter in some of the Cereal Grains.

INORGANIC CONSTITUENTS.	WHEAT.		BARLEY.		OATS.	
	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.
Potash	23.72	12.44	13.64	6.31	26.18	19.14
Soda	9.05	0.16	8.14	0.61		9.69
Lime	2.81	6.70	2.62	9.53	5.95	8.07
Magnesia	12.03	3.82	7.46	3.22	9.95	3.78
Oxide of Iron and Manganese	0.67	1.30	1.48	0.83	0.40	1.83
Phosphoric Acid	49.81	3.07	38.93	3.08	43.84	2.56
Sulphuric Acid	0.24	5.82	0.10	1.63	10.45	3.26
Chlorine	0.00	1.09	0.04	0.97	0.26	3.25
Alumina	0.00	0.00	0.21	1.39	0.06	0.00
Silica	1.17	65.38	27.10	70.58	2.67	48.42
	99.50	99.78	99.72	98.15	99.76	100.00

B. Inorganic Matter in some Cultivated Field Plants.

INORGANIC CONSTITUENTS.	FIELD BEAN.		Turnip Roots.	Potato Tubers.	Ryegrass Hay.	Red Clover.
	Seeds.	Straw.				
Potash	33.56	53.08	41.96	55.75	8.03	26.7
Soda	10.60	1.60	5.09	1.86	2.17	7.07
Lime	5.77	19.99	13.60	2.07	6.50	37.09
Magnesia	7.99	6.69	5.34	5.28	4.01	4.45
Alumina	0.56	0.22	1.28	0.52	0.36	0.20
Oxide of Iron		0.22				
Do. Manganese		0.16				
Phosphoric Acid	37.57	7.24	7.58	12.57	12.51	8.80
Sulphuric Acid	1.00	1.09	13.60	13.65	...	5.98
Chlorine	0.73	2.56	3.60	4.27	...	4.86
Silica	1.15	7.05	7.95	4.23	64.57	4.85
	98.93	100.00	100.00	100.20	98.15	100.00

C. Inorganic Matter in the Wood and Bark of different Trees.

INORGANIC CONSTITUENTS.	Oak Wood.	Beech Wood.	Elm.		Lime Tree.	
			Wood.	Bark.	Wood.	Bark.
Potash	8.43	15.83	21.92	2.22	35.80	16.14
Soda	5.65	2.88	13.72	10.09	6.03	5.69
Lime	75.45	63.33	47.80	72.70	29.93	60.81
Magnesia	4.49	11.29	7.71	3.19	4.14	8.03
Oxide of Iron	0.57	0.79	0.88	0.62	7.97	1.23
Phosphoric Acid	3.46	3.07	3.62	1.79	4.84	4.01
Sulphuric Acid	1.16	1.35	1.28	0.62	5.30	0.74
Chlorine	0.01	0.14	...	...	0.89	1.33
Silica	0.78	1.32	3.07	8.77	5.26	2.27
	100.	100.	100.	100.	100.16	100.25

528. The comparative results of such analyses are well seen in the following table by Johnston, by an examination of which we can detect the characteristic and predominating ingredients in certain plants :—

NAMES OF PLANTS.	Potash and Soda.	Lime.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Silica.
Wheat	33	3	12	59	0.25	1
Barley	22	3	7	39	0.10	27
Oats	26	6	10	44	11	3
Rye	34	5	10	50	1	0.4
Maize	33	1	16	45	3	1
Rice	30	1	12	53	0	3
Beans	44	6	8	38	1	1
Peas	44	5	8	33	4	0.51
Wheat Straw	13	7	4	3	6	65
Barley do.	7	10	3	3	2	71
Oat do.	29	8	4	3	3	48
Rye do.	18	9	2	4	1	65
Maize do.	35	8	7	17	0	28
Rice do.	14	0	5	1	4	74
Bean do.	55	20	7	7	1	7
Pea do.	5	55	7	5	7	20
Red Clover	36	33	8	8	3	7

NAMES OF PLANTS.	Potash and Soda.	Lime.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Silica.
Potatoes	57	2	5	13	14	4
Turnips	47	14	5	8	14	8
Beet	56	9	5	8	2	10
Cabbage	32	21	6	12	22	0.74
Potato Haulm	44	17	7	8	7	4
Turnip do.	34	23	3	9	13	1
Elm Bark	12	72	3	1.7	0.6	8
Elm Wood	35	47	7	3	1.2	3
Lime Bark	21	60	8	4	0.7	2
Lime Wood	41	29	4	4	5	5
Cherry Bark	23	44	5	3	0.8	21
Cherry Wood	36	35	11	9	4	2
Scotch Fir Seeds	23	2	15	45	...	10

529. From these tables it will be seen that the quantities of different mineral matters vary in different plants, and in different parts of the same plant. Silica is present in large quantity in the stems of grasses, while it forms usually a small proportion of grains, leguminous plants, and succulent roots. Phosphoric acid is more abundant in the grain of cereal plants than in the straw; it exists also in considerable quantity in nutritive seeds and in potatoes and turnips. Lime abounds in the stems of beans and peas, in clover, and in the bark and wood of trees; while it exists in small quantity in the cereal plants and grasses. The proportion of lime in the bark of trees is greater than in their wood. Potash and soda enter more largely into the composition of green crops than into that of white crops; they are also more abundant in the wood than in the bark of trees.

530. Most plants contain more or less of potash and soda in their composition. The former prevails in inland plants, the latter in maritime and marine plants. Some succulent sea-shore plants, such as Salsola Kali, and Salicornia herbacea, yield a large quantity of soda in their ashes. M. Göbel examined the halophytes, or alkali-yielding plants of the Caspian Steppe, and found that young plants gave more soda than old ones. The following are some of his results:—

	Per cent. Soda.		Per cent. Soda.
Salsola clavifolia (foliosa) young, dried	42	Salsola Kali, young . .	25
Tamarix laxa, young . . .	33.6	Halocnemum caspicum, do.	22.9
Salsola brachiata, do. . . .	33	Anabasis aphylla, do. . . .	19
Halimocnemis crassifolia, do.	30	Kochia sedoides, old . . .	9.16

Some species of plants which grow both in maritime and inland situations contain a preponderance of soda in the former locality, and of potash in the latter. This is the case with the common Sea-pink (Armeria maritima), Scurvy-grass (Cochlearia officinalis), and sea-side Plantain (Plantago maritima). Dr. Voelcker analysed the ashes of the Sea-pink grown in different localities near Edinburgh—on the sea shore, on elevated trap rock, and on light sandy soil in Mr. Lawson's nursery, as well as specimens grown on rocks on the mountains of Braemar. He found the proportion of alkaline chlorides, as well as that of silica, considerable; the quantity of soda was more abundant in the ash of specimens grown near the sea-shore; soda was entirely replaced by potash in the ash of the plant grown in the nursery. The proportion of magnesia in the natural state was greater than in the cultivated condition. In the Braemar specimens lime seemed in part to replace the alkaline salts.*

531. The presence of lime has been detected in almost all plants. It is an abundant ingredient of the soil, and is often associated with magnesia. In combination with phosphoric acid, it is an essential ingredient of the nitrogenous matter of cereal grains, and of many other cultivated plants. As sulphate it occurs largely in some of the Charas and Medicks. It sometimes appears as an encrustation on the cells of plants, in the form of carbonate. This is seen in species of the genus Chara (especially Chara hispida) which grow in ponds (p. 354). In the interior of cells it is often seen in a crystalline form, constituting Raphides (p. 37). Oxalate of lime crystals occur in Rhubarb root; in the best Turkey Rhubarb they constitute 35 per cent. of the dried tissue, in East India Rhubarb 25 per cent., and in English Rhubarb 10 per cent. In some of the Cactus tribe (Fig. 88, p. 37), especially in old specimens of Cereus senilis, these crystals are so numerous as to render the stem brittle. Crystals of phosphate, sulphate, carbonate, tartrate, malate, and citrate of lime also occur in the cells of plants.

532. The presence of silica (SiO_3) in plants gives solidity and firmness to their stems. The quantity in some plants (p. 330) is very large.

Thus, the ashes of	Equisetum limosum	contain	94.85	per cent. of Silica.
„	Equisetum arvense	„	95.48	„
„	Equisetum hyemale	„	97.52	„
„	Calamus Rotang	„	97.20	„

In these plants, as well as in grasses, the silica exists in the form of small plates, grains, or needles, as may be shown by the action of sulphuric acid. In the Bamboo (Bambusa arundinacea, and other species) the quantity of silica at the joints is frequently very large, and may be collected in masses, to which the name of Tabasheer is

* See Voelcker's Paper in the Transactions of the Botanical Society of Edinburgh.—Annals of Nat. History, 2d series, vol. vii. p. 266.

given. In the Diatomaceæ, belonging to the lowest tribe of Algæ, the cells have a siliceous covering, which enables them to retain their form, even after being acted on by strong acids. Dr. George Wilson finds that in many siliceous plants fluorine also exists in marked quantity.

533. Iodine was considered formerly as an ingredient of maritime and marine plants only, but it has been recently detected in fresh-water plants, as well as in many ordinary land plants, by Chatin,* and by Macadam.† The following are some of the plants in which iodine has been found:—Water-cress, Marsh Marigold, Water Lily, Common Reed, Forget-me-not, Water Mint, Iris, Digitalis, Oak, Beech, Birch, Common Ferns, Mosses and Lichens, species of Juncus, Carex, Potamogeton, Ranunculus, Veronica, Senecio, Alchemilla, Galium, &c. Chatin says that iodine is more abundant in plants which grow in running waters than in those of stagnant pools, and that occasionally plants which contain iodine when growing in water, lose it when they are developed in dry places. The experiments of Dickie ‡ and Voelcker § lead to the conclusion that plants which contain iodine when growing on the sea shore, lose it when they occupy an inland situation.

534. The presence of fluorine in plants was first detected by Will of Giessen, and his observations have been confirmed and greatly extended by Dr. George Wilson.¶ It occurs in small quantity in plants, and it is often associated with silica, from which it is separated with great difficulty. Plants growing on the sea-shore, such as Sea-pink and Scurvy-grass, have been proved by Voelcker to contain fluorine. The test for the presence of fluorine is the etching which hydrofluoric acid produces on glass. The following are some of Wilson's results:—

Table of Plants in which Fluorine has been found. The numbers represent grains of ashes. The blanks imply that the weight was not known.

Ashes in Grains.	Name of Plant.	Indication of Fluorine.
200	Smooth naked Horse-tail (Equisetum limosum)	Distinct etching.
	Common Bamboo (Bambusa arundinacea) .	do.
	Charcoal (derived chiefly from Oak, and to a smaller extent from Birch) . . .	do.
	Coal	do.
	Barley Straw	do.
	Hay (Rye-grass)	do.
35	Variegated rough Horse-tail (Equisetum variegatum)	Faint etching.

* Chatin, various Papers in Comptes Rendus, vols. xxx. to xxxv.

† S. Macadam, Trans. Bot. Soc. Edin., in Annals of Nat. Hist., 2d series, xi. 231.—Edin. New Philosophical Journal, vol. liii. p. 315.

‡ Dickie, Trans. Bot. Soc. Edin., in Annals of Nat. History, 1st series, xi. 74.

§ Voelcker, Trans. Bot. Soc. Edin., in Annals of Nat. History, 2d series, vii. 266.

¶ Wilson, Trans. Bot. Soc. Edin., in Annals of Nat. Hist., 2d series, xi. 228.

Ashes in Grains.	Name of Plant.	Indication of Fluorine.
19	Dutch Rushes or Rough Horse-tail (Equisetum hyemale)	Faint etching.
255	Marsh Horse-tail (Equisetum palustre) .	do.
	Tussac-grass (Dactylis cæspitosa) . .	do.
99	Sea Lyme-grass (Elymus arenarius) . .	do.
495	Sugar Cane (Saccharum officinarum) . .	do.
1040	African Teak (Oldfieldia africana) . .	do.

535. The siliceous stems which were found to abound most in fluorine, were exactly those which contained most silica. In particular, deep etchings were procured from the Equisetaceæ (horse-tails), and from the Gramineæ (grasses), especially the common Bamboo. The last is known to contain silica in such abundance, that it collects within the joints in white masses, nearly pure. The Horse-tails are scarcely less remarkable, for the amount of silica contained in their stems, which has led to the employment of one of them (Dutch rush, Equisetum hyemale), in polishing wood and metals. The African Teak, which like the Bamboo is known sometimes to secrete silica, is also found to contain fluorine, though much less largely than the plants named ; whilst the strongly siliceous stems of barley and rye-grass also yield the element in marked quantity. The Sugar-cane, however, gives less striking results than might have been expected, and the same remark applies to the Malacca-cane. Dr. Wilson's general conclusions are as follows :—1st. That fluorine occurs in a large number of plants. 2d. That it occurs in marked quantity in the siliceous stems of the Gramineæ and Equisetaceæ. 3d. That the quantity present is in all cases very small, for although exact quantitative results were not obtained, it is well known that a fraction of a grain of a fluoride, will yield, with oil of vitriol, a quantity of hydrofluoric acid sufficient to etch glass deeply, so that the proportion of fluorine present even in the plant ashes which contain it most abundantly does not probably amount to more than a fraction per cent. of their weight. The proportion of fluorine appears to be variable, for different specimens of the same plant did not yield concordant results. In this, however, there is nothing anomalous, for some Bamboos yield Tabasheer largely, whilst others are found to contain none. It seems not unlikely that soluble fluorides ascending the siliceous stem of a plant, on their way to the seeds or fruits in which they finally accumulate, may be arrested by the silica, and converted into insoluble fluosilicates (fluorides of silicon and of a metal) ; and a Bamboo, for example, secreting Tabasheer, may effect this change where one less rich in silica cannot determine it. The slow or quick drying of a stem may also affect the fixation of fluorides in the stems or trunks of plants.

536. Plants derive all their inorganic materials from the soil, and it is consequently of importance to determine the composition of the latter. But, before proceeding to the consideration of soils, it may be

remarked that some plants are enabled to grow without coming into contact with the soil. Thus in the Botanic Garden of Edinburgh, Ficus elastica, Ardisia crenulata, Agave (Littæa) gemmipara, Billbergia nudicaulis, and Phœnix farinifera, have continued to grow for nearly four years suspended in the air, and merely moistened by common water allowed to come into contact with the roots by the capillary action of a worsted thread. Ficus australis has grown suspended in the air for nearly twenty-five years. The plants have produced leaves and some of them flowers. They derive their organic nourishment from the air, and the quantity of inorganic matter in the water appears to be sufficient to supply their wants in that respect for a long period. What are called air-plants or Epiphytes, such as Tillandsias and Orchids, are usually attached to other plants, from the decaying bark of which they may derive inorganic matter. In hot-houses these Epiphytes have also a quantity of moss round their roots, which is another source of inorganic matter. Lichens seem to have the power, in many cases, of acting upon hard rocks, and deriving from them inorganic matters. Mulder states that mould plants found on the surface of saccharine and gummy solutions, as well as in vinegar and other organic substances, consist of cellulose and nitrogenous compounds, without any inorganic matter. These plants, according to him, leave no ash on being burnt.

III. COMPOSITION AND PROPERTIES OF SOILS AS SUPPLYING FOOD FOR PLANTS.

537. Having considered the various organic and inorganic matters which enter into the composition of plants and of vegetable products, and having noticed the chief sources whence plants derive their carbon, oxygen, hydrogen, and nitrogen, we shall now examine generally the nature of the soil, as the source whence the mineral or inorganic matters required for vegetable growth and nutrition are derived. We have seen that the atmosphere, with its carbonic acid, water, nitric acid, and ammonia, is capable of supplying the organic constituents of vegetables. At the same time we have found that sulphur and phosphates enter into the composition of some of the most important sanguigenous (blood-producing) products. To the salts of sulphuric and phosphoric acid in the soil, we must look, therefore, for the means of enabling plants to assimilate their organic products. While we allow that the atmosphere is the great reservoir whence the organic elements are derived, still we cannot consider it as the exclusive source. It is probable that some of the carbon, oxygen, hydrogen, and nitrogen of plants may be supplied by the soil, and at all events we have seen that these elements cannot be combined in the form of albumen, fibrine, and caseine, without certain mineral matters of telluric origin.

538. The atmospheric supply of food is pretty uniform, and is not

under the control of man. It is to the terrestrial (telluric) supply he must look as that which can be increased and modified by his efforts. The horticulturist and farmer direct their attention to the soil, and by alterations in its composition endeavour to effect changes in the plants which they cultivate. It is therefore of importance to ascertain the mechanical nature and chemical composition of the soil.

539. The following are the substances which enter generally into the composition of soils :—Silica, clay, lime, and humus or vegetable mould. According to the preponderance of one or other of these ingredients, soils are usually classified. Thus we have—

1. Sandy or siliceous soils, containing upwards of 80 per cent. of siliceous sand.
2. Clayey or argillaceous soils, containing above 50 per cent. of clay.
3. Calcareous soils, containing above 20 per cent. of lime.
4. Marly soils, in which the proportion of lime is more than 5 per cent., and does not exceed 20 per cent. of the whole weight of the dry soil, while that of the clay is more than 20 and less than 50 per cent.
5. Loamy soils, in which there is less than 5 per cent. of lime, while the clay varies from 20 to 50 per cent.
6. Humus soils, or vegetable moulds, which vary much in composition, from the garden mould which contains 5 to 10 per cent. of organic matter, to the peaty soil, in which it may be 60 or 70 per cent.

540. The presence of sand and gravel in soils renders them loose and friable. Such soils part with moisture easily, and are usually dry. When the proportion of sand is very large, the soils are barren and unproductive. Sprengel gives analyses of sandy soils containing from 90 to 98 per cent. of silica and quartz sand. The addition of clay, chalk, and marl, is useful in rendering sandy soils more tenacious. As silica enters more or less into the composition of plants, it must be taken up from the soil by the roots of plants. In order that this absorption may take place, the silica must be dissolved in water. In its uncombined condition it is insoluble, but by combining with alkalies such as potash, it forms soluble silicates, which enter the cells of plants.

541. Clayey soils contain a large quantity of insoluble silicates and of alumina, which does not appear to be an essential constituent of plants, although it is occasionally found as an accidental addition to their tissues. The presence of clay has a tendency to make soils stiff and firm, so that they can retain the roots of plants and give them support. Clay soils are usually moist, impervious, and cold. Heavy clay land is improved by draining, by burning, and by mixing chalk and sand with it. Mr. Way finds that clay in the soil removes various important matters from the manures put upon it, and does not allow the active ingredients to pass off into the drains. It retains the alkalies, as ammonia, potash, soda, and magnesia. If a quantity of ammonia highly pungent is thrown on a filter of clay, made permeable by

sand, the water which first comes away has no smell of ammonia. Solutions of potash and soda in a caustic state are by this means deprived of their alkalies. Quicklime, dissolved in water, according to Mr. Way, is removed by passing it through clay. Carbonate of lime is so effectually removed, that hard water may be rendered soft. Pure clay will absorb 2-10ths per cent. of its weight of ammonia, that is, 1000 grains would separate 2 of ammonia. The action of clayey soil in absorbing ammonia seems to be due to the presence of certain silicates. When ammonia is added, double silicates are formed, such as the silicate of alumina and ammonia, from which the ammonia is easily removed by carbonic acid, or by a solution of common salt. It may be in this state that silica is taken up by cereal crops, the silica being deposited in the straw.*

542. Calcareous soils contain, as has been stated, upwards of 20 per cent. of lime. This substance exists abundantly in the vegetable juices, and hence its presence is required in all productive soils. Calcareous soils exhibit different physical characters according to the proportion of lime, clay, silica, &c., which enter into their composition. Some of them are deep, loose, dry, and productive; others are shallow, stony, and not favourable for vegetation. The addition of lime to soils is often highly beneficial, by destroying noxious weeds, and by preventing disease in crops. Lime, in combination with phosphoric acid, is a valuable ingredient of soils. Sulphate of lime or gypsum seems to be useful not merely in supplying sulphuric acid and lime, but also in fixing ammonia. In marly soils lime exists in the proportion of 5-20 per cent. In their characters they resemble more or less calcareous or clay soils. They are less retentive and less impervious than clay soils, but usually not so open as many calcareous soils. When clay predominates clay-marl is formed; when siliceous sand replaces the clay the soil is called a sandy-marl. In loamy soils lime is in smaller quantity, and the clay does not exceed 50 per cent. In them sand, clay, lime, and humus are in a fine state of division and intimate mixture, so that they constitute excellent soils, and may be placed next to the richer garden moulds. Many fertile alluvial deposits are loamy soils. According to the preponderance of sand, clay, and lime, these soils are either sandy loams, clayey loams, or marly loams.

543. Humus soils contain much vegetable mould. This is in itself insoluble, and cannot be taken up by plants. By the action of air and moisture, &c., the humus is decomposed, and various acids are formed, which seem to be capable of supplying carbon to plants. Humic, ulmic, and geic acids, which are formed in the soil, consist of $C_{40}\ H_{12}\ O_{12}$, with the addition of 2 or more equivalents of water; so also apocrenic acid is composed of $C_{48}\ H_{12}\ O_{24}$, and crenic acid of $C_{24}\ H_{12}\ O_{16}$. Vegetable moulds also absorb gases, such as ammonia, in large quantity, and thus supply nutritive matter to plants. These

* Way, on the power of Soils to absorb Manures.—Journal of the Royal Agricultural Society of England, xi. 313; Gardener's Chronicle, May 22, 1852.

soils are clayey, loamy, or sandy, according to the predominant character of the earthy admixtures; and when the organic matter preponderates, they become peaty or boggy. Their fertility varies much according to their composition.

544. The alkalies, potash and soda, are important constituents of plants, and they exist in greater or less quantity in soils. They enter into the composition of minerals, such as felspar. They are taken up by plants in combination with acids. They render silica soluble, and they are essential to the development of acids, such as oxalic, citric, and malic, with which they are found in combination. They appear to replace each other in certain circumstances. In many fertile soils magnesia exists in combination with carbonic acid, phosphoric acid, and lime. Einhoff mentions a productive marl containing 20 per cent. of carbonate of magnesia. Sprengel mentions another containing 28 per cent. It appears, therefore, that carbonate of magnesia with silica in the soil has no prejudicial effect. In flax there is a large proportion of magnesia. In its caustic state magnesia is injurious to vegetation.

545. Iron has been detected in greater or less quantity in the ashes of all plants. It exists in the soil in combination with oxygen, sulphur, and carbon. The oxides of iron are found, more or less, in all soils, and the peroxide, which is the most abundant, imparts that reddish colour so often observed on the earth's surface. Peroxide of iron may remain inert in soils where no strong acid exists by which it can be dissolved. The protoxide of iron is of less value than the peroxide for vegetation, as it readily forms salts which are injurious to plants. It frequently abstracts oxygen from the soil, and becomes fully oxidised. It is probable that iron is taken up by plants from the soil in the form of a carbonate dissolved in carbonic acid water. The peroxide has the power of absorbing ammonia from the atmosphere, and thus contributes to vegetable nutrition. An excess of iron, especially of the protoxide, seems to be injurious to plants cultivated for food.

546. Manganese exists sparingly in plants, and it is found in the soil combined with peroxide of iron. It is often inert. Its oxides, like those of iron, are insoluble in pure water, and hence it must be supplied to plants in combination with acids, which form with it soluble salts. Sprengel found a marl containing 4 per cent. of oxide of manganese useful in improving grass lands.

547. The presence of iodine in plants having been fully recognised by many observers, as already noticed, we must look for the sources whence it is supplied to vegetation. Chatin believes that there is an appreciable quantity of iodine in the atmosphere, in rain water, and in the soil, varying in different districts, and that the relative amount of iodine, in any one locality, determines, to a great extent, the presence or absence of certain diseases, such as goitre and cretinism. Mr. Stevenson Macadam,* from a very accurate series of experiments, has

* Macadam on the general distribution of Iodine.—Edinburgh New Philosophical Journal for October 1852.

been led to the conclusion, that air and rain water do not contain iodine, at least in such quantity as to be detected by the most delicate tests. As potassa was used by Chatin in his experiments, and as Macadam finds iodine in this substance, it is probable that the observations of the former chemist require to be verified. The existence, however, of iodine in ordinary potash, leads to the suspicion that this element is more extensively distributed in the vegetable kingdom than we have hitherto been led to believe. It is probable that the iodine of plants is derived from soluble iodides in the soil. Iodine is said to exist in coal and in the waters of the globe. The waters from igneous rocks, and from the rocks of the coal formation, are said to contain a considerable quantity of iodine. It is found in combination with sulphur, the ores of iron and manganese, and the sulphuret of mercury.*

548. The sources of the Fluorine found in plants, Wilson regards as pre-eminently two, (1) simple fluorides such as that of calcium, which are soluble in water,† and through this medium are carried into the tissues of plants; and (2) compounds of fluorides with other salts, of which the most important is probably the combination of phosphate of lime with fluoride of calcium. This occurs in the mineral kingdom in apatite and phosphorite, and in the animal kingdom in bones, shells, and corals, as well as in blood, milk, and other fluids. Fluorides are much more widely distributed than is generally imagined. They exist in well, river, and sea water. The trap rocks near Edinburgh, and in the neighbourhood of the Clyde, as well as the granites of Aberdeenshire, and the ashes of coal, contain fluorides, so that the soils resulting from the disintegration of those rocks cannot fail to possess fluorides also. All plants, accordingly, may be expected to exhibit evidence of their presence, in the following portions of their tissues or fluids :—1. In the ascending sap, simple fluorides. 2. In the descending sap, in association with the albuminous vegetable principles, and in the seeds or fruits, in a similar state of association, fluorides along with phosphates. 3. In the stems, especially when siliceous and hardened, fluorides in combination with silica.

549. The productiveness of soils is very various. Some are entirely barren, such as quartz rock. This kind of soil is seen in many mountainous districts in which the bare quartz rock continues to show itself without any vegetable covering whatever. Others contain materials fitted for nourishment, but not available until they are disintegrated. This is the case with many granitic rocks containing valuable nutritive matter which can only be taken up by plants after the rocks have been pulverized by the action of the weather. Some hard granites which are not thus acted upon, are barren. Some soils are unproductive on account of their physical characters, such as very stiff clays; others are so on account of being too loose and sandy;

* Edinburgh New Philosophical Journal, July 1851, 136.

† G. Wilson on the solubility of the Fluoride of Calcium in Water.—Transactions, Royal Society of Edinburgh, xvi. 145. According to Wilson, pure water can dissolve 1-26923th of its weight of Fluoride of Calcium.

while others, from excess of water, are too moist, and require draining before they can be productive.

550. The presence of substances in an unavailable form is the most common cause of sterility in soils. Thus most soils contain abundance of felspar which consists of potash, lime, and the various inorganic matters required by plants. Its formula is $Al_2O_3\ 3SiO_3 + KOSiO_3$; the alumina being often replaced by lime, magnesia, or oxide of iron, and the potash being sometimes replaced by soda. Felspar, however, may not be in a state of disintegration, and thus, not capable of being applied to the purposes of plants. When exposed to the air however, this felspar may gradually be disintegrated and rendered fertile. When this disintegration takes place easily, the soil may continue fertile for a long time without additions; so long indeed as any felspar remains to disintegrate. This rapid disintegration, however, does not usually take place in soils. The weather acts slowly by means of carbonic acid and water. On some hard felspars there occurs a scanty vegetation, which after many years may be burned, and then when the soil is turned up, a good crop is produced.

551. Barren felspar soils may be rendered fertile—by exposure to the air, or in other words, by lying fallow; by frequent ploughing and turning up; by the use of quicklime, which acts by accelerating the decomposition of felspar and clay, and separating the silica and potash from the former; by burning or calcination which acts in the same way as lime. Thus fallow, ploughing, liming, and burning act in the same way on barren felspar soils, by causing decomposition, and separating the materials required for the nourishment of plants. They all promote the solubility of different parts of the soil.

552. Below the ordinary soil there occurs what is called the subsoil, in which there is less organic matter than on the surface. Into this soil many soluble matters are carried down by rains. The effect of subsoil and trench ploughing is to bring up these matters and render them available for the use of plants. The beneficial results of this kind of ploughing will depend upon the composition of the subsoil. By subsoil ploughing, the subsoil is loosened, so as to be easily acted upon by air and water, and the efficiency of the drainage is increased. This kind of ploughing, however, is not fitted for all soils. In some cases it may do harm. Thus it will not be beneficial in the case of wet undrained land, nor in the case of dry sandy loam resting on a gravelly or sandy bottom. In the former case, the depth of wet soil will be increased, and in the latter, the deficiency of clay not being supplied, the porosity of the soil will be injuriously augmented so as to render the land too dry. Subsoil ploughing can only be practised with advantage in drained land. The depth of this kind of ploughing varies from 12 to 18 or 20 inches, and it is made at right angles to the lines of the drains. When judiciously performed, its effects will be to render the subsoil by degrees fit for the nourishment of plants. This kind of ploughing puts the land into a state which

facilitates the changes produced by air and water. Hence its effects are not always immediately visible. After the subsoil has been loosened and changed by the action of the weather, it is then, by means of trench ploughing, mixed with the ordinary soil, and thus the latter becomes deepened.

553. A soil, though fertile, may not be fitted for all kinds of plants. If the soluble silicates are deficient, green crops may grow, but not white crops. The absence of magnesia is said sometimes to prevent crops from bearing fruit, inasmuch as the phosphate of magnesia is an essential element of the husk of grain. Deficiency of sulphates prevents the formation of albuminous compounds, which always contains sulphur. In order, then, that we may know the crop best fitted for any soil, there must be a complete analysis of both. As regards the soil, it is not enough that we know its ingredients; we must also ascertain how much of it is available to the plant, and how much of it may be rendered so by the action of the weather. This requires a laborious series of investigations.

IV. ROTATION OF CROPS AND APPLICATION OF MANURES.

554. Some plants, we have seen, require certain inorganic matters in larger quantity than others, and it is upon the knowledge of this that the rotation of crops is founded. The soil is constantly losing inorganic matters. Oats contain 4 per cent. of ashes, hay 9 per cent. A ton of hay removes 200 lbs. of ashes, and these ashes are the very substances required by another ton of hay. By constantly cultivating the same crop, we deprive the soil, to the depth to which the roots extend, of certain materials, while others are left nearly untouched; but by alternation of crops, the latter may be made available for the purposes of growth. Farmers on this account have different crops succeeding each other in the same field. Wheat, barley, and oats are described as silica plants; peas, beans, and clover as lime plants; turnips and potatoes as potash plants. These crops, from the difference in their predominant inorganic ingredients, are made to alternate with each other. The three rotations most commonly followed in Scotland are the four-course shift, or what is known as the Norfolk system, the five-course, and the six-course. The four-course shift usually consists of—1st year, Turnips; 2. Wheat and barley, and in many cases wholly barley; 3. Grass; 4. Oats. The five-course is simply the grass being allowed to remain for two years; while the six-course shift, or system of rotation, consists of—1. Turnips; 2. Wheat and barley; 3. Clover; 4. Oats; 5. Beans or potatoes; 6. Wheat. The system of rotation, in other words, the number of years over which it extends, varies in different countries.

555. In some virgin soils, rich in phosphates and other inor-

ganic matters, the same plants may be cultivated successfully for many years. This occurred in Virginia, where for 100 years the same crops were grown without manure; but ultimately exhaustion took place, and the crops became deficient. On lava soils there are often good crops. Thus, the soils of Vesuvius, formed by disintegrated lava, produce excellent crops for many years in succession. It must be remarked, however, that frequently important materials exist in the soil in an insoluble state, and that unless means are taken to render them soluble, the plant cannot avail itself of them. A soil thus considered as comparatively barren, may in reality have abundant materials of fertility in its composition.

556. Dr. Daubeny has made the following series of experiments on the rotation of crops:—

TABULAR VIEW OF EXPERIMENTS ON ROTATION OF CROPS.

NAME OF CROP.	No. of Years during which experiments continued.	Planted in same or different Plots.	Averages of first Five Years.	Averages of whole Period.	REMARKS.
			Lbs.	*Lbs.*	
Potatoes (Solanum tuberosum)	9	In the same plot	72.9	68.9	Merely cleaned from dust before weighing.
	9	In different	92.8	89.1	
Flax (Linum usitatissimum)	10	Same	15.0	12.6	Dried in sun before weighing.
	10	Different	19.9	22.7	
Beans (Vicia Faba)	10	Same	32.8	24.7	Do.
	10	Different	34.8	33.6	
Barley (Hordeum vulgare)	10	Same	30.0	28.9	Do.
	10	Different	46.5	42.1	
Turnips (Brassica Rapa)	10	Same	104.0	100.8	In a green state when weighed.
	10	Different	173.0	176.5	
Hemp (Cannabis sativa)	9	Same	32.55	30.13	Dried in sun before weighing.
	7	Different	—	40.0	
Poppy (Papaver somniferum)	9	Same	21.9	18.2	Do.
	9	Different	20.3	18.7	
Clover (Trifolium pratense)	10	Same	10.9	14.8	Do.
	6	Different	—	16.9	
Buckwheat (Polygonum Fagopyrum	10	Same	11.6	9.1	Do.
	10	Different	12.5	10.6	
Oats (Avena sativa)	...	Same	—	28.0	Do.
	...	Different	—	32.4	
Parsley (Petroselinum sativum	10	Same	61.25	39.75	Do.
	6	Different	—	87.8	

These experiments show a manifest advantage on the side of shifting crops, varying from 1 to 75 per cent., more generally approaching nearer the latter.

557. There is often, however, a great quantity of fertilising matter in the soil, but not in a condition immediately available for the growth of plants.* Hence, in some cases where the crop is deficient, there

* Daubeny on the distinction between the dormant and active ingredients of the soil.—Journal, Royal Agricultural Society of England, vii. 237.

are valuable materials still in the soil unassimilated. Thus phosphates exist often potentially in a dormant state in the soil in great abundance, but it is not until they have been brought into a soluble form that they are of any use as the food of plants. Daubeny endeavoured to find out the nature of the dormant materials by ascertaining how much of them water, impregnated with carbonic acid, is capable of dissolving out in a given time. It is of importance for an agriculturist to discover the dormant inorganic materials, and to adopt means of rendering them available. Allowing the ground to lie fallow, and stirring and pulverising of it are methods by which air and moisture are admitted, and time is allowed for the decomposition of the materials, which are thus rendered available for plants.

558. In wild plants the phosphates are less abundant than in cultivated crops. The former do not, like the cultivated plants, produce a large quantity of sanguigenous food in a short space of time, and hence less phosphates are required. Plants have a great power of taking up phosphates, and cultivation increases this power. It is said that an acre of hay removes 100 lbs. of phosphates. In wild tropical vegetation there is a luxuriant growth, but the plants form cells, fibres, wood, resin, &c., and produce a comparatively small amount of sanguigenous compounds. All evergreen and perennial plants require less phosphates than the ordinary cultivated plants. They are enabled to extend their vegetating processes over many years, and do not demand a large quantity of phosphates within a limited period. In the case of perennials in a wild state the leaves fall on the soil and restore the inorganic matter. Cultivated plants, on the other hand, are annual and herbaceous, grow rapidly, and produce a large amount of sanguigenous products, requiring abundance of phosphates, which are annually removed.

559. The atmospheric food of plants generally continues the same, but the terrestrial food varies much. The former is not under the control of the cultivator; the latter is. Hence we must look to the terrestrial food in an experiment as to nutrition. Having ascertained the chemical composition of the plant and of the soil, we must either add the matter which is deficient, or we must render the food already in the soil more available for plant life. In regard to ordinary wild plants, there is sufficient materials in the atmosphere and soil to carry on all the processes of plant-life, more especially in the case of perennial plants, where time is allowed. In the case of cultivated crops, the object is to produce certain matter in abundance within the period of a year or less; hence the necessity for the application of manures which supply nutritive matter in larger quantities than exist in the soil at any one period.

560. The materials of which plants are composed, and which are all withdrawn from the unorganized world, are given back to the air and soil again by the disintegration of the living structures of which they have formed a part. If plants were not used for food, they would by their decay restore all that they had taken away

for the purposes of growth. But as they contribute to the nourishment of man and animals, it follows that a portion of vegetable matter is constantly removed in order to build up the animal structures. This portion must be again supplied in order that the plant may be nourished. This is the principle of the application of manures. The farmer and horticulturist add to the soil what has been removed from it by crops. In order to do this properly, there must be a knowledge of the composition of the plant, of the soil, and of the manure; and hence the importance of accurate chemical analyses. In addition to this, attention must be directed to the functions of plants, and to the mode in which they take up nourishment; and the materials of growth must be supplied in such a way as to be made available for the purposes of plant-life.

561. The object of manuring is to improve the properties of the soil, and to supply what has been taken from it by crops, which have been used for the food of man and animals. We may either supply the whole or some portion of the vegetable constituents in a soluble state, or we may add to the soil something which will decompose and act on its insoluble ingredients, so as to render them fit for the use of plants. Natural manures, such as those of the farm-yard, are excellent, because they restore to the land nearly all the substances which have been taken from it. Other manures supply one or two ingredients only. The exposure of the soil to the influence of the weather tends to make up for loss, by causing the decomposition of substances previously unfit for vegetable nutrition. Fallow then acts, in a certain degree, in restoring the fertility of the soil, but it will not give us all that is required, and, moreover, involves loss of time and money.

562. In the case of cultivated plants, those manures are considered the most valuable which furnish the materials necessary for forming the azotized compounds required for the sanguigenous food of man and animals. Hence the importance of manures containing ammonia and phosphates, substances which do not usually exist abundantly in the soil, and which are annually required in large quantity by crops. It has been found by comparative experiments that the quantity of gluten in wheat and other cereal grains is increased by the use of ammoniacal and phosphatic manures. The sewerage of towns, in this point of view, is one of the most valuable manures, and it is to be regretted that so little is done to save it for the purposes of the farmer and horticulturist. The quantity of solid and liquid excreta sent into the sea is enormous. In China great attention is paid to proper manuring, and to the saving of proper materials necessary for the growth of plants. In this respect the Chinese set an example to the inhabitants of Britain, where there is annually an enormous waste of fertilizing materials. Millions of pounds of phosphates in this country are lost, and hence the demand for bone earth and guano. The latter manure may be said to be these phosphates restored; for,

after being carried into the sea the phosphates contribute to the growth of sea-plants ; these become the abodes of the lower classes of marine animals on which fishes feed ; and they in their turn supply food to the piscivorous birds which furnish guano.

563. The soil has a great power of absorbing ammonia, and supplies it gradually to the roots of plants in a state fit for their nutrition. The vigour of plants is much increased by the judicious application of ammonia either in the soil or in the air. M. Ville* found that ammonia, when added to the atmosphere in which plants grew, increased the vigour of their growth, and rendered their produce more nitrogenous. When $\frac{1}{2500}$ of this gas was added to the air, the effects became perceptible at the end of eight or ten days, and they went on increasing. The leaves became of a deep green, their stalks becoming long and stiff, and their surface broad and shining. Ultimately the plants were found to contain twice as much nitrogen as those grown in pure air. The following were the results ascertained after the plants had been dried at a temperature of 248° Fahrenheit :—

	PLANTS IN PURE AIR.		PLANTS IN AMMONIACAL AIR.	
	Total Produce Grains.	Nitrogen. Grains.	Total Produce Grains.	Nitrogen. Grains.
Experiments in 1850 . .	64.19	1.266	110.16	4.313
Experiments in 1851 . .	68.72	0.494	135.20	1.501
Experiments in 1852 . .	11.868	0.043	21.99	1.890

564. Ville, however, states that if ammonia is applied to plants several months before flowering, there is nothing remarkable produced in their vegetation ; the ordinary succession of growth is not disturbed. Sometimes the plant fruits earlier and better. But if the addition of ammonia to the air is delayed till the plant is about to come into flower, then the flowering is arrested, and vegetation takes a new start ; the stem lengthens and branches, numerous leaves are produced, and if the season is not too far advanced the suspended flowering takes place, but the blossoms are all blind. In grain crops which do not branch, the effect is to cause them to tiller, and no seeds are produced. Air dosed with 0.025 gr. of ammonia per cubic yard was found to be very beneficial to Orchids. In the months of June, July, and August, the effect of the ammonia appeared to be rather injurious, causing yellow spots and drying up of the leaves, owing to the roots not being able to supply the due amount of mineral matters required

* Ville, Comptes Rendus, 1852.

for the increased and more vigorous growth of the leaves. Hence the plant drew from some of its leaves the mineral matter required, and thus they faded. The leaves absorbed abundance of organic elements, but they wanted the inorganic matter necessary for assimilation. This balance between roots and leaves must be kept up. It has been remarked, for instance, in Cucurbitaceous plants, in dry weather occurring after heavy rains, that sometimes the inorganic matter appears as a saline efflorescence on the leaves.

565. It is essential that ammonia should be supplied in moderate quantity at a time, and at the proper season. It requires, also, the presence of phosphates, in order that its full effect may be secured in the production of nitrogenous matter. Some manures give off ammonia in large quantity by a process of fermentation; and in order to prevent the loss thus occasioned, it is frequently necessary to add sulphuric acid or sulphate of lime, so as to procure a non-volatile sulphate of the alkali.

566. Manures may be divided into—1. *Farm-yard manure*, containing all the ingredients required for a crop. This, when applied to the soil, is slowly decomposed, and its effects extend over several years, so that it exerts a beneficial influence upon all the crops of a rotation. It may be called in general a slowly-acting manure. 2. *Special manures*, composed of ingredients which are intended for the special benefit of the crop to which they are applied, while comparatively little effect is expected to be produced on those that succeed it. These may be called rapidly-acting manures. The first is of importance for cereals which are slow-growing plants; the second are valuable for green crops, which of all others require the greatest quantity of nourishment in a given time. While ammonia may be supplied by both, still, in the former it is slowly produced by a gradual combination between nitrogen and hydrogen, while in the latter it is ready formed, and capable of being at once used by the plant.

567. *Farm-yard manure* consists of complex animal and vegetable compounds, which by free exposure to the air undergo a kind of fermentation, so as to be converted into other substances, of which carbonic acid and ammonia are the most important. This fermentation is promoted by moistening and turning over the manure, in order to permit the free access of air. In this way the production of ammonia is facilitated, and the manure is in a condition to supply it at once to the young plants, which is of great importance for the vigour of the future crop. By this mode of preparation the manure is calculated to produce rapid effects on plants which come quickly to maturity. In order that farm-yard manure may act rapidly, and that the loss caused by exposure to the air may be prevented, a proportion of a special manure containing ammonia may be at once added to it.

568. Farm-yard manure may be applied in a solid or in a more or less fluid state. The term *liquid manuring* is properly given to the use made of the urine of cattle, containing a large amount of urea,

which, by decomposition, becomes carbonate of ammonia. Of late, however, this has been mixed with other matters from the farm-yard, as well as with carbonaceous and peaty substances, and the whole has been pumped over the field in the form of a fluid containing solid ingredients suspended in it. This kind of fluid manure is more beneficial than liquid manure properly so called. The latter, while it supplies ammonia, does not furnish the necessary phosphates, and by adding to the vigour of the plants, it impoverishes the soil of them. The former resembles in many respects the sewerage of towns, to which allusion has been made, and which is known to act most energetically in promoting the growth of plants.

569. Among *Special manures* there are some which supply ammonia and phosphates either separately or united, others furnish acids or bases, such as Sulphuric acid, Nitric acid, Potash, Soda, Lime, &c. The liquor of gas works and soot owe their manurial value principally to ammonia. Bones are prized on account of the phosphate of lime in their composition, which amounts in general to about 50 per cent. In place of using bone-dust, which acts slowly, from the insoluble nature of the phosphate of lime, farmers are in the habit of mixing bones with sulphuric acid, and thus getting a soluble compound of phosphoric acid and lime (superphosphate), which, when dissolved in water, is easily taken up by the roots of plants. The addition of sulphuric acid also acts beneficially in supplying sulphur for the azotized compounds.

570. The phosphates are highly important in an agricultural point of view. Unless they are present, no albumen nor other azotized matter can be formed. Carbonic acid and ammonia may be present; but without phosphates they cannot form sanguigenous food. Hence phosphates may be considered as the test of value of a manure in this respect. The organic matter can be supplied by the atmosphere, but the phosphates cannot. They must be added, if deficient. Many limestones and marls act as manures, from the phosphates which they contain; so do coprolites, which are the fossil dung of extinct animals. In the manufacture of superphosphate of lime, coprolites are sometimes mixed with bones and sulphuric acid. Beds of bone chalk exist, which are rich in phosphates of lime, and which might be valuable manure. In Estremadura, in Spain, Daubeny saw beds of this nature from 7 to 16 feet thick.* Numerous phosphatic nodules have been found in some parts of England. The phosphate of lime in these nodules seems to have been derived from the decomposition of marine animals, which had peopled the seas in those parts during the tertiary period. The phosphate, at first dissolved in sea-water by the agency of carbonic acid, was afterwards precipitated as that solvent escaped, and at the moment of its deposition was attracted by any hard solid body near it. Hence the origin of those pseudo-coprolites which occur in the Crag

* Daubeny on the Occurrence of Phosphorite in Estramadura.—Journal of Royal Agricultural Society of England, vol. v. p. 406.

of Suffolk; hence also the origin of the phosphatic matter often found encrusting the bones and teeth of marine animals found in the same locality. As the phosphatic nodules abound over a wide district, from the river Orwell northwards along the coast of Suffolk, they have been used as manure. They are powdered and acted upon by sulphuric acid, and are thus converted into superphosphate of lime. Phosphatic marls also exist in many English counties. Beds of phosphates extend from one side of England to the other, in a direction from north-east to south-west, viz., from Flamborough Head to the southern coast.

571. It is useful to bear in mind that in many analyses phosphate of lime has been mistaken for alumina, and hence erroneous statements have been given as to the composition of crops and soils. It would appear that bone earth, farm-yard manure, and guano, owe much of their value as manure to the phosphates which they contain. The increased cultivation of green crops in this country may be owing to the deficiency of phosphates in the soil; for these crops require less phosphates than grain crops, and are less sanguigenous.

572. One of the most important special manures is Guano, or the dung of sea-fowl, which has accumulated for centuries in some parts of the coast of South America and Africa, and now forms enormous deposits. The consumption of this manure in Britain, in 1851, is stated to be from 80,000 to 100,000 tons. Its value depends partly on ammoniacal salts and partly on phosphates. Some guanos, as Peruvian, Anagamos, and Bolivian, are rich in ammonia; while others, as Patagonian and Saldanha Bay, are rich in phosphates.

573. The following is Dr. Anderson's analysis of different kinds of guano:—*

TABLE OF THE AVERAGE COMPOSITION OF DIFFERENT SORTS OF GUANO.

	Anagamos.	Peruvian	Ichaboe. New.	Ichaboe. Old.	Patagonian.	Saldanha Bay.
Water	13.61	13.73	18.89	24.21	24.36	21.03
Organic Matter and Ammoniacal Salts	57.90	53.16	32.49	39.30	18.86	14.93
Phosphates	19.50	23.48	19.63	30.00	41.37	56.40
Lime	...	...	2.49	...	2.94	...
Sulphuric Acid	...	...	...	...	2.21	...
Alkaline Salts	6.97	7.97	6.91	4.19	2.70	6.10
Sand	2.02	1.66	19.59	2.30	7.56	1.54
	100.00	100.00	100.00	100.00	100.00	100.00
Ammonia	20.53	17.00	10.42	8.50	2.66	1.62

* See Transactions of Highland and Agricultural Society, January and July 1851.

574. Johnston has given the following arrangement of Guanos:—

	Water, per cent.	Organic Matter, per cent.	Phosphates, per cent.
Bolivian Guano	5 to 7	56 to 64	25 to 29
Peruvian do.	7 „ 10	56 „ 66	16 „ 23
Chilian or Valparaiso do. . .	10 „ 13	50 „ 56	22 „ 30
Ichaboe do.	18 „ 26	36 „ 44	21 „ 29
Saldanha Bay do.	17 „ 34	14 „ 22	45 „ 56
Patagonian do.	14 „ 40	16 „ 38	17 „ 40

575. Guano is very liable to adulteration, and it is absolutely essential for the farmer that the specimens should be carefully analyzed. Without chemistry the farmer possesses no means of judging whether he is applying to his land a material containing 55 per cent. of phosphate of lime or 24; 17 per cent. of ammonia or $1\frac{1}{3}$; or whether there may not be as much as 50 to 60 per cent. of foreign matter intermixed with useful constituents, without any fraud on the part of the vender. The adulterations consist of yellow sand, ground limestone, yellow marls and clays, gypsum, and ground coprolites.* Anderson states that genuine Peruvian guano should not be too dark-coloured, nor have too strong ammoniacal odour; it should contain lumps of a lighter colour than the powdery part; it should not be gritty when crushed between the fingers, and a bushel of it should weigh about 50 lbs.

576. Mr. E. J. Quekett states that guano, when viewed under the microscope as an opaque object, appears to consist of particles of an earthy brown colour, mixed with crystalline bodies of various sizes, some of which appear to be particles of sand, and others to be crystalline matter differing according to the locality whence the guano has been procured; so that the Ichaboe guano may be readily distinguished from the Peruvian, the former having much more of the crystalline matter than the latter. It happens, however, that the goodness of the guano does not depend on the presence or absence of this crystalline matter, and consequently it forms no criterion of its value. But although the microscope will not enable us to determine accurately the value of that substance, it is quite capable of determining whether it has been adulterated with foreign matters or not. Upon viewing it as a transparent object, the nature of many of the bodies composing it becomes apparent, and it is found to consist of organized, crystalline, and mineral matters. The organisms appear to be fragments of dried muscular fibre, either of birds or fish, minute fragments of shells, spicula of sponges, and (especially in that from Ichaboe) skeletons of

* Anderson on Adulteration of Guano.—Transactions of Highland Society, January 1851, and July 1852. Way on the Composition of Guano, in Trans. of Royal Agricultural Society of England, x. 196.

animalcules of various kinds, such as Corcinodiscus and Actinocyclus.* By analysis, the crystalline matter is found to be composed of sulphate of potass and ammonia.

577. Various other special manures have been recommended, containing one or two of the inorganic constituents of plants. Nitrates and Carbonates of Potash and Soda appear to act by furnishing alkaline matter as well as nitrogen and carbon. Sea salt (Chloride of sodium) is considered by Mr. Way as beneficial both to white and green crops. He thinks that it probably acts on the silicates of lime present in the soil, setting the lime free, and acting on the silica so as to render it fit for the purposes of vegetable life. In the case of cultivated plants which naturally grow near the sea, such as Sea kale, Asparagus, Cabbage and its varieties, salt may be expected to be useful. Lime acts beneficially as a manure in the case of some plants, prejudicially as regards others. Thus the Corn marigold (Chrysanthemum segetum), Common heather (Calluna vulgaris), and various species of Carex, become rare when clay lands are improved by lime. When mixed with soil, lime prevents the formation of free acids, which in wet clay lands result from the decomposition of organic matters and various processes of oxidation. It also renders acids already present in the soil innocuous. It aids in the decomposition of vegetable matter in the soil, and thus promotes the formation of carbonic acid. In combination with phosphoric acid, we have already noted its efficacy. In the form of sulphate or gypsum, it is useful in absorbing ammonia, and probably in supplying sulphur.†

578. Specific manures are applied in various ways. They are either thrown broad-cast over the soil, or they are used as a top-dressing in the case of grass, or they are sown in drills along with seeds. The last is by many looked upon as the best method, inasmuch as the ammonia and other manurial matters are immediately brought into contact with the young plant at the time when it is of importance to increase its vigour. In making experiments with these manures, it is of importance not to confine the trial to one crop, but to conduct it through a whole rotation.

579. Occasionally a green crop is grown with the view of being afterwards ploughed into the soil, and of supplying, during its decomposition, materials which had been taken up by its roots from a considerable depth in the soil. This is called green manuring. Common Spurrey, Vetches, and Clovers, are sometimes employed in this way. Sea-weeds are also used as manure. They furnish salts of potash, soda, and lime, and they may probably be useful in the case of cultivated plants whose natural habitat is in the neighbourhood of the sea. In the Edinburgh Botanic Garden, Sea-weeds have been applied with

* See figures of these animalcules in Taylor's Scientific Memoirs, vol. iii. plates 7 and 8.

† For other specific manures, see Anderson on various Manufactured Manures.—Trans. Highland Society, January 1852. Voelcker on Artificial Manures.—Journal of Agriculture, March 1852. Boussingault and Payen on Manures.—Comptes Rendus, x. 323, xi. 657.

good effect to the Coco-nut Palm, which thrives best within the influence of the sea.*

580. Recapitulation of the chief points noticed in Chemico-Physiology :—

1. Plants consist of organic and inorganic constituents.
2. Organic constituents form the bulk of vegetable tissue; they are combustible, and cannot be produced artificially from their elements.
3. Inorganic constituents are in small quantity; are incombustible, and may be produced artificially.
4. Organic constituents are either unazotized or azotized; the former consisting of carbon, oxygen, and hydrogen; the latter of carbon, oxygen, hydrogen, and nitrogen.
5. Certain azotized compounds also contain sulphur and phosphates, and are particularly important in the case of cultivated crops used for food, in consequence of being sanguigenous or blood-forming.
6. The elements of the vegetable organic constituents exist in the atmosphere and in the soil, in the form of carbonic acid, water, ammonia, and nitric acid.
7. Inorganic constituents form the ash of plants, and consist of metals, metalloids, bases, and acids, in various states of combination.
8. Inorganic matters are supplied by the soil, and are hence called terrestrial or telluric food; they are important in building up the tissues of plants.
9. Phosphates and sulphates in an especial manner are important in the development of sanguigenous products.
10. Soils consist chiefly of organic matter, silica, and clay, mixed with salts of lime, magnesia, potash, and soda.
11. In the case of cultivated plants which require to collect a large amount of food in a short time, the nature of the soil requires to be particularly attended to.
12. The soil becomes exhausted by the continued growth of plants, more especially of cultivated crops.
13. Rotation of crops is founded on the fact that some plants take up a larger quantity of certain inorganic matters than of others; and hence white and green crops, which require different proportions of inorganic constituents, are made to succeed each other.
14. When a soil is deprived of nutritive materials, they must be supplied in order to keep up its fertility.
15. The fertility of the soil is kept up by the application of manures.
16. In order that manuring may be conducted properly, there must be a complete analysis of the crop, the soil, and the manure.
17. Manures are divided into farm-yard manure and special manures.
18. Farm-yard manure supplies all the ingredients for crops, and it usually acts slowly, so as to show its effects during a whole rotation.
19. Special manures supply special substances, and are more particularly suitable for quick-growing crops. Their effects generally cease with the crop to which they are applied.
20. The most valuable ingredients in manures are ammonia and phosphates.

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* For fuller details relative to Chemico-Physiology, the student may consult the following works:—Boussingault Economie Rurale; Davy's Agricultural Chemistry, by Shier; Dumas, on the balance of Organic Nature; Gregory's Handbook of Organic Chemistry; Johnston's Lectures on Agricultural Chemistry; Liebig's Chemistry of Agriculture and Physiology, translated by Playfair; Liebig's Letters on Chemistry, translated by Gregory; Morton's Cyclopædia of Agriculture; Mulder's Chemistry of Vegetable and Animal Physiology, translated by Fromberg; Schleiden, Die Physiologie der Pflanzen und Thiere, und Theorie der Pflanzen-cultur; Wilson's Rural Cyclopædia; Daubeny, on the Scientific Principles of Manuring—Journal of Agricultural Society of England, ii. 232; also various articles by Anderson, Way, Voelcker, and others, in the Journal of Agriculture, and Transactions of the Highland Society, and in the Journal of the Royal Agricultural Society of England.

CHAPTER III.

PHYSIOLOGY OF THE ELEMENTARY TISSUES OF PLANTS.

I. FUNCTIONS OF CELLS AND OF CELLULAR TISSUE.

581. When we consider that cells are of universal occurrence in the Vegetable Kingdom, and that they constitute, in some instances, the entire structure of plants, we can easily understand their importance in a physiological point of view. They are capable of carrying on all the functions of plant-life. We have already remarked, that the life of an individual cell may represent that of the entire plant. In the case of a unicellular Alga, as Palmella (Fig. 1075), we meet with a simple cell which absorbs nutriment from the atmosphere and the soil, and forms certain organizable matters, some of which are employed in building up its texture, while others are secreted or set apart for ulterior purposes in its economy. Those actions are frequently accompanied by an evident movement of fluids and granules. In the progress of time cellules are developed in the interior of the cell, which are discharged as independent cell-plants capable of performing all the functions of the parent cell. In other instances, the original cell gives origin to new cells, either by means of nuclei (Fig. 1076), or by a constant process of division (Fig. 1077), until at length a cellular plant is produced consisting of numerous cells variously arranged. In higher Cryptogamics, the cells undergo transformations fitting them for their special functions. Vital operations are carried on in all plants by means of cells, the constitution and functions of which vary according to the nature of the plants and the position in the scale of organization which they occupy. In the higher classes of plants, certain cells are concerned in the secretion of organizable products, which are elaborated by others into new tissues. The life of the higher species of plants results from the regular action of cells, which are of unequal value as regards the formation of new organs and new products. In cells there are observed the absorption and movements of fluids, the elaboration of these by exposure to air and light, and the formation of new cells.

582. In its early state a plant consists of one or more cells. These appear to be produced from a viscid substance of an albuminous nature, to which the names of *Protoplasm*, *Cytoblastema*, and *Vegetable Mucus* have been given. This substance is first homogeneous, then granular.* It is coagulated by alcohol, and coloured yellowish-brown by iodine. It is considered as the earliest stage of vegetable tissue, and as being endowed with a certain formative power. By Barry, the organizing matter is called Hyaline, from its pellucid nature. Some say that in this protoplasm nuclei are developed which give origin to cells; others state that the nitrogenous matter becomes at once divided into cell-like cavities, each of which produces a covering of cellulose for itself. The formation of nuclei or cells in a protoplasmic matrix, without the influence of another cell previously existing, may be called *extra-cellular*.

583. When a cell has been produced, we can then trace some of the stages by which new cells are formed. This process is called cell-

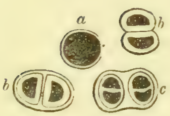

Fig. 1075.

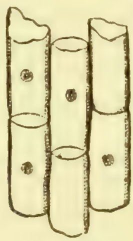

Fig. 1076.

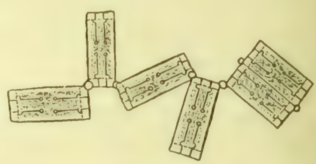

Fig. 1077.

development or *Cytogenesis*, and it has engaged the attention of many able physiologists. There appear to be four modes in which vegetable cells are multiplied, viz., by nuclei, by division, by gemmation, and by conjugation. New cells originate in the protoplasmic fluid contained in a parent cell by a process of *intra-cellular* formation. The new cells may either proceed from a nucleus, or, as Schleiden calls it, *Cytoblast;* or they may be formed at once in the protoplasm. In the former case, the nucleus becomes as it were the centre of vital action, and on one side of it a bladder-like vesicle arises (Fig. 1078, *b*). This original vesicle is bounded by a protoplasmic membrane, which ultimately becomes covered with a deposit of cellulose. The protoplasmic membrane forms the inner lining (primordial utricle of Mohl) of the new cell, and to it all the subsequent vital actions of the cell

Fig. 1075. Unicellular Alga (*Palmella cruenta*). The cell, *a*, absorbs, secretes, and forms new cells, by a process of fissiparous division, first into two, *b b*, and then into four parts, *c*.

Fig. 1076. Cells containing nuclei or cytoblasts, from which new cells are produced by intra-cellular cytogenesis.

Fig. 1077. Diatomaceous Alga (*Diatoma marinum*), the cells of which are increased by a constant process of fissiparous or merismatic division. The plant increases by abscission of segments.

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* Some say that it consists of minute fibres, which, when united together, form the cell-wall; see page 420.

are referred.* The nucleus either remains in the cell-wall, or it is absorbed. The newly formed cell contains a formative fluid in which nuclei are produced, which, in their turn, give origin to other cells. Besides a nucleus, there are seen occasionally in cells very minute bodies called nucleoli, which some consider as being concerned in forming the wall of the nucleus. The nuclear formation of cells has been fully illustrated by Schleiden in the case of the Embryo plant. According to Mohl the nucleus is in the centre of the cell, and is attached to its walls by filamentous processes of protoplasm, as seen in the hairs of Tradescantia. When no nucleus is present, the protoplasm at once forms cells. This is called non-nuclear or free cell-formation. In both instances the formation of new cells takes place in the interior of previously formed cells. In progress of increase, nucleated and non-nucleated cells cause absorption of the walls of the parent cell, which finally disappears. It sometimes happens that the nucleus itself divides into two by a contraction in the middle, and each of its parts gives origin to cells. In this way a rapid multiplication of cells takes place. In Figure 1078, *b*, there is represented a parent or mother cell, containing two nucleated cells in its interior. These gradually increase, cause absorption of the walls of the parent cell, and become free. In Figure 1078, *a*, the parent cell still remains, enclosing five nucleated cells.

584. After a cell is formed, we often remark that its contents divide into two or four parts. This is accomplished by the folding inwards of the protoplasmic inner lining, the primordial utricle of Mohl. Each division forms for itself a covering of cellulose. These newly formed cells increase, cause absorption of the walls of the parent or mother cell, and separate from it as distinct cellular formations capable of going through the same process of division. Sometimes a cell divides into two or more parts, each of which becomes a separate cell, without any destruction of the walls of the original one, as shown in Figure 1079. This is accomplished by a similar folding of the inner lining, and a subsequent formation of cellulose in each division, but it differs from the previous method of division in the circumstance that the walls of the parent cell remain without being absorbed. These modes of cell-multiplication are called *fissiparous*, or *merismatic*.

585. Cells are also produced by a process of budding; in other words, by a continuous growth from various parts of previously formed cells. A cellular protuberance or mammilla appears either at the apex or at the sides of these cells, which elongates and ultimately divides by a partition or septum into two, one of which is arrested in its development, and the other goes on elongating and dividing. In this way a continuous row of cells is produced, as in certain Algæ

* In cells which have not attained complete development, this inner layer may be seen, especially after long immersion in alcohol. By this means it is separated from the outer covering. Iodine causes it to assume a yellow or brown colour. It may be traced in young shoots of Elder and of the Fig, in the roots of Monocotyledons, and in young hairs. After secondary layers of lignine have been deposited in cells, the membrane loses its activity, and is no longer visible.

and in the Yeast plant (Fig. 1080), or a branching filament, as in some kinds of Confervæ (Fig. 1081), and moniliform Fungi (Fig. 1082), or a flattened thallus composed of interlacing cells, as in Lichens (Fig. 1020, p. 343). This mode of cell-multiplication is *gemmiparous*, and is said to take place by a process of *gemmation.*

586. Another mode in which new cells are formed is by the *conjugation* or union of two cells having different contents (Fig. 1083). This is well seen in Zygnema and other allied plants, and it will be particularly noticed under Embryogeny. This process may be called *generative cell-production.* The cell developed in this way constitutes the spore or germ in the lower class of plants, and the first cell of the embryo in the higher plants (Fig. 910, *e*, p. 303). The embryonic cell produces nuclei, by means of which a multiplication of cells is effected.

587. The rapidity with which cells are developed in some cellular plants is astonishing. Ward observed Phallus impudicus shoot up

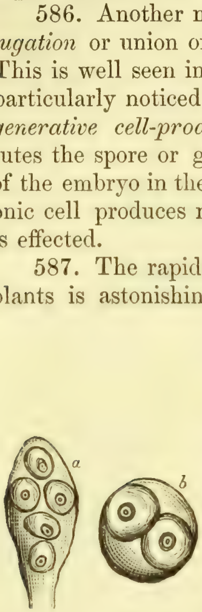

Fig. 1078.

Fig. 1079.

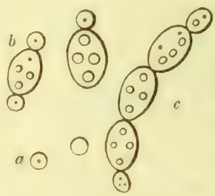

Fig. 1080.

Fig. 1081.

three inches in the space of twenty-five minutes. Bovista giganteum (gigantic puffball) has grown in a single night in damp weather from the size of a mere point to that of an enormous gourd. From an approximative calculation, it is found that in this plant not less than 20,000 new cells were formed every minute. Kieser calculated that the tissue of some Fungi augmented at the rate of 60,000 cells per minute. Large tracts of snow in the arctic regions and in alpine

Fig. 1078. Nucleated cells. *a*, Very young leaf of Crassula obliqua, showing the parent-cell containing five nucleated cells in its interior; *b*, cell from the young bud of a species of Aloe, containing two cells with nuclei or cytoblasts. The contained cells by their increase destroy the parent-cell.

Fig. 1079. Portion ot a cellular plant (*Conferva glomerata*), showing at *a* the primordial utricle or inner cell-wall folding inwards, so as to make a septum or partition, which is represented at *b* in a completed state. Each portion of the divided cell forms a covering of cellulose, and becomes an independent cell.

Fig. 1080. Cells of the Yeast plant (*Torula cerevisiæ*), in different stages of growth; *a*, single cells *b*, cells giving off buds either at one or both ends; *c*, a congeries of cells united, those at the extremities producing new cells in the form of cellular buds.

Fig. 1081. Cells of an Alga (*Chætophora*), giving off new cells, *a*, by a process of budding. These new cells appear first as protuberances from the sides of previously formed cells.

districts are sometimes suddenly reddened by the development of innumerable cells of the Red Snow-plant.

588. Cellular tissue is very hygroscopic. If cellular plants, such as Sea-weeds, are dried, and then put into water, they take up the fluid rapidly. These plants may be sent from a distance in a dry state, and when moistened, they assume their proper forms. Some of them, as the different species of Tangle (Laminaria), have been used as hygrometers. In Mosses, the cellular teeth of the peristome (Fig. 1084, *p*), curve inwards on the application of moisture, by the distension of the outer row of cells. The twisting of the stalk of Mosses, and of the awn of the wild Oat, are accounted for in a similar manner. The fronds of a species of Lycopodium (L. squamatum), from Brazil, curl inwards in the dry season, so that the plant appears like a brown ball, and during the wet season they spread out so as to cover

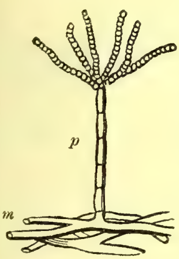

Fig. 1082.

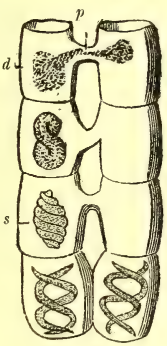

Fig. 1083.

Fig 1084.

Fig. 1085.

Fig. 1086.

the soil. The plant called Rose of Jericho (Anastatica hierochuntina), shows a similar hygroscopicity in its pod; and some of the Cape species of Mesembryanthemum open their seed-vessels when moisture is applied. In Figures 1085 and 1086, a seed-vessel is represented in a closed state when dry, and in an open expanded state when moist. The spores or germs of Horse-tails (Equisetum), are provided with cellular clavate filaments, which contract and expand under the in-

Fig. 1082. A species of Mould-fungus (*Penicillium*), consisting of long cells, *m*, producing cellular buds, which form a continuous row of cells, *p*, by gemmation and division, bearing branching moniliform threads, *c*, composed of a congeries of united cells, which seem to be formed in the same way as the cells of the Yeast plant.

Fig. 1083. Cellular filaments of an Alga (*Zygnema*), uniting by tubes, *p*, which allow the contents of one cell, *c*, to pass into another, *d*, and thus give origin to new cells, *s*, which receive the name of spores. This is called generative production of cells.

Fig. 1084. Sporangium of the Extinguisher-moss (*Encalypta*), showing the teeth of the peristome, *p*, which fold inwards when moisture is applied—this movement being caused by the distension of the outer thin-walled cells, of which the teeth are composed.

Fig. 1085. Seed vessel of a species of Mesembryanthemum in a closed state.

Fig. 1086. The same seed-vessel, with its valves expanded, after having been moistened by water. The swelling of the inner cells causes the curvation outwards.

fluence of moisture and dryness, and thus assist in placing the germ properly in the soil (Figs. 1087 and 1088). These Equisetum spores are interesting objects under the microscope, and their movements are seen by breathing upon them. Hairs, which are composed of cells, also show hygroscopic properties. The Pappus of Scorzonera, and the hairs of Andropogon, have been used as hygrometers.

589. Liquids pass through the walls of cells by a process of imbibition. Thin-walled cells take up fluids very rapidly. To the movement of fluids, through membranes of different kinds, Dutrochet has given the names of Endosmose, or inward movement, and Exosmose, or outward movement.* These movements take place both in living and in dead tissue, and they are influenced by the nature of the fluids and of the membrane. The fluids on either side of the membrane must differ from each other in density, and they must have an affinity for the interposed membrane, and for each other. By the endosmotic process, a thin liquid passes in large quantity and with great force through

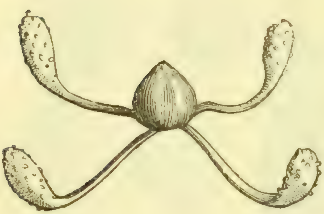

Fig. 1087.

Fig. 1088.

Fig. 1089.

Fig. 1090.

a vegetable or animal membrane, in order to mix with a denser liquid, while the latter passes outwards in small quantity by a slower exosmotic movement. If a unicellular plant, as one of the cells of the Yeast plant (Fig. 1080, p. 410), is placed in a dense liquid, the contents of the cell pass outwards rapidly, and the cell becomes more or less collapsed; if, on the other hand, it is put into a thin liquid, the reverse takes place, so that the cell is distended.

590. The cells of plants contain liquids of different densities, and hence these movements must be constantly taking place, so as to cause an interchange of their contents. The bursting of the seed-vessel of

Fig. 1087. Spore of Horse-tail (*Equisetum*), with hygrometric club-shaped cellular filaments expanded in a dry state.

Fig. 1088. The same spores with the hygrometric filaments coiled round it, in consequence of the application of moisture.

Fig. 1089. Ripe fruit of Balsam (*Impatiens noli-me-tangere*), in its unopened condition.

Fig. 1090. Fruit of the same plant opening by five recurved valves. The opening and curvation is traced in part to endosmose taking place in the cells.

* Dutrochet, Recherches sur l'Endosmose et l'Exosmose, Paris, 1828.

the Elaterium (Ecbalium Elaterium), and of the Balsam (Impatiens), is traced in part to the distension of cells by endosmose, which causes a curvation in the parts and an ultimate rupture (Figs. 1089 and 1090). It must, however, be borne in mind, that endosmose is modified in the living plant by the vital actions going on in the cells, and that it is to these actions we must refer the continued movements of fluids through the cell-walls.

591. The endosmotic phenomena may be illustrated by means of a tube of glass containing syrup or a saturated solution of salt, the end of which is covered by a membrane, such as a piece of bladder, and then placed in water. In this case the water will enter in such quantity into the interior of the tube, through the membrane, that the fluid will rise. With a membrane about 1.6 inch in diameter, a tube of about $\frac{1}{12}$ inch, and syrup of density 1.083, the fluid rose, according to Dutrochet, more than an inch and a half in an hour and a half; when the syrup had a density of 1.145, the fluid rose nearly three inches; and when the density was 1.228, the rise was four inches.

592. The force with which the movement takes place is very great. Dutrochet estimated that in the case of syrup of density 1.3, the force of endosmose was equal to the pressure of $4\frac{1}{2}$ atmospheres. He used an instrument called an endosmometer to measure the intensity of the force. This instrument is represented in Figure 1091. There is a bent tube, *t*, attached to a graduated scale; the lower end of the tube is large, and is covered by a membrane. In the interior of the enlarged extremity syrup is placed, and mercury is poured in, so as to occupy the lower curvature, *m*. When the apparatus is placed in water, *w*, the fluid rises in the tube. The extent to which it pushes up the mercury indicates the force.

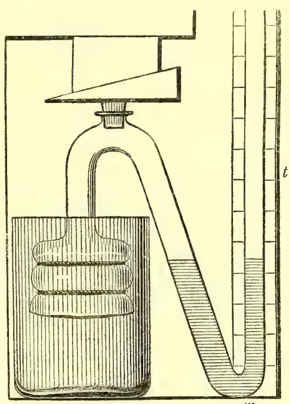

Fig. 1091.

593. In many cells there is observed a distinct motion of fluids and granules. Schleiden thinks that this takes place probably in all active formative cells at a certain stage of growth. Mohl looks upon it as a universal phenomenon, and says that it is connected with the pro-

Fig. 1091. Endosmometer or measurer of Endosmose used by Dutrochet. It consists of a glass tube, *t*, which is twice bent upon itself, and has a large open bell-shaped extremity, *w*. The portion of the tube below this extremity and the second curvature, *m*, is wider in its calibre than that part which is attached to a graduated scale, *t*, a portion of which only is represented in the Figure. The open end of the bell-shaped extremity is covered with bladder, which is firmly tied over it. Syrup is then introduced by the orifice at the top of the arch, and the opening is secured by a cork and wedge. Mercury is introduced into the tube so as to fill a portion of the lower curvature, as represented by the dark lines, and the syrup is made to fill the space between the mercury and the bladder. When the apparatus is placed in water, *w*, a process of endosmose goes on by which the water passes in large quantity through the bladder, and the force is estimated by the extent to which the mercury rises in the tube, *t*. The exosmose of the syrup goes on slowly and in small quantity. There is thus an in-going strong current, and an out-going weak current.

toplasm, and not with the watery cell-sap. This intra-cellular movement or circulation is seen in many aquatic plants as well as in certain hairs. It was first noticed by Corti in Chara* in 1774, afterwards by Amici in Caulinia fragilis,† and then by Treviranus in 1807. It has received the names of *Rotation* and *Gyration.* It is confined to individual cells, and its direction is more or less spiral. In Characeæ (p. 354) this spiral intra-cellular movement is observed easily under a moderate microscopic power. In Chara the axis is composed of elongated cells placed end to end, surrounded by a number of small secondary cells, which take a spiral course round the primary cells from left to right, and which are often encrusted with carbonate of lime. In Nitella, another genus of Characeæ, there are no secondary

Fig. 1092.

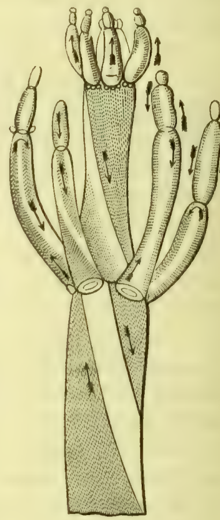

Fig. 1093.

spiral cells. The movements are most easily seen in the species of Nitella, which have unencrusted tubular cells. If the species of Chara are employed, the calcareous covering must be removed in the first instance. In Nitella flexilis (Fig. 1092) each joint, *a*, consists of a

Fig. 1092. One of the Characeæ (*Nitella flexilis*), consisting of cellular tubes which form the axis and branches. In these elongated cells the movement of rotation or gyration is observed.

Fig. 1093. A small portion of a Chara magnified to show the intra-cellular circulation. The arrows mark the direction of the fluid and granules in the different cells. The clear spaces are parts where there is no movement. The circulation in each cell is independent of that in the others.

* Corti, Osservazioni microscopische sulla Tremella et sulla circolazione del fluido in una piante acquajuola.

† Amici, sur le Caulinia fragilis.—Annales des Sc. Nat., 1st series, ii. 42; Osservazioni sulla circolazione del succhio nella Chara, 1818.

single cell composed of a membranous envelope, within which is arranged a layer of green granules, covering every part except two longitudinal lines, as seen in Figure 1093, which remain nearly colourless. During the healthy state of the plant, a constant motion of fluid containing granules takes place within the green layer, the current passing obliquely up one side, changing its direction at the extremity, and flowing down the other side. The stream takes a spiral course, and the ascending and descending currents are bounded by the transparent spaces already noticed, which appear to be caused by the adhesion of an internal membranous sac to the outer envelope. The space between the outer and inner wall is thus divided into two cavities, which communicate with each other at the ends of the cell. The rounded bodies which are carried forward in the circulation are of various sizes, and they undergo changes so as gradually to become incorporated with the tissue of the cells. The fluid does not pass from one cell to another, and if one of the long cells is divided by a ligature, a separate movement is seen in each division. Rotation continues for some days in detached cells placed in water.

594. In the cells of Vallisneria spiralis (Fig. 1094), a diœcious aquatic found in ditches in the south of Europe, a spiral intra-cellular movement takes place, and is easily seen under the microscope by laying a portion of the leaf in water, and making a slanting section of the end of it, so as to render the object more transparent by transmitted light. If the movement is not visible, the leaf may be immersed for a short time in water of the temperature of 70° or 80°. The piece of the leaf should always be prepared for an hour before it is exhibited. There are two kinds of cells in the plant, epidermal and parenchymatous; the former being small, from $\frac{1}{300}$ to $\frac{1}{400}$ of an inch square, the latter being elongated and muriform, with their long diameter $\frac{1}{100}$ to $\frac{1}{80}$ of an inch, and their short diameter $\frac{1}{600}$ to $\frac{1}{400}$. It is chiefly in the latter that the evident movements take place. There are spaces between these cells containing air, which give rise to the dark longitudinal lines marking the edges of the large internal cells when seen under the microscope. In the cells there are numerous green chlorophyll grains, some starch granules, and an occasional large nucleus, which are carried with a mucilaginous fluid round the interior of the

Fig. 1094.

Fig. 1094. Vallisneria spiralis, an aquatic plant found in the south of Europe. Under this name however, are included Vallisneria Micheliana, found in Italy, and Vallisneria Jacquiniana, which is a native of France, East Indies, and South America. In the cells of the plant the movements of rotation are well seen under the microscope. A small portion of the leaf may be taken, and the ends cut very obliquely, so as to make a transparent object. The application of a moderate heat to the water in which the portion of leaf is placed often expedites the circulation. *a*, The male plant; *b*, the female plant.

walls of each cell, as represented in Figure 1095. This movement is seen not only in the leaf-cells, but also in those of the root, flower-stalk, spathe, and calyx. The movement takes different directions in different cells, but it seems to keep the same course in any given cell; for if stopped, it resumes the same direction. The motion continues for many days in a detached piece of the leaf when kept in water. The rapidity of the movement varies from $\frac{1}{2}$ an inch to 5 inches per hour. According to Mohl's experiments made at the temperature of 66° to 68° Fahr., the quickest motion was 1-125th of a Parisian line,* the slowest 1-600th, and the mean 1-185th. The nucleus moved with the same velocity as the granules of chlorophyll. The current was often quicker in one cell than in another, and occasionally a spontaneous stoppage took place at certain points.†

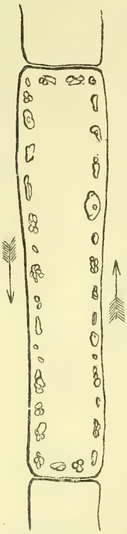

Fig. 1095.

595. In Vallisneria the motion ceases entirely at about 45° Fahr., while in Chara it goes on at a lower temperature. A moderate heat quickens the circulation, but if above 150°, the motion ceases. It is said to go on even in darkness, and the presence of green granules does not appear to be necessary, for it is seen in the transparent roots of Vallisneria. Prussic acid, solutions of opium, of acetate of lead, and of corrosive sublimate, alcohol, acids and alkalies, cause cessation of the movements. In the epidermal cells of Vallisneria, as well as in the young shoots of Chara, there has been observed, under a high magnifying power, and with subdued light, a rotation of the globular bodies on their own axes.

596. Similar movements are well seen in the cells of Anacharis Alsinastrum, an aquatic plant which seems to have been introduced into Britain from America, and is now naturalized.‡ It belongs to the same natural order as Vallisneria, and it is much more easily procured. Among other plants exhibiting rotation, the following may also be noticed :—Water soldier (Stratiotes aloides); stipules of various species of Pond-weed (Potamogeton); transparent stipules at the base of the leaf-stalk of Frogbit (Hydrocharis Morsus Ranæ); rhizome of Arrow-head (Sagittaria sagittifolia).

Fig. 1095. Large internal cell of Vallisneria, showing the direction of the currents in intra-cellular rotation. There is an occasional nucleus seen in the course of the circulation along with the chlorophyll grains.

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* A Parisian line is = .088815 of a British inch.

† These measurements were made by observing the passage of the image of a granule across the field of a glass micrometer fixed in the ocular, and at the same time counting the strokes of a second-pendulum. Mohl remarks, the smallness of these numbers may surprise many, especially when they are compared with the apparently considerable velocity which the movements exhibit under the microscope; but it must be remembered that in these circumstances the motion is seen quickened several hundred times.

‡ See Paper by Mr. George Lawson in the Scottish Florist for April 1853.

597. Spiral movements of rotation are also seen in the elongated cells forming the hairs of the Nettle, Loasa, Pentstemon, Galeopsis, Borage, Melon, and other plants, as well as in the separate cells of the staminal hairs of the Virginian Spider-wort (Tradescantia virginica). The hairs of Tradescantia assume either a blue or white colour, and are composed of several cells united together in a moniliform manner. In each of the cells the motion is seen, but it requires a higher power of the microscope than in the case of Chara, Vallisneria, and Anacharis. In every vesicle there is a nucleus, and there appears to be an inner and outer envelope in the space between which the movement of fluids takes place. In the hairs of Tradescantia, the velocity of the current, according to Mohl, varied from 1-300th to 1-900th of a Parisian line in a second, the mean velocity being 1-500th. The nucleus required from a quarter to half an hour to pass through one-third or one-half the longitudinal axis of the cell, progressing not more than 1-45,000th of a Parisian line in a second, which is much too little to allow of the movement being seen directly, even by the application of the strongest magnifying powers. In the stinging hairs of Urtica baccifera, the quickest motion observed by Mohl, at the temperature 66–68° Fahr., was 1-625th of a Parisian line in a second, the slowest 1-875th, the mean 1-750th. In the hairs of Cucurbita Pepo, the quickest was 1-770th, the slowest 1-2760th, the mean being 1-1857th of a Parisian line in a second. The protoplasmic motion is also seen in the stinging hairs of the Chili Nettle (Loasa), and in the hairs of the corolla of Campanula Medium.

598. The cause of these intra-cellular motions is obscure. They appear to be connected with the nourishment of the cell and the process of cytogenesis. Some have attempted to account for them by physical causes, but the explanations given are very unsatisfactory. Certain authors have referred the phenomenon to endosmose depending on different densities in the cell contents, while electrical agency has been called into requisition by others. Amici thinks that in Chara the rows of chlorophyll-granules which line the walls of the cells exercise a galvanic action upon the sap, and thus give rise to the motion. The action of the nucleus has also been thought to account for the phenomenon. It is not connected with the general circulation of the sap, but is a special movement in individual cells. As yet no good explanation has been brought forward, and all we can say is, that the movements are of a physico-vital nature.

599. Some cells connected with the lower tribes of plants move about in a liquid medium. Species of Oscillatoria have an undulating movement, and when placed in water in the field of the microscope, they seem to pass from one side to the other. Their elongated filamentous cells sometimes twist, and then project themselves forward by uncoiling. If we take good specimens of Nostoc verrucosum newly gathered, and put them on a plate full of water, we find that in two or three days the external pellicle bursts, and strings of cells spread out in the water,

and form a green pellicle at the bottom of the plate. These, when viewed by the microscope, are seen to be no longer of great length and twisted in various ways, but divided into numerous fragments of unequal length, which move about in all directions with a slow but perceptible motion.

600. In many Algals the cellular spores are surrounded by vibratile hairs called cilia, which continue to move for some time in fluid after the spore (zoospore) has been discharged from the plant (Fig. 1096). The ciliary motions cease when the spore begins to sprout. The cilia sometimes project from one end of the spore (Figs. 1097, 1098, 1, 2), at other times they surround it entirely (Fig. 1098, 3). Similar moving cells are seen in Stephanosphæra and other genera of Volvocineæ, which are now referred to the vegetable kingdom by Sie-

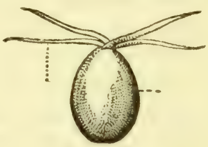


Fig. 1097.

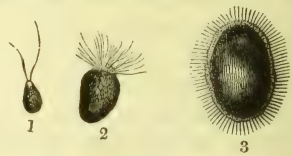


Fig. 1098.

Fig. 1096.

Fig. 1099.

Fig. 1100.

Fig. 1101.

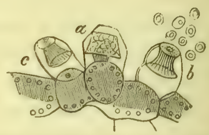


Fig. 1102.

bold, Williamson, Cohn, Busk, and others.* Each of the moving spores or microgonidia of these plants has four cilia.

Fig. 1096. A Confervaceous Alga (*Vaucheria ovoidea*), consisting of an elongated club-shaped cell, from one end of which is discharged a cellular germ or spore, provided with vibratile filaments called cilia, which display movements in water.

Fig. 1097. Moving spore of a Conferva (*Chætophora*), provided with four vibratile cilia. It is called a Zoospore or Sporozoid on account of the motions it displays for a certain time in water.

Fig. 1098. Zoospores or Sporozoids of Algæ, being cells provided with moving cilia. 1. Zoospore of Conferva glomerata, with two cilia at one end. 2. Zoospore of Prolifera rivularis, with a tuft of cilia at one end. 3. Zoospore of Vaucheria, surrounded by cilia.

Fig. 1099. Two Phytozoa, with moving cilia, contained in the antheridium of a Sea-weed (*Fucus serratus*).

Fig. 1100. Phytozoon, with two vibratile processes, from the globule (antheridium) of a species of Chara.

Fig. 1101. Phytozoon, with cilia, from the antheridian cells of the prothallium of a Fern (*Asplenium septentrionale*).

Fig. 1102. Antheridia from the prothallium of the Common Brake (*Pteris aquilina*). *a*, An unopened antheridium. *b*, An antheridium bursting at the apex, and discharging free cellules, each of which contains a ciliated spiral filament (spermatozoid); on its exit this spiral body moves about actively with a rotatory motion, when seen in water under the microscope. *c*, Antheridium after the discharge of the cellules, assuming a brown colour.

* Williamson on Volvox globator, in Memoirs of the Lit. and Phil. Soc. of Manchester, vol. ix.; and Quarterly Journal of Microscop. Science, i. 45. Busk on Volvox globator, in Quarterly Journal

601. In the antheridia of Cryptogamic plants there occur free cellules containing bodies called Phytozoa, Spermatozoids, or Seminal filaments, which have vibratile moving processes. In Figure 1099 two of these phytozoa are represented in the antheridium of a Sea-weed (Fucus serratus), and in Figure 1100, a similar body is exhibited as taken from the globule of a species of Chara. In Figure 1101 there is shown a phytozoon as discharged from the prothallian cells of Ferns. Figure 1102 exhibits these antheridian cells in different stages of growth, the discharge of the phytozoary cellules being delineated at *b*. The cause of the movements of zoospores and phytozoa has not been ascertained. The subject has engaged the attention of many able physiologists, such as Thuret and Decaisne, Suminski, Mercklin, and Hoffmeister.*

II. FUNCTIONS OF VESSELS AND OF VASCULAR TISSUE.

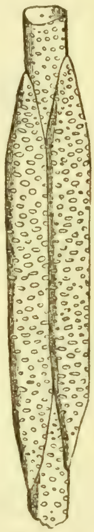
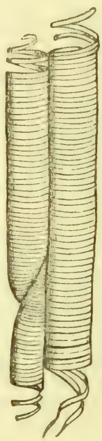
602. We have seen that the plant, in its earliest stage of development, consists entirely of cells. It is from them, accordingly, that the other structures are formed. Some cells become elongated, so as to form fusiform tubes, the walls of which are thickened and strengthened by deposits of different kinds, and thus give rise to woody tubes, dotted vessels, and fibro-vascular tissue. In connection with these vessels are observed nucleated cambium cells, which appear to be concerned in

of Microscop. Science, i. 31. Cohn on a new genus of Volvocineæ, in Siebold and Kolliker's Zeitschift für Zoologie, iv. 77; translated in Ann. Nat. Hist., 2d series, x. 323.

* For fuller particulars relative to the development and functions of cells, the student may consult the following works and papers :—Alison, on Vital Affinity—Trans. Royal Soc. Edin., xvi. 165, and xx. 385. Amici, on the Movements in Caulinia fragilis—Ann. des Sc. Nat., 2d ser., i. 41. Barry, Researches in Embryology—Philosophical Transactions, 1838, p. 301, 1839, p. 307, 1840, p. 529, 1841, p. 193; Edin. New Phil. Journal, 1847. Carpenter's Principles of Physiology, General and Comparative, p. 88. Cohn, zur Lehre vom Wachsthum der Pflanzen Zelle, in Nova Acta Natur. Curios. xxii., 2d part, 509. Hartig, Beiträge der Entwickelungsgeschichte der Pflanzen, 1843. Harting, on the Growth of Cells—Linnæa, xix. Hassall, on Chara, Fresh-water Algæ, i. 85. Inman, on Circulation in Cells of Vegetables—Proceed. Lit. and Phil. Soc. of Liverpool, No. iv. p. 26, 1848. Meyen, sur la Circulation du Suc Cellulaire dans les Plantes—Annales des Sc. Nat., 2d series, Bot., iv. 257. Mohl, Grundzüge der Anatomie und Physiologie der Vegetabilischen Zelle; on the Structure of the Vegetable Cell, in Taylor's Scientific Memoirs, iv. 91; on the Anatomy and Physiology of Cells, translated by Henfrey; sur l'Accroissement de la Membrane Cellulaire—Botan. Zeitung, 1846, 337, and Annales des Sc. Nat., 3d series, Bot., vii. 129; on the Movement of Fluids in the interior of Cells—Bot. Zeit., Jan. and Feb. 1846; Annales des Sc. Nat., 3d series, Bot., vi. 84; Annals of Nat. Hist., xviii. 61. Naegeli, on the Nuclei, Formation and Growth of Vegetable Cells, translated from Zeitschrift für Wissenschaftliche Botanik, in Ray Society's Reports, 1846, p. 213, 1849, p. 93. Pouchet sur les Globules Circulatoires de la Zannichellia palustris—Ann. des Sc. Nat., 2d series, iii. 39. Quekett, on Vallisneria—Physiolog. Journ., i. 33, 65. Schleiden, on Phytogenesis, translated from Muller's Archiv. in Taylor's Scientific Memoirs, i. 281; Principles of Botany, translated by Lankester, 31. Schwann, Mikroscopische Untersuchungen ueber die Uebereinstimmung in der Structur und dem Wachsthum der Thiere und Pflanzen, Berlin, 1839. Slack, on the Motion of Fluids in Plants—Trans. Soc. Arts, xlix. 142, 177. Thuret, sur les Zoospores des Algues, &c.—Ann. des Sc. Nat., 2d series, Bot., xix. 206; 3d series, xiv. 214. Thwaites, on the Cell Membrane of Plants—Annals of Nat. Hist., xviii. p. 15. Unger, ueber die Samenthiere der Pflanzen—Nova Acta Natur. Curios., xviii. 785. Varley, on the Circulation in Chara vulgaris—Trans. Soc. Arts, xlviii. 387, xlix. 179.—See also other references to papers on Zoospores and Phytozoa of Cryptogamic plants, in notes, pp. 320 and 356.

their development. Barry maintains that in every instance in which fibres are present in tissues, he has noticed filaments of a similar nature in the earliest state. Agardh has recently stated that fibres are the origin of the tissues, and that the cell-walls are made up of bundles of solid fibres interwoven together. In the case of Conferva Melagonium, Griffithsia equisetifolia, and Polysiphonia complanata, he has shown in the cell-walls numerous bundles of fibres, which cross each other at the joints so as to form the diaphragm. They also seem to pass from the inner lining of one cell to that of the cells in immediate contact with it. The fibres are especially evident when the walls are ruptured. Between the bundles of fibres there are spaces which are traversed by finer fibres, with faint traces of a connecting gelatinous substance.* The tubes forming the wood (Fig. 1103) are pervious to fluids in their young state, but their walls soon become thickened by



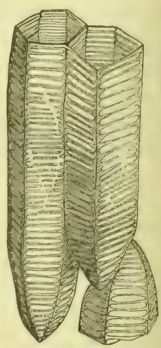


Fig. 1105. Fig. 1103. Fig. 1104. Fig. 1106. Fig. 1107. Fig. 1108.

deposits of lignine, and in the heartwood of trees their cavities are obliterated. This filling up of the tube takes place often in a concentric manner, and when it is completed, the active life of the cell or

Fig. 1103. Woody tissue, consisting of fusiform tubes, the walls of which are thickened by deposits of lignine.

Fig. 1104. Dotted, pitted, and porous vessels, consisting of fusiform tubes, with depressions on their walls caused by the mode in which the thickening matter is deposited.

Fig. 1105. Dotted vessels composed of cells united together, with the partitions obliterated.

Fig. 1106. Spiral vessels from the Melon, with the fibres partially unrolled.

Fig. 1107. Spiral and annular vessels from the Melon.

Fig. 1108. Scalariform vessels of Ferns.

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* Agardh, De Cellula Vegetabili fibrillis tenuissimis contexta, Lundæ, 1852.

tube may be considered as having terminated. The dotted or porous vessels (Fig. 1104) constituting bothrenchyma, do not exist in all vascular plants. Thus they do not usually exist in Conifers. Their walls are thickened to a certain extent by deposits, but spaces are left of a thinner nature. Occasionally they seem to be formed, as in Rhubarb, by a filling up of the inter-spaces between fibres, until a small pit only remains; or, as in Alnus serratula, by a number of lines arranged at first like those of a ladder, and then united by transverse ones forming a grating, the angles being finally filled up and rounded; or, as in Populus tremuloides, by a uniform deposit over the whole membrane. These vessels appear to be employed in the rapid and easy transmission of fluids, and, according to Morren, they are so constructed as to unite the utmost possible strength with the greatest lightness. Some of these dotted vessels, more especially those included under articulated or moniliform bothrenchyma (Fig. 1105), seem to be produced by the union of cells, the partitions between which are ultimately absorbed, so as to form continuous tubes, with annular depressions on the outside, marking the points of union between the cells.

603. The functions of the fibro-vascular tissue (Figs. 1106, 1107, 1108), consisting of spiral vessels or tracheæ, and their modifications (p. 27), have been long a subject of dispute. Early authors, such as Grew and Malpighi, considered them as tubes for the transmission of air, probably from their resemblance to air-tubes of animals. Hales* mentions that air-bubbles arose from the vessels of the Vine when cut, and Bischoff,† in his Dissertation on the Functions of the Spiral Vessels, says that he distinctly observed air to come from the spirals of Cucurbita Pepo when the stem was cut across with a very sharp knife, as well as when the vascular bundles were placed under water and gently pressed. During the day this air was found to contain 27.9 to 29.8 per cent. of oxygen. When the cut stem was inserted in coloured solutions, he found that the fluid in these circumstances entered the spiral vessels as well as the other tissues. The recent experiments of Hoffmann‡ confirm in a great measure these observations. He found that in Monocotyledons and Ferns, spiral vessels and those allied to them, such as annular and scalariform vessels, usually contained air in their normal condition; but if there was a rapid and copious entrance of sap, then the fibro-vascular tissue took up liquids as well as air. When the roots were cut across and immersed in water, then the liquid passed into all the tissues, including the spirals. From all the observations made, it would appear that spiral vessels and their allies are receptacles for gaseous matter formed in the course of the movement of the sap.

604. Laticiferous vessels (Fig. 1109) are distinguished from others by their branching and anastomosis. Some look upon them as inter-

* Hales, Vegetable Statics, p. 155, *et seq.* † Bischoff, de Vasorum Spiralium functione, Bonn. 1829.
‡ Hoffmann, on Circulation of Sap—Scientific Memoirs, Natural History, November 1852, 1.

cellular canals lined by a special membrane. Most authors believe that they contain the elaborated sap which has been exposed to the influence of air and light. The fluid contained in these vessels is sometimes clear and transparent, at other times opaque, from the presence of granules of resin, caoutchouc, and other matters. In plants with milky and coloured latex, as the India Rubber plant (Ficus elastica), the Taban, or Gutta Percha tree (Isonandra Gutta), Dandelion, Lettuce, the Cow tree (Fig. 1110), Euphorbias (Fig. 1111), and Celandine (Fig. 1112), when examined under the microscope, evident movements have been perceived in the laticiferous vessels. In making this examination, it is necessary to fix upon a more or less transparent organ, and to examine it while still attached to the plant, so as to avoid all sources of fallacy. In the calyx of the Celandine, the orange-

Fig. 1109.

Fig. 1110.

coloured fluid contained in the laticiferous vessels can be distinctly seen, as represented in Figure 1113, moving with great rapidity, so as to resemble in many respects the appearance presented by the circulation in the web of a frog's foot. In the stipule of the India Rubber plant, a similar motion, but usually slower and less apparent, may be detected without injuring the plant. These movements were noticed by Schultz, and were called by him vital. Mohl and others have recently attempted to show that the movements are merely caused by injury done to the tissues in submitting them to microscopic examination. But this will not account for those cases where the motion of the latex was seen in an organ without detaching it from the plant. Moreover, it is by no means difficult to distinguish between the continuous rhyth-

Fig. 1109. Branching and anastomosing tubes of laticiferous vessels. In them there is an evident movement of granules of latex, as represented in some of the tubes in the Figure, the arrows marking the direction of the current.

Fig. 1110. Cow-tree of the Caraccas (*Galactodendron utile*), yielding a bland milky juice, which is used as food. The milk is contained in laticiferous vessels.

mical motion in these vessels and that caused by pressure or by injury. When the stipule of Ficus, still attached to the plant, is laid gently on a glass plate under the microscope, we may, by applying artificial pressure, show that the oscillation thus caused is different from the circulation in the vessels. The movement in the laticiferous vessels has received the name of *Cyclosis*. It seems to take place in all direc-

Fig. 1111.

tions, the currents, as shewn in Figures 1109 and 1113, running in contrary directions in contiguous vessels. The movement is said to be most vigorous in parts which are in the progress of development. It is promoted by the application of heat, and it is checked by cold

Fig. 1111. Caper Spurge (*Euphorbia Lathyris*), yielding an acrid milky fluid, which is contained in laticiferous tissue, and exhibits the movement of Cyclosis. When the plant is wounded in the slightest degree there is an abundant flow of milky sap.

and by an electric shock. Carpenter considers it as analogous to the capillary circulation in animals. It is not caused by a *vis a tergo*, because it is by no means constant in its direction, and there is no

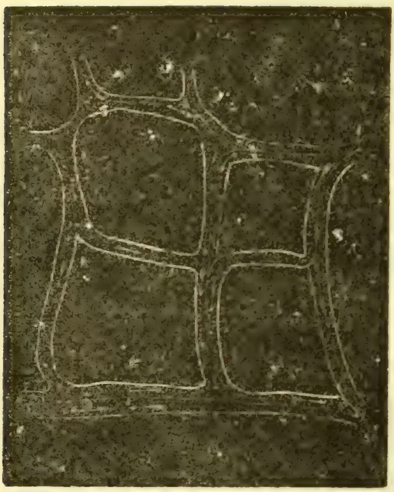

Fig. 1113.

Fig. 1112.

organ to supply a propelling force; and it cannot be attributed to a *vis a fronte*, like that which operates in causing the sap to ascend from the roots to the leaves. Moreover, it goes on for some time in parts detached from the rest, where neither of these powers can be exerted. There is no evidence of contraction in the vessels themselves to account for the phenomenon. It seems to be a peculiar vital movement con-

Fig. 1112. Celandine (*Chelidonium majus*), the laticiferous vessels of which contain an orange-coloured granular fluid. In the calyx, the movement of the granules can be seen under the microscope.

Fig. 1113. Portion of sepal of Celandine (*Chelidonium majus*), showing the laticiferous vessels, the course of the currents in the vessels being indicated by the arrows.

nected with formative actions, and attributable to affinities existing between the tissues and the fluids concerned in nutrition.*

605. Recapitulation of some of the chief points connected with the Physiology of the elementary vegetable tissues :—

1. Cells are met with, to a greater or less extent, in all plants.
2. Some plants are entirely cellular, and in them all the functions of life are carried on by means of cells.
3. Living cells have the power of absorbing fluids, of elaborating secretions, and of forming new cells.
4. Cells increase in size, and become altered in form and in composition, during the progress of growth.
5. Cytogenesis, or cell development, takes place through the medium of an albuminous matter called Protoplasma or Cytoblastema.
6. Multiplication of cells takes place either by means of nuclei (cytoblasts) developed within parent cells; or by fissiparous (merismatic) division, caused by the folding inwards of the primordial utricle; or by budding (gemmation); or by union of two parent cells having different contents (conjugation).
7. Cells absorb fluids through their walls by an endosmotic action; and cellular tissue exhibits hygroscopic properties.
8. Movements take place in the interior of cells, to which the name of intra-cellular rotation has been given.
9. These movements are connected with the nutrition of the cell and the production of new cells.
10. Undulating movements are evident in some cellular plants, such as Oscillatorias.
11. Movements of individual cells, by means of vibratile processes (cilia), have been observed in the lower classes of plants. These moving cells are called Zoospores or Sporozoids.
12. Movements of spiral ciliated filaments are seen in cellules discharged from the antheridian cells of many Cryptogamic plants. These moving filaments are called Phytozoa or Spermatozoids.
13. Vessels are produced from cells by processes of elongation and transformation, or by the union of cells and the absorption of the partitions between them.
14. The walls of vessels are strengthened by ligneous deposits, which either spread continuously over their inner surface, or appear in the form of fibres of different kinds.
15. Woody tubes at first contain fluid, but their cavities are finally obliterated by deposits of lignine
16. Dotted or Pitted vessels usually contain sap.
17. Fibro-vascular tissue of different kinds seems to be fitted chiefly for containing air.
18. Laticiferous vessels contain elaborated sap, which exhibits the movement of Cyclosis.

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* For further remarks on the functions of vessels, the student should consult:—Barry, on Fibre — Phil. Trans., 1848, p. 89. Bischoff, de vera Vasorum Plantarum Spiralium structura et functione commentatio, Bonn, 1829. Hoffmann, on the Circulation of the Sap in Plants—translated from Botan. Zeit. in Scientific Memoirs by Henfrey and Huxley, part i. 1, 1852. Mohl, ueber den Milchsaft und seine Bewegung, &c.—Bot. Zeitung, Nos. 33, 34, 35 (1843), also 1846, 833. Anatomy and Physiology of the Vegetable Cell, translated by Henfrey, 94. Schultz, die Cyklose der Lebensaftes in der Pflanzen—Nova Acta, xviii. Suppl. ii.; sur la Circulation et sur les Vaisseaux Laticifères dans les Plantes. Tristan, sur les Canaux Laticifères—Annales des Sciences, 3d series, Bot. i. 176. Unger, ueber die Genesis der Spiral-gefässe—Linnæa, xv. 385.

CHAPTER IV.

PHYSIOLOGY OF THE DESCENDING AXIS OR ROOT.

606. The Root is the descending system of the plant, and is the organ directly concerned in the absorption of nourishment from the soil. In its earliest state it is a cellular prolongation from an axis which is common to it and the stem. In cellular plants, the root consists also of cells. Root-cells are developed in a downward direction, and the fibrils spread through the soil, so as to absorb nutriment and to fix the plant firmly. The additions to roots are made at their extremities, and there it is that the chief absorbing cells are situated, constituting what have been called Spongioles. The cellular points of roots are shown in Figures 1114, *sp*, and 1115, *r*. Connected with young roots there are hairs or cellular prolongations from the epidermis, which also absorb fluid food. These hairs die early with the epidermis from which they sprung; the root then becomes covered with a corky layer, while its extremity continues to grow and send out fresh hairs. Any injury done to the absorbing extremity interferes more or less with the proper nutrition of the plant.

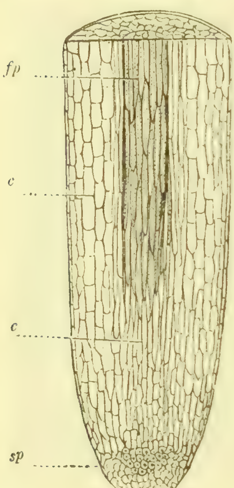

Fig. 1114.

Fig. 1115.

607. As plants are fixed to a spot, their food must be always within reach, and it is requisite that the roots should have the power of spreading, so as to secure renewed supplies of nutriment. A beautiful provision is made for this by the elongation of the roots taking place at their extremities, so that their advancing points are enabled

Fig. 1114. Vertical section of an Orchis root, highly magnified. The absorbing extremity of the root or spongiole, *sp*; the cells, *c c*, gradually pass into vessels, *fp*.

Fig. 1115. Duck-weed (*Lemna minor*), an aquatic plant which forms the "green mantle" of the pools. The extremities of the roots, *r*, called spongioles, are covered with a beautiful cellular sheath.

easily to accommodate themselves to the nature of the soil in which the plant grows. If roots had increased by additions throughout their whole extent in the same way as stems, they would in many instances, when meeting with an impenetrable soil, have been twisted in such a way as to unfit them for the free transmission of fluid. But by the mode of lengthening at the point, they insinuate themselves easily into the yielding part of the soil, and when obstacles are presented to their progress, they wind round about them until they reach a less resisting medium. They are thus also enabled to move from one part of the soil to another, according as the nourishment is exhausted.

608. The root, in its growth, keeps pace with the development of the stem and its branches. As the stem shoots upwards and developes its leaves, from which water is constantly transpired, the roots continue to spread, and to renew the delicate cells and fibrils which absorb the fluid required to compensate for that lost by evaporation, or consumed in growth. There is a constant relation between the horizontal extension of the branches and the lateral spreading of the roots. It is not by watering a tree close to the trunk that it will be kept in vigour, but by applying the water on the soil at the part corresponding to the ends of the branches. The rain which falls on a tree drops from the branches on that part of the soil which is situated immediately above the absorbing fibrils of the roots. We have here, says Roget, a striking instance of that beautiful correspondence which has been established between processes belonging to different departments of nature, and which are made to concur in the production of such remote effects as could never have been accomplished without these preconcerted and harmonious adjustments.*

609. If the roots are not allowed to extend freely, they exhaust the soil around them, and are prevented from receiving a sufficient supply of food. The plants in such a case, deprived of their proper means of support, become stunted and deformed in their appearance. How often do we see plants subjected to very injurious treatment in green-houses and hot-houses. They are put into pots of small dimensions, and they are permitted to grow until their roots completely fill the pots—nay, even sometimes until they actually force the whole plant upwards. The gardener's attention being thus drawn to them, they are transplanted; but instead of being placed in a liberal supply of earth, they are put into pots only slightly larger than the first, and by continued shiftings of a similar nature, they are kept in a state of starvation. This restricting of the roots may, no doubt, like other injuries done to plants, cause them to flower for a time; but it interrupts the growth of their branches and leaves, and destroys their natural habit. On the other hand, by adopting a system which gives the roots freedom, and puts no arrest on their development, we are imitating what takes place in nature. This is our best and surest guide, if we wish to have well-grown specimens of plants.

* Roget's Bridgewater Treatise, on Animal and Vegetable Physiology.

610. If we wish trees to be firmly rooted, we must allow the branches to spread freely. When they are so planted that the branches and leaves of contiguous trees do not interfere with each other, and thus all parts are exposed to air and light equally, the roots spread vigorously and extensively, so as to fix the plants in the soil, and to draw up copious supplies of nourishment. But in crowded plantations, where the branches are not allowed freedom of growth and exposure, and the leaf-buds are consequently either arrested or feebly developed; the roots, also, are of necessity injured. They do not spread, and the trees are liable to be blown over by the wind; they exhaust the soil in their vicinity, circumscribed by the roots of the trees around; their functions become languid, and thus they react on the stem and branches, so that the additions to the wood are small, and the timber is of inferior quality. In such a plantation there is a marked difference between the trees on the outside and those in the centre; the former, having their branches and leaves fully exposed on one side, grow with comparative vigour, and form excellent timber on that side of the stem where light and air are admitted; while the latter, hemmed in on all sides, are drawn up like bare poles, producing a small amount of ill-conditioned wood. A crowded plantation, in which the trees are allowed to increase in size until they interfere with each other, cannot be easily reclaimed; for every attempt at thinning in this advanced stage of growth is accompanied with the risk of exposure to the blast, which speedily levels trees having no firm hold of the soil.

611. When the roots of different trees come into contact, it occasionally happens that they become united by natural grafting. Goeppert noticed this in the case of Abies pectinata and excelsa, on the Alps. In such cases, after the upper part of the trunk of the firs has been sawn off, the stumps have continued to retain their vitality, in consequence apparently of nutriment conveyed from the roots of the contiguous trees, with which they had become united.*

612. The spreading of roots in favourable circumstances is often remarkable. Thus, the roots of trees and other plants, when they reach reservoirs of water, as wells or drains, are found to increase very rapidly, and extend to a great length. Drains are sometimes completely blocked up by roots, in consequence of a single fibril entering at a small crevice, and then expanding into a large fibrous mass. The roots of the common Whin have been found extending into drains at a distance of six feet from the plant; Horse-radish roots have been detected in a drain at the depth of seven feet; the roots of Elm have filled up drains fifty yards distant from the tree, and so also roots of Ash, Willow, and Alder.†

613. Roots, by depriving the soil of certain nourishing matters, render it unfit for the growth of the same species of plant, although it

* Goeppert, sur la Formation des Bourrelets sur le Sapin.—Annales des Sc. Nat. 2d series, xix. 181.

† Journal of the Royal Agricultural Society of England, i. 361.

may still be able to contribute to the growth of other species. This is the principle of the rotation of crops, to which allusion has been made at p. 396. This exhaustion of the soil, according to Roget, affords an explanation of the phenomenon called *fairy rings*, consisting of circles of dark green grass seen in old pastures.* These have been traced to the successive generations of certain fungi spreading from a central point. "The soil which has once contributed to the support of these fungi, becomes exhausted or deteriorated with respect to the future crops of the same species, and the plants therefore cease to be produced on these spots; the second year's crop consequently appears in the space of a small ring, surrounding the original centre of vegetation; and in every succeeding year the deficiency of nutriment on one side necessarily causes the mycelium and roots to extend themselves solely in the opposite direction, and thus the circles continually proceed by annual enlargement from the centre outwards. An appearance of luxuriance of the grass follows as a natural consequence; for the soil of an interior circle will always be enriched and fertilized with respect to the culture of grass by the decayed fungi of the preceding year's growth. It often happens, indeed, during the growth of these fungi, that they so completely absorb all nutriment from the soil beneath, that the herbage is for a time totally destroyed, giving rise to the appearance of a ring bare of grass surrounding the dark ring; but after the fungi have ceased to appear, the soil where they had grown becomes darker, and the grass soon vegetates again with peculiar vigour. When two adjacent circles meet, and interfere with each other's progress, they not only do not cross each other, but both circles are invariably obliterated between the points of contact; for the exhaustion occasioned by each obstructs the progress of the other, and both are starved. It would appear that different species of fungi often require the same kind of nutriment; for, in cases of the interference of a circle of Agarics with another of Puff-balls, still the circles do not intersect one another; the exhaustion produced by the one being equally detrimental to the growth of the other, as if it had been occasioned by the previous vegetation of its own species."† Way finds that the fungi forming fairy-rings (such as Agaricus oreades and graveolens) contain a large quantity of phosphoric acid and potash in their composition; and hence, as these are required for the nourishment of grass, the growth of fungi destroys the pasture at first. Subsequently, however, when the fungi decay, they restore to the soil valuable manure, which causes a vigorous growth of herbage.‡

614. Roots require a season of repose. This is too little attended to in the case of plants cultivated in our hot-houses. We generally find that there is a constant stimulus applied in the way of heat and

* Wollaston, Phil. Trans. for 1807, p. 133; Dr. James Hutton, on certain natural appearances of the hill of Arthur's Seat, near Edin.—Trans. Roy. Soc. Edin. ii. 3.

† Roget, Bridgewater Treatise on Animal and Vegetable Physiology, i. p. 55.

‡ Way, on fairy rings in pastures.—Journ. Eng. Agric. Soc. vii. 549.

moisture, and thus the plants are kept always in an active growing state. We ought to imitate what we see in nature. Even in warm climates, where there is not the frost of winter, there is a dry season when the functions of plants are more or less completely suspended. Hence, hot-house plants ought, at certain times, to get sparing supplies of water, so as to bring them into a dry state. Their activity is then checked, and the action of the leaves is arrested. By this means, too, there is a slow accumulation of sap, and the plant is ready, when heat and moisture are supplied, to burst forth with renewed vigour.

615. The roots of plants should not be disturbed at the time when they are in active operation. During the season of growth when the branches and leaves are pushing forth, the roots are also developing their rootlets, and constantly renewing their delicate absorbing extremities. Any attempt to transplant at this period is attended with serious injury, because those minute fibrils are destroyed by means of which the fluid transpired by the leaves is restored. It is only in autumn, when the rootlets cease to grow, and absorption becomes languid, or in early spring before their activity begins, that transplanting can be prudently conducted. In transplanting large trees it has been customary to cut the roots all round at some distance from the trunk the season before they are removed. Thus an opportunity is afforded for the production of new fibrils, which, after transplantation, are ready to absorb nourishment. If, however, the transplanting is properly effected, there seems to be no reason why the tree should not be allowed to form its fibrils and spongioles in the new ground in which it is to be placed.

616. Recently, however, Mr. M'Glashen has introduced a method of transplanting, by which the plants are easily taken up, with a large ball of soil round their roots, in a state fit for transportation to a distance. This process saves the trench digging and packing of the roots which were required in the plans pursued by Sir Henry Steuart and Mr. William M'Nab. It consists in driving spades or cutters into the soil at a proper distance from the plant, so as to enclose a square piece of soil; the upper portions of the iron cutters, after being driven in so as to be on a level with the soil, are fastened together either by hooks or by an iron frame, and then the handles of the cutters or spades are forced out from each other by means of iron bars, thus causing the lower portion of the spades to press inwards. In this way a mass of earth of a wedge-form is secured, and the whole can be easily raised up by means of levers or screws on either side. The stem of the tree is also firmly held by means of iron or wooden bars passing from one side of the apparatus to the other; and in this way a traction power is exerted in the centre, in addition to that at the different sides. The apparatus, in its simplest and smallest form, consists of two semi-cylindrical iron cutters or spades, which are pushed into the soil separately, and are fastened together at the upper part of the iron portion by means of hooks; the wooden handles are then pushed outwards and

secured in their position by a rod passing between them. The soil and plant are then easily taken out in one mass without any disturbance of the roots.*

617. The spongioles and cellular hairs of the fibrils of roots absorb fluid food, and by diffusion communicate the matter absorbed to the neighbouring cells, and these in turn send it through their membrane upwards into the stem. Senebier proved by experiments that the absorption takes place principally by the cells at the points of the roots. After the corky layer is formed, the cells seem to have less power of taking up fluids through their walls. The imbibition by the roots may be traced in part to the process of endosmose already described (p. 412), and in part to certain vital actions going on in the cells. By virtue of the chemical composition of its cell-walls and juices, and by vital affinity, a plant absorbs one substance more quickly than another, and consequently in a given time more of one than of another.

618. That the roots of plants have a certain power of selection was proved by the experiments of Saussure.† He immersed the roots of plants in water, containing in solution an equal weight of two different salts, and when the plants had absorbed half the water, he took them out and evaporated the remaining water, so as to determine how much of the salts remained. This of course indicated what the plants had taken up. The salts were not absorbed in equal quantities. Thus, when a solution containing equal parts of muriate of soda and sulphate of soda was employed, the plant took up 20 grains of the former salt and only 7 of the latter. In the case of a solution of muriate and sulphate of potash, 17 grains of the former were absorbed and only 10 of the latter.‡ This difference in the proportion of salts taken up was only observable so long as the roots were entire; for when their extremities were cut off the saline matters were taken up in the same proportion. The absorption of saline matters by the roots of plants varies in individual plants of the same species, as well as in plants belonging to different species. The absorption, according to the observations of Saussure, does not seem to have reference to the value of the substances as nutriment. Substances are taken up which prove injurious to plants. Trinchinetti placed different species of plants in mixtures of two salts—nitre and common salt—which do not decompose each other, and he found that one plant absorbed the one, and another plant the other salt, in preference. Thus Mercurialis annua and Chenopodium viride absorbed much nitre and little salt, while Satureia hortensis and Solanum Lycopersicum took up much salt and little nitre. From a solution of sal-ammoniac and common salt, Mercurialis absorbed more of the former, while the common Bean took up

* See Figures of the apparatus in Gardener's Chronicle, March 12, 1853.

† Saussure, Recherches Chimiques sur la Vegetation, 247, 261. See also Braconnot, Annales de Chimie, lxi. 137; and Schrader, Gehlen's Journal, v. 255.

‡ In repeating these experiments of Saussure, it is of importance to select salts which do not react upon each other by the process of double decomposition, otherwise the results may be complicated and unsatisfactory.

more of the latter.* Daubeny concludes from his experiments that the roots of plants, to a certain extent at least, possess a power of selection, the earthy constituents being determined as to quality by some primary law of nature, although the amount may depend on the more or less abundant supply of the principles presented to them from without.†

619. Besides absorption, it has also been stated that excretion takes place by roots, or in other words, that matters which have been taken up from the soil, and which are not required for the use of the plant, are again returned by the roots. This subject was investigated by Macaire,‡ who looked upon these excretions as injurious to plants. The recent observations of Gyde and others, however, lead to the belief that the excretions of roots are in small quantity, and that they do not possess the deleterious properties which were attributed to them. It is probable that the substances given off by roots may be referred to a process of exosmose.§ It has been stated that carbonic acid is sometimes given off by roots. Wiegmann and Polsdorff ascertained that, when plants were grown in quartz sand, which had, in the first place, been made red-hot, and had afterwards been digested in nitro-muriatic acid, they furnished potash, lime, magnesia, and silica in their ashes; and they attributed this to the action of carbonic acid given off by roots, and decomposing the quartz sand.

620. Some roots which do not ramify have reservoirs of nutriment stored up in the form of nodulose or tubercular masses. This occurs in terrestrial Orchids (Fig. 1116), and in Dahlias (Fig. 1117). In the case of Spondias tuberosa, the tubercles of the roots contain a large quantity of watery fluid. In climbing plants, such as Ivy (Fig. 124, p. 53), the root-like processes by which they are attached to trees or walls seem to be means of support rather than organs of nutrition. Aerial roots take up nourishment from the atmosphere chiefly. This is the case with the roots of many Epiphytic Orchids (Fig. 1118), and, in consequence of not being in a resisting medium like the soil, the elongation in them seems not to be confined to the extremities, as shown by the experiments of Lindley on Vanilla and Aerides cornutum. The roots of these Epiphytes or air-plants may derive some nourishment from the decomposition of the bark of the trees on which they grow, as well as from the decay of mosses, lichens, &c. which accumulate around them, but their principal nutriment appears to be supplied by the water, carbonic acid, and ammonia of the air. Atmospheric food is that which is supplied also to the aerial roots of the Screw Pine (Fig. 122, p. 53), and Banyan (Fig. 121, p. 52), before they reach

* Trinchinetti, sulla facolta assorbente delle radici.

† Daubeny on selection by roots—Linn. Trans. xvii. 253.

‡ Macaire-Prinsep, sur les Excretions des Racines; Mem. de la Soc. Phys. et d'Hist. Nat. de Genève, tom. v. 287—Annales des Sc. Nat. 1st series, xxviii. 402. Brugmans, de mutata humorum in regno organico indole.

§ Gyde, on Radical Excretions—Trans. of Highland and Agricultural Society, October 1843, p. 75, and March 1846, p. 273.

the soil. Roots, when exposed to the air, lose their fibrils, and take on the functions of stems, so as to produce leaf-buds. This was shown by an experiment of Duhamel, who inserted the branches of a Willow into the soil, and after they were fairly rooted there, raised the natural roots out of the ground, so as to be exposed to the air. In this instance the young roots perished, and the older roots became transformed into leaf-bearing branches.

621. Some plants, in place of sending their roots into the soil, or extending them into the air, have the power of attaching themselves to other plants in such a way as to prey upon their juices. These are called parasites. Some of them have green leaves, such as the Mistleto (Fig. 125, p. 53); others have only white or brown scales, as the Scalewort and Broom-rape (Fig. 126, p. 54). In the former, the juices, after being taken up by the plant, are altered in the leaves by exposure to air and light. Some of these are root-parasites; in

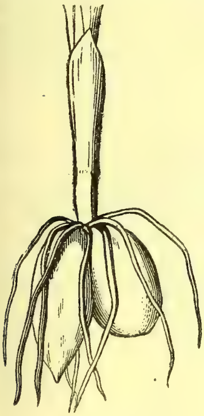

Fig. 1116.

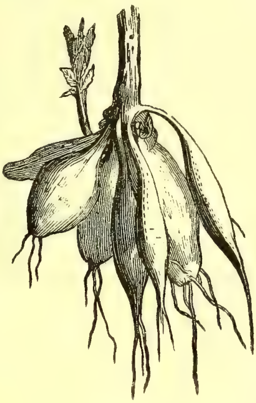

Fig. 1117.

Fig. 1118.

other words, become attached to the roots of other plants; as Broom-rape, Eyebright, Bastard Toad-flax, and Cow wheat; others are stem parasites, growing by attachment to the stems of other plants; as the Mistleto, Myzodendron, Rafflesia (Fig. 127, p. 54), and Dodder (Fig. 128, p. 54).* All of them send cellular prolongations more or less deeply into the tissue of the plants on which they feed, and by means of these, which act as roots, they derive nutriment. They often cause

Fig. 1116. Roots of a terrestrial Orchid, partly in the form of fibres, and partly in the form of tubercules, two of which are seen in the Figure. These tubercular roots contain much nutritive matter.

Fig. 1117. Large roots of Dahlia, containing a store of nourishing matter.

Fig. 1118. An Epiphytic Orchid, with its thickened and shortened stems, and its aerial roots, which elongate throughout their whole extent.

* Griffith, on Rhizanths—Trans. Linn. Soc., xix. 303. Mitten, on the Parasitism of the root of Thesium linophyllum—Lond. Journ. of Bot. 1847, vi. 146. Decaisne, sur le Parasitism des Rhinanthacées—Annales des Sciences, 3d series, Bot. viii. 5. Bowman, on the Mode of Growth and Nutrition of Lathræa squamaria, Scalewort—Linn. Trans. xvi. 399.

great injury to the plants on which they grow. Thus the Dodders destroy Lint, Clover, and other crops; their seeds are mixed with those of cultivated plants, and when sown with them, they sprout like the rest; but ere long the young plant produces suckers, which lay hold of the neighbouring stems, and then the Dodder acts as a true parasite, losing all connection with the soil. Many Fungi act as parasites by sending their mycelium or cellular rhizome into the tissues of living plants. These will be noticed when speaking of the Diseases of Plants.

622. Recapitulation of the chief facts connected with the Physiology of Roots:—

1. Roots are usually subterranean, and absorb nourishment from the soil, while they fix the plant.
2. Roots, when aerial, absorb nutriment from the atmosphere.
3. Parasites have roots which absorb nourishment from the sap of other plants.
4. Subterranean roots are developed in a downward direction; they increase by their extremities, and thus accommodate themselves easily to the soil.
5. They are at first cellular, and in the lowest class of plants they continue so; while in higher plants they exhibit in their after growth woody and vascular tissue.
6. Aerial roots appear sometimes to increase throughout their whole length.
7. The spreading of roots bears a relation to that of the branches.
8. The extremities of the roots, called spongioles, with their cellular hairs, are the chief absorbing parts.
9. The entrance of fluid into the cells of the root depends on endosmose, and also on certain vital affinities.
10. Roots absorb certain substances in larger quantity than others, and these vary in different species; hence the necessity for rotation of crops.
11. Roots also appear to give off, by exosmose, certain matters which have not been applied to the purposes of plant life.
12. Some roots, which do not spread much, have reservoirs of nourishment attached to them.

CHAPTER V.

PHYSIOLOGY OF THE ASCENDING AXIS OR STEM.

623. The stem produces buds which are developed as branches, leaves, or flowers. It conveys fluids in various directions, and allows the organs of plants to be exposed to the influence of air and light. In the case of subterranean stems (p. 64), the leafy and flowering branches are sent upwards into the air, and they perform the functions of aerial stems. Herbaceous stems carry on their functions for one

Fig. 1119.

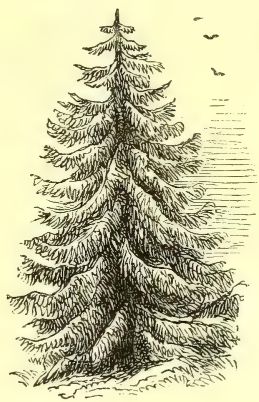

Fig. 1120.

year, or for a limited period, while those of a woody nature continue to perform their functions for many years. While the former attain a moderate size, and perish after a brief period of existence, the latter are permanent, and frequently, as in the case of trees, acquire a great height and diameter. Herbaceous axes occasionally attain a large size, as may be seen in Bananas and Plantains (Fig. 1119). Many

Fig. 1119. Herbaceous shoot from the underground stem of the Banana (*Musa sapientum*). This aerial herbaceous branch bears leaves, flowers, and fruit, and dies after fruiting.

Fig. 1120. Larch (*Larix europæa*, or *Pinus Larix*), a conifer, indigenous on the Alps of middle Europe. Its stem reaches upwards of 100 feet in height.

coniferous trees, as the Larch (Fig. 1120), the Scotch Fir (Fig. 1121), the Norway Spruce (Fig. 1122), the Weymouth Pine (Fig. 1123),

Fig. 1121.

Fig. 1122.

Fig. 1123.

Fig. 1124.

Fig. 1125.

the Red Pine (Fig. 1124), Douglas' Pine, Lambert's Pine, the Norfolk Island Pine (Fig. 1125) and other Araucarias, have stems varying

Fig. 1121. Scotch Fir (*Pinus sylvestris*), a coniferous tree, native of Scotland. Its stem sometimes reaches to upwards of 100 feet in height.

Fig. 1122. Common Spruce (*Pinus Picea, Pinus Abies,* or *Abies excelsa*), a coniferous tree of northern Europe, with a stem attaining the height of 100 feet.

Fig. 1123. Weymouth or White Pine (*Pinus Strobus*), a North American conifer, with a stem from 150 to 200 feet high.

Fig. 1124. Red Pine (*Pinus resinosa*), a coniferous tree of North America. Its stem attains a height of 80 to 100 feet.

Fig. 1125. Norfolk Island Pine (*Araucaria excelsa,* or *Altingia excelsa*), an Australasian conifer, the stem of which attains the height of 220 or 230 feet.

from 100 to 200 or more feet in height. Dicotyledonous forest trees in Britain, such as the Oak, sometimes attain the height of 120 feet. Forest trees on the Continent and in America are sometimes 150 feet

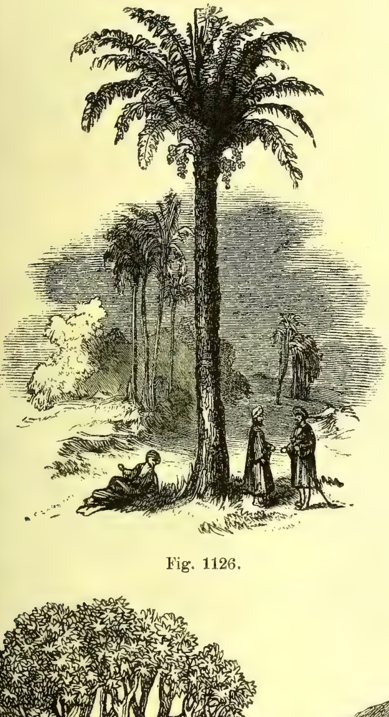

Fig. 1126.

Fig. 1127.

Fig. 1128.

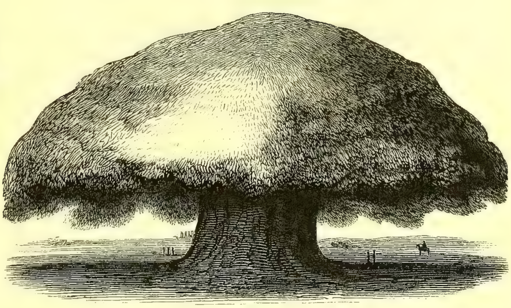

Fig. 1129.

high. Monocotyledonous stems, such as those of Palms (Figs. 1126, 1127), are usually unbranched, and their height is sometimes 150 or

Fig. 1126. Date Palm (*Phœnix dactylifera*), the Palm of Scripture, found in Palestine and Egypt. It attains a height of 50 or 60 feet.

Fig. 1127. Palmyra Palm (*Borassus flabelliformis*), an Indian Palm, the stem of which sometimes attains the height of 100 feet.

Fig. 1128. Dragon-tree (*Dracæna Draco*) of Orotava, having a stem 70 feet in circumference.

Fig. 1129. Baobab-tree (*Adansonia digitata*) of Western Africa, having a stem 90 feet in circumference.

even 180 feet. Acotyledonous stems, as those of species of Alsophila, Dicksonia and other Tree-ferns (Figs. 934, p. 312, and 967, p. 322), attain a height of 50 or 60 feet. Some cellular stems also attain a large size. Dr. Hooker mentions a sea-weed—Lessonia fuscescens—with a trunk 5-10 feet long, and as thick as the human thigh.* Stems often attain a great thickness. The stem of the Dragon tree of Orotava (Fig. 1128) is 70 feet in circumference; that of the Baobab (Fig. 1129) has a circumference of 90 feet; some Cedars of Lebanon (Fig. 1130) at the present day have a girth of 40 feet.† Chestnut trees (Fig. 1131) have occasionally a circumference of 60 feet, and

Fig. 1130.

Fig. 1131.

trees of the South American forests are mentioned by Martius with a girth of 84 feet at the base of the trunk.

624. The following are the measurements given by Zuccarini of the stems of some conifers, showing their height and diameter, and the proportion which these bear to each other:—‡

Fig. 1130. Cedar of Lebanon (*Cedrus Libani*), a coniferous tree having a stem 40 feet in circumference.

Fig. 1131. Chestnut-tree (*Castanea vesca*), having a stem which frequently attains a large size. Some have been measured 60 feet in circumference. The famous Chestnut of Ætna, called Castagna dei Cento Cavallei, is made up of several stems combined.

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* Dr. Joseph Hooker's Botany of the Antarctic Expedition—Cryptogamia Antarctica, 152.

† Wilson's Lands of the Bible, ii. 389.

‡ Zuccarini on the Morphology of the Coniferæ, in Ray Society's Reports on Botany, 1846, 23.

NAMES OF TREES.	Height.	Diameter.	Proportion.
Araucaria excelsa, Norfolk-island Pine (Fig. 1125)	220 Feet.	24 Feet.	1 to 9
Abies excelsa, Norway Spruce (Fig. 1122)	180 "	6 "	1 to 30
Abies pectinata, Silver Fir .	180 "	7 "	1 to 26
Pinus sylvestris, Scotch Fir (Fig. 1121)	130 "	6 "	1 to 22
Pinus bracteata . . .	120 "	1 "	1 to 120
Larix europæa, Larch (Fig. 1120)	120 "	12 "	1 to 10
Taxus baccata, Yew . .	120 "	18 "	1 to 7
Taxodium distichum, Deciduous Cypress	120 "	36 "	1 to 3.5

625. The following are some measurements of Palms given by Martius,* partly from cultivated specimens :—

SPECIES.	Length of Caudex in feet.	Girth at the base in feet.	Girth immediately below the leaves in feet.	Number of Internodes.	Age. Years.	Locality.
Acrocomia aculeata .	15	3	$1\frac{1}{2}$	45?	50	Loddiges Garden.
Acrocomia sclerocarpa .	46	8	4 ?	...	80?	Brazil.
Chamærops humilis, *var.* elata or arborescens	22	$1\frac{1}{4}$	10 inches.	1107?	140?	Paris Garden.
Cocos flexuosa . . .	9	$3\frac{3}{4}$	2	...	15	Do.
Cocos nucifera (Fig. 166, p. 70)	$72\frac{1}{2}$	7	$4\frac{1}{2}$	...	70	Brazil.
Elais guineensis (Fig. 180, p. 87) . . .	11	$4\frac{3}{4}$	$2\frac{1}{4}$	...	...	Vienna Garden.
Euterpe edulis . . .	64	4	$2\frac{1}{2}$	207	40?	Brazil.
Euterpe oleracea . .	107	$4\frac{1}{2}$	$1\frac{1}{2}$	343	...	Para.
Livistona chinensis . .	5	$4\frac{1}{2}$	$2\frac{1}{2}$	57	42	Loddiges Garden.
Mauritia flexuosa . .	84	$8\frac{1}{2}$	5	...	...	Amazon.
Oenocarpus Bataua . .	85	4	...	...	36?	Para.

Many Palms attain much greater heights than those enumerated in this table. Thus, Euterpe oleracea is frequently 120 feet high, Oreodoxa oleracea 130, Mauritia vinifera 150, Ceroxylon Andicola 160 to 180, and the slender stem of Calamus rudentum runs among the trees of the forest to the length of 500 feet. While some Palms, such as Kunthia montana and Oreodoxa frigida, have slender reed-like stems, others, such as Cocos butyracea and Jubæa spectabilis, have trunks which are three or even five feet in diameter.

626. The following are the measurements made by Mr. James M'Nab of some of the Palms in the Edinburgh Botanic Garden. In giving the height the leafy part at the top of the caudex is included, along with the tub in which the plant is growing :—

* Martius, Historia Naturalis Palmarum, tom. i.

SPECIES.	Height of Plant.	Girth at surface of Soil.		Girth immediately below the crown of leaves.		Number of Rings.	Probable Age.	Spread of Leaves.
	Feet.	Feet.	In.	Feet.	In.		Years.	Feet.
Acrocomia aculeata . .	38	2	9	1	6	98	80 ?	18
Areca triandra . . .	19	0	9	0	7	29	20	12
Caryota urens	42	2	10	2	0	24	20 ?	18
Chamærops humilis, *var.* arborescens .	20	1	7	1	5	240	60 ?	9
Cocos nucifera (Coco-nut)	18	3	4	3	0	15	25	24
Euterpe montana, (Mountain cabbage)	36	3	3	0	11	74	30 ?	14
Livistona chinensis . .	38	5	8	2	9	86	45 ?	20
Sabal umbraculifera . .	36	6	4	...		...	50 ?	28
Sagus (Metroxylon) Rumphii (Sago) .	40	4	6	...		...	30 ?	27
Seaforthia elegans . .	22	2	2	1	3	20	25 ?	16

627. By means of terminal and lateral buds, stems increase in height and diameter. In their earliest state they are composed of cellular tissue, in the midst of which there is developed vascular tissue, which is arranged in different ways, as already described (p. 69). The cellular tissue of the young dicotyledonous stem is early separated into two portions—a medullary or inner, and a cortical or outer—by the formation of vascular and woody bundles, which increase in concentric zones (Fig. 1132.) The medullary portion or pith is at first succulent, and contains much nutritive matter, but in most instances it becomes dry,* and often breaks up into cavities, as in the stems of the Walnut, Jessamine, and Umbelliferæ. In its young state, the pith seems to be a reservoir of nourishment for the embryo plant during its early growth. The sheath surrounding the pith (Fig. 1132, *t*) contains numerous spiral vessels, which extend upwards and outwards to the leaves. In ordinary circumstances these vessels contain air. The outer cellular portion of the stem constitutes the bark, which protects the other tissues, and often contains secretions, such as gums, resins, and alkaloids. When the bark is green, it seems to exercise the same functions as leaves. It is united

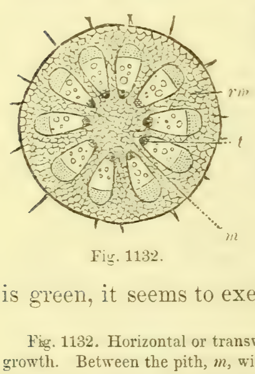

Fig. 1132.

Fig. 1132. Horizontal or transverse section of an exogenous or dicotyledonous stem of one year's growth. Between the pith, *m*, with its sheath, *t*, there are cambium cells forming a cylinder or thickening zone. These cells are concerned in the formation of wood. The pith and bark are united by cellular bands, *rm*, called medullary rays.

* The dry cellular tissue of the stem is sometimes used for paper, as in the case of Rice paper or Schola, which is produced in India from the stem of Æschynomene paludosa, in the Malay Archipelago from that of Scævola Taccada, and in China from that of Aralia papyrifera (Tung-tsaou.)

to the pith by medullary rays (Fig. 1132, *rm*), which give a character to the wood. The cells and vessels of the stem are concerned in the circulation of sap, as will be afterwards noticed, and the woody tubes, when fully formed, give stability aud durability to the trunk.

628. Between the pith and bark, as well as at the extremities of the buds and roots, there exist cambium cells, which, according to Schacht, form the first stage of the vascular bundles, and give origin to the proper parenchyma or nourishing tissue. A cylindrical layer of this cambium or organizing tissue is distributed in all the most perfect plants, so as to divide the parenchyma into pith and bark, as well upwards in the stem, as downwards in the root.* In Dicotyledons, this cylindrical layer, called by Schacht the *thickening zone*, is active as long as life remains. It is by means of it that the stem enlarges—the cells of the tissue forming, toward the interior, new wood, and, toward the exterior, new bark (Fig. 182, p. 78).

629. In Monocotyledons (Fig. 192, p. 88) and the higher Cryptogams (Fig. 971, p. 324), the thickening zone—in other words, the cylindrical layer of organizing tissue—continues active only for a short period of time, and hence these plants do not enlarge beyond a certain point; and at length they grow only in one direction—namely, in height. This thickening layer of cambium, while it adds to the size of the stem of Monocotyledons, causes the increase of the vascular bundles. After a certain period, however, this zone becomes woody, and then the vascular bundles only grow at their extremity, by means of unchanged cambium cells which are in immediate connection with the bundles. This cambium of the vascular bundles is essential to them, and gives them their character. In Monocotyledons it is situated in the centre of the bundles, and is surrounded by spiral, pitted, or woody vessels; in Cryptogams it surrounds the vascular bundles. The vascular bundles in both these classes of plants are limited, and they can only increase laterally by ramifying, as in Dracæna and some Tree-ferns.

630. The cambium appears to be the immediate agent in the development of new tissues. The origin of the cambium cells, and the mode in which the wood of trees is formed, as well as the influence exerted by the leaves and green parts of plants, have long been subjects of dispute among physiologists. Grew and Malpighi thought that the new woody layers were formed by the bark, while Hales maintained that they were formed from the previously existing wood.† Dr. Hope loosened the bark of trees, and found new layers of alburnum formed on its inside. Duhamel‡ put plates of silver between the woody and cortical layers, and found the new formation on the outside of the plates; he also removed a portion of the bark of a plum-tree, and replaced it with a similar portion of a peach-tree, and after union

* Schacht, Physiologische Botanik. Die Pflanzenzelle, der innere Bau und das Leben der Gewächse, Berlin, 1852.

† Malpighi, Opera, 1686, i. 28; Grew, Anatomy of Plants, 1682; Hales, Vegetable Statics, Lond. 1727, p. 338.

‡ Duhamel, La Physique des Arbres, ii. 28.

had taken place, he ascertained that at the point of junction a thin layer of wood had been formed by the peach bud, and none by the wood of the plum. Hence these experimenters concluded that the new wood was produced by the bark. De Candolle, as the result of his observations, maintained that both the bark and the wood were concerned in the formation of woody matter.* All appear to agree in looking upon the cambium layer as concerned in the development of the wood.

631. We have seen that recent authors have ascertained more fully the nature of cambium, and that they consider it in the light of active formative tissue, developing cells and vessels in an upward and downward direction.† Some adopt the view that there are in reality two systems in plants, an ascending and a descending one; and that what takes place in the sprouting of the embryo, continues to be manifested during the life of the plant. This view, variously modified, was adopted by De la Hire in 1708, was supported by Darwin and Knight, and was particularly espoused by Aubert du Petit Thouars in 1806, and subsequently by Gaudichaud and others.‡

632. According to Petit Thouars and Gaudichaud, we see in the embryo a radicular and a caulinary portion, the one having a tendency to ascend, the other a tendency to descend. In both of these systems cells and vessels of different kinds occur. In Dicotyledons the ascending system is connected with the medullary sheath, and passes into the buds and leaves, while the descending system is the woody tissue sent down from the leaves between the sheath and the bark. The woody fibres of the leaves, favoured by the cambium, are developed from above downwards. In the wood the ligneous tissue of the upper leaves envelopes that of the inferior ones, while in the bark the fibrous tissue is inserted in the reverse way—the internal layer, corresponding also to the superior leaves, being the newest. The extension of the cellular tissue of the stem takes place in a horizontal or transverse direction.

633. In following out these views, it has been remarked that a Monocotyledon in its simplest form may be said to consist of an axis (Fig. 1133, *b*), producing a leaf, *c d*, and bud, *e*, at its upper part, and a root, *a*, below. It may be represented as a phyton,§ or single plant or bud, having an axis or axial merithal, *b*, with a leaf or foliar merithal, *c*, *d*, divided into a laminar, *d*, and petiolary portion, *c*, the latter usually sheathing the axis, and a radicular merithal, *a*, whence roots are produced. This phyton is capable of producing others having a similar constitution; and thus a more complicated Monocotyledonous plant consists of a series of phytons placed one above another, the

* De Candolle, Physiologie Végétale, i. 165.

† Brisseau-Mirbel, Nouvelles Notes sur le Cambium, Paris, 1842. Mohl, sur le Cambium—Ann. des Sc. Nat. 2d ser. Bot. xi. 321.

‡ De la Hire, Explication Physique de la direction Verticale des Tiges des Plantes, &c.—Mem. de l'Acad. Franc., 1708; Darwin's Phytologia; Du Petit Thouars, Essais sur la Végétation; Gaudichaud, Recherches sur l'Organographie, la Physiologie et l'Organogenie des Végétaux, 1841.

§ Petit Thouars looks upon a bud as a phyton or young plant, while Gaudichaud considers each leaf as a phyton.

parts being alternate, as seen in Figure 1134. Each phyton has a distinct leaf, producing a bud in its axil, or at the part where it is united to the axis; it has also an ascending or foliar, and a descending or radicular system. In the case of the first phyton, the latter descends at once into the soil; but in the case of the others, it passes downwards through the first axis before it reaches the ground, or in some instances it appears externally at the base of the phyton, and thus becomes for a time aerial (Fig. 1134, *r*, *r*′). A Monocotyledonous plant thus may be said to consist of a series of phytons, arranged one within the other, with shortened axes.

634. A Dicotyledon, on the other hand, in its simplest state may be said to consist of an axis, producing two leaves at its summit and roots below (Fig. 1135). It may be represented as two phytons united, the foliar merithals, *c d*, being placed opposite to each other. In the Monocotyledon each node produces one leaf, and is unifoliar; in the Dicotyledon, two, and is bifoliar. This tendency to produce two leaves at a node does not, however, remain permanently in all Dicotyledons, for by the extension of internodes the foliar merithals

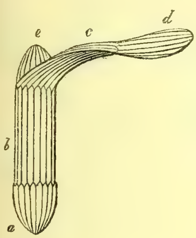

Fig. 1133

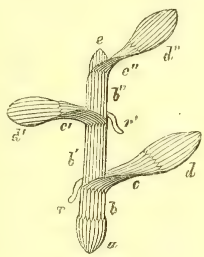

Fig. 1134.

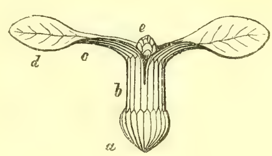

Fig. 1135.

frequently become alternate. A Dicotyledonous plant may be considered as consisting of a series of phytons (Fig. 1136), which produce an ascending foliar system, and a descending radicular one.

635. In the phytons or foliar types of these two great classes of plants, cells and vessels of different kinds are united; and the phytons may be considered, in reference to the entire plant, precisely in the same way as the simple cell is regarded when compared with the various tissues forming the compound individual. A phyton may be thus re-

Fig. 1133. A Monocotyledonous phyton, consisting of an axis, *b*, producing a radicular descending portion, *a*, and a bud or growing point, *e*, which is developed in the axil of a leaf, *c d*. According to Gaudichaud's view, the phyton is represented by a leaf, of which *d* is the laminar merithal, *c* the petiolary merithal, *b* the tigellary merithal, and *a* the radicular merithal.

Fig. 1134. A Monocotyledon represented by a series of unifoliar phytons placed one above another Each phyton has an axis, *b b*′ *b*″, and a leaf, *c d*, *c*′ *d*′, *c*″ *d*″, with a radicular portion, *a*. The roots of the upper phytons pass downwards, and sometimes appear externally, *r r*′, as occurs in Screw Pines, Palms, &c. The growing point of the axis is at *e*. In each leaf there is represented the laminar merithal, *d*, and petiolary merithal, *c*.

Fig. 1135. A Dicotyledonous phyton, consisting of two unifoliar phytons united. In this bifoliar phyton there is an axis, *b*, called by Gaudichaud a tigellary merithal, a radicular portion or merithal, *a*, and a leaf, with its petiolar portion, *c*, and laminar portion, *d*. The bud or growing point is at *e*.

garded as an organ furnishing a type of all parts which enter into the composition of the nutritive and reproductive compound organs. While the embryo of Phanerogamous plants may be considered as a phyton produced by the process of reproduction, the bud may be reckoned a phyton produced by the vegetative process. A bud has a certain degree of vitality inherent in itself, and it may be called a fixed embryo, or one attached to the plant, and depending for its vigour upon it, but frequently capable of growing when separated from it. A tree is composed of a series of buds (Fig. 1137, *b*), each having independent vitality, and yet all united on a common axis, on the life of which they depend for their continued growth and vigour. Buds may be taken from one tree and grafted upon another, and in some instances buds, or bodies equivalent to them, separate spontaneously from plants, and form independent individuals. This latter phenomenon occurs in Bryophyllum (Fig. 334, p. 141), Pinguicula, Malaxis, viviparous plants, and in

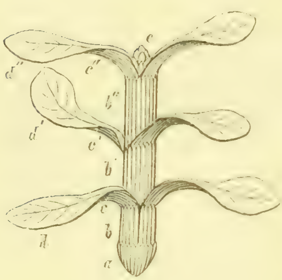

Fig. 1136.

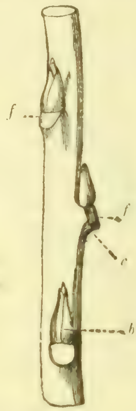

Fig. 1137.

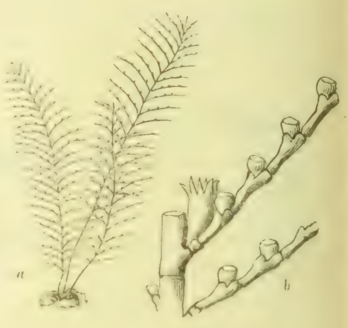

Fig. 1138.

the bulbils of Lilium bulbiferum and Dentaria bulbifera. In all this there is a remarkable analogy with what occurs in Compound Polyps. In Sertularian Polyps (Fig. 1138), there are numerous separate individuals united on a common stalk, each having a certain inherent vitality, and yet all depending on the general life of the compound Zoophyte.

Fig. 1136. A Dicotyledon represented by a series of bifoliar phytons placed one above another, with their axes, $b\ b'\ b''$, their leaves, $c\ d$, $c'\ d'$, $c''\ d''$. The radicular portion of the lower phyton is *a*; those of the other phytons pass down in the axis. The growing point is *e*.

Fig. 1137. Branch of Glycine, showing lateral buds, *b*. These buds may represent separate plants fixed on a common stem. Gaudichaud calls them fixed embryos. Each bud has a separate vitality, so that it can be transplanted and grafted on another plant; at the same time it depends for its continued existence on the life of the tree to which it is attached. Each of these buds may be called phytons according to Petit Thouars. The scars of fallen leaves and their vessels are seen at *c f f*.

Fig. 1138. Plumularia pinnata, a compound Zoophyte. *a*, Natural size of the animal. It may be compared to a tree with numerous living buds, each of which has a separate vitality, but all depending for continued existence on the life of the compound individual. A portion of the compound Zoophyte is magnified at *b*, showing the separate Zoophytes, all of which, except one, have discharged their ova.

636. The Radicular or vertical theory of wood formation has been supported by reference to the arrangement of the vascular bundles in Palms (Figs. 1139 and 1140) and Dracænas (Fig. 1128, p. 437), and to the development of aerial roots from different parts of the stems of Screw Pines (Fig. 1141), Figs, Vellosias, and Tree-ferns (Fig. 165, p. 70). Many travellers, such as Gardner,* who examined Palms in their native countries, have espoused the vertical theory of wood formation. In these plants the bundles of woody vessels can be traced from the base of the leaves, taking a peculiar curved direction downwards, and interlacing in a remarkable manner (Fig. 1139). In many Palms

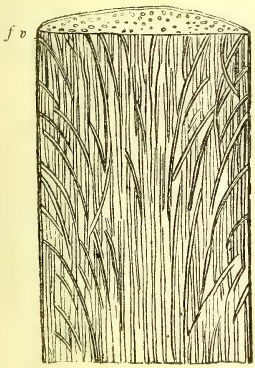

Fig. 1139.

Fig. 1140. Fig. 1141.

the fibres appear externally bursting through the stem, and appearing as roots. In the case of Screw Pines (Fig. 1141), the formation of external or adventitious roots is very remarkable; in them the thickness

Fig. 1139. Vertical section of the stem of a Palm, showing the vascular bundles, *fv*, curving downwards and interlacing. This peculiar arrangement suggests the idea of roots ramifying.

Fig. 1140. Coco-nut Palm (*Cocos nucifera*), having a tall, unbranched stem, bearing a cluster of leaves and fruit at the top. The stem increases in diameter by the addition of cells and vascular bundles in the interior, the latter being traced to the leaves, and interlacing in a remarkable manner.

Fig. 1141. Screw Pine (*Pandanus odoratissimus*), showing numerous adventitious roots sent down from different parts of the stem. The stem below the points where the aerial roots appear is thinner than above. Gaudichaud thinks that these roots are in reality the vascular bundles, which, in place of passing downwards from the leaves in the interior of the trunk, appear externally. Hence, he says, arises the difference between the diameter of the stem above and below.

* Annals and Magazine of Natural History, vi. 57.

of the stem is diminished below the points whence the roots proceed, as if the woody matter had appeared externally in place of proceeding internally. Adventitious descending roots are also seen in many of the Fig tribe, such as the Banyan (Fig. 121, p. 52) and Peepul tree. In Tree-ferns the lower part of the stem is often much enlarged by these aerial roots being applied closely to it (Fig. 165, p. 70). Brown says that in Kingia (an Australian plant) the leaves send down, between the true stem and the bases of the petioles which form the only bark of the tree, a series of adventitious roots closely covering the stem, and resisting to a great degree the action of external destructive agents, such as fire. A further development of this root structure is seen in Barbacenia and Vellosia, where the whole outer part of the stem is made up of interlaced roots, which are traced inwards and upwards to the leaves. Beautiful specimens of Vellosia stems are seen in the Botanical Collection of the British Museum.

637. In Bananas and Plantains, as grown in the hot-houses of Britain, we often see roots proceeding from the base of the leaves forming the herbaceous shoot. Roots are to be seen proceeding from sound portions of the wood of Willows, and running into those which are decayed. Mr. John Lowe mentions a curious instance of this in the case of a species of Willow (Salix viminalis), near Sleaford, in Lincolnshire. In this tree the trunk became decayed in the centre, and a large woody root, 18 inches in circumference, descended from the upper sound portion of the stem through the rotten spongy central mass, and when it reached the lower part gave off branches, which extended into the soil. This radicular stem finally produced leaf-buds and leaves. In a large specimen of Mountain Ash at Prestonhall, near Edinburgh, there is an appearance which seems to confirm the view of woody matter being formed in a downward direction from branches. A large branch was broken off, laying bare the interior of the stem to a considerable extent. The tree still lived, and from the upper branches distinct roots were sent downwards, which gradually covered a large portion of the wound. The growth was traced in a downward direction, and the root-like appearance of the fibres was quite evident. In Figure 1142 is shown an example of fibres descending from a branch in a species of Dracæna, and spreading over the inner woody bundles.

638. Cagnat, as already noticed (p. 102), has remarked, that the form of the woody portion of the stem is regulated by the arrangement of the leaves.* His observations show the importance of the leaves in the production of wood, and seem to support the radicular view of Gaudichaud. The fasciculated stems of certain climbing Sapindaceæ (Fig. 1143) and Bignoniaceæ, are referred by the latter author to the mode of development of the first leaves, and to the consequent primary arrangement of the woody bundles which are successively covered in the same order by the descending fibres from the other

* Cagnat, sur la disposition des Feuilles.—Ann. des Sc. Nat. 3d ser. Bot. ix. 362.

leaves. In these anomalous stems the central fasicle is often the most powerful, forming the mass of the stem, while the lateral bundles are weak, and form accessory axes. This arrangement is illustrated in Figure 1144, where the buds around the end of the cutting or slip produce separate fasciculi of fibres, *a*, which may represent the incipient state of such stems as those represented in Figure 1143. The fibres sent down from the buds cover the old fibres, *b*, of the central fasciculus.

639. These views of Gaudichaud and others have been opposed by many able physiologists, more especially by Mirbel, Payen, Naudin, and Trecul. Mirbel has examined in a particular manner the development of the Date, and he has been led to the conclusion that the fibres increase from below upwards, and not from the leaves downwards.* He says that a Monocotyledon produces at its summit a mass of cellular tissue called a phyllophore, into which the vessels from the

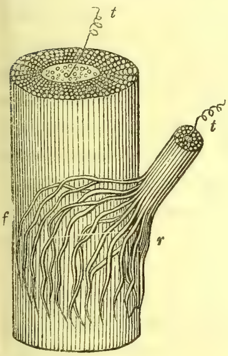

Fig. 1142.

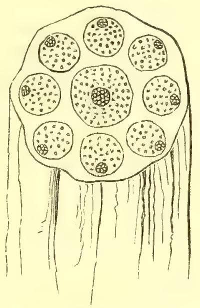

Fig. 1143.

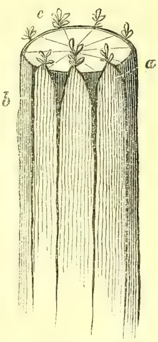

Fig. 1144.

stem penetrate to form the vascular system; after this the leaves are produced. The vessels, he says, come from the internal periphery of the young part of the stem, and arise at all heights, and the roots have at first no immediate connection with the leaves. Trecul has examined the stems of Dicotyledons, and has been led to deny the downward tendency of the wood formation. He states that after the bark has

Fig. 1142. Truncated stem of a Dracæna after maceration, showing the tracheæ, *t t*, of the ascending systems of the stem and branch. The radicular system of the old stem, *f*, is seen in the form of fibres, and the radicular woody bundles, *r*, of the branch are disposed in a grasping manner over those of the old stem. The fibres, according to Petit Thouars and Gaudichaud, come from the bases of the leaves, and belong to the descending system.

Fig. 1143. Stem of a climbing Brazilian plant belonging to the natural order Sapindaceæ. It consists of a congeries of vascular fasciculi separated from each other by cellular tissue. The central bundle is largest, and contains pith, with a medullary sheath, and spiral vessels. The other fasciculi have pith and no spirals. The form of the stem, according to Gaudichaud, depends on the phyllotaxis and on the mode in which the radicular woody bundles are sent down from the leaves.

Fig. 1144. Slip or cutting of root of Maclura, showing a number of buds, *c*, from which proceed radicular fibres, *a*, which are interposed between the bark, *b*, and the fibres of the old wood. The young fibres are traced to the buds, and in their progress downwards they remain distinct. This example is brought forward by Gaudichaud as illustrating his vertical theory of wood formation, and as explaining the development of such stems as those represented in Figure 1143.

* Mirbel, Recherches sur la structure du Dattier—Annales des Sciences Nat. 2d ser. xx. 5.

been removed, a new layer of woody tissue and bark is formed at detached points, into which the medullary rays are continued directly without the slightest interruption. He thinks that the woody tissue is a lateral development from the already existing longitudinal cells, and that fresh bark is formed on the woody tissue by the development of cells from the tissue, while the medullary rays penetrate directly into the new patches of wood. According to him the fibro-vascular bundles are not continued without interruption from the extremities of the leaves to the rootlets ; the diameter of the stem may increase without the intervention of ligneous fibres descending from the leaves or buds ; and the tissue of the wood and vessels, as well as the medullary rays and bark, are formed in situ, independently of the tissues higher up.*

640. The production of woody fibres, without the presence of leaves, has been considered as being proved by the occurrence of peculiar woody excrescences in the bark of many trees, such as Oaks, Elms, Beeches, and Cedars. The bird's eye Maple is said to be the timber cut from trees affected with these excrescences. The *bruscum* of the Romans, so much prized by their cabinet-makers, is supposed to have been Maple wood twisted by this means into singular forms. Dutrochet called these knots embryo-buds, and many look upon them as an abortive state of branches, the leaves of which have been only partially developed. Their origin is obscure, and their connection with leaves has not been distinctly traced.

641. Amidst these opposing theories, it is difficult to come to a decided conclusion. There is undoubtedly an ascending and a descending system in plants—a stem developed in an upward, and a root in a downward direction. The leaves are also of importance in the formation of wood, and the cambium cells are the active tissue of the stem. In so far all are agreed. The points of difference are the exact relation which the leaves bear to the woody fibres of the stem, and the direction in which these fibres are developed. The peculiar arrangement of fibres in the stems of Palms, and the production of aerial roots from various stems, favour in some measure the vertical theory of wood formation ; while the woody excrescences occurring in the bark of some trees, and the production of particles of woody matter in the centre of decorticated portions of wood, and at the lower part of wounds, as shown by Trecul, seem to show that woody fibres are formed in some instances without any direct connection with leaves. While the weight of authority is in favour of the views recently propounded by Trecul, still there are many facts brought forward by Gaudichaud which still require explanation, and which are not easily accounted for, unless we suppose an upward and downward tendency to be impressed on the tissues of the stem and of the buds, in the same way as on the embryo at its earliest growth. Physiologists in general concur in believing, that without the presence of leaves on the stem, no woody matter is formed.

* Trécul, sur l'accroissement en diamètre des vegetaux dicotylédonés ligneux—Annales des Sc. Nat. 3d ser. xvii. 250.

This will be considered in the next chapter when the functions of leaves are considered.*

642. While the recent woody tubes are full of fluid, the older ones become obliterated by deposits of lignine or cellulose. The heartwood of trees thus becomes hardened and less liable to decay than the alburnum; and the durability of wood depends on the quantity of duramen and the nature of the ligneous deposit. This has been already noticed at pages 78 and 79. Hartig made some experiments on the durability of timber, and he found that small parts of Lime-tree, Black American Birch, Alder, and trembling Poplar inserted in the soil decayed in three years; Common Willow, Horse-Chestnut, and Platanus in four; Maple, Purple Beech, and Common Birch in five; Hornbeam, Ash, and Lombardy Poplar in seven; Robinia, Oak, Scotch Fir, Weymouth Pine, and Spruce Fir were decayed a little to the depth of a quarter of an inch in seven years; while Larch, Common Juniper, Virginian Juniper, and Arbor-vitæ were not decayed at the end of seven years. Thin boards of the same woods decayed in the following order:—Platanus, Horse-Chestnut, Lime-tree, Poplar, Birch, Purple Beech, Hornbeam, Alder, Ash, Maple, Spruce Fir, Scotch Fir, Elm, Weymouth Pine, Robinia, Oak, Larch. From recent observations made by the Duke of Buccleuch at Granton, it would appear that the wood of the Greenheart-tree (Nectandra Rodiæi), withstands decay better than other kinds of wood, more especially when exposed to the action of sea-water.

643. Boucherie† has attempted to render the wood of trees more durable and hard while its elasticity is retained, to prevent warping, and to diminish its combustibility, by causing the stem in the fresh state to absorb solutions of pyrolignite of iron and of chloride of lime. This may be done either when the tree is in the ground, or immediately after being felled. In a growing tree he made a large opening in the lower part of the trunk, sawing out a portion of the stem so as to allow the tree to be supported only by two narrow portions of the wood on each side; then by putting a waterproof bag around the stem below this large transverse opening, so that he could insert the fluid into it, he found that he could cause the tree to absorb rapidly a large

* For further details regarding the physiology of the stem, consult, in addition to the works and papers already quoted, the following:—Dutrochet, Memoires, 1851. Henfrey, on the structure and growth of Monocotyledons—Annals of Nat. History, 2d ser. i. 180. Gaudichaud, replique à Mirbel—Ann. des Sc. Nat. 2d ser. xx. 32. Knight, in Philos. Trans. 1808. Mirbel, sur la nature et l'origine des couches corticales du liber des arbres Dicotylédonés—Ann. des Sc. Nat. 2d ser. Bot. iii. 43. Mirbel, Rapport sur une Memoire de M. Gaudichaud, relative au développement et à l'accroissement des tiges, &c.—Ann. des Sc. Nat. 2d ser. v. 24. Mohl, de structura Palmarum in Mart. Gen. et Spec. Palmarum, trans. in Ray Society's Reports for 1849. Aubert du Petit Thouars, sur la formation des Arbres, Paris, 1823. Naudin, sur le développement des axes des vegetaux—Ann. des Sc. Nat. 3d ser. Bot. i. 162. Schleiden, on the theory of stem formation, in Wiegmann's Archiv. for 1839. Trécul, sur la structure et le développement du Nuphar luteum; Memoires sur l'origine des Bourgeons adventifs.—Ann. des Sc. Nat. 3d ser. Bot. viii. 268; Recherches sur l'origine des racines adventives—Ann. des Sc. Nat. 3d ser. Bot. v. 340. Unger, ueber Bau und Wachsthum des Dikotyledonenstammes, Petersburg, 1840.

† Boucherie, Memoire sur la Conservation des Bois, Paris, 1840—Ann. de Chimie et de Physique, lxxiv. 113. Annales des Ponts et Chaussées, 1844. Boucherie says, that a Poplar 92 feet high absorbed in six days nearly 66 gallons of a solution of pyrolignite of iron.

quantity. By this means the fermentescible sap was displaced by a fluid less liable to change. Sometimes he caused the tree to be cut down and to be placed in an inclined position, with the lower end of the trunk immersed in the fluid to be absorbed; at other times the tree was laid in a horizontal position, while the barrel, or bag containing the fluid, was placed in a vertical position above the cut extremity. In the same way colour was imparted to wood by making the stem absorb in succession fluids, which by their union developed a coloured compound. Boucherie's plan of preserving timber was practised on a large scale in the forest of Compiegne, and was favourably reported upon by several physiologists.*

644. Recapitulation of the chief facts relative to the physiology of the stem :—

1. The stem or ascending axis bears the leaves and flowers, and exposes the organs of plants to the action of air and light.
2. The fluids taken up by the roots pass through the cells and vessels of the stem in order to reach the leaves.
3. The height and diameter of stems vary much. Some are upwards of 200 feet high, and others attain a diameter of 30 feet.
4. The cambium cells are those which are concerned in the development of new tissues. They have been called organizing cells.
5. In Dicotyledons these cambium cells are situated between the wood and bark, and at the growing points of the stem and branches. They constitute a cylindrical layer called the thickening zone. They form new layers of bark on the outside, and new layers of wood on the inside.
6. In Monocotyledons and the higher Acotyledons the thickening zone is active only for a short time, and the formative cambium cells are afterwards in immediate connection with the vascular bundles—development taking place chiefly in an upward and downward direction.
7. The formation of wood has given rise to much dispute among physiologists; some believing that it is formed in situ by the action of the formative cells, others conceiving that it is produced by the cambium cells in a descending direction, so as to be a radicular prolongation from the leaves.
8. The first theory is called horizontal, and it has been espoused by most physiologists, more particularly by Duhamel, De Candolle, Mirbel, Schleiden, Naudin, Henfrey, and Trecul.
9. The second theory is called vertical, and has been supported by Knight, Du Petit Thouars, and Gaudichaud, who look upon it as corroborated by the production of aerial roots, and by the interlacing of the fibres in the stems of Palms.
10. In the radicular or vertical view of wood formation, each bud of a tree is considered as a fixed embryo or young plant, producing leaves in an upward direction, and woody roots downwards.
11. There is an ascending and a descending system in all plants, and it appears to be difficult to account for some of the phenomena connected with stem formation, without taking these into account.
12. Physiologists agree that the production of woody fibres depends much on the development of the leaves, and that in order to produce good timber the leaves must be fully exposed to air and light. Cagnat has shown that the form of the woody stems depends on the arrangement of the leaves.
13. While the woody tubes of plants contain fluids in their early state, they often become obliterated by deposits of lignine, as in the heartwood of trees.
14. Boucherie has shown that the stems of trees can be made to absorb various fluids which act in preserving the wood from decay.

* Comptes rendus, 1840, i. 636, ii. 894; also report by Chevallier, Decaisne, and Gaultier de Claubry, in 1851.

CHAPTER VI.

PHYSIOLOGY OF THE LEAVES.

645. The leaves are arranged upon the axis in such a way as to be fully exposed to the influence of air and light (Phyllotaxis, p. 95). They are thus enabled to perform very important functions. The fluids which reach the cells and vessels of the leaves undergo changes by which they are elaborated and fitted for the formation of various vegetable secretions. In ordinary plants the non-development of the leaves arrests the formation of woody matter and of many important products. Leaves have the power of absorbing carbonic acid, ammonia, water, and aqueous solutions. They also exhale a certain amount of water, and they give off gaseous matters, especially oxygen. Thus leaves, in the performance of their functions, absorb and exhale watery and gaseous substances.

I. ABSORPTION BY LEAVES.

646. When liquids are brought into contact with the leaves of plants, absorption takes place. Bonnet found that plants of Mercurialis, with the surface of their leaves in contact with water, absorbed as well, and kept for a time nearly as fresh as those of which the roots were immersed in the liquid. The under surface of ordinary leaves took up liquids rapidly in consequence of the thinness of the cuticle, the laxity of the cellular tissue (Fig. 1145), and the presence of stomata (Fig. 1146), while the thick and hard epidermis on the upper surface having few stomata, presented an obstacle to absorption.* The hairs which occur especially on the under surface of leaves, seem to act like cellular rootlets, and to absorb moisture. Hoffmann ascertained that liquids are absorbed by the leaves in large quantity, and that in such cases they pass downwards by the tracheæ and the prosenchyma immediately surrounding them (Fig. 1147), displacing for a time the air usually contained in the spiral vessels.† He states that after every fall of rain or dew there is an absorption by the leaves, and that this is followed by an immediate descent of sap. The absorption takes place with greater or less rapidity according to the nature of the

* Bonnet, Recherches sur l'usage des Feuilles dans les plantes, Gotting. 1754.

† Hoffmann on the circulation of the sap in plants, in Scientific Memoirs—Nat. Hist. i. 46.

leaves, and the fluid passes through the intercellular spaces, as well as

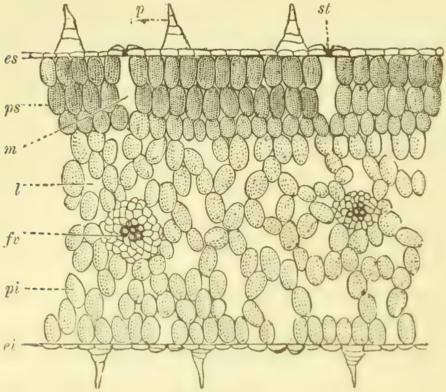

Fig. 1145.

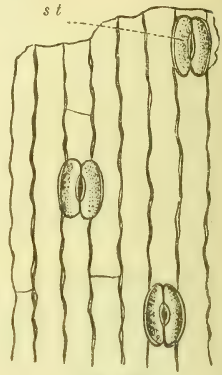

Fig. 1146.

the cells and vessels. The greater and the more rapid the absorption, so much the more have the fluids a tendency to enter the spiral vessels. The absorbing power of the epidermis of leaves varies. When composed of delicate thin-walled cells, with numerous stomata, the imbibition of liquids is carried on rapidly; but when the epidermal cells are hardened, and have thick walls, absorption is much impeded. Some gaseous matters are taken up rapidly by leaves. Boussingault found that air was speedily deprived of carbonic acid by coming into contact with the leaves of the Vine for a few minutes. He placed a shoot of a Vine, bearing twenty leaves, in a glass globe, and while the sun shone on the apparatus, drew through it in an hour fifteen litres* of atmospheric air, which contained .0004 to .00045 of carbonic acid, and at

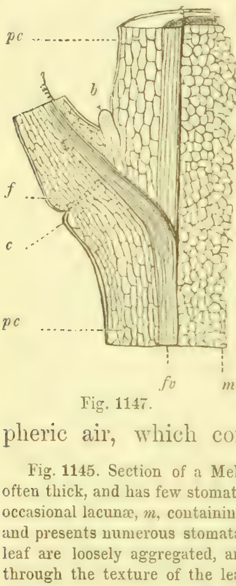

Fig. 1147.

Fig. 1145. Section of a Melon-leaf, perpendicular to its surface; *es*, upper epidermis, which is often thick, and has few stomata, *st*; below it are parenchymatous cells closely aggregated, *ps*, with occasional lacunæ, *m*, containing air; *ei*, the lower epidermis, which is usually thinner in its texture, and presents numerous stomata and hairs; the parenchymatous cells, *pi*, on the lower sides of the leaf are loosely aggregated, and present numerous air cavities, *l*; the bundles of vessels, *fv*, run through the texture of the leaf; *p*, hairs on the surface. Absorption of fluids and air, as well as exhalation, in most instances takes place most rapidly by the under surface. The fluids in the cells, intercellular spaces, and vessels of the leaf, are elaborated by the agency of air and light.

Fig. 1146. Epidermis of a Lily, showing stomata, *s t*, which open and close in the performance of their functions. Absorption and exhalation take place chiefly by means of stomata.

Fig. 1147. Vertical section of a branch, showing the mode in which the vascular tissue of the leaf communicates with the centre of the stem; *pc pc*, the parenchyma of the stem; *fv*, the fibro-vascular tissue surrounding the pith, *m*, and proceeding to the leaf, *f*; *c*, the pulvinus; between *f* and *c* there is seen a depression indicating the points where the leaf is articulated to the stem; *b*, a bud in the axil of the leaf. When the leaf falls the separation takes place at the articulation. The fluids of the stem pass into the leaf, and are thus elaborated under the agency of air and light.

* A litre is = 0.220097 gallons, or 1.760773 pints English.

the exit of the air from the globe, the carbonic acid was diminished to .0001 or .0002. Chevandier calculates that the trees of a forest during the five summer months in which they bear leaves, withdraw from the column of air around them about 1-9th of its contents of carbonic acid.* Vogel and Wittwer† caused 1,144,730 cubic centimetres‡ of atmospheric air to pass over a plant in the course of nine days; this air contained on an average 0.000380 of carbonic acid, and after contact with the plant it contained 0.000056 carbonic acid. In another experiment, carried on during a period of six days, they caused 1,255,350 cubic centimetres of atmospheric air to pass over a Pelargonium in full leaf, and they procured the following results:—

	Carbonic Acid.
The air contained, during the day . .	0.000539
„ „ during the night . .	0.000403
After it had passed over the plant,	
The air contained, during day . . .	0.000162
„ „ during night . . .	0.000267

These experiments would lead to the conclusion that both during day and night plants absorb a portion of carbonic acid.§ Saussure states that the leaves of plants during darkness absorb oxygen gas, the quantity varying in different species of plants, from a half to eight times the volume of the leaves in the course of twenty-four hours. The leaves of fleshy and aquatic plants absorb, generally speaking, less than those of ordinary deciduous trees and shrubs.‖ Leaves have the power of taking up ammonia from the atmosphere, and, according to some authors, they also absorb nitrogen.

647. Some researches have been made by Garreau¶ in regard to the absorption of different liquids by the external surfaces of plants, and more especially by the leaves. In making his experiments, he employed endosmometers (long tubes with large open bulbs at the end) of nearly equal calibre, the diameter of the orifice of the ball being in all of them about half an inch, and the diameter of the tube about one-twelfth of an inch. Each epidermis, or cuticular surface, was fixed to the end of the endosmometer by means of a wax thread, and covered by wax at the margin. The fluid in the bulb of the en-

* Boussingault, Economie rurale, i. 66. Mohl on the Vegetable Cell—Trans. by Henfrey, 82.

† Vogel and Wittwer de l'Influence de la Végétation sur l'atmosphère—Ann. des Sciences Nat. 3d ser. Bot. xvi. 373.

‡ A centimetre = 0.393708 of an English inch.

§ Garreau introduced a young green and leafy branch of Fagopyrum cymosum into a glass flask securely closed, and connected with a caoutchouc bag containing 200 cubic centimetres of carbonic acid. A communication was established between the flask and the bag, and after six hours' exposure to the light of the sun, it was found that the air of the flask and bag only contained 75 centimetres of the acid gas; the rest had been absorbed by the plant—Ann. des Sc. Nat. 3d ser. Bot. xvi. 288.

‖ Saussure, Recherches Chimiques sur la Végétation, 1804, p. 99.

¶ Garreau, Recherches sur l'absorption et l'exhalation des surfaces aériennes des plantes—Ann. des Sc. Nat. 3d ser. xiii. 321.

dosmometer was a solution of one part of sugar, in two parts of water. The following table shows the cuticles employed, the nature of the liquid used for endosmotic absorption, the duration of the experiment, and the result (ascent of the fluid in the tube) obtained in each case :—

Name of the plants the epidermis of which was tested.	Nature of fluid to be absorbed.	Duration of experiment.	Result in milli-metres.*
1. Outer epidermis of the sheath of an old leaf of the Leek	Distilled water.	24 hours.	000
2. do.	Weak solution of ammonia.	24 ,,	000
3. do.	Weak solution of potash.	24 ,,	000
4. do.	Weak solution of acetic acid.	24 ,,	000
5. do.	Weak solution of alcohol.	24 ,,	000
The same results were obtained with the inner epidermis.			
6. Outer epidermis of sheath of young leaf of Leek .	Distilled water.	24 ,,	010
7. Inner epidermis of do. .	Do.	24 ,,	015
8. Inner epidermis of old scale of Onion	Do.	24 ,,	000
Same results with diluted aqua ammoniæ and diluted acetic acid.			
9. Outer epidermis of old scale of Onion	Do.	24 ,,	000
10. Inner epidermis of young scale of Onion . . .	Do.	24 ,,	020
11. Do. do.	Solution of acetate of morphia.	24 ,,	020
12. Do. do.	Solution of sulphate of strychnia.	24 ,,	030
13. Do. do.	Solution of arsenious acid.	24 ,,	020

648. These experiments show that the epidermis of old but living leaves of the Leek and Onion has no endosmotic or absorbing properties. The young epidermis, on the other hand, is endosmotic, and seems to lose this property as it gets old. The epidermis, therefore, seems to be permeable by fluids only in the case of young leaves. The absence of absorption in the epidermis of old leaves is attributed by Garreau to the fatty or waxy matter which covers them,

* A millimetre is equal to 0.03937079 of an English inch, or nearly 1-25.

and with which they are impregnated. In Ferula tingitana it was found that the epidermis of the sheathing portion, which contained fatty matter, did not absorb until it was washed with soap and water. The upper surfaces of leaves which did not absorb liquids in their ordinary state, became absorbent when thoroughly cleaned and washed either with water alone, or with soap and water. Rain, by its effect on the surfaces of leaves, may thus increase their absorbing power. The epidermis of the bark of young shoots, where there is only a small quantity of fatty matter present, absorbed water, and when the epidermis was removed the absorption was much increased.

649. Garreau says that the results he obtained were not influenced by the number of stomata, for the kinds of epidermis which absorbed most, belonged to such plants as Potamogeton lucens, in which no stomata exist. His conclusions are:—1. The cuticle possesses a decided endosmotic property, the intensity of which is greater the younger the organ which it covers; when leaves become old they seem to lose their absorbing power. 2. The absorption of the cuticle is greater the less there is of fatty or waxy matter in it. 3. The cuticle which covers the superior surface of the ribs, and more especially that which covers the petiole at the point where it joins the stem, is that part of the foliar surface which has the most marked power of absorption. 4. In some instances in which the cuticle or outer skin is absorbent, the epidermis or inner layer of integument presents obstacles to absorption. 5. Simple washing with distilled water, more especially washing with soap and water, augments the absorbing property of leaves. 6. When leaves have lost their power of absorbing water, they can still take up carbonic acid.

II. EXHALATION BY LEAVES.

1. EXHALATION OF WATERY FLUID, OR TRANSPIRATION.

650. The leaves of plants, in the performance of their functions, give off a quantity of watery fluid. This constitutes what is commonly called *transpiration.* The quantity of liquid transpired varies according to the structure of the leaves and the nature of the climate. When the texture of the leaf is hard and dry, as in Banksias, Proteas, and many other Australian plants, or the skin covering the leaf is thick and dense, and has few stomata or pores, as in the American Aloe and the Oleander (Fig. 1148), the amount of transpiration is comparatively small. In this way certain succulent plants, as Cactuses (Fig. 1149), are enabled to withstand the effects of dry and hot climates, without being destroyed by the great loss of water by exhalation. The thick covering of hairs on some leaves, as on those of Culcitium, seems to be connected also with the amount of transpiration. Some very hairy plants, as Verbascum Thapsus, Shepherds Club, have been known to

resist the effects of great drought. The hairs have the power of becoming more or less erect, and of absorbing the dew, while in dry weather they lie flat on the surface and hinder the passage of fluid. In leaves with a very thin epidermal covering or skin the exhalation is great.

651. Schacht remarks that in the epidermis of plants the external sides of the cells become thickened generally more than the internal. They offer, especially when corky, resistance to the evaporation of the liquids in the parts filled with sap. They would completely prevent transpiration, were it not for the presence of stomata, which allow gaseous and vaporised substances to be exhaled as well as absorbed. The epidermis of the stem, as soon as it dies, is replaced by cork,

Fig. 1148.

Fig. 1149.

which, when completely formed, prevents all transpiration, although by its porosity it may condense gases at the surface of the plant. The presence of corky matter in the cell-walls, which has been noticed by Mitscherlich (page 31), may thus materially modify the functions of absorption and exhalation. In order that leaves may perform their functions properly, there must be a certain degree of exhalation. If from the leaves being covered with soot or dirt, or with the cottony productions of scale insects, the proper amount of exhalation is prevented, much injury is done to the plant. Hence, the importance of having the leaves of plants, when growing in hot-houses and conservatories, well washed and cleaned, in order that they may perform their healthy functions.

Fig. 1148. Rose-bay (*Nerium Oleander*), with lanceolate leaves, the upper epidermis of which is very dense, and resists exhalation.

Fig. 1149. Cochineal-Cactus (*Opuntia cochinellifera*), a succulent plant, the epidermis of which resists exhalation of liquids. On this plant the cochineal insect feeds. The male insect is represented at *a*. It is the female which supplies the cochineal

652. The passage of vapour through the pores of the leaf is an imperceptible process, which is constantly going on, and the existence of it is ascertained by its effects. Woodward endeavoured to ascertain the quantity of watery fluid transpired by leaves, by placing four plants of Spearmint, with their roots in water, in a situation fully accessible to light, during fifty-six days, from 2d June to 28th July. The following table shows the quantity of water absorbed (allowance being made for evaporation), and the quantity exhaled :—

	Original Weight.	Gain.	Water expended.	Difference, or Water exhaled.
No. 1.	127 grs.	128 grs.	14,190 grs.	14,062 grs.
No. 2.	110 ,,	139 ,,	13,140 ,,	13,001 ,,
No. 3.	74 ,,	168 ,,	10,731 ,,	10,563 ,,
No. 4.	92 ,,	284 ,,	14,950 ,,	14,666 ,,

These experiments show that a large proportion of the absorbed fluid is again given out by transpiration.* Hales made various experiments on the amount of exhalation.† He found that a common Sun-flower, 3½ feet high, weighing 3 lbs., with a surface of leaves equal to 5616 square inches, exhaled 20 ounces of liquid in the course of a day; a Cabbage plant, with a surface of 2736 square inches, was found to exhale, on an average, 19 ounces; a Vine of 1820 square inches, from 5 to 6 ounces; and a Lemon-tree of 2557 square inches, 6 ounces per day. The following are the results of these experiments on exhalation or transpiration from equal areas :—

NAME OF PLANT.	Time of Experiment.	Depth of Transpiration.
Vine	12 hours, day.	$\frac{1}{191}$ of an inch.
Sun-flower . .	A day and a night.	$\frac{1}{165}$,,
Cabbage . . .	12 hours, day.	$\frac{1}{86}$,,
Apple-tree . .	12 hours, day.	$\frac{1}{104}$,,
Lemon-tree . .	12 hours, day.	$\frac{1}{243}$,,

Hales remarked that Evergreens exhaled less than plants with deciduous leaves, and he associates this with their capability to endure the cold of winter.

653. Professor Burnett endeavoured to determine the amount of exhalation by putting fresh plants into a glass vessel graduated so that the quantity of water put in might be accurately known, and the quan-

* Woodward, Thoughts and Experiments on Vegetation—Philosophical Transactions for 1699, xxi. 193.

† Hales, Vegetable Statics, p. 4.

tity lost might be ascertained by the change in its height—the surface of the water being covered with a stratum of oil half an inch thick, which closely invested the stalks and prevented evaporation from the surface of the water. A leaf of a Sun-flower, weighing $31\frac{1}{2}$ grains, treated in this manner, absorbed in four hours 25 grains of water, and at the end of the time it had only increased in weight by $4\frac{1}{2}$ grains, so that $20\frac{1}{2}$ grains had disappeared by exhalation.*

654. Professor Henslow has proposed the following three sets of experiments on exhalation, each of them requiring two tumblers, one two-thirds full of water, the other empty. Place a card, or a piece of stiff paper varnished with a solution of shell-lac in alcohol, over each of the three tumblers containing water, large enough to cover it completely; then place an empty tumbler, mouth downwards, upon each of the cards. Call the three sets of experiments A, B, and C. Make a top to one of the sets of tumblers, B, by rolling round them two or three folds of thick paper, sufficient to prevent light from penetrating. Drill a hole in the middle of each card, just large enough to admit a leaf stalk (say of Ivy). In each hole insert the stalk of a leaf, so as to dip into the water in the lower tumbler, whilst the blade of the leaf is enclosed in the inverted empty tumbler. Place A and B in the direct rays of the sun—B with the cover on; place C in clear daylight, but removed from the influence of the direct rays of the sun. In less than five minutes the empty tumbler of A will be coated on the inside with a cloud of dew; but on taking the cover off B, it will be seen that no dew is there, neither as yet will any be found in the empty tumbler of C. If B be again closed, and matters left as before, the dew will be found to increase rapidly in A, and after some time a little will be seen in C. In B none will be found, except that occasionally there will be seen a deposit on the side of the empty tumbler opposite to the side on which the sun has been shining. In A the dew arises from the rapid exhalation of steam from the leaf when exposed to the direct rays of the sun, and the supply is kept up through the leaf-stalk. In C the exhalation is not so rapid, from want of the direct rays of the sun; while in B there is none, in consequence of the leaf being in the dark. The steam occasionally seen in B arises from mere evaporation from the leaf and card, &c.—this steam being deposited on the cooler side of the tumbler, or the one opposite to that on which the sun's rays fall; it is the effect of common evaporation and subsequent condensation. The same thing takes place in the upper part of the lower tumbler, immediately above the water. The steam which rises there condenses on the side opposite to the sun, which is kept cool by being shaded by the card above it. In A the moisture continues to accumulate over the whole surface of the tumbler, and is due to the light, rather than to the heat of the sun. These experiments lead to the conclusion that exhalation is due to the combined

* Burnett on the development of the several organic systems of vegetables, in Journal of Royal Institution of Great Britain, i. 83.

effect of light, and the vital power of the leaves.* The illuminating rays, according to Daubeny, have much more effect in this respect than the heating rays.†

655. The amount of light must have a powerful influence in regulating exhalation.‡ This amount, we know, is very different in different quarters of the globe. It has been stated that a vertical ray of light in its passage through the clearest air, loses at least one-fifth of its intensity before it reaches the earth's surface. From this cause and from the actual condition of the atmosphere, it has been estimated that, under the most favourable circumstances, of 1000 rays emanating from the sun, only 378 on an average penetrate to the surface of the earth at the Equator, 228 at latitude 45°, and 110 at the Poles, while in cloudy weather these several proportions are a great deal less. Hence, the structure of leaves requires to be adapted to the various degrees of exhalation produced in these different conditions. When the first rays of the morning sun rouse the dormant energies of the leaves, they begin to exhale ; but at that time of the day the temperature of the air is so cool, that the steam condenses as fast as it is discharged, hence, in the morning, there is much moisture on grass, totally independent of dew. If a plant is kept in darkness it soon becomes dropsical, because the roots continue slowly to absorb moisture, while the leaves have no power to exhale it. The moisture and dryness of the atmosphere have an effect on exhalation. The drier the air the more do plants absorb and exhale.§

656. Garreau¶ made a series of experiments on the exhalation of leaves, by enclosing a living leaf between two bell-jars, one applied to the upper, and the other to the under surface, and ascertaining the quantity of liquid exhaled by means of chloride of calcium, which absorbs water with great rapidity. He found that the exhalation from the lower surface of the leaf was usually double, and even triple or quadruple, that of the upper surface. The same results were obtained even when the leaf was reversed. The quantity of water exhaled has a relation to the number of stomata. The exhalation is greater at the line of the ribs, or at the part of the epidermis where there is least fatty or waxy matter. The secretion of this matter in abundance during the warm days of summer, may tend to prevent the plants being injured by rain and by the heat of the sun. By impeding exhalation, it tends to retain the moisture which is necessary for the functions of the leaves.

657. The difference of the exhalation is seen in the following table, in which leaves of the same plant were exposed to the air, some

* Dutrochet thinks that the effect of light in causing transpiration is the cause of the incurvation of stems when exposed on one side to light.

† Daubeny, on the effects of Light upon Plants — Phil. Trans. for 1836, p. 149. Philosophical Magazine, 1836, p. 415.

‡ While evaporation goes on independently of vitality, and is regulated entirely by the moisture and dryness of the atmosphere, exhalation is a chemico-vital action, which is specially influenced by light.

§ Miquel, sur l'Exhalaison des Feuilles.—Ann. des Sc. Nat. 2d ser. xi. 43.

¶ Annales des Sciences Nat. 3d ser. Bot. xiii. 335.

of them with the surface wiped, so as to take off a portion of the fatty covering, and others with the surface in the natural state :—

NAMES OF PLANTS.		Weight of Leaf.	Weight after six hours' exposure to air.	Difference.
Centranthus ruber (Red Valerian)	Rubbed	1.00	0.70	0.10
	Natural	1.00	0.80	
Clematis Vitalba (Traveller's joy), two leaflets	Rubbed	0.50	0.30	0.10
	Natural	0.50	0.40	
Syringa vulgaris (Lilac)	Rubbed	0.80	0.65	0.10
	Natural	0.80	0.75	
Convallaria majalis (Lily of the Valley) . . .	Rubbed	3.00	2.90	0.05
	Natural	3.00	2.95	
Sedum verticillatum (Verticillate Stone-crop), 16 hours in the air . .	Rubbed	2.00	1.70	0.20
	Natural	2.00	1.90	
Gentiana lutea (Yellow Gentian), two bracts	Rubbed	3.50	3.20	0.20
	Natural	3.50	3.40	
Iris florentina (Orris-root Iris), 24 hours . . .	Rubbed	13.50	11.70	0.60
	Natural	13.50	12.30	

658. Similar results, but more marked, were obtained when the surfaces of the leaves were washed with soap and water, care being taken to note the weight before and after the washing, for it sometimes happens that a small quantity of water enters through the epidermis covering the ribs, and through the stomata. The following table shows the exhalation from natural leaves, and from those whose surface had been cleaned with soap and water :—

NAMES OF PLANTS.		Weight of natural Leaves.	Weight after washing.	Weight after 15 hours' exposure to air.	Loss.
Syringa vulgaris (Lilac)	Cleaned with soap	0.67	0.70	0.29	0.38
	Natural	0.67	—	0.45	0.22
Clematis integrifolia (Entire-leaved Clematis)	Cleaned	0.47	0.52	0.14	0.33
	Natural	0.47	—	0.21	0.26
Acer Pseudo-platanus (Sycamore) . . .	Cleaned	4.00	4.05	1.85	2.15
	Natural	4.00	—	3.10	0.90
Centranthus ruber (Red Valerian) . . .	Cleaned	1.30	—	0.30	1.00
	Natural	1.30	—	0.40	0.90
Phlox paniculata (Panicled Phlox) . . .	Cleaned	0.50	—	0.32	0.18
	Natural	0.50	—	0.36	0.14
Stachys sibirica (Siberian Stachys . . .	Cleaned	0.71	—	0.19	0.52
	Natural	0.71	—	0.55	0.16

The waxy or fatty matter of the epidermis seems to have a marked effect in preventing too copious exhalation, and thus, in the plants of warm countries, it operates in keeping the leaves and stems of plants in a succulent state. The conclusions which M. Garreau draws from his experiments on exhalation of fluids are—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 stomates. 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.

659. In some plants, when water is supplied abundantly, there is a sort of distillation of liquid from the leaves. Arendt noticed this in a stalk of Urtica dioica when immersed in water. The liquid passed upwards in the grooves on the upper surface of the petiole, followed the ribs of the leaves, and then dropped from the apex of the leaves.* Gaertner observed a peculiar dropping from the leaves of Richardia africana (Calla æthiopica).† From the extremity of the leaves of this plant a watery fluid has been observed to drop in considerable quantity. The amount varies at different periods of the day, being most copious after mid-day. It ceases with the development of the spathe and organs of reproduction. A similar watery secretion has been noticed in other Araceous plants, such as Arum Colocasia and a plant called Caladium distillatorium; the water in these instances flows from an orifice near the point of the leaf, upon the upper surface, in which terminates a canal running along the margin of the leaf, while smaller canals, running along the principal ribs, open into the marginal one. Williamson found that from each healthy leaf of the latter plant about half-a-pint of liquid dropped during the night.‡ Water also drops from the margins of the leaves of Canna indica, angus-

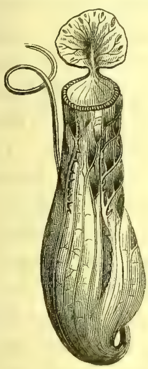

Fig. 1150.

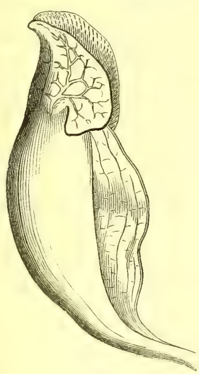

Fig. 1151.

Fig. 1150. Pitcher or ascidium of a Pitcher-plant (*Nepenthes distillatoria*), containing a secretion which holds saline matters in solution.

Fig. 1151. Pitcher of a species of Side-saddle plant (*Sarracenia purpurea*), containing a watery secretion in its interior.

* Arendt, Recherches sur l'activité capillaire des tegumens exterieurs de quelques plantes.—Ann. des Sc. Nat. 2d ser. Bot. xix. 327.

† Gaertner, Pflanzen physiologische Untersuchungen, &c. in Flora, 1842. Wilson, Phytologist, i. 612.

‡ Schmidt, in Linnæa, vi. 65; Williamson on Caladium distillatorium, in Annals of Nat. Hist. 2d series, i. 188.

tifolia, and latifolia. In the hollow leaves of plants, such as Nepenthes (Fig. 1150), Sarracenia (Fig. 1151), Dischidia, and Cephalotus, a quantity of watery exhalation accumulates. Voelcker analyzed the liquid in the pitcher of Nepenthes, and found it to consist of water, containing in solution malic acid and a little citric acid, chloride of potassium, carbonate of soda, lime, and magnesia.*

660. The exhalation of watery fluid from the leaves of plants influences the climate of a country. Humboldt remarks, plants exhale water from their leaves, in the first place, for their own benefit. But various important secondary effects follow from this process. One of these is maintaining a suitable portion of humidity in the air. Not only do they attract and condense the moisture suspended in the air, and borne by the wind over the earth's surface, which, falling from their leaves, keeps the ground below moist and cool ; but they can, by means of their roots, pump it up from a very considerable depth, and, raising it into the atmosphere, diffuse it over the face of the country. Trees, by the transpiration from their leaves, surround themselves with an atmosphere constantly cold and moist. They also shelter the soil from the direct action of the sun, and thus prevent evaporation of the water furnished by rains.† In this way they contribute to the copiousness of streams. When forests are destroyed, as they are everywhere in America by the European planters, with an imprudent precipitation, the springs are entirely dried up, or become less abundant. In those mountains of Greece which have been deprived of their forests, the streams have disappeared. The inconsiderate felling of woods, or the neglect to maintain them, has changed regions noted for fertility into scenes of sterility. The sultry atmosphere and the droughts of the Cape de Verd Islands are attributed to the destruction of forests. It is stated that in large districts of India, climate and irrigation have rapidly deteriorated from a similar cause, and that the government are now using means to avert and remedy the mischief. In wooded countries, where the rains are excessive, as in Rio Janeiro, the climate has been improved by the diminution of the trees. Gardner says, that since the axe has been laid on the dense forests surrounding the city of Rio Janeiro, the climate has become dry. In fact, so much has the quantity of rain diminished, that the Brazilian government was obliged to pass a law prohibiting the felling of trees in the Corcovado range.‡ Müller states that the cultivation of grain, which has so completely transformed one part of the wilderness of Australia, has already exercised a most beneficial influence on the increase of rain.§

661. Dr. Cleghorn remarks,¶ the conservation of forests is unques-

* Voelcker, on the Chemical Composition of the Liquid in the Ascidia of Nepenthes.—Annals of Nat. Hist. 2d series, iv. 128.

† Humboldt's Aspects of Nature, by Mrs. Sabine, i. 127.

‡ Gardner's Travels in Brazil.

§ Müller, on the Flora of South Australia, in Hooker's Journal of Botany, vol. v. 72.

¶ Report on the probable effects of the Destruction of Tropical Forests, by Dr. Cleghorn, Dr. Royle, Captain Baird Smith, and Captain Strachey, in Proceed. of Brit. Assoc. 1851.

tionably a subject of great importance. It is now occupying the attention of the government of India, and of many other governments, and it will sooner or later engage that of all our colonies. The physical history of every country proves incontestably that a moderate extent of forests, especially on mountain slopes and elevated rocky ground, where tillage is impracticable, promotes in a high degree both the agricultural and manufacturing interests of individuals, as well as the physical soundness and productive resources of extensive countries. It appears that the influence of forests in a physical, economical, and hygienic point of view, is deserving of a more complete investigation than it has yet received. By felling trees which cover the tops and sides of mountains, men in every climate prepare at once two calamities for future generations—the want of fuel, and the scarcity of water.*

662. It is necessary to keep up the correspondence between the fluid given off by the leaves and that taken up by the roots. If the former exceeds the latter, the leaves become languid and fall off. This is one cause why plants growing in the rooms of dwelling-houses succeed badly. The atmosphere is too dry, and the exhalation from the leaves is not compensated by the fluids taken up by the roots. This cannot be remedied by an extra supply of water, for the roots are not capable of taking up the additional quantity required. Hence the use of Wardian Cases† in preventing the loss caused by transpiration, and thus enabling the plants to live even in a warm and dry room.

2. EXHALATION OF GASEOUS MATTER.—VEGETABLE RESPIRATION.

663. The leaves of plants give off gases, the nature and quantity of which vary according to the circumstances in which the plants are placed, and their state of vigour or decay. Hence leaves produce important effects on the atmosphere, and we shall find that they are employed as the means of keeping up its purity. In the year 1771, Priestley observed that plants were able to grow in air vitiated by the breathing of animals, and that they soon restored such air to its original purity.‡ Percival confirmed these observations, and showed that air containing so much carbonic acid as to prove destructive to animal life, was rendered fit for respiration after plants had grown in it.

664. Ingenhousz examined the subject more fully, and made an

* For further details regarding exhalation of liquids by leaves, in addition to the papers and works referred to, the student may consult—Carpenter, Principles of Physiology, General and Comparative, p. 770. Gmelin, de Plantarum Exhalationibus, Tubing. 1847. Guéttard—Memoires Par. 1748, p. 569, and 1749, p. 265. Lawes, on the Comparative Evaporating Properties of Evergreen and Deciduous Trees, in Journ. of Hort. Soc. of London, vi. 227. Miquel, sur l'Exhalaison Aqueuse des Feuilles—Ann. des Sc. Nat. 2d ser. xi. 43. Mohl, ueber die Functionen der Blatter, Tubing. 1836.

† A description of these Plant-cases will be given in the sequel.

‡ Priestley, on Air, 86.

extensive series of experiments.* In air that had been so far depraved by respiration as to extinguish a lighted candle, he placed a plant of Peppermint, and then exposed the vessel for three hours to the sun, at the end of which time the air again supported flame. When a Nettle was put into a similar portion of impure air during the night, the air was not improved ; but when exposed to the sun for two hours, its original purity was restored. Such was also the case with plants of Mustard. When similar portions of the same impure air were confined in vessels with similar plants, and respectively placed in sunshine and shade, the air exposed to the sun recovered its purity in a few hours, while that in the shade was rendered more impure than before. Ingenhousz also performed experiments with immersed leaves, and found that they purified the air in the course of a very few hours in sunshine.

665. From five hundred experiments conducted between the months of June and September, Ingenhousz concludes that plants possess the power of giving out oxygen ; that this operation commences some time after the sun has risen above the horizon, is more or less vigorous according to the clearness of the day and the exposure of the plant to sunshine, and is suspended during night ; that in the shade, plants deteriorate the air ; that leaves, stems, and green branches purify the air, and that acrid and poisonous plants in this respect act in the same way as the most salutary ; that the pure air (oxygen) proceeds chiefly from the lower surface of leaves, and that young leaves do not furnish so much as those which have acquired their full vigour ; that some plants yield purer air than others, and that aquatics excel all others in this respect ; and lastly, that the sun does not possess the power of improving the qualities of atmospherical air without the concurrence of plants.

666. Senebier also instituted a series of experiments which proved the production of oxygen gas by plants exposed to the direct rays of the sun. He considered the oxygen as derived from the decomposition of carbonic acid ; and he thought that plants in a healthy state do not give out carbonic acid in darkness.† Ellis corroborated the statements of Ingenhousz, but he was disposed to consider the deteriorating effects of plants during darkness to be greater than had been supposed.‡ De Saussure found that when a plant was confined in a definite volume of pure atmospheric air, the air was unaltered in volume and composition after an equal number of days and nights. He thought that the plant formed as much carbonic acid by night as it had consumed during the day. But if a quantity of carbonic acid was added to the atmosphere in which the plant grew, or if it was made to absorb carbonic acid water, then it exhaled a quantity of oxygen. From his experiments

* Ingenhousz, Experiments upon Vegetables, Lond. 1776.

† Senebier, Memoires Physico-Chimiques, i.; Physiologie Végétale, iii. 104; Traité sur la Rapport des Plantes avec l'Air Atmospherique, Genève, 1807.

‡ Ellis, Inquiries into the Changes induced in Atmospheric Air by Plants and Animals.

he concluded that oxygen was exhaled during the day by the green parts of plants, while the carbonic acid present in the atmosphere was absorbed; that during the night carbonic acid was given off, while an absorption of oxygen took place; and that pale plants, such as Fungi, and the parts of plants not green, such as roots, stems, and flowers, as well as etiolated plants, exhaled carbonic acid.*

667. The following experiment has been suggested by Professor Henslow, as a simple means of showing that oxygen is given off by the leaves of plants:—Fill two or three tumblers with pond or spring water, which always holds some carbonic acid in solution. Place a leaf or two under the water in each tumbler. Common Laurel leaves do well, with a split shot or small piece of lead at one end, to keep the leaf under water, and at the same time vertical. Put one tumbler in common daylight, the others in the direct rays of the sun. In the former, no immediate effect will be observed, but in the latter, numerous bubbles appear on the surface of the leaves. These bubbles are probably portions of air separated from the water by the process of heating (as is seen in heating a tumbler of spring water by a fire or lamp); after a little (half-an-hour or more), other bubbles appear at the cut end of the leaf, and here and there on its surface. These bubbles increase rapidly in size, and rise to the surface. They proceed from the interior of the leaf, and are oxygen separated by the leaf from carbonic acid. The leaf is composed of cells, with spaces between them containing air of some sort. These spaces are abundant on lower surface, hence its paleness. By soaking leaves, as Laurel leaves, the air is expelled and water enters, and in a day or two the under surface becomes spotted and then dark. On Laurel leaves, after soaking for two or three days, the experiments on gaseous exhalation can be well shown, the oxygen coming off frequently in a stream. The effect is stopped by a shade being interposed, and may be excited by the reflected light from a looking-glass. The lower side of the leaf, during the giving off of the oxygen, resumes its pale colour.

668. Daubeny says that the action of light on plants causes the leaves to emit oxygen and decompose carbonic acid, and to become green when etiolated; that it maintains their irritability, and causes the plants to exhale water by the leaves, and to absorb watery fluid by the roots. He made experiments in regard to the effects which plants produce on the atmosphere, by placing them in large bell-jars containing 6-800 and sometimes 12-1300 cubic inches of air—the jars resting on mercury covered with a thin film of water, and so contrived that they could be pressed down in the mercury to expel the air when required, and to admit of the introduction of carbonic acid in a regulated quantity. The amount of carbonic acid added varied from 2 to 11 per cent. The plants added to the oxygen of the air so long as

* De Saussure, Recherches Chimiques sur la Végétation, pp. 35, 36. Saussure, Annales de Chim. xxiv. 133. Grischow, Physikalisch-Chemische Untersuchungen ueber die Athmungen der Gewächse und deren Einfluss auf die gemeine Luft, Leipzig, 1819.

carbonic acid was supplied, and the following are the comparative results in sunshine and shade :—

1. During fine weather and bright sunshine.

a Plants in a jar of air, without flowers, and with leaves alone.

	Maximum increase of Oxygen in the jar.
Cupressus (Cypress)	2.00 per cent.
Cedrus (Cedar)	3.75 „
Syringa vulgaris (Common Lilac)	6.50 to 8.75 „
Pelargonium	2.00 to 5.00 „
Mesembryanthemum	2.40 „

b Plants in a jar of air, with flowers and leaves.

Dahlia	3.75 per cent.
Helianthus (Sunflower)	1.00 „

2. During bad weather, and in diffused light.

Syringa persica (Persian Lilac)	3.00 per cent.

The greatest amount of oxygen that can be added to the air of a jar by the influence of a plant he states to be 18 per cent. The purification of the air ceases when there are no leaves.*

669. Aquatic plants appear to surpass all others in their power of decomposing carbonic acid. In some lakes in volcanic countries, where carbonic acid rises in great quantity through the waters, vegetation is very vigorous, and the separation of oxygen goes on rapidly. In speaking of the floating islands on the lake Solfatara, in Italy, Sir Humphry Davy remarks—"The high temperature of this water, and the quantity of carbonic acid that it contains, renders it peculiarly fitted to afford a pabulum or nourishment to vegetable life. The banks of Travertine are everywhere covered with Reeds, Lichens, Confervæ, and various kinds of aquatic plants; and at the same time that the process of vegetable life is going on, the crystallizations of the calcareous matter, which is everywhere deposited in consequence of the escape of carbonic acid, proceed, giving a constant milkiness to what, from its tint, would otherwise be a blue fluid. So rapid is the vegetation, owing to the decomposition of the carbonic acid, that, even in winter, masses of Confervæ are constantly detached by the currents of water from the bank, and float down the stream, forming often small islands on its surface."† Schleiden mentions that there is a rich vegetation round the springs in the valley of Gottingen, which abound in carbonic acid.‡

670. Morren, of Geneva, examined in a particular manner the oxygenation of the water of ponds by means of Confervæ, and he found

* Daubeny, on the Action of Plants on the Atmosphere.—Phil. Trans. 1836, p. 163.
† Sir H. Davy's Consolations in Travel, 3d edit. p. 116. ‡ Wiegmann's Archiv. iii. 1838.

that it varies according to the intensity of the solar light and the elevation of the sun. It commences at daybreak, increases slowly at first, then rapidly, and reaches its maximum at four to five o'clock in the afternoon. In winter there must be a long succession of fine days before the water attains the same degree of oxygenation as in summer. The oxygen thus formed is sent into the atmosphere. The marshes of Anké, in Batavia, produce a variety of plants, such as Grasses, Rushes, Water Beans, &c., which grow from the bottom of the stagnant water, and the interstices between these plants are covered with Pistia Stratiotes (called Water Lettuce in the West Indies), which, floating on the surface of the water, decomposes noxious gases, under the influence of the solar ray, and gives out respirable air. Such plants not only give a supply of oxygen, but also tend to purify the water, and render it more fit for animal life. Cloez and Gratiolet state, as the result of recent experiments, that the decomposition of carbonic acid is performed with great rapidity by submerged aquatic plants, and that they separate more oxygen in a given time than most other plants.

671. We have seen that Ingenhousz early propounded the statement that carbonic acid was given off during darkness, and that his views in this respect were opposed by Senebier. Since their day the subject has been carefully investigated, but the views of physiologists are still divided. Some maintain that oxygen is given off by the leaves during the day, and a moderate quantity of carbonic acid is exhaled by a process of endosmose during night; others say that carbonic acid is exhaled by plants in greater or less quantity at all times, and that during the day it is decomposed so as to give out oxygen; while a third set of authors state that no carbonic acid is evolved by leaves in a healthy state, and that their true function is one of deoxidation, or rather decarbonization, which consists in the fixation of carbon and the elimination of oxygen.

672. The first of these views was for a long time generally adopted, but some recent experiments have tended to throw doubts upon it, and to confirm the views of Senebier. Mohl still supports this view. He says plants have a double respiration—one consuming carbonic acid and exhaling oxygen by day in the green-coloured organs, and one connected with a consumption of oxygen and a formation of carbonic acid in the green organs by night, and in those not green, by day and night. If we wish to speak of a respiration in plants, he says, this oxygen-consuming breathing deserves the name far more than the exhalation of oxygen by the green organs connected with the nutrient processes.*

673. The second view was propounded by Burnett, who considers the constant exhalation of carbonic acid both by day and by night as true vegetable respiration, while the decomposition of carbonic acid

* Mohl on the Vegetable Cell, translated by Henfrey, 85, 87.

during light, accompanied with the evolution of oxygen, is regarded by him as a process of digestion; respiration thus going on at all times, and consisting, like that of animals, in the separation of carbon, while digestion only goes on during light.* He has been supported by Carpenter, who says that the respiration of vegetables is not an occasional process, but one which is constantly going on during the whole life of the plant—by day, by night, in sunshine, and in shade—and consists in the disengagement of the superfluous carbon of the system, either by combination with the oxygen of the air, or by replacing with carbonic acid the oxygen that has been absorbed from it. If the function is checked the plant soon dies, as when placed in an atmosphere with a large amount of carbonic acid, and without the stimulus of light which enables it to decompose the acid gas.† Henfrey says a distinction is to be drawn between the process of respiration in which the liberation of superfluous oxygen takes place, leaving the other elements combined in an assimilated or organic condition, and that process in which the assimilated matter is again chemically altered by the oxidation of a certain amount of carbon, which is liberated as free carbonic acid by plants unprovided with leaves, but under most circumstances decomposed again by green plants. He thinks that carbonic acid is given off by living plants as a vital process even during light, and he suggests that the re-absorption of the evolved acid gas during the day has disguised the fact in most previous experiments.‡ Ellis says that the deteriorating process in which oxygen gas is consumed goes on at all times and in all circumstances when vegetation is active. It requires a suitable temperature to display itself, and when that temperature falls below a certain point it ceases. On the other hand, the purifying process in which oxygen gas is evolved is chiefly dependent on the agency of light. The former he considers to be accomplished by the agency of the air, and to be essential to the life and growth of the plant; the latter, to be subordinate, depending on the agency of light, and though necessary to the perfection of vegetation, yet not essential to its existence.§

674. Garreau has made an extensive series of experiments on the respiration of plants.¶ In his early experiments he used the same apparatus as that employed by him for determining the exhalation of liquids, namely, two bell-jars, with their open ends applied respectively to the upper and under sides of the leaf, so as to enclose a circular portion between them. By means of lime-water in the vessels he determined the quantity of carbonic acid given

* Burnett, on the development of the several organic systems of vegetables—Journal of Royal Institution of Great Britain, i. 93.

† Carpenter, Principles of Physiology, general and comparative, p. 730

‡ Henfrey, Outlines of Structural and Physiological Botany, p. 103. The Garden Companion, July 1832, p. 97.

§ Ellis on Plant Cases, &c.—Loudon Mag. of Bot. xv. 502.

¶ Garreau, sur la respiration des plantes—Annales des Sc. Nat. 3d ser. Bot. xv. 1, and xvi. 5.

off at different hours. The experiment lasted for several hours in each case, and the quantity of carbonate of lime formed was dried and weighed. The results are given in a tabular form :—

NAMES OF PLANTS.	Extent of surface of leaf in metres.	Duration of Experiment.	Nature of the light.	Surface.	Quantity of carbonate obtained.
Polygonum orientale	0.040	12 hours.	Shade.	Upper. Under.	0.000 0.000
Rheum undulatum (Undulated Rhubarb) . . .	0.075	do.	do.	Upper. Under.	0.000 0.000
Nicotiana rustica (Rustic Tobacco)	0.040	do.	do.	Upper. Under.	0.000 0.000
Tropæolum majus (Indian Cress) .	0.040	do.	do.	Upper. Under.	0.000 0.000
Asclepias Syriaca .	0.075	6 hours.	6 hours of burning sun 111° F.	Upper. Under.	0.005 0.005
Tropæolum majus (Indian Cress) .	0.040	8 do.	8 hours do.	Upper. Under.	0.005 0.010
Tilia europæa (Lime Tree)	0.075	7 do.	7 hours 113° F.	Upper. Under.	Traces 0.015
Aralia racemosa, terminal leaflet, .	0.040	6 do.	6 hours 115° F.	Upper. Under.	0.005 0.010
Rheum undulatum (Undulated Rhubarb)	0.280	5 do.	5 hours 111° F.	Entire leaf.	0.025

From these and other experiments he drew the conclusion that the upper and under surfaces of the leaves give off carbonic acid in certain circumstances, and that the under surface gives off more than the upper; that the leaves or surfaces of the leaves which exhale most, also give off most carbonic acid; that the quantity of carbonic acid gas emitted bears a relation to the number of stomata; that the leaves do not give out carbonic acid, either in the shade or in the sun, at a moderate temperature, but that the exhalation of this gas takes place in small quantities, under the influence of the sun when accompanied with great heat; that the carbonic acid seems to be formed in the interior of the plant.

675. Subsequently, however, Garreau was led to adopt Burnett's view, that carbonic acid is expired at all times by plants, but that it is decomposed during the day as rapidly as it escapes from the plant. This latter circumstance, in his opinion, accounts for its non-appearance in his experiments already detailed. He endeavoured to prove this by making similar plants grow in two jars containing equal volumes of air, the one being supplied with a solution of baryta, the other having none. In the first jar he expected the carbonic acid, when evolved, to be at once fixed more or less completely by the

baryta before being decomposed by the reducing action of the leaves. The following are some of his latest results :—

NAMES OF PLANTS.	Dates.	Atmospheric air with or without solution of Baryta.	Temperature. Fah.	Duration of Experiment. Hours of the day.	CO_2 expired. Cubic centim.	Remarks.
Kitaibelia vitifolia .	July 30	Without With	64°.4	10 to 4	0 12	Rainy, with occasional sunshine.
Rhus radicans . .	July 31	Without With	66°.2	11 to 5	0 11	Moist, and rather dull.
Fraxinus excelsior	Aug. 1	Without With	64°.4	11 to 5	0 6	No sun, rather dull, rain.
Acer eriocarpum .	Aug. 1	Without With	66°.2	12 to 6	24 41	Rather dull.
Syringa vulgaris .	Aug. 4	Without With	64°.4	12 to 6	0 6	Three hours of beautiful sunshine.
Glycyrrhiza echinata	Aug. 7	Without With	71°.6	12 to 6	0 8	Four hours of sunshine.
Asclepias Cornuti	Aug. 5	Without With	73°.4	7 to 7	7 37	Six hours of exposure to a very fine sunshine.
Fagopyrum cymosum	Aug. 6	Without With	77°	7 to 7	9 30	Do.
Ficus Carica . . .	Aug. 6	Without With	75°.2	9 to 6	9 24	Do

These experiments, he thinks, shew that the carbonic acid, which is exhaled during sunshine, is decomposed in a great measure by the action of light so soon as it is formed, and that a high temperature increases the quantity of carbonic acid expired. The conclusions at which he finally arrives are as follow :—1. Leaves, during the day, both in sunshine and shade, give out carbonic acid, and this gas is exhaled in larger quantity in proportion to the increase of temperature. Buds give out more of the acid gas than leaves. 2. Two antagonistic processes are going on simultaneously in leaves both in shade and in sunshine—the one a process of combustion, attended with the evolution of carbonic acid, the other a process of reduction, attended with the evolution of oxygen. 3. The accumulation of carbon in plants is owing to the predominance of the second process over the first. 4. The evolution of carbonic acid is connected with the presence of protein compounds, such as protoplasmic and albuminous matter. 5. The process of combustion is to be considered as constituting vegetable respiration, while the process of reduction is to be viewed as connected with the function of nutrition.*

676. The third view of vegetable respiration has been brought prominently forward of late years by Mr. Haseldine Pepys. From

* Garreau, sur la Respiration des Plantes, in Annales des Sc. Nat. 3d ser. Bot. xvi. 292.

careful experiments, conducted during several years, he is satisfied that leaves, which are in a state of vigorous vegetation, always operate so as to keep up the purity of the air by absorbing carbonic acid, and disengaging oxygen; that this function is promoted and accelerated by the action of light; that it continues during night although more slowly; and that carbonic acid is never disengaged when the leaf is healthy.* He also finds that the fluid abundantly exhaled by plants during their vegetation is pure water, and contains no carbonic acid; and that the first portions of carbonic acid gas contained in an artificial atmosphere are taken up with more avidity by the plant than the remaining portions. The carbonic acid which is given off by leaves is attributed to a state of disease or alteration in the healthy state of the tissues, and in many experiments (as in Garreau's), the abnormal condition of the plant may perhaps account for the appearance of carbonic acid. In some of Mr. Ellis's experiments, the decaying condition of the leaves gave rise to a fallacy in the results. Cloez and Gratiolet confirm Pepys' observations. They state that oxygen is disengaged rapidly in solar light, insensibly in diffused light, and not at all in darkness, and that in the latter case no carbonic acid whatever is given off by plants.

677. From all that has been stated, it would appear that an absorption of carbonic acid by the leaves of plants and an elimination of oxygen takes place during daylight, and that this process ceases in a great measure during the night. The exhalation of carbonic acid by healthy leaves is still doubtful, and the appearance of this acid gas may in many of the experiments be traced to an abnormal condition of the leaves. The great function of the leaves thus seems to be deoxidation, by means of which they are instrumental in keeping up the purity of the atmosphere. This function of plants is antagonistic in its results to animal respiration; for while the latter takes oxygen from the atmosphere, and replaces it by carbonic acid, the former removes carbonic acid, fixes carbon, and gives out oxygen. The processes of respiration and combustion are pouring into the atmosphere a large quantity of carbonic acid gas, while the active leaves of plants are constantly removing it, and, under the action of light, substituting oxygen. While plants thus get carbonaceous food, the air is by them kept in a state fitted for animal life. The proper, constant, and unexhaustible sources of oxygen gas, as Liebig remarks, are the tropics and warm climates, where a sky seldom clouded permits the glowing rays of the sun to shine upon a most luxuriant vegetation. The temperate and cold zones, where artificial warmth must replace the deficient heat of the sun, produce on the contrary carbonic acid in superabundance, which is expended on the nutrition of tropical plants. Vegetable culture heightens the healthy state of a country. The life of animals is connected intimately, then, with the vegetable productions of the globe, not merely as regards the materials for their food, but also in reference to the air which they breathe.

* Pepys, on the Respiration of the Leaves of Plants—Phil. Trans. 1843, p. 329.

678. How interesting, says Johnston, is it to contemplate the relations, at once wise and beautiful, by which dead organic matter, intelligent man, and living plants, are all bound together. The dead tree and the fossil coal lie almost useless things in reference to animal and vegetable life. Man employs them in a thousand ways as ministers to his wants, his comforts, or his dominion over nature; and in so doing, he himself directly, though unconsciously, ministers to the wants of those vegetable races, which seem but to live and grow for his use and sustenance. How beautiful also does the contrivance of the expanded leaf appear! The air contains only one gallon of carbonic acid in 2500, and this proportion has been adjusted to the health and comfort of animals, to whom this gas is hurtful. But to catch this minute quantity, the tree hangs out thousands of square feet of leaf, in perpetual motion, through an ever-moving air; and thus, by the conjoined labours of millions of pores, the substance of whole forests of solid wood is slowly extracted from the fleeting winds.*

679. As the decomposition of carbonic acid is only carried on vigorously during the day, it follows that an accumulation of it will take place in the atmosphere during darkness. Saussure found, from a mean of fifty-four observations made in a country district, that the proportion of carbonic acid in the atmosphere during the night was to its proportion in the day-time as 432 to 398; or in other words, the carbonic acid in the atmosphere was diminished nearly 10 per cent. during daylight.† It is said also that during summer, when animal life is more active, the proportion of carbonic acid is greater than in winter, as 7.13 to 4.79 parts in 10,000. The usual quantity of carbonic acid in the atmosphere, before being drawn into the lungs, is about 1-2500th; in that returned from the lungs it is about 1-25th, or it has increased 100 times in quantity. So long as plants are kept in a vigorous and healthy state, they do not give off any carbonic acid. If, however, they are kept long in the dark they begin to fade; the green colouring matter called chlorophyll is not produced as it ought to be; the plants are blanched or etiolated, and in fact get into a state of disease. In such circumstances no oxygen is given off, but, on the contrary, carbonic acid is produced.

680. Experiments have been made by Draper‡ as to the particular rays of the spectrum which are concerned in the decomposition of carbonic acid by the green parts of plants. They were made with a series of tubes half an inch in diameter and six inches long, which were arranged so that the coloured spaces of the spectrum fell on them. In these tubes water impregnated with carbonic acid and a few green leaves of Poa annua were placed. In the tube that was in the red space a minute bubble of gas was sometimes formed, sometimes none at all; that in the orange contained a considerable quantity; in the

* Johnston, Elements of Agricultural Chemistry and Geology, 6th edit. 41.

† Saussure, sur la variation de l'acide carbonique atmospherique—Ann. de Chim. et de Phys. ii. 199, xliv. 5. Edin. New Philos. Journal, xl. 22.

‡ Draper, Chemistry of Vegetation, p. 177.

yellow ray a very large amount was found, comparatively speaking; in the green a much smaller quantity; in the blue, indigo, and violet, and the extra-spectral space at that end, not a solitary bubble. The results are tabulated thus:—

Oxygen set free in the		extreme red ray . . .	.00	to	.33
—	—	red and orange	20.00	„	24.75
—	—	yellow and green . . .	36.00	„	43.75
—	—	green and blue	4.10	„	.10
—	—	blue	1.00	„	.00
—	—	indigo	.00		
—	—	violet	.00		

Hence he drew the conclusion that the light-giving rays and those nearest the yellow have the greatest effect in the decomposition. Light, therefore, seems to act in this process according to the intensity of its illuminating power, while the heating and the tithonic or chemical rays have no effect.

681. Cloez and Gratiolet* also endeavoured to discover the comparative influence of coloured glass on the decomposition of carbonic acid by the green parts of plants, and they found that the decomposition is most rapid under colourless unpolished glass, then comes yellow glass, then colourless transparent glass, then red, green, and lastly, blue glass. They were satisfied that these differences were not caused by differences of temperature. As regards the influence of temperature, they state that the decomposition of carbonic acid gas, by aquatic plants exposed to light in a temperature raised gradually from 39.2° F., does not commence until the temperature is 59° F., and is at its maximum at 86° F. The decomposition of the same gas, by plants exposed to light in a temperature which is lowered from 86° F., continues when the temperature is as low as 57.2°, 55.4°, 53.6°, 51.8°, but ceases when it is as low as 50° F.

682. It has been stated that plants, when blanched, give off carbonic acid. Morot says that in partially etiolated plants, when exposed to the direct rays of the sun, the yellow portion of the tissue gave out carbonic acid, while the green parts gave out oxygen. Plants having no green leaves exhale carbonic acid. Thus Lory found, from thirty experiments, that Orobanches (Fig. 126, p. 54) in every stage of their growth, whether exposed to light or not, absorb oxygen and give out carbonic acid.† The carbonic acid appeared to proceed, not from a direct union between the carbon of the plant and the oxygen of the air, but from processes going on in the interior of the plant. Lory took two parts of the same weight, one of Orobanche Teucrii, and the other of the leafy stalk of Teucrium Chamædrys, on which it was parasitic, and placed them in two jars of the same capacity, filled with six

* Cloez et Gratiolet, Recherches sur la Végétation.—Comptes Rendus, t. xxxi. p. 626, for 1850.

† Lory, sur la Respiration des Orobanches et autres plantes vasculaires depourvues de parties vertes—Ann. des Sc. Nat. 3d ser. Bot. viii. 158.

volumes of air to one of carbonic acid. Both were exposed to light from 9 A.M. until 3 P.M. of the succeeding day, and at the end of that time the air in which the Teucrium was placed contained no trace of carbonic acid, while that in which the parasitic Orobanche was placed yielded a large quantity of carbonic acid and a diminished amount of oxygen.

683. Draper and Ville think that plants also exhale nitrogen gas, and Cloez and Gratiolet were led to the same conclusion from their experiments. Some maintain that the ammonia taken up by plants is with the view of supplying not merely nitrogen in certain quantity, but likewise hydrogen; and that in the same way as carbonic acid is absorbed and oxygen is given off, so ammonia is absorbed and nitrogen is exhaled. If nitrogen is given off by plants, it seems probable that it is derived from the ammonia, and not from the air. Those who support this view state the antagonism between animals and plants in the following manner:—Animal respiration gives rise to carbonic acid gas, which is absorbed by plants, the carbon and part of the oxygen being fixed, and another part of the oxygen being exhaled: again, animal decomposition gives rise to ammonia, which is absorbed by plants, the hydrogen and part of the nitrogen being assimilated, and another portion of the nitrogen being exhaled. These statements, however, require confirmation.

III. INFLUENCE OF LEAVES ON VEGETABLE SECRETIONS.

684. By means of the processes of absorption and exhalation which are carried on by leaves under the influence of air and light, the contents of the cells and vessels are elaborated and fitted for the production of various important secretions. To the action of the leaves must be traced in a great measure the elaboration of the azotized and unazotized compounds, to which allusion has already been made (p. 370). When the functions of the leaves are interrupted by non-exposure to light, or by the attacks of disease, and when plants are deprived of their leaves by injuries of various kinds, their secretions are either wholly stopped, or they become altered in their nature. When leaves are blanched by being excluded from air and light, they lose their properties, their fragrant oils and resins are not developed in a proper manner, chlorophyll is not formed, nor is woody matter produced.

685. The importance of leaves in the production of timber is universally acknowledged. If they are prevented from performing their functions properly, by being kept in darkness or in the shade, wood is imperfectly formed; and if the leaves are constantly stripped off a tree, no additions are made to its woody layers. Some troublesome weeds with underground woody stems may be enfeebled and ultimately

extirpated by repeatedly cutting off their whole foliage. The difference of the wood in crowded and properly thinned plantations, depends in a great measure on the growth and exposure of the leaves. Wood grows more rapidly, and the zones or circles are larger, when there is free exposure. Hence the necessity of judicious planting if we wish to have good timber. The following measurements made of a Spruce Fir in a crowded plantation of 1000 acres in Yorkshire, and given several years ago in the Gardener's Chronicle, shows the state of the zones of wood in such cases :—

In the first 5 years, the tree grew		26	tenths of an inch	in diameter.
In the second do.	do.	24	—	—
In the third do.	do.	20	—	—
In the fourth do.	do.	12	—	—
In the fifth do.	do.	8	—	—
In the sixth do.	do.	6	—	—
In the seventh do.	do.	10	—	—

Thus, in the course of 35 years the Fir only attained a diameter of 10.6 inches, in place of 18—the annual growth of timber beginning to diminish after the first five years, and the diminution going on with great rapidity after the fifteenth year of growth, when the trees were becoming more and more crowded. At the end of the thirtieth year the annual growth was little more than one-tenth of an inch, whereas in the early years it had been more than five-tenths. The increase in the last five years seems to have been due to some of the trees having been accidentally cleared away, thus allowing more light and air to reach the leaves.

686. When a tree forms large circles of woody matter, and thus grows rapidly, it has been found that the quality of the timber is better than when the same species forms small circles and grows slowly. An examination was some time ago made of the naval woods in the dockyards of Britain, and it was found that the most durable Oak was that which had grown quickly, and had increased at the rate of one inch in diameter in the course of the year. Some excellent Oak taken from York Minster was ascertained to have had an annual growth of eight-tenths of an inch. Professor Barlow, of Woolwich, examined two specimens of timber—No. 1 from a fast-grown tree, No. 2 from a slow-grown tree. Both specimens were squared down to 2 inches, and they were broken on props placed 50 inches apart. Their specific gravity and their strength are given as follows :—

	Specific gravity.	Deflected one-fiftieth of an inch with	Broken with
No. 1 . . .	903 . . .	660 lbs. . . .	999 lbs.
No. 2 . . .	856 . . .	414 „ . . .	679 „

Thus the fast-grown timber exceeded the other in specific gravity, as well as in tenacity and strength.

687. These observations show the importance of allowing the leaves to be well developed and fully exposed, if we wish the production of timber to proceed vigorously and profitably. The same thing may be proved in regard to all the other secretions formed by plants. Thus, Potatoes grown in the shade, by which the functions of their leaves are impeded, become watery, and produce little starch in their tubers. The same causes which operate in the formation of timber also affect the development of roots, and hence the precautions taken to secure the good quality of the former have a powerful influence on the latter. Roots in their turn, by the absorption of nutriment, convey to the leaves materials for forming wood, and the more they extend the greater is the supply which they obtain. There is thus a reciprocal action between the leaves and the roots, each being dependent on the other for the due performance of their functions.*

688. While in the cultivation of trees, shrubs, and ordinary flowering plants, the object of the gardener is to allow the leaves to perform their functions perfectly, there are certain cases in which he endeavours to interrupt these functions, and to produce an unnatural condition, by which the plants are rendered more suitable for domestic purposes. All are familiar with the fact that blanching deprives the leaves of their green colour, and prevents them from acquiring their usual qualities. This depends on the effect of darkness in arresting the formation of chlorophyll or the green colouring matter, and in hindering the production of various secretions. In the case of Asparagus and Seakale, gardeners succeed by artificial etiolation (blanching) in preventing the plants from producing woody tissue—cells and thin-walled vessels being alone formed which are delicate in their texture. The tenderness and succulence of the *heart* of the cabbage are due to the outer leaves obstructing the access of light. In Celery the effect of blanching is to deprive the plant not only of the woody tissue, but also of certain other secretions which render it in its ordinary condition unpalatable. It is thus distinctly proved that leaves owe their green colour to the action of light, and that it is only when light and air are supplied freely, that they can form the secretions which are required for the vigorous and normal growth of the plant.

689. In certain instances we arrest the growth of the leaves with the view of making a tree produce flowers or fruit. This is accomplished by pruning, an operation which ought to be performed with care and judgment. In the case of forest trees, if properly planted, no pruning is required, except the removal of dead or decaying branches. The form and symmetry of a forest tree is best preserved by allowing it to grow freely in a congenial soil without being disturbed. It is different in the case of cultivated fruit trees, where the object is not so much the symmetry of the tree as the production of fruit. In them pruning may be defined the act of removing scientifi-

* See further remarks on this subject at page 428, paragraph 610.

cally certain branches, or parts of them, for the purpose of increasing the productiveness of the tree and the size of its fruit. A shoot is removed by a clean cut with a sharp knife, the incision making a sloping wound at an angle of 45° at the back of a bud, and not so low as its base. Pruning should be performed on young branches of moderate diameter. When large branches are lopped off injury is done, and in the case of forest trees a snag is left which gives rise to the formation of a knot in the wood, and frequently, from the exposure of a large wound, the weather causes decay in the wood. By a constant process of pruning, trees become stunted in their growth. By restricting roots and pruning the branches peculiar dwarf-looking trees are produced by the Chinese. Oaks have thus been reared which, after attaining a great age, are only one foot and a half high. The removal of leaf-buds, or, as it is called, disbudding, is another mode in which pruning is practised.

IV. EFFECTS OF VARIOUS GASES UPON LEAVES.—WARDIAN CASES.

690. In considering further the functions of the leaves, it is of importance to notice the effects produced upon them by different gases. The atmospheric air, with its oxygen, nitrogen, carbonic acid, and ammonia, is the gaseous mixture best fitted for the growth of plants. Certain gases in their unmixed state are poisonous to plants, while others do not seem to produce any deleterious effects further than the retardation of growth caused by the exclusion of atmospheric air. Saussure found that a plant of Lythrum Salicaria flourished for five weeks in hydrogen gas, and the Messrs. Gladstone ascertained that nitrogen, oxygen, and nitrous oxide were innocuous.* Plants would not of course continue to be vigorous in such atmospheres, for they would be deprived of the carbon which is necessary for them, and which can only be procured from carbonic acid.†

691. Plants, when exposed to light, will thrive in an atmosphere containing a considerable amount of carbonic acid, but they cease to perform their functions in an atmosphere composed of carbonic acid alone. Daubeny found that Ferns and Lycopodiums, which are the plants most nearly allied to those of the coal epoch, can at the present day exist without injury in an atmosphere containing at least 5 per cent. of carbonic acid, and he thinks that this in some degree supports Brongniart's hypothesis as to the cause of the enormous production of carbon by the plants of that epoch. While plants in bright light can

* Messrs. Gladstone, on the growth of plants in various gases—Philosophical Magazine, 1851, 4th series, ii. 215.

† Saussure, Recherches Chimiques sur la Végétation, 194, 209. Annales de Chimie et de Physique, xxiv. 227.

live in an atmosphere containing 5 to 10 per cent. of carbonic acid, Daubeny ascertained that the addition of a larger per centage caused injurious effects. He put five species of plants under a jar containing about 2800 cubic inches of air. To this air one per cent. of carbonic acid gas was at first added, and a daily increase to the same amount in the quantity present was kept up until the proportion reached 20 per cent. This same quantity was then maintained in the jar for 20 days, by successive additions, to compensate for the ascertained amount of leakage; and the appearance of the plants was noted from time to time. It was not till the 13th day that any sensible alteration for the worse was observed. The experiment was, however, continued for 17 days more, with the following results:—

Pteris longifolia. All the old fronds were dead, but the vitality of the rhizome was not destroyed.

Pteris serrulata was slightly damaged.

Nephrodium molle was in the same condition as Pteris longifolia.

Gymnogramma chrysophylla had its old fronds slightly damaged, and they were of a yellow colour.

Adiantum cuneatum. All the fronds had died down.

Thus it was proved that this amount of carbonic acid, even when gradually added, would in time prove fatal to plants. That the effect was attributable, not to the diminution in the proportion of oxygen consequent on the addition of a large amount of carbonic acid, but to something positively deleterious in the latter gas itself, was inferred by exposing plants to air impregnated with 20 per cent. of hydrogen, which in the course of 10 days appeared to exert no sensible influence upon their health.*

692. In the atmosphere of towns, more especially those in which chemical and other manufactories exist, there are many gaseous and other matters present which interfere in a marked degree with the growth of plants. Every cultivator knows the difficulty of growing Roses and many valuable garden flowers in such situations. Drs. Turner and Christison were led to examine the influence of gases on plants, on account of having been called upon to give evidence as to the effects of a black-ash manufactory on the vegetation in its neighbourhood.† They found that many gases, even in minute quantity, injured and destroyed the leaves of plants, some of the gases acting as irritant poisons, others as narcotic poisons. The former destroyed the texture of the leaves and altered their colours, while the latter killed the leaves without producing any local effects on the textures. Sulphurous acid gas, which is very commonly met with in the atmosphere of towns was found to be exceedingly deleterious. Where four or even

* Daubeny, on the influence of carbonic acid gas on the health of plants, in Report of British Association for 1849, p. 56, and 1850, p. 159.

† Turner and Christison on the effects of the poisonous gases on vegetables—Edinburgh Medical and Surgical Journal, xxviii. 356.

only 2 cubic inches were introduced, along with a young Mignonette plant, into the air of a glass jar, capable of containing 470 cubic inches, the leaves of the plant became greenish-grey and drooped much in less than $2\frac{1}{2}$ hours; and, though then taken out and watered, it soon died altogether. The extraordinary destructiveness of the gas is still better exemplified in the following experiment:—" A wide-mouthed bottle, containing a mixture of 6 cubic inches of air, and 25-100ths of a cubic inch of sulphurous acid gas, was fixed mouth uppermost, on a stand 20 inches high; at the bottom stood a young Mignonette plant, a young Laburnum tree 6 inches in height, and a young Larch, which had been transplanted at least five days before and had recently been well watered; and, over the whole was placed and carefully luted to the table, a glass jar 2 feet high, and of the capacity of 2000 cubic inches, so that the proportion of sulphurous acid was nearly a 9000th part. The jar stood in a situation where it was exposed to a bright diffused light, but not to the sunshine." In the course of 48 hours all the plants were evidently affected. The tips of some of the leaves of the Mignonette and Larch were shrivelled, and of a greyish colour, and some of the Laburnum leaves were marked with greyish-yellow spots. After a renewal of the air with the same proportion of the gas, the plants were allowed to remain 48 hours longer in it, and the result was, that the leaves of the Mignonette and Larch were withered, especially at the tips, while those of the Laburnum were affected in a marked degree throughout their whole extent, and the slightest touch caused them to fall off. The effect of the gas in repeated experiments seemed to resemble, in many respects, the ordinary decay of leaves in autumn. In some of the experiments, the proportion of the acid gas was a ten-thousandth only, the quantity being one-fifth of a cubic inch, and yet the destruction of the leaves was complete in 48 hours. This proportion of the gas, although destructive to plants, is hardly, or not at all discoverable by the smell.

693. The effects of other irritant gases on the leaves of plants were also well marked. Thus, muriatic or hydrochloric acid gas in small quantity was very destructive. A fifth part of a cubic inch of the gas was mixed with three inches of air, and placed under a receiver, in the same way as in the experiment with sulphurous acid gas; the plants experimented on being a healthy Laburnum tree, five inches in height, and a small Larch tree. The effects on the Laburnum were evident in the course of nine or ten hours. " In twenty-four hours the leaves had all acquired a dull greyish-green colour and dry appearance, and their edges were crisped and curled." The Larch leaves were wrinkled and dry, especially at the tips. Neither of the plants, however, were killed. All the unfolded leaves were destroyed, but new buds afterwards came out. " This gas must, therefore, be very injurious to vegetable life, when even so small a quantity as a fifth of an inch, although diluted with 10,000 parts of air, destroyed the whole vegetation of a plant of considerable size in less than two

days." In some experiments it was found that one-tenth of a cubic inch in 20,000 volumes of air had nearly the same effects. This minute proportion could not be detected by the smell. Chlorine and nitric acid gas produced similar injurious effects in a more or less marked manner. Vapours proceeding from the chimneys of chemical manufactories take effect through the epidermis of the plant exposed to them. Corn and grasses have a flinty skin, and hence they are not easily acted upon by acid vapour. Corn crops are not likely to be injured by alkali works unless the acridity of the vapour is excessive, or unless they are exposed to it when young and tender. Such is also the case with grass land. Elms, Sycamores, and some other trees suffer little from acid vapours. The reason of this has not been ascertained. Probably their surface is protected by some peculiarity of structure.

694. Acid gases attack first the tips of the leaves and then extend to the stalks, and it is found that when the quantity is not great the parts not attacked generally survive, if the plants are removed into the air. Narcotic gases act very differently. Thus, Drs. Turner and Christison found that 4½ cubic inches of sulphuretted hydrogen in 80 volumes of air, in the course of 24 hours, caused several of the leaves of a plant to hang down perpendicularly from their stalks in a flaccid state, without injuring their colour; and though the plant was then removed into the air, the whole stem soon began to droop, and the plant died. When 6 cubic inches of the gas were mixed with 60 times their volume of air, the leaves began to be affected in 10 hours; they became quite flaccid, but did not appear changed in colour. When the leaves had once drooped the plants did not in any instance recover when removed into the air.

695. The effects produced by ammonia, cyanogen, carbonic oxide, and common coal gas, are in many respects similar to those now described, viz., a drooping of the leaves without alteration of colour, and the death of the plant even though removed into the air. The phenomena, when compared with what was observed in the instances of sulphurous and hydrochloric acid, would appear to establish, in relation to vegetable life, a distinction among the poisonous gases nearly equivalent to the difference existing between the effects of the irritant and narcotic poisons on animals. The gases which rank as irritants in relation to animals seem to act locally on vegetables, destroying first the parts least supplied with moisture. The narcotic gases, including under that term those which act on the nervous system of animals, destroy vegetable life by attacking it throughout the whole plant at once—the former probably only abstracting the moisture of the leaves, the latter acting by some unknown influence on their vitality. The differences now noticed seem to indicate that the injury caused to plants by the air of towns must be owing to some irritant gas, such as sulphurous acid. The plants are rarely killed altogether, they are only blighted for a season, and again renew their leaves in spring.

This repeated injury of the leaves must however tell ultimately on the life of the plants.*

696. The experiments just detailed show the importance of attending to the nature of the atmosphere in which plants grow. The

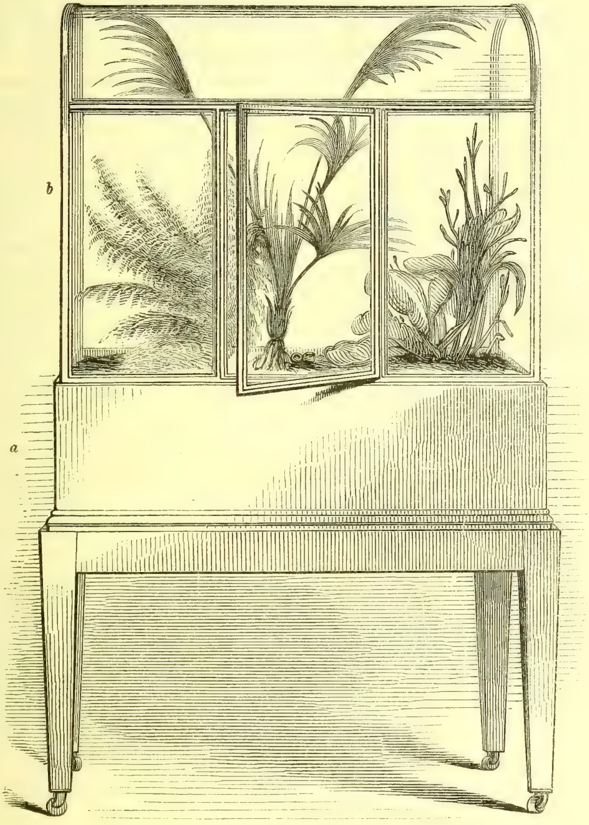

Fig. 1152.

blighting effects of the air of large cities are owing to the gases contained in the smoke, and unless means are taken for guarding against

Fig. 1152. A Wardian Case for a drawing-room, consisting of a strong wooden box or trough, *a*, supported on a stand, and covered with a glazed frame, *b*. The box is filled with loam, sand, and peat, laid over a layer of gravel and broken bricks. Water is freely poured over the soil at first, and it is allowed to drain off by means of two holes in the bottom of the box, which are subsequently stopped up with corks. After the plants have been put into the soil, the glazed frame, made of wood, zinc, or brass, is fitted on carefully in a groove on the upper part of the box. In the frame there is a glass door for the purpose of allowing the removal of dead leaves, and of permitting air to enter freely when the atmosphere in the Case is too moist. This kind of Case, along with others, is to be seen in the Museum of Economic Botany at the Edinburgh Botanic Garden.

* Experiments of a similar kind were performed by Messrs. Gladstone, and reported to the British Association in 1850 and 1851.

these, it is not to be expected that town vegetation can be luxuriant. The common gas used in houses is also prejudicial to vigorous growth, and this combined with the dry atmosphere of rooms is the cause of plants not succeeding well in private dwellings. The transpiration from the leaves in such circumstance is very great, and it is impossible to make the roots take up sufficient moisture to supply the loss. Hence the leaves fall off and the plants become sickly.*

697. With the view of enabling plants to grow in the atmosphere of towns, notwithstanding the fuliginous matter and gases with which it is loaded, Mr. N. B. Ward invented closely-glazed Cases, in which he succeeded in cultivating tender plants, even in one of the most populous and smoky localities of London. Two of these Cases are represented in Figures 1152 and 1153. Each consists of a strong box or trough, *a*, made of well-seasoned wood, containing earth. The bottom of the box is covered to a moderate depth with gravel and broken bricks, over which the soil is spread, composed of fibrous loam, sand, and peat. The nature of the soil may be varied according to circumstances, and the box may be divided into compartments containing soils of different kinds. The soil is well watered, and the superfluous water is allowed to run freely from two holes in the bottom of the box. After draining fully, the holes are tightly closed with corks, and the glazed roof or cover, *b*, is fitted on carefully in a groove round the upper part of the box. This glazed cover may be formed in various ways. It is frequently made of zinc, with large panes of glass, the upper one being curved as in Figure 1152.†

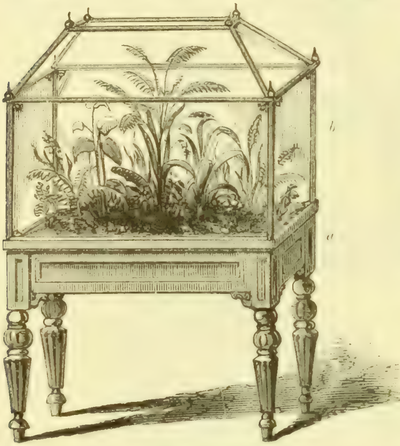

Fig. 1153.

698. Plants from various countries are enabled to thrive in such a Case without interference. In May 1838 Mr. Daniel Ellis‡ constructed, under the direction of Mr. James M'Nab, a Plant-case, of which the following are the dimensions:—Stand 1 foot 10 inches in height, trough or box $8\frac{1}{2}$ inches, cover 1 foot $7\frac{1}{2}$ inches—the total

Fig. 1153. Another form of Wardian Case, prepared by Messrs. Drummond and Son, Canonmills, Edinburgh. It is constructed on the same principle as that in Figure 1152.

* The nitric acid generated in the air during thunder storms may perhaps act injuriously on the leaves of plants, unless its effects are neutralized by the presence of ammonia in the atmosphere.

† A variety of beautiful forms of Cases are given by Mr. Ward in his work on Closed Plant-cases, London, 1852. He gives an account of Fern-Cases, Alpine-Cases, Drawing-room Cases, Spring-flower Cases, Tropical-Cases, Window-Cases, Aquatic-Cases, and Transport-Cases.

‡ A full account of this Case, with drawings, is given in Loudon's Gardener's Magazine, xv. 481. The Case may be seen in the Museum of Economic Botany of the Edin. Botanic Garden.

height being thus 4 feet 2 inches, the length 3 feet, and the breadth $1\frac{1}{2}$ foot. The box was made of well seasoned St. Domingo mahogany, the sides being $1\frac{1}{4}$ inch thick, mitred and dovetailed together at the corners. The frame-work of the cover was made of brass, and brass rods extended across the roof for the purpose of suspending plants. Mr. Ellis gives the following statement regarding the growth of plants in this Case after trial of a year, during which no fresh water was given :—

PLANTS IN THE CASE.	Country.	Remarks.
Chamærops humilis . .	South of Europe	Increased $\frac{1}{4}$ its original size
Gentiana verna	Britain	Flowered
Adiantum Capillus Veneris	Britain	Increased $\frac{1}{8}$
Primula farinosa . . .	Britain	Flowered
Primula scotica . . .	Britain	Flowered
Chamærops Palmetto . .	North America	Increased $\frac{1}{3}$
Dionæa muscipula . . .	North America	Increased $\frac{1}{8}$
Sarracenia purpurea . .	North America	Increased 4 times its original size
Epigæa repens	North America	Increased $\frac{1}{2}$
Aloe retusa	Cape of Good Hope	Increased $\frac{1}{3}$, flowering spikes appeared
Testudinaria Elephantipes	Cape of Good Hope	Made a shoot 10 inches long
Rhododendron Chrysanthum	Siberia	Increased $\frac{1}{2}$
Cycas revoluta	China	Increased $\frac{1}{8}$
Nepenthes destillatoria .	Ceylon	Increased $\frac{2}{3}$
Cypripedium venustum .	Nepaul	Increased $\frac{1}{5}$
Echinocactus multiplex .	Mexico	Increased $\frac{1}{2}$
Echinocactus peruvianus .	Mexico	Increased $\frac{1}{2}$
Epiphyllum truncatum .	Brazil	Increased $\frac{2}{3}$
Cereus flagelliformis . .	Peru	Increased $\frac{1}{2}$
Lycopodium stoloniferum .	Cuba	Very luxuriant

699. Plants, in these Cases, are enabled to stand great changes of temperature without being injured, and they are protected from noxious matters in the atmosphere, besides having always sufficient moisture. Ferns and Lycopodiums, in an especial manner, succeed in such Cases. Those ferns which require much moisture and shade, such as Trichomanes radicans, can be grown successfully. The atmosphere, however, can be varied as regards moisture and dryness, and thus can be suited to different tribes of plants. The Cases are well fitted for rooms or dwelling-houses, inasmuch as they prevent the excessive exhalation which so generally injures plants grown in these circumstances. The windows of a room may be converted by means of double sashes into such Cases, and occasionally Wardian conservatories of large size are thus constructed. Ward has erected one at Clapham, in which he

cultivates Ferns, small Palms, Bamboos, Musas, Cannas, Clerodendrons, Achimenes. Passion-flowers, Manettias, and Aristolochias, cover the pillars and festoon the roof, from which also Orchids are suspended. A tank at the end affords accommodation for aquatic plants; and the whole, as Moore remarks, forms a beautiful miniature tropical forest scene.* An aquatic plant case, or parlour aquarium, has been employed by Mr. Warrington on the Wardian principle.†

700. The Cases have been applied most successfully to the transport of living plants, and many valuable productions have thus been introduced into different countries. Mr. Ward mentions that in June 1833 he filled two Cases with Ferns, Grasses, &c., and sent them to Sydney in safety. "The Cases were refilled at Sydney in February 1834, the thermometer being then between 90° and 100° in the shade. During their voyage to England they encountered very varying temperatures. The thermometer fell to 20° in rounding Cape Horn, and the decks were covered a foot deep with snow. At Rio Janeiro the thermometer rose to 100°, and in crossing the line to 120°. In the month of November, eight months after their departure, they arrived

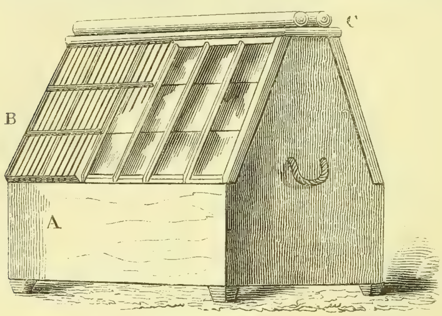

Fig. 1154.

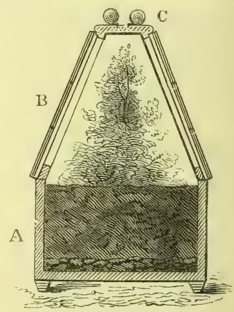

Fig. 1155.

in the British Channel, the thermometer being then as low as 46°. The Cases were placed upon deck, and the plants had not been watered during the whole voyage, and yet, on their arrival in Britain, they were in a most healthy and vigorous condition." The transplantation of Coffee, and other plants whose seeds do not long retain vitality, has been effected by this means most successfully. Plants of Musa Cavendishii have been introduced into the Navigation Islands with the hap-

Fig. 1154. A Wardian Case, designed by Messrs. Drummond and Sons, Canonmills, fitted for being sent to a distance; consisting of a trough, *a*, supported on feet, containing soil as in the other figures, and a sloping roof, *b*, glazed on both sides with long narrow strips of thick glass. At one side of the glass roof is shown the protective wire grating, which is made so as to cover the glass on both sides. The canvas on the rollers, *c*, at the top of the case can be unrolled at pleasure, so as to cover the glass roof.

Fig. 1155. A cross section of the same portable Wardian case, showing the form of the roof, *b*, the extent of the soil, *a*, the contained plants, and the rollers, *c*.

* A representation of this fern-house is given in the Gardener's Magazine of Botany, vol. iii. 149, 1851.

† The Gardener's Mag. of Botany, January 1852, p. 5, where a drawing is given of the Case.

piest results; Tea plants have been transported in great numbers from China to India under the direction of Mr. Fortune, and they are now growing vigorously in the Himalayas. Mr. Fortune sent to the Horticultural Society of London a number of these cases filled with plants from China. In the old mode of conveyance, one plant only in a 1000 survived the voyage from China to England, whereas, by the Wardian method, 215 out of 250 arrived in perfect health.* From the Botanic Garden of Edinburgh there was lately sent to India a case containing plants of Cinchona Calisaya (true Yellow-bark), Jalap, and Scammony, which the East India Company wished to introduce into their possessions, and the Garden at Madras, under the charge of Dr. Cleghorn, has been supplied with various important plants.

701. The Cases used in such instances are strongly and coarsely made. The glass covering is firmly fixed, and the glass itself is thick, and glazed in pieces of moderate size, so as to avoid the risk of fracture.† A Wardian transport case is represented in Figures 1154 and 1155, in which the glass frame is protected with a grating of iron wire, and in which there are canvas coverings capable of being unrolled, so as to screen from the direct rays of the sun if necessary. The soil should not be less than 8 or 10 inches deep, and the plants should be fairly established in it for some time before it is sent off, the soil being afterwards kept down by cross-bars of wood. The most important matter to be attended to in the transmission of plants in this way is their exposure to light. The moisture supplied at first should be sufficient for the voyage, and unless there is some one on board who understands the cultivation of plants, the cases should never be opened from the time they are shipped until they arrive at their destination. When a person accompanies the cases who is acquainted with their management, then they may be opened, and the plants examined from time to time with the most beneficial results. The stillness of the atmosphere seems to contribute in no small degree to the safety of the plants during vicissitudes of temperature, and the effect of the spray of the sea is prevented by the closeness of the covering. The bottom of the cases should be raised at least six inches from the deck of the vessel, so as to be less liable to injury when the decks are washed.‡

702. When Cases arrive at their destination, the plants should not be rashly exposed by the immediate removal of the glass frame. By attending to this, the plants will be less liable to be injured. It is an error to suppose that no interchange of air takes place between

* Fortune on the Transmission of Living Plants by Sea, in Journ. of Hort. Soc. of Lond. ii. 115.

† Loudon's Encyclopædia of Gardening, edit. 1835, pp. 539, 540.

‡ Mr. Fortune gives the following directions as to the Cases when shipped:—"Do not move them from the poop; never allow them to be opened; should any accident happen to the glass, repair it immediately, either with glass, or, where that cannot be had, with a piece of thin board; in stormy weather, when there is any probability of spray coming over the poop, throw an old sail over the Cases; and lastly, never allow the sailors to throw a drop of water over them when they are washing decks in the morning."

the interior of the Cases and the atmosphere. They are not hermetically sealed, and by the law of diffusion of gases, the smallest chink will allow such an interchange to take place. But it is accomplished slowly, and many of the impurities in the air are prevented from entering the cases. Even in a glass globe hermetically sealed, plants will continue to live for many years, as was proved by an experiment conducted by Dr. Graham in the Botanic Garden of Edinburgh.*

V. COLORATION OF LEAVES.

703. The green colour of leaves depends on the production of chlorophyll (p. 34), which is only developed under the agency of light.† The leaves in the young bud are of a pale yellowish hue, and assume their green tint in proportion as they are exposed to light. The change of colour takes place more or less rapidly, according to the intensity of the light. The leaves of French Beans, which sprung white out of the earth, were observed by Senebier to become green in one hour under exposure to very bright sunshine.‡ Plants, when grown in darkness, have pale leaves, which become green on exposure to light. It is said that an etiolated plant, when exposed to light, becomes green at the end of twenty-four hours, even under water. Diffuse day-light, and even the light of lamps, will cause a green coloration,§ but the intensity of the colour is much less than in full sunshine.||

704. Ellis states that "in North America the operation of light in colouring the leaves of plants is sometimes exhibited on a great scale, and in a very striking manner. Over the vast forests of that country, clouds sometimes spread and continue for many days, so as almost entirely to intercept the light of the sun. In one instance, just about the period of vernation, the sun had not shone for twenty days, during which time the leaves of the trees had reached nearly their full size, but were of a pale or whitish colour. One forenoon the sun broke forth in full brightness, and the colour of the leaves changed so fast, that by the middle of the afternoon the whole forest, for many

* For full details in regard to Wardian Cases, consult Hooker's Companion to the Botanical Magazine, 1836, i. 317. Ward, on the Growth of Plants in closely Glazed Cases, London, 1852. Ellis, on a Plant-case or Portable Conservatory, in Loudon's Gardener's Magazine, xv. 481. The Gardener's Magazine of Botany, iii. 149, in which a representation is given of a large Case in Mr. Ward's suburban residence at Clapham Rise, a visit to which is recommended to all who wish to see this system of growing plants carrying out to perfection. Report of Growth of Plants in Closed Glass Vessels—Brit. Assoc. Reports for 1837, p. 501.

† Mulder says that chlorophyll is a peculiar body quite distinct from wax or fat, and that it may be decomposed, so as to form substances of a yellow, black, or blue colour. The mixture of these colours gives rise to the varieties of shades of green. Oxidizing and deoxidizing agents decompose chlorophyll, and change its colour.

‡ Senebier, Mem. Physico-Chimiques, ii. 78-91.

§ De Candolle, Mem. des Savants Etrangers, i. 334.

|| M. Gris states that the soluble protosalts of iron, when absorbed by roots or leaves of plants, give rise to an increased production of chlorophyll.—See Comptes Rendus, xxi. p. 1386.

miles in length, exhibited its usual summer dress."* The progress of coloration in an etiolated leaf, when exposed to sunshine, was observed by Senebier. The most tender parts first passed from white to yellow; the yellow then became deeper; next some green spots appeared on different parts, which multiplied, extended, and met, till the whole exhibited a green colour.† Green plants, when placed in darkness, lose their leaves, and if allowed to grow in darkness, they afterwards produce yellow, or rather whitish-yellow leaves.

705. Morot says that chlorophyll is formed from amylaceous matters and ammonia under the influence of light, and that its formation is accompanied with the disengagement of water and oxygen. Leaves do not give out oxygen because they are green, but they do so during the process of becoming green.‡ Ellis attributes the green coloration not to the evolution of oxygen, but to the predominance of alkaline matter consequent on the deoxidation of carbonic acid. Thus he says the decomposition of carbonic acid, under the agency of light, gives rise at once to the evolution of oxygen and the formation of the green colour. Dr. Hope thinks that there exists in leaves a peculiar colorable principle called xanthogen, which affords yellow compounds with alkalies. This substance has the power of forming a green colour by the action of light.§ Etiolated or blanched plants become unhealthy, and they are said in such circumstances to evolve carbonic acid. In the case of Leguminous plants, etiolation is attended with the production of a substance called asparagine or malamide, already noticed (p. 379).

706. Experiments have been made in regard to the effects of the different rays of the spectrum in the production of the green colour of leaves. Senebier ascribed it to the violet rays,|| and Ritter and Wollaston to the chemical or tithonic rays, which are next the violet. Hunt thinks that the blue rays have the greatest effect in producing the green colour.¶ Morren, Daubeny, Draper, and Gardner, say that the yellow rays have the greatest effect in producing chlorophyll, as well as in deoxidation.** These rays have the greatest illuminating power.†† Gardner's experiments were performed by sending rays

* Ellis, on a Plant-case for growing Plants, &c.—Loudon's Mag. xv. 494.

† Senebier, Mém. Physico-Chimiques, ii. 88.

‡ Morot, sur la Coloration des Végétaux.—Ann. des Sc. Nat. 3d ser. Bot. xiii. 160.

§ Hope, Observations on the Coloured and Colorable Matters in the Leaves and Flowers of Plants, in the Proceedings of the Royal Society of Edinburgh for 1836, p. 126.

|| Senebier, Mém. Physico-Chimiques, ii. 55.

¶ Hunt, on the Chemical Action of the Solar Spectrum.—Phil. Mag. for 1840, xvi. 272.

** Draper, Chemistry of Plants, p. 61; Phil. Mag. for 1840, xvi. 81. Daubeny, on the Action of Light upon Plants—Trans. British Assoc. for 1833, p. 436; Phil. Trans. for 1836, p. 149. Gardner, on the Action of Yellow and of Indigo Light on Plants—Phil. Mag. for 1844, p. 1.

†† It is well known that the different parts of the spectrum vary in illuminating power, and that the yellow has the greatest power in this respect. A fine printed paper, held in succession in the different colours, is legible at very different distances. When held in the yellow it can be seen at a considerable distance, but held in the violet it cannot be read unless it is placed near to the eye. The other coloured spaces of the Newtonian spectrum have been shown by Fraunhöfer to possess intermediate illuminating powers.

through a prism. He sowed a great variety of seeds, and allowed them to grow in darkness till they were ready for the experiment. The number of plants exposed to each ray averaged 100. The spectrum was allowed to fall on the specimens at a distance of fifteen feet from the prism, and undecomposed light was shut out by screens. Five jars, containing each about 200 turnip seedlings, were placed respectively in the orange, yellow, blue, indigo, and violet rays, at 9 A.M. on 13th August, the day being bright, and the temperature in the shade at noon being 80° F., in the sun 95°. The duration of sunshine was $6\frac{1}{2}$ hours, and the results at $3\frac{1}{2}$ P.M. were as follow:—

Jar.	Light.	Height of plant at 9 A.M.	Result.	Order.
1	Orange	1 inch	Green	2
2	Yellow	1 ,,	Full green	1
3	Blue	$1\frac{1}{4}$,,	Slight olive	*
4	Indigo	1 ,,	Yellow	0
5	Violet	$1\frac{1}{4}$,,	Yellow	0

On August 14 the same plants were used, with the addition of a fresh crop (No. 6) in the green ray. The exposure lasted from 9 A.M. till 3 P.M., or during 6 hours of sunshine. The temperature in the shade at noon was 85° F., and in the sun 105°. The results at 3 P.M. were as follow:—

Jar.	Light.	Height at 9 A.M.	Result.	Order.
1	Orange	$2\frac{1}{4}$ inches	Full green	2
2	Yellow	$2\frac{1}{4}$,,	Perfect green	1
3	Blue	3 ,,	Slight green	4
4	Indigo	3 ,,	Yellow	0
5	Violet	$3\frac{1}{2}$,,	Yellow	0
6	Green	1 ,,	Fair green	3

The 5th column in the tables contains a comparative estimate of the depth of colour, assuming unity of the highest value. When the plant did not become green, the value is negative. In the 1st table, opposite the blue, there is no mark in the 5th column, but there was a visible alteration designated olive, indicating the tint which vegetables assume in passing from the yellow colour of darkness to green. The tables also seem to show that the blue and violet rays had the greatest effect in promoting the growth of the plants.*

707. Gardner also gives the following table, showing the active

* This will be noticed when speaking of the germination of the seed.

and inactive rays of the spectrum in producing the green colour of plants:—

Experiment.	Plants.	Hours of Sunshine.	Total Time.	Active Rays.				Inactive Rays.		
				Red.	Orange.	Yellow.	Green.	Blue.	Indigo.	Violet.
1	Turnips	22	109	4	2	1	3	0	0	0
2	Beans	14	95	—	2	1	3	0	—	—
3	Turnips	8	69	4	2	1	3	—	—	—
4	Turnips	23	101	—	—	—	1	0	0	0
5	Turnips	17.5	52	—	2	1	3	4	0	0
6	Turnips	5.5	6	4	2	1	3	0	0	0

The figures indicate the order of the colour in the particular observation, 1 being the highest value. The sign — indicates that the effect of the ray was not tested, or that the result was defective. In the 5th experiment the blue ray produced a green colour, but the usual effect was a light olive. It usually takes many hours of light to develope chlorophyll. Gardner says he has seen it developed in two hours, but it generally took six or more. The experiments indicate that the less refrangible rays are most active in producing the green colour of plants. It is not stated that the blue, indigo, and violet rays will not effect this change in time, but that they are remarkably inactive. The maximum action is in the yellow light, and diminishes on either side. By making light traverse a solution of bichromate of potass, so as to have all the tithonic rays absorbed, it was found that plants still acquired a green colour, so that detithonized light is capable of producing green matter.*

708. The ray which produces green colour in plants, is also said to be that which decomposes carbonic acid.

TABLE showing the force of the Solar Rays in producing the Green Colour of Plants, in decomposing Carbonic Acid, and in Illumination.

Places of Spectrum examined.	Production of Chlorophyll.	Decomposition of Carbonic Acid.	Illuminating Power.
Extreme red	0.000	0.0000	0.0000
Commencement of orange	—	.5550	—
Centre of orange . . .	.777	—	—
Centre of yellow . . .	1.000	1.0000	1.0000
Centre of green . . .	.583	—	—
Centre of blue	.100	—	—
End of blue	—	.0027	—

* Yellow substances have a remarkable power of absorbing the chemical or tithonic rays. Photographists find that these rays will not pass through yellow-coloured glass.

709. In temperate climates the leaves during the period of their diminished activity exhibit changes of colour which give rise to the yellow, brown, and red autumnal tints. These colours seem to depend on different states of oxidation in the chlorophyll. Hunt thinks that the brown colouring of the autumnal leaves is due to the rays called by Herschell parathermic, which can scarcely be said to have a defined place amid the calorific radiations, but which are usually most strongly manifested in the red rays. A slight tint of green was found to stop these parathermic rays, and on that account glass stained green with oxide of copper has been used in glazing the Palm House at Kew.* Macaire-Prinsep says that the leaves, in assuming a yellow colour, cease to give out oxygen under the influence of light.† He, as well as Ellis, think that the yellow and red tints are due to the production of an acid of some sort. The autumn tints are often very bright. The Plane tree (Platanus orientalis), the Hyrcanian Maple (Acer hyrcanum), and Balsam Poplar (Populus balsamifera), exhibit yellow leaves in autumn ; Acer villosum, rich nankeen brown ; Quercus tinctoria, Cratægus regia, and Rhus coriaria, brown ; Persian Oak, Cratægus coccinea, Cratægus punctata, and Cratægus obtusata, red ; Acer circinatum, Pyrus depressa, P. arbutifolia, and P. serotina, bright crimson ; Virginian Creeper (Ampelopsis hederacea), deep crimson ; Rhus typhina, reddish purple. Many Evergreens retain the usual tint of their leaves. The leaves of Dacrydium cupressinum have a fine green during summer, they become of a brown colour on the approach of winter, and again resume their green hue in spring.

710. It is of importance to consider in planting what is to be the effect produced in autumn. The tints may thus be well contrasted, and give rise to most beautiful groups. Lindley remarks that Berberis aquifolium, with its brown crimson leaves, forms a charming contrast with the ever-verdant sameness of Laurels, Bays, and other Evergreens. The Indian Chitra (Berberis aristata), with its dark brown wood, crimson leaves, and scarlet fruit, and a few yellow waving plumes of the French Tamarisk (Tamarix gallica), form pleasing groups, especially when contrasted with the hoary branches and apricot-coloured fruit of the Cratægus odoratissima. Red Maples, scarlet Oaks, and crimson Sumachs, may be contrasted with yellow Planes and Maples, and with Evergreens.

711. Variegation in leaves is produced either by an alteration in the green chromule or chlorophyll, or by the presence of air in certain foliar cells. Sometimes a single group of cells contains the yellow product of the decomposition of the chlorophyll, as in Phalaris arundinacea picta, a variety which appears in a dry soil, and disappears in a wet one ; or as in variegated varieties of Holly. At other times

* Hunt, on the chemical action of solar radiations, in Report of Brit. Assoc. 1850, p. 137. On coloured glass employed at Kew—Report of Brit. Assoc. 1847.

† Macaire-Prinsep, Mém. sur la coloration automnale des feuilles—Mém. de la Soc. Phys. et d'Hist. Nat. de Genève, iv. 43.

the epidermis separates itself from the cells lying under it in particular places, and the layer of air lying between these appears like a bright silvery spot, as in Begonia argyrostigma and Carduus Marianus. Treviranus states that in Monocotyledons the variegations form bands parallel to the veins; in Dicotyledons, such as Carduus Marianus, the white is produced in the veins, while in such as Aucuba japonica, the yellow spots are distributed without order. He states also that variegation is sometimes visible on the upper surface of the leaves, and not on the under. Variegation, according to Morren, has its seat deeper in the leaf than what is called spotting.* The latter is confined to the cuticle or skin, while the former extends to the parenchyma or cellular tissue below.

712. There are various kinds of variegation; they have been reduced to a tabular form by Morren, of which the following is a brief abstract:—

1. Leaves with a border of white, yellow, pale green, or purple; seen in varieties of Box, Holly, Guelder-Rose, Beech, Chestnut, Cornel, Elm.
2. Leaves having the centre of the leaf white or yellow, the border being green; seen in varieties of Holly, Spindle-tree, Bird Cherry.
3. Leaves with the centre and border green—the one being separated from the other by a white or yellow zone; seen in Snowberry plant (Symphoricarpus racemosus).
4. Leaves irregularly marked with white or yellow spots, such as in Aucuba japonica.
5. Leaves having the ribs and veins green, and the intermediate cellular tissue or parenchyma white or yellow; this is seen in some varieties of Aucuba japonica, Barberry, Manna-Ash, Elder.
6. Leaves having ribs and veins white or yellow, while the intermediate parenchyma is green; seen in varieties of Apple, Elder, Wood-Sorrel, Common Avens, Common Maple.
7. Leaves striped with longitudinal, parallel, or converging bands; this is seen in many Monocotyledons, as Crown Imperial, Lily of the Valley, Hemerocallis fulva.
8. Leaves having three or four tints on the upper surface, distributed in the parenchyma between the principal ribs or veins, and following their direction; seen in marbled varieties of Oak, Sycamore, Horse Chestnut, Hawthorn, Cherry, Laurel, Elm, Guelder-Rose.
9. Leaves or leaflets, white, yellow, or red at one side of the midrib, the other green; seen in Lilac, Spindle-tree, Black Birch, Rhamnus Frangula, Box, Common Maple, Viburnum dentatum.
10. Leaves with the base or the apex only discoloured, as in varieties of Cornus mascula and alba.
11. Leaves having one or several discoloured transverse bands perpendicular to the direction of the midrib; seen in varieties of Cornus mascula and Viburnum dentatum.
12. Leaves entirely yellow or White, as in varieties of Juniperus Sabina, Common Juniper, Oak, Horse Chestnut, Thuja orientalis, Acer platanoides.

* Dodonæa ou Recueil d'observations de Botanique. See also Sageret sur le moyen de faire naître les végétaux à feuilles panachées—Hort. Belg. 1836, p. 145.

713. These various modes of variegations have been thus classified: 1. Margined and bordered; 2. discoidal; 3. zoned; 4. spotted; 5. and 6. reticulated; 7. striped; 8. marbled; 9. variegated by half; 10. variegated at the point; 11. fasciate; 12. entirely discoloured or albinism.* The causes of variegation are stated to be disease in the cellular tissue produced by climate and soil, hybridization, fertilization with variously coloured pollen, and grafting.†

VI. IRRITABILITY AND CONTRACTILITY OF LEAVES.

714. Certain leaves display evident movements under the influence of light, heat, and a stimulus either of a mechanical or chemical

Fig. 1156.

Fig. 1157.

nature. The effects of light and darkness are frequently very marked in causing the elevation and depression of leaf-stalks, and the expansion and folding of leaves. The changes which take place in leaves

Fig. 1156. Compound leaf of Robinia, showing an intumescence where the leaf-stalk joins the stem, and swellings at the base of each of the pinnæ. The leaflets (pinnæ) close during darkness, by folding upwards, so as to bring their upper surfaces into contact. The cellular swellings at the base of the petiole and leaflets seem to be concerned in those hinge-like movements.

Fig. 1157. Compound leaf of Gleditschia triacanthos, the leaflets of which close during darkness. Swellings exist at the base of the leaf-stalks and leaflets.

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* Gardener's Magazine of Botany for 1851, p. 211.

† For further remarks on the colours of leaves, see Macaire-Prinsep, sur la coloration automnale des feuilles—trans. in the Edin. New Philosophical Journal, vi. 270. Mohl, sur la coloration hibernale des feuilles—Annales des Sciences Nat. 2d ser. Bot. ix. 212. Morot, Recherches sur la coloration des Végétaux—Ann. des Sc. Nat. 3d ser. Bot. xiii. 160.

during darkness were included by Linnæus under what he called the *sleep of plants.* During darkness leaves often hang down, and, in the case of compound leaves (Figs. 1156 and 1157), there is also a folding of the leaflets, either in an upward direction, as in the sensitive Mimosas, or downwards, as in Tephrosia caribæa. Hoffmann thinks that the sleeping and awakening of leaves are due to temperature, and that light only influences the phenomenon in so far as it contains calorific rays. Plants expand their leaves after the receipt of a certain sum of degrees of temperature.*

715. Very obvious movements occur in the leaves of many species belonging to the natural orders Leguminosæ, Oxalidaceæ, and Droseraceæ. Among Leguminous plants may be noticed species of Mimosa, Robinia, Æschynomene, Smithia, Desmanthus, and Neptunia; in the family of Oxalidaceæ, many species of Oxalis exhibit a certain degree of irritability, but it is chiefly observed in the pinnate-leaved Biophytum sensitivum; while among Droseraceæ the leaves of Dionæa muscipula have a remarkable irritability, and those of the species of Drosera also exhibit traces of it. In some plants the movements are most marked in the young state.

716. The movements exhibited by the leaves of plants may be divided in the following manner:—†

1. Movements which depend upon the periodical returns of day and night. Under this head are included the phenomena of the sleeping and waking of plants, which are influenced solely by light and darkness. In general the parts during the night resume, as far as possible, the position which they occupied in the bud, and this the more accurately, the younger and more tender the leaf.
2. Movements, which besides being influenced by light and darkness, are also occasioned by any external or chemical agency, as evidenced by the following sensitive plants:—

Æschynomene indica.
„ „ pumila.
„ „ sensitiva.
Averrhoa Bilimbi.
„ Carambola.
Biophytum (Oxalis) sensitivum.
Desmanthus lacustris.
„ „ stolonifer.
„ „ triqueter.
Dionæa muscipula.
Drosera rotundifolia, and other species.
Mimosa asperata.
„ casta.
„ dormiens.
„ humilis.
Mimosa pellita.
„ pernambucana.
„ pigra.
„ pudica.
„ quadrivalvis.
„ sensitiva.
„ viva.
Neptunia plena.
Oxalis Acetosella.
„ carnosa.
„ corniculata.
„ Deppei.
„ purpurea.
„ stricta.
Smithia sensitiva.

* Hoffmann, Untersuchungen ueber den Pflanzenschlaf; sur le sommeil des Plantes—Annales des Sc. Nat. 3d ser. Bot. xiv. 310; also Botanical Gazette, iii. 62.

† Schleiden's Principles of Botany, translated by Lankester, p. 551.

3. Movements independent, to a certain extent, of external influences, as in some of the leaflets of

Hedysarum cuspidatum.
„ gyrans.
„ gyroides.
Hedysarum lævigatum.
„ vespertilionis.

717. Brignoli, Morren, and others, observed excitability and movements in the ternate and quaternate leaves of several species of Oxalis (Fig. 1158), at a high temperature, and in the pinnate leaves of Biophytum sensitivum, and of Averrhoa Carambola.* In the case of the species of Oxalis, when the sun darts its rays at mid-day on these plants, the leaflets are flat and horizontal, and are so placed that their margins are in contact. But if the common petiole is struck gently and repeatedly, or if the whole plant is agitated, at the end of about one minute, provided the heat is great and the sun bright, each leaflet folds upon itself from below upwards, and subsequently hangs down. The same phenomenon takes place during darkness.

Fig. 1158.

Fig. 1159.

718. In Mimosa pudica and sensitiva, which usually receive the name of sensitive plants, the motions of the leaves are very conspicuous. They are influenced by light and darkness, and they are exhibited on the slightest touch. In these plants the leaf, as repre-

Fig. 1158. Wood-sorrel (*Oxalis Acetosella*), with its ternate leaves, which are said to display a certain amount of irritability when exposed to bright sunshine. During the night each of the three leaflets, forming the compound leaf, fold on their midrib, and then fall down towards the common petiole. Some say that this plant is the true Irish Shamrock.

Fig. 1159. Branch and leaves of Sensitive plant (*Mimosa pudica*), showing the petiole in its erect state, *a*, and in its depressed state, *b*; also the leaflets closed, *c*, and the leaflets expanded, *d*. At the base of the petiole, a swelling or intumescence (pulvinus) is observed, and smaller swellings exist at the base of each partial petiole, and at the base of each leaflet. During darkness the leafstalks hang down, and the leaflets are closed, while the reverse is the case during light. The cellular swellings at the base of the petioles and leaves are concerned in the movements.

* Morren, sur l'excitabilité et le mouvement des feuilles chez les Oxalis, Bulletin de l'Acad. Roy. de Bruxelles, vi.—Annales des Sc. Nat. 2d ser. Bot. xiv. 350. Bruce, account of the sensitive qualities of Averrhoa Carambola—Phil. Trans. lxxv. 356.

sented in Figure 1159, is a compound bipinnate one, having four partial leafstalks proceeding from a common petiole. The small pinnules or leaflets are expanded horizontally when the plant is in the light and in its natural state, but when it is in darkness, as well as when the leaves are touched or irritated, the pinnules fold upwards, so as to bring their upper surfaces into contact, and at length the petiole is depressed, so that the entire leaf falls down. When the whole leaves are thus folded and depressed the plant appears as if it were withered and dead. When light is introduced, or when the irritation is removed, the leaflets gradually unfold, and the leaf-stalk rises. In the ordinary state of the plant these motions go on daily. If two of the leaflets at the extremity are touched, or are irritated by heat from a lens, or by electricity, without agitating other parts, they fold upwards, and a similar movement takes place in the adjoining leaflets in regular succession from the apex to the base of the petiole. The irritation is also communicated to the neighbouring partial petiole, the leaflets of which fold in a reverse order, namely, from base to apex. The movement may be propagated until the partial petioles converge and fall down; and, finally, the general leafstalk is depressed. If the lower leaflets are first irritated, the foldings take place from the base to the apex of the petiole; if the middle leaflets are touched then the foldings occur on each side.

719. The stem itself seems not to be directly concerned in the motions. It may be injured in various ways without causing contractions to take place. A section may be made of it with a leaf attached, and yet the leaflets may remain expanded. If, however, there is applied to the stem any irritating substance, such as a mineral acid which can be absorbed by the cells, then in process of time the petioles fall and the leaflets fold. Fée states, that the cut leaves of the plant, when placed in water, retain their irritability for several days. Artificial light from six lamps, according to De Candolle, caused the expansion of the leaves. He exposed sensitive plants for several days to the influence of light during the night, and of darkness during the day. In these circumstances, the plants at first opened and shut their leaves irregularly, but at the end of some days they became accustomed to their new position, opening their leaves in the evening (their time of light), and closing them in the morning (their time of darkness). When the plants were exposed to continued light they still exhibited alternations of sleeping and waking, but each of the periods was shorter than usual. When they were kept in continued darkness the alternations of sleeping and waking became very irregular.* M. Zantedeschi, from experiments performed at the Botanic Gardens at Venice, Florence, and Padua, maintains that the lunar rays affect the motions of sensitive plants. He distinctly traced

* De Candolle, Physiologie Végétale, ii. 860. Mémoire sur l'influence de la lumière artificielle sur les plantes—Mém. de Savans Etrangers, i. 370.

the movements to the influence of the moon's light, and not to the action of heat. The chief plants experimented on were Mimosa ciliata, M. pudica, and Desmodium gyrans. The results, ascertained at the temperature of 70° Fahrenheit, when Saussure's hygrometer indicated a medium state of humidity, were, that the leaf-stalks of Mimosa ciliata, under the influence of moonlight, were raised $\frac{1}{10}$ of an inch; those of Mimosa pudica were raised $1\frac{2}{10}$ inch; whilst the leaflets of Desmodium gyrans exhibited distinct vibrations.*

720. The action of the wind, or any general agitation, causes the simultaneous folding and depression of the leaves; but the quick repetition of an irritation exhausts the sensitiveness towards it. It appears that the plants may become accustomed to a weak stimulus. Thus, Desfontaines carried a sensitive plant with him in a coach, the jolting of which caused the leaves to close, but ere long the plant became accustomed to the motion, and the leaves expanded. The more vigorous the plant, and the higher the temperature to which it is exposed, the more sensitive it is. The leaf of the Mimosa is sensitive of various kinds of stimuli, such as shaking, wounding, burning, contact of irritating fluids, electric and galvanic shocks. Many chemical stimuli cause the leaves to fold. Thus the vapour of prussic acid, of chloroform, and of ether, is found to produce this effect; and in such cases the irritability of the leaves is either destroyed, or, at all events, a considerable period elapses before it is restored. Marcet says that one or two drops of chloroform placed on the tip of the petiole made it droop, and caused the leaflets to close in succession from apex to base. The influence extended to the other partial petioles and their leaflets. Although the leaflets expanded afterwards, yet they were nearly insensible to the excitement produced by touch. When chloroformized several times they at length lost their contractility.† Professor Simpson found that the vapour of chloroform affected the sensitive plant. If the vapour was either too strong or too long continued, the plant was destroyed. When it was weak, and applied only for a few minutes, the leaflets in some plants closed, as when irritated, and did not expand again for an unusual length of time. In other plants under exposure to chloroform, no closure of the leaflets took place, and in a few minutes the plant became so anæsthetized that the mechanical and other irritations of the leaflets and petiole did not produce the common movements, nor did the irritability become restored for a considerable time afterwards.‡

721. The Yellow-water Sensitive plant (Neptunia plena), found in the East and West Indies and in South America, exhibits irrita-

* Comptes Rendus, Oct. 1852.

† Marcet, on the action of chloroform on the Sensitive plant—Edin. New Philosophical Journal, xlvi. 293.

‡ Edin. New Philos. Journal, xlvi. 295.

bility in its petioles and leaflets.* The leaves of Venus's Fly-trap (Dionæa muscipula), an American marsh plant, are provided with a jointed blade (Fig. 1160), on each half of which are placed three hairs, with swellings at their base. When these hairs are touched or irritated in any way, the two halves of the leaves close. Flies and other insects are often found enclosed in the leaf, and hence the name given to the plant. It is said that the Sundews (Drosera) of our marshes also exhibit a certain degree of contractility, but this has not been distinctly proved. Their leaves (Fig. 1161) are provided with viscid glandular hairs, to which insects are often found adherent, while the leaves are partially folded.

722. In the case of Hedysarum (Desmodium) gyrans, a native of the East Indies, the phenomena of leaf-motions are very remarkable.

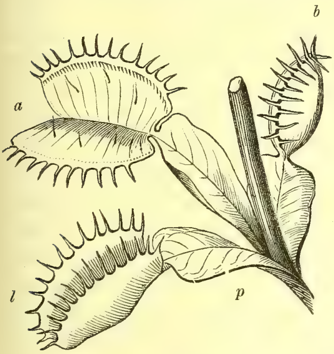

Fig. 1160.

Fig 1161.

Fig. 1162.

The leaf, as represented in Figure 1162, is unequally pinnate, having a large leaflet or pinna at the extremity of the stalk, and two pairs of

Fig. 1160. Leaves of Venus's Fly-trap (*Dionæa muscipula*), which exhibit evident irritability. The leaf consists of two parts, a lamina or blade, *l*, and a petiole or leafstalk, *p*. The two halves of the blade are united by a sort of hinge, *a*, and there are on each of them three hairs, which, when touched, cause the folding of the laminæ in the way represented at *l* and *b*. At the base of each of the hairs there is a swelling. The irritation seems to be communicated by means of the vessels to the midrib, and the folding is owing to the turgescence of the lower cells of the midrib. The motion is of the nature of a hinge-joint.

Fig. 1161. Leaf of a species of Sundew (*Drosera rotundifolia*), covered with glandular hairs. These hairs secrete a viscid fluid, which often detains insects. The leaves are sometimes seen partially folded. This folding is supposed to be due to irritability.

Fig. 1162. A portion of the branch and leaf of the moving plant of India (*Hedysarum* or *Desmodium gyrans*). The leaf is impari-pinnate, and often pinnately-trifoliolate. The large odd leaflet, *a*, becomes more or less horizontal, under the influence of light and heat, and is depressed during darkness or cold. Besides the movement of rising and falling, it has also a lateral oscillatory motion, so that it often becomes oblique in its position relative to the leaf-stalk. At its base there is a cellular intumescence. The smaller leaflets, *b*, of which there are either one or two pairs, have also swellings at their base. They exhibit constant jerking movements, by which they approach and retire from each other, and these motions go on to a certain extent during darkness.

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* Botanical Magazine, Fig. 4695, February 1853.

small pinnæ placed laterally. The large leaflet exhibits oscillatory lateral movements, as well as the ordinary sleep movements, in an upward and downward direction. During the day it rises and appears to have slow motion from one side to the other, so that it often is seen in an oblique position as regards the stalk; during the night it is depressed and motionless. The little pinnæ, on the other hand, constantly exhibit a jerking motion, by which they first approach to each other, and then retire, the length of time required to complete their movements being about three minutes when the plant is vigorous and exposed to bright light. The leaflets exhibit motions even in darkness, although to a less extent. Other species of Hedysarum (p. 494), exhibit similar movements.*

723. The cause of these phenomena is obscure. Some have supposed that they are to be ascribed to the presence of a peculiar nervous system in plants. But there is no evidence of the existence of such a system, and the motions do not require that we should have recourse to such a theoretical explanation. All may be accounted for by changes in the contents of the cells. In some cases cells display evident contractility, so that when touched their fluids exude. This may be observed in the Wild Lettuce (Lactuca virosa) when growing vigorously, and it is also supposed to occur in the cells at the base of the stings on the Nettle leaves (Fig. 97, p. 43). In the case of the sensitive Mimosas, there are evident cellular swellings at the base of the small leaflets, as well at the base of the petioles, to which allusion has been made at page 133. These swellings, when touched directly, communicate motion to the leaves. They consist apparently of two kinds of cells, some of which display contractility, and others distensibility.† When in their ordinary state these functions are balanced; but when mechanical or chemical stimuli are applied, a change in the cell-contents takes place, accompanied with a derangement of equilibrium. When the swellings at the base of the leaflets are touched gently on the superior surface, then the liquid contents of the upper contractile cells are sent into the distensible inferior ones, and the leaflets fold upwards. This change, however, is not effected by touching cautiously the lower surface of the swellings. Again, in the swelling at the base of the petiole, the reverse is the case, for there the lower cells are contractile, and the upper distensible, and the movement caused is in a downward direction. Touching the upper side of the intumescence at the base of the petioles does not give rise to the movement. If a portion of the lower side of the swelling is removed, then the balance between its resistance and the expansive tendency of the cells on the upper side is destroyed, and the petioles remain depressed, according to Dutrochet. Any irritation applied to one part of the leaf is propagated by means of the vascular system to another

* Nuttall, Genera of North American Plants, ii. 110.

† Dutrochet, sur la structure intime des Animaux et Végétaux, 1824.

part, and more especially it is communicated to the distensible portion of the cellular swellings just mentioned.

724. In the day time, and under the influence of light, according to Fée, the fluids drawn to the surface of the plant are kept in equilibrium by rhythmical evaporation. There is a constant renewal of fluids to supply those which have been transpired. A blow or wound, or the application of cold, interrupts the equilibrium, the circulation is deranged, and liquids pass quickly from the cells into the vessels, and thus cause distension. During the night the sap is feebly drawn to the surface, and thus a change takes place in the relative contents of the different cells and vessels.* The phenomena are thus referred to changes in the fluid contents of the cells and vessels caused by certain vital actions. Mohl refers the movements partly to the distension of the cells, and partly to different states of tension in the tissues, and he considers the movement of irritability as not identical with the sleep movement. He says that the articulations are composed of numerous parenchymatous cells containing chlorophyll, each also exhibiting in its interior a larger or smaller globular mass of a substance strongly refracting light. The parenchymatous tissue, he says, exhibits a considerable distension. If a flat portion is cut longitudinally out of the middle of the joint, and afterwards this portion is cut lengthways into thin strips, the cellular tissue forming the sides of the strips immediately expand about one-fifth longitudinally, while the vascular bundle in the middle continues as before. Hence, he says, the vascular bundle appears to be too short in proportion to the turgescent mass of cellular tissue of the articulation, while the latter is compressed in the direction of the longitudinal axis in the uninjured part. In the ordinary state of the plant, the expansion of the cellular tissue of the upper side of the articulation maintains the equilibrium with the cellular tissue forming the under side, and thus curvation is prevented. But if the cellular tissue is cut away down to the central vascular bundle on the upper side of the articulation of a leaf still attached to the plant, the cellular tissue of the lower side having now lost its antagonist can pursue its expansion, and the leaf becomes at once pressed upwards at a sharp angle—the reverse occurring when the cellular tissue of the under side is removed.†

725. In the case of Hedysarum gyrans and other species, the movements are probably referrible to changes in the contents of the cells and vessels, not directly induced by mechanical irritation, and only partially influenced by the stimulus of light and heat. In Venus's Fly trap (Dionæa muscipula) the irritation of the hairs is apparently communicated by means of vessels to the cells between the two halves

* Fée, Mémoire Physiol. et organog. sur la Sensitive et les plantes dites sommeillantes — Comptes Rendus, 1846, xxiii. 602.

† Mohl, on the Anatomy and Physiology of the Vegetable Cell, translated by Henfrey, p. 152.

of the leaf-blades, in such a way that distension takes place in the lower cells, and thus the leaves close. The object of these various movements is not known.*

VII. DEFOLIATION, OR THE FALL OF THE LEAF.

726. Leaves continue to perform their active functions for a certain length of time, and are then replaced by others. In temperate climates these functions go on vigorously during spring and summer, but towards the end of autumn they become languid. In the ordinary trees of this country the leaves fall off during winter, a latent bud having originated in their axil whence new leaves arise in spring. In warm climates the dry season often causes a similar exuviation of the leaves. This is observed in the Brazilian forests called Caatingas. The times of the appearance and of the fall of the leaves vary in different countries, and from them may be deduced conclusions as to the nature of the seasons.

727. The periods of leafing (foliation or frondescence), and of the fall of the leaf (defoliation), are taken into account in determining the climate of different countries, and of different parts of the same country. In Britain, while some plants, such as the Honeysuckle and Gooseberry, put forth their leaves in February and March, others, such as the Oak and Ash, do not show leaves till May. The following are the statements by Berghaus as to the periods of foliation :—

Beech unfolds its leaves at Naples in end of March.
,, in England on 1st May.
,, at Upsal beginning of May.
Foliation of Elder at Naples 1-18th January.
,, at Paris about 14th February.
,, in England about 8th March.
,, at Upsal 1-8th March.
Lilac unfolds its leaves near Naples first half of May.
,, near Paris about 12th March.
,, at Upsal beginning of March.
Foliation of Oak takes place at Naples beginning of April.
,, at Paris in May.
,, in England 26th April.
,, at Upsal during first days of May.

Defoliation also occurs at definite periods of the year.†

* For further remarks on this subject, see Carpenter's Principles of Physiology, general and comparative, p. 991. De Candolle, Physiologie Végétale, ii. 853. Dutrochet, du reveil et du sommeil des plantes—Annales des Sc. Nat. 2d ser. Bot. vi. 177. Miquel et Meyen sur l'irritabilité du Mimosa Sensitiva—Annales des Sc. Nat. 2d ser. Bot. xiii. 318. Virey, quelques considerations nouvelles sur l'acidité dans les plantes irritables—Journ. de Pharmacie, 1839, p. 289.

† Berghaus, on the Epochs of Vegetation, in Edin. New Phil. Journal for 1841, xxx. 182.

728. The following table by Quetelet and Hartmann shows the periods of foliation and defoliation in different parts of Europe in the year 1841 :—*

NAMES OF PLANTS.	APPEARANCE OF LEAVES.				FALL OF THE LEAVES.	
	Gefle.	Brussels.	Lyons.	Ghent.	Brussels.	Ghent.
Æsculus Hippocastanum, Horse Chestnut	May 15	...	Mar. 29	...	Oct. 25-30	Oct. 24
Acer Pseudo-platanus, Sycamore . . .	...	April 23	...	March 27	Oct. 25-30	...
Vitis vinifera, Vine .	...	April 23	...	...	Nov. 10-15	...
Tilia europæa, Lime-tree	May 21	March 26	...	March 24	Oct. 20-25	Sept. 12
Juglans regia, Walnut	...	April 27	...	April 25	...	Oct. 3
Prunus Cerasus, Cherry	...	March 27	...	...	...	Oct. 27
Pyrus Malus, Apple .	...	March 24	...	March 17	Nov. 1-5	Oct. 29
Pyrus Aucuparia, Mountain Ash .	May 12	...	...	...	...	...
Ribes Grossularia, Gooseberry . .	...	March 12	Mar. 17	March 14	...	...
Ribes rubrum, Red Currant	...	March 18	Mar. 20	March 17	...	...
Sambucus nigra, Elder	...	March 18	Mar. 15	March 14	Nov. 5-10	Oct. 24
Syringa vulgaris, Lilac	...	March 12	Mar. 15	March 14	Nov. 5-10	Oct. 24
Fraxinus excelsior, Ash	May 25	...	...	...	...	...
Daphne Mezereum, Mezereon	May 3	March 16	Mar. 24	...	...	...
Ulmus campestris, Elm	May 22	March 29	...	March 26	Nov. 1-5	Oct. 31
Salix babylonica, Weeping Willow	...	March 17	Mar. 24	March 17	Nov. 15-20	...
Populus fastigiata, Italian Poplar .	...	April 1	...	...	Oct. 20-25	Sept. 24
Populus tremula, Aspen	May 19	...	...	...	...	...
Corylus Avellana, Hazel	May 16	March 24	Mar. 25	March 18	...	Oct. 27
Quercus Robur, Oak .	...	April 28	...	...	Nov. 10-15	...
Betula alba, Birch	May 14	March 27	...	...	Nov. 1-5	...
Alnus glutinosa, Alder	May 20	...	...	...	...	...

By keeping a register of the periods of foliation and defoliation, an accurate estimate may be formed of the state of the climate in different years. This subject has engaged the attention of the British Association, and tables have been prepared for the purpose of obtaining the results of such periodical phenomena.†

729. The fall of the leaf has not received the attention it deserves from physiologists. The reason frequently given for this phenomenon is the choking up of the cells and vessels of the leaf by deposit of earthy and saline matters, in consequence of the process of absorption in autumn not keeping pace with the exhalation of watery fluid. There is no doubt that mineral substances do accumulate in the leaves

* Grisebach, Report on the progress of Geographical Botany, in Ray Society's Reports for 1849, p. 321.

† British Association Report for 1850, p. 338.

in autumn, but there seems to be no proof that this is the sole cause of their fall. When autumn approaches, it is found that a gradual separation takes place between the leaf-stalk and the stem or the axis to which it is attached. This is not a mere accidental occurrence, but is a process for which regular provision is made, as has been explained by Dr. Inman.* He found that even when the shoots of a tree are young and vigorous in early spring, there is a faint line visible externally in many instances which marks the place where the separation is to take place (Fig. 1147, p. 452, *f*, *c*). The line of demarcation only extends for a short way inwards at this time, and the leaves, when pulled off, take some of the bark along with them, in consequence of the joint not being complete. As the season advances the line of division extends more deeply; cells containing crystals are developed in considerable quantity, and iodine shows by the blue colour the presence of starch, which could not be detected in the young state of the joint. A cellular process of bark dips inwards, "reaches the fibro-vascular bundles, where it receives a slight check, but soon continues its progress until these are nearly absorbed, and the prolongation of the epidermis has entirely covered the surface of the joint or articulation." The fall of the leaf does not, therefore, arise simply from the cold of winter and other vicissitudes, but is a regular process of disjunction which goes on from the time the leaf-stalk is fully formed until the leaf has ceased to perform its functions.

730. In cold climates various causes operate in causing defoliation. As the light and heat diminish there is a cessation of the functions of cells and vessels, evaporation takes place from the surface, inorganic matters accumulate in the tissues, the leaf becomes dry, its attachment to the stem is loosened, and then it either falls by its own weight, or is detached by external agencies of different kinds. Dr. Fleming† states, that winter is not the immediate cause of defoliation. Many leaves fall before the approach of winter, others perish in spring. He divides trees in reference to the duration of their leaves into three classes:—1. Those in which the leaves cease to perform their functions when the bud is complete. 2. Those in which the leaves continue to perform their functions until new ones appear the following season. 3. Those in which the leaves continue to perform their functions for several years.

731. The leaves of the first class are *deciduous*, and they seem to be connected with the ripening of the bud. When this takes place, these leaves change their colour and perish. In Willows, even in midsummer, many of the branches become naked from the fall of such leaves. In trees having two evolutions of buds in the season, as the Beech, the leaves produced in spring fall sooner than those which are developed on the summer shoots. When leaves fall off early, the bark

* Inman, on the causes which determine the fall of leaves—Proceed. of the Lit. and Phil. Soc. of Liverpool for 1848, No. iv. p. 89.

† Fleming on the Temperature of the Seasons, p. 86.

in its young and green state may be considered as occupying their place, and performing their functions. In many leafless plants, as Cactuses, the green branches perform the functions of leaves. This is also the case with the green frond or stalks of Liverworts and other Cryptogamic plants. Leaves of the second class Dr. Fleming calls *annual*. These continue till new leaves are produced, and are cast off in the order of their development. In Evergreen trees and shrubs the leaves of one season continue their functions until those of the next season are produced. Thus, although the plants have always leaves on their branches, there are a certain number which fall off annually, but the shoots are not left bare. The leaves of the plants of this class appear, therefore, to exercise a greater influence, in the economy of vegetation, than those connected with the first. Here the plant requires the aid of leaves at all times—no other organs, in ordinary cases, appearing to be capable of exercising their functions, or acting as a substitute. The leaves of the third class Dr. Fleming calls *persistent*. Their duration does not seem to be regulated by the perfection of the bud, nor by the development of new leaves. They continue their functions for several years. This is the case with ordinary Evergreen Firs. In these plants the leaves of various years seem to be required for the complete formation of the stem and its secretions. On the same tree, may be seen leaves two, three, or more years old.

732. In trees with persistent leaves defoliation is very irregular. Occasionally the leaves perish in the order of their production, but at other times those of a few years old may be changing colour or falling off, while those many years old may be vigorous. The leaves of Araucaria imbricata in Britain do not exhibit symptoms of decay; the tree does not seem to defoliate, and hence the leaves are truly persistent. The disjunction between the leaf and the stem of a plant is effected at the time when the leaves are no longer required for its growth, and the part where the leaf was attached is marked by a scar in which the bundles of vessels are regularly arranged as in the leaf or leafstalk. The scar varies in its form and appearance in different plants, and hence it may be used as a means of distinction. In fossil botany the scars of the leaves are of importance in determining Stigmarias, Lepidodendrons, Sigillarias, and Ferns.

733. The sap absorbed by the roots, and which contains various inorganic matters in solution, reaches the leaves, and is thus exposed to air and light. There is a large transpiration of watery fluid, and the inorganic matters not required for the organism and secretions of the plant are stored up in the leaves, forming at times incrustations on the walls of the cells. The quantity of ash left after burning leaves varies at different periods of the plant's growth. Vernal leaves contain a small amount of ash, while autumnal ones leave a large quantity when burned. The latter contain from 10 to 30 times more ashes than the wood of the same plant. Thus the—

Dried leaves of Elm	yielded	11	per cent	of ashes.
Wood of do. . . .	,,	2	,,	,,
Dried leaves of Willow	,,	8	,,	,,
Wood of do. . . .	,,	0.45	,,	,,
Dried leaves of Beech	,,	6.69	,,	,,
Wood of do. . . .	,,	0.36	,,	,,
Dried leaves of Oak	,,	4.05	,,	,,
Wood of do. . . .	,,	0.21	,,	,,
Dried leaves of Pitch Pine		3.15	,,	,,
Wood of do. . . .	,,	0.25	,,	,,

Leaves thus contain a large amount of ash, which consists of various salts of lime and potash, &c. Hence, when they fall, they return important substances to the soil. The use of leaf-mould as a manure, depends in part on this circumstance. Fallen leaves in place of being swept away as useless ought to be carefully incorporated with the soil, and thus the mineral matters which were not required for this year's growth, when dissolved and diffused in the soil, serve for the nourishment of the plant next season.*

734. Recapitulation of the principal facts connected with the physiology of leaves :—

1. Fluid matters absorbed by the roots are carried up through the stem to the leaves, in which they are exposed to the influence of air and light.
2. The spiral arrangement of leaves on the stem is calculated to promote full exposure to these influences.
3. Leaves absorb liquids and gases of different kinds, more especially water, carbonic acid, and ammonia.
4. This absorption is modified by the nature of the cuticle as regards its texture, its hairiness, and the number of its stomata.
5. When the cuticle is of a corky or waxy nature it resists absorption.
6. Absorption in ordinary leaves takes place most rapidly by the under surface, where the stomata are most abundant.
7. In the leaves of aquatic plants, especially those which are submerged, absorption takes place through every part of the leaf.
8. Leaves exhale watery fluids by a process of transpiration.
9. This function seems to be especially influenced by light, and differs from ordinary evaporation.
10. Transpiration is modified by the structure of the leaves, by the nature of the epidermis as regards density and hairiness, and by the number of stomata.
11. Transpiration in ordinary aerial leaves is usually greatest on the under surface.
12. The quantity of watery fluid exhaled varies in different instances.
13. In some plants there is, during a certain period of their growth, a constant dropping of water from the sides and extremities of the leaves.
14. The fluids exhaled and secreted by leaves are sometimes deposited in pitcher-like appendages.
15. Transpiration is connected with important processes going on in the cells and vessels of plants; it also has a marked effect on the nature of the climate of a country, as seen in the case of wooded countries.

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* For additional remarks on defoliation, consult Giordano, Cenno sulla decolorazione e caduta delle foglie in autumno, Torino, 1835. Vaucher, Mémoire sur la chute des feuilles, Genève, 1828. Vrolik, de Defoliatione Vegetabilium, Lugd. Bat. 1796.

16. Leaves exhale gaseous matters in large quantity.
17. The carbonic acid absorbed by leaves, as well as that taken up by the roots and carried to the leaves, is decomposed under the influence of light, and while its carbon is retained for the nourishment of the plant, its oxygen is given off.
18. By this deoxidating or decarbonizing process, leaves keep up the purity of the atmosphere, and counteract the effects of animal respiration and combustion, which are essentially processes of oxidation.
19. During darkness this function of deoxidation ceases more or less completely.
20. Some authors state that during darkness an absorption of oxygen takes place, and an evolution of carbonic acid by an exosmotic process.
21. Other authors maintain that an evolution of carbonic acid always takes place both by day and by night, and that this is true vegetable respiration, and that during the day the carbonic acid is decomposed more or less completely, and oxygen given off by a process of digestion.
22. The leaves of aquatic plants have a great power of decomposing carbonic acid, and of exhaling oxygen.
23. The effect of light in decomposing carbonic acid depends on its illuminating power, and the phenomenon is found to proceed most vigorously in the yellow rays.
24. The evolution of nitrogen by the leaves of some plants is still a matter of doubt.
25. Plants in a decaying or diseased state, etiolated plants, as well as certain brown and pale-coloured plants, are said to exhale carbonic acid.
26. Leaves elaborate various important secretions, under the agency of air and light.
27. The formation of good timber depends on the full exposure of the leaves, and hence in crowded plantations woody matter is not properly developed; the early and judicious thinning of forests is of great importance in the production of timber.
28. The leaves of plants grown in darkness do not form woody matter; such plants become blanched, cells and thin-walled vessels alone are produced, and hence they are delicate and tender.
29. Certain gases act prejudicially as regards leaves, either by depriving them of atmospheric air, or by poisoning them.
30. Plants do not thrive in an atmosphere of pure hydrogen or nitrogen.
31. Although the leaves of plants can decompose carbonic acid, yet plants are killed by being grown in this gas without a proper admixture of atmospheric air.
32. Certain gases, as hydrochloric and sulphurous acid gas, destroy leaves by their irritant local action, but unless their action is long continued, the plants may still live, and push forth new leaves. These gases act injuriously in very minute quantity.
33. Other gases, such as sulphuretted hydrogen gas, destroy leaves by a general narcotic action, which affects the whole plant, and causes its death. These gases also act injuriously in very minute quantity.
34. The atmosphere of towns contains fuliginous matter and many gases which are injurious to plants; and this is more especially the case in towns where chemical manufactories exist.
35. Closed glass cases, called Wardian Cases, are well fitted for the growth of plants in such localities, by preventing the effect of noxious vapours. They are also suited for rooms in which the atmosphere is dry, and they are especially useful for transporting living plants to a distance.
36. The green colour of leaves depends on their exposure to light, especially to the yellow rays, which are the most illuminating rays of the spectrum.
37. Leaves grown in darkness become etiolated or blanched, and exhibit a pale yellowish colour.
38. Leaves assume yellow and red tints in autumn, owing to the oxidation of their juices. Trees may be so planted as to give beautiful contrasts in their autumnal tints.
39. Variegation in leaves is produced by an alteration in the chlorophylle of particular cells, or by the presence of air in some of the cells.

40. During darkness the leaves of many plants are folded and depressed. This was called by Linnæus the sleep of plants.
41. Certain leaves display peculiar irritability and contractility, and they are hence called sensitive.
42. These phenomena are traceable to a change in the contents of the cells and vessels, which give rise to distension and contraction. They are connected with peculiar cellular swellings at the base of the leaf-stalks and leaves.
43. The movements of these irritable leaves are of a hinge nature, and they are caused by various mechanical and chemical stimuli.
44. An irritation applied to one part of sensitive leaves is propagated frequently to other parts in succession.
45. The defoliation or fall of the leaf is caused by diminution in light and heat, cessation of the function of cells and vessels, accumulation of inorganic matter in the tissues, and the gradual formation of a division at the base of the stalk.
46. Some leaves fall after the bud is complete, others continue to live till new leaves appear, while a third set remain for several years before they fall.
47. The periods of foliation (frondescence) and of defoliation give indications as to the nature of the seasons.
48. Leaves contain a large quantity of inorganic matter, and when they fall they restore it to the soil.

CHAPTER VII.

GENERAL CIRCULATION OR MOVEMENT OF THE SAP.

735. Plants are not provided with a circulating system like that of animals, and they do not exhibit movements of fluids to and from a common centre. Although, says Hales, they have not an organ like the heart, by the alternate dilatation and contraction of which fluids are forced through a series of anastomosing tubes, yet has nature wonderfully contrived other means most powerfully to raise and keep in motion the sap. Liquids are diffused throughout the whole plant by the action of cells and vessels having a different chemical constitution and different functions. One cell takes the juice from another, and acts by diffusion on the others. The cells of the rootlets imbibe by endosmose fluid matters which are carried into the stem, and the cells of the leaves, by their exhaling functions, aid in promoting a general movement of sap throughout the whole system.

736. It is not easy to make experiments on the motion and course of the sap, both on account of the minuteness of the vegetable tissues, and the unavoidable injury which must be inflicted on them in any attempt to observe these living actions under the microscope. We cannot, as in animals, put ligatures on vessels, nor by an injecting apparatus send coloured matters into them. Endeavours, however, have been made to trace the course of the sap by causing the roots to absorb solutions of substances which can be easily detected by chemical reagents at different parts of their progress. Thus a weak solution of acetate of lead has been employed, which can be detected by iodine, sulphuretted hydrogen, and other tests; also a solution of ferrocyanuret of potassium, which can be tested by chloride of iron, or by sulphate of the peroxide of iron. The last has been used recently by Hoffmann* in his experiments, and he finds the blue colour produced by the action of salts of iron on the ferrocyanuret a good means of tracing the course of the sap. As the Prussian blue thus formed is insoluble in water, a little care in dissecting enables us to avoid the spreading of the colour to unaffected parts.

737. It may be remarked in general, in regard to these experi-

* Hoffmann, on the Circulation of Sap in Plants, in Botan. Zeitung, vi. and viii. translated in Scientific Memoirs, Nat. History, part i. Nov. 1852.

ments, that very different results followed, according as the absorption took place by the uninjured roots, or by the cut surfaces of plants. In the latter instance, the fluids were found in vessels which they did not enter in the former case. In cellular plants the sap seems to move through all parts, and is not confined to any definite set of cells. In vascular plants, it appears in general that the sap enters the cells and woody vessels (and perhaps the intercellular spaces); and that the spiral vessels and those allied to them, such as annular and scalariform vessels, very generally contain air when the sap enters slowly. But when there is a rapid movement of sap either from the root upwards or from the leaves downwards, especially in Dicotyledons, then the spiral vessels take up fluids as well as air. It seems probable that the spiral vessels and their allies are receptacles for gaseous matter formed in the course of the movement of the sap.

738. In truly cellular plants, as Fungi, the course of the circulation has no accurately fixed boundaries, and presents no anatomical peculiarities. The fluid is found to proceed both forwards and laterally in the cells and intercellular spaces, proceeding most rapidly in those parts where the tissue is most lax. In plants such as Lichens, where the tissue is dense, and in which there is not much fluid, the sap passes with great slowness between and through the cells. In the case of mosses possessing leaves, the fluid was found to pass through the stem and fruit-stalk, and in the leaves it moved most rapidly in a peculiar layer of cells along the margin of the leaves, and not in the midrib. Probably the condensed cells and vessels of the midrib are concerned in the conduction of fluids from the leaves in a downward direction.

739. In Ferns, it was observed that the scalariform vessels and closed spirals contained air, and that they did not take up any of the solution of the ferrocyanide. If the petiole of the frond is cut across and inserted in the solution, then the latter passes into the scalariform vessels, driving out the air. The leaf of the Fern, when dipped in the liquid, absorbs it, but it does not pass into the scalariform vessels. In Ferns there did not appear to Hoffmann to be any path for descending juices, and this is probably connected with their mode of growth, which is by additions to their summit (acrogens). The streaked vessels in Ferns seem to be destined exclusively for gaseous matters, while the fluids absorbed from the earth first ascend within the loose cellular tissue in the vicinity of those vessels, and are from them diffused throughout the remainder of the tissues after suitable elaboration.

740. In Monocotyledons the solution of the ferrocyanide ascended chiefly through the elongated cells surrounding the spiral vessels, and the latter contained, in ordinary circumstances, air in their interior. That the spiral vessels of Monocotyledons contain air was proved by Hoffmann, not merely by finding that they never exhibited the blue colour in their interior, but also by the following experiment:—If a stem of Dioscorea bulbifera, held the wrong end upwards, is cut across, and the wound immediately dipped in a drop of thick solution of gum,

there is no difficulty in seeing bubbles of air emerge slowly from the spiral vessels and inflate the dense fluid, when the stem is squeezed from the root upwards towards the wound. In certain instances, however, when there is a large mass of fluid passing rapidly through the stem, the air in the spirals may to a certain extent be displaced. This, however, may be looked upon as an accidental occurrence, and not as the normal state of the vessels.*

741. In the case of dead scales of Monocotyledonous bulbs, the fluid was imbibed by all parts of the tissue, by the spirals as well as other vessels, and by the cells. This points out the difference between living and dead tissue. In fleshy Monocotyledons, such as Aloe picta, the movement of sap seems to be very slow. When watered with a solution of the ferrocyanide, no absorption was observed after five weeks. The absence of absorption after a stated period Hoffmann says is the less remarkable, since these plants can remain for seven months of every year in a dry part of a conservatory without even being watered, therefore without requiring any other liquid than that which they receive through evaporation when other plants are watered.

742. In regard to the course of the sap in Dicotyledons, numerous experiments have been made. Walker, Burnett, and others made incisions into the bark and wood of trees in spring and summer, and marked the points where the sap made its appearance. In this way they endeavoured to trace the course of the fluids in the stem. Walker concludes, from his experiments, that the spring sap begins to flow at the root, that it ascends slowly upwards, and bleeds successively as it ascends to the very extremity of the tree; that there is no descent of sap until after the development of the leaves.† Burnett cut notches in the trunks of various trees in spring, at different heights in each tree, from one to six feet from the ground; and in every instance the sap was seen distinctly exuding from the lowest side of the lowest section first, and progressively rising to the others day by day. The chief current was axial in the first instance, and afterwards the sap entered the branches. To the progress of the sap in the direction of the axis he attributes the early development and vigour of terminal buds.‡ Mohl states that when a ring of bark is taken off, the flow of the sap to the parts above it is not interrupted; but if a portion of the wood is carefully removed without injury to the bark covering it, then the portion of the plant above the wound dries up at once.§

743. Hoffmann bored holes in the stems of trees, such as the Sycamore, and inserted quills with the inner ends cut off obliquely,

* The tuber of Anomatheca cruenta, one of the Iridaceæ, is recommended by Hoffmann for experiment, as in it the spiral vessels, parenchyma, elongated vessels, and bark cells are distinct, and widely separated from each other.

† Walker's Experiments on the Motion of Sap in Trees, in Trans. Royal Soc. Edin. i. 3.

‡ Burnett, on the Development of the several Organic Systems of Vegetables, in Journal of the Royal Institution, vol. i.

§ Mohl, on the Vegetable Cell, translated by Henfrey, p. 71.

and the orifices looking upwards—the quills being cemented in their place. In this way he made experiments with the spring sap, by inserting the roots of plants in a solution of the ferrocyanuret of potassium, and testing the fluid at different heights as it was discharged in drops from the quills. He found that the exudation of the sap in spring occurred obviously earlier in the lower than in the upper part of the stem, and that the ascent of the fluid was confined to that side of the stem which corresponded to the absorbing root.

744. In spring, it appears that the sap, as it increases in quantity, besides filling the cells and vessels of the wood, also enters the spiral vessels. This is the time when the plant bleeds freely on being wounded. As the leaves expand, transpiration of fluids takes place, and then the spiral vessels contain air. In some climbing plants, this state of fulness in the spirals, as well as in the wood, continues permanently.* After the leaves expand, in ordinary trees the conduction of sap takes place through the newer woody vessels and cells, and not through the fibro-vascular tissue. The circulation of the sap during summer, when the leaves are most active, differs from that in spring, in the circumstance that the trees do not bleed when wounded. In summer, as in spring, there exists a rapid ascent of crude sap ; but in addition to this, there is a descent of the elaborated fluids from the leaves to all parts of the plant. Hoffmann states that there is also a descent of unelaborated fluids after every shower of rain.

745. Some authors believe that the chief channels by which the sap ascends are the intercellular canals,† which are more or less continuous from one end of the plant to the other, and that from them it passes to the other parts, each cell and vessel taking from the general circulation what is required for its growth and nutrition. In this view the cells and vessels would be regarded as secreting organs, acting in various ways on the general mass of crude sap, and separating from it by a chemico-vital action different liquid and gaseous matters.‡ The recent experiments of Hoffmann do not support this theory of sap movement, and the general opinion of physiologists appears to be that in its upward progress the sap passes through the newer pleurenchyma, as well as through the intercellular spaces, until it reaches the leaves, where it is elaborated. The different layers of wood convey sap in different quantity, the youngest being those chiefly concerned in the process. The conveyance of sap is not carried on by the old layers of wood when they become hardened by deposits. Hence trees, with a large amount of hard wood, and a moderate quantity of sap wood, dry readily, while trees, like the Birch, with a large quantity of alburnum, have sap movements even in the central layers of wood.

* Gaudichaud, sur l'Ascension de la Sève dans une Liane (Cissus Hydrophora), in Ann. des Sc. Nat. 2d ser. Bot. vi. 138. This plant was found by Gaudichaud to contain a large quantity of sap, which poured out freely when the stem was cut.

† Rainey, experimental inquiry into the cause of the ascent and descent of the sap, London, 1847.

‡ This view was advocated by the late Mr. James Tetley, a zealous botanical student.

746. While such is the way in which the sap of Dicotyledons ascends, it is not easy to trace the mode of its after-diffusion. The usual opinion is, that after undergoing changes in the leaves and other green organs, it descends in the direction of the bark, and is thence conveyed to all the active cells and vessels of the stem. Experiments similar to those already detailed were made by Walker and Burnett as to the descent of the sap. When incisions were made in the bark, after the sap had reached the leaves, it was found that the upper portion of the cut was first moistened apparently by liquid from the upper part of the stem. If a complete ring of bark is cut off, then the growth of the portion below the wound ceases, the thickness of the stem is not increased, and, in the case of the potato, according to Mohl, no tubers are formed. At the same time the part of the stem above the wound increases much, and, in the case of trees, a thick layer of wood is formed. Mohl says that the deposition of starch in the cells of the medullary rays in autumn, seems to show that the elaborated sap not employed in nutrition on its way to the root has passed to the wood through these rays.

747. It would thus appear that there is a descent of elaborated sap from the leaves towards the bark, and that from this it is diffused through the rest of the tissue. Rainey thinks that the descent is through the vessels and not the cells nor intercellular spaces; and Hoffmann maintains that there is still doubts as to the conduction of the sap by the bark. Schultz considers the laticiferous vessels as those through which the elaborated sap descends. The motion of the fluids in them has already been noticed (p. 422). These vessels are reckoned by Carpenter and Draper as representing in some degree the capillary system of animals.*

748. Thus, as represented generally in Figure 1163, the sap in a Dicotyledonous tree describes a sort of circle not in determinate vessels, but by a definite path, through different parts of the plant; passing upwards from the roots, *a a*, through the newer woody tissue, *b b*, reaching the leaves, *c c*, and after elaboration descending towards the exterior of the trunk, *d d*, whence it is diffused in various directions, both internally and externally. An absorption of water, containing various matters in solution, is constantly going on through the extremities of the rootlets. This crude sap is carried forward through the cells, vessels, and intercellular passages, by a force which acts by propulsion. The stimulus of light, acting on the cellular tissue of the leaves, or on green stems when no leaves are present, enables these parts to elaborate the organic compounds which are necessary for vegetable nutrition. The leaf-action may be reckoned one of attraction or suction. The diffusion of the elaborated matters constitutes the descent of the sap.

749. Gaseous matters are carried up along with the sap. The gases appear to be chiefly common air, carbonic acid, and oxygen. In the

* Carpenter, General Physiology, p. 675. Draper, Chemistry of Plants, 29.

sap of the Vine, Hales mentions the presence of air, and Geiger and Proust detected in it carbonic acid. Occasionally the air is separated, and accumulates in the spiral vessels, or in certain cavities. Air cavities exist in the pith and leaves of many plants (pp. 76 and 106), more particularly in the floating leaves of aquatics (Fig. 85, p. 37, and Fig. 314, p. 134). Liebig thinks that the rise of the sap may be referred to a disengagement of gas which takes place in the capillary vessels.*

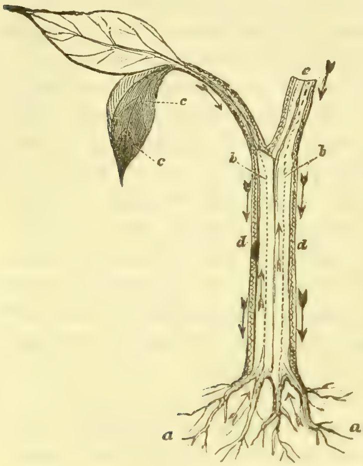

Fig. 1163.

750. Various causes conspire in originating and keeping up the movement of the sap. During winter, when vegetation is arrested, the cells of perennial plants are filled with albuminous and starchy matters. The conversion of starch into sugar in spring will at once determine an endosmotic action in the cells. We have already seen (p. 413) that two dissimilar liquids, when separated by a membrane, mix together. The one increases in bulk and rises; the other diminishes in the same degree, and consequently sinks below its original level. This phenomenon of mixture through a membrane, accompanied with change of volume, occurs in the cells of plants. It has been referred to chemical and electrical action, and, according to Draper, depends on the capillarity of the walls of cells. The cells of the root, with their delicate walls, allow the fluids from the roots to pass readily by imbibition. A physico-chemical endosmotic action takes place by which the fluid is propelled upwards. As the sap is constantly parting with its fluid-contents, more especially when it reaches the leaves, the fluid in the upper cells is thickened, and consequently the thinner fluid below passes in by endosmose. In addition to this, there are vital actions going on in the cells and vessels, which give rise to a constant interchange of ingredients.

751. Schacht says the property which certain cells have of absorbing and elaborating one substance more abundantly than another, produces an ascending and a descending current. It is possible that each cell may direct the substances it holds in solution upwards, laterally, or downwards, according to the demands of the neighbouring cells. The current of sap will consequently be directed according to

Fig. 1163. Ideal section of the stem of a Dicotyledon, showing the general course of the sap, as indicated by the arrows. The roots, *a a*, absorb liquids, which pass through the newer pleurenchyma and intercellular spaces, *b b*, reach the leaves, *c c*, and after elaboration descend towards the outer part of the trunk, *d d*, whence they are diffused in various directions; *e*, marks the section of a branch.

* Liebig, on the motion of the juices, &c. p. 99.

the wants and the degrees of vital activity of cells having different functions. The active processes of cell-formation going on at the extremity of the stem powerfully promote the ascent of nutritive juices. As the cambium of the vascular bundles extends from the extremity of the root to the apex of the stem, there is a constant transmission of fluids from cell to cell. As new cells are constantly formed at the extremity of the stem, by means of which azotized and other matters are consumed, there is a constant demand for a supply from below.

752. The exhalations going on in the leaves naturally give rise to a constant flow of fluids to supply the place of those which have been carried off. The capillary action of the intercellular canals may also aid in the movement, in proportion as watery fluid is removed from their extremities. Hales, from his experiments, deduces the presence of a powerful attractive force in every part of the plant. There is first an absorbent power in the roots, and then there is a transpiration from the surface of the leaves which demands a constant supply of watery fluid. The absorption of liquid must be equal to that lost by exhalation. If not, the circulation will cease. Unless there is a balance between absorption and exhalation, plants will diminish in vigour, and become diseased. When a plant is in its normal state of activity it does not absorb more than it consumes; the Vine and Birch only bleed in the spring when there are between the wood and bark more substances in solution than can be elaborated in the absence of leaves. This abnormal state is the result of chemical action inside the plant; when warm weather arrives, the starch collected in the autumn in the bark and sap-wood is converted into sugar and dextrine; absorption takes place through the cells of the roots; the earth loaded with moisture yields water in abundance; the transformation of starch continues, and with it diffusion. The sap, which cannot be immediately consumed, forces its way into the woody and vascular cells previously filled with air. But as soon as the extremity of the stem regains its activity, as soon as a sufficient number of leaves are developed, the sap disappears from these cells, and retains its former course; thenceforward the Vine and Birch cease bleeding.* Hales showed by experiment that the quantity of water absorbed by a shoot was in direct proportion to the number of its leaves, and that the quantity of water sunk to one-half when half the leaves were cut off. If a plant standing in the open air has one of its branches introduced into a hot-house during winter so that the leaves are expanded, absorption immediately commences at the roots. Thus the action of the leaves has a powerful effect on the absorption and movement of fluids. The experiments of Boucherie† in regard to the passage of fluids through the wood (p. 449), also show the power of the leaves in promoting the movement of fluids. Mohl made experiments on dicotyledonous trees in regard to the absorption of pyrolignite of iron, the

* Schacht, La Vie de la Plante, in Annales des Sc. Nat. 3d ser. Bot. xvii. 292.

† Boucherie, Comptes Rendus, 1840, ii. 894.

diffusion of which through the plant can be easily detected by the dark colour it imparts. He found that young trees sawn off and placed in the fluid absorbed it rapidly, until all parts were saturated with it.

753. The various physical, chemical, and vital causes operating in the movement of the sap may be thus enumerated :—Endosmose acting as a *vis a tergo* or propelling power, and commencing in the cells of the root; chemico-vital actions causing changes in the contents of the cells and vessels; capillarity in the intercellular canals; and a *vis a fronte* or attracting power depending on the transpiration from the leaves. Heat and light materially promote the movement of the sap. If a branch of a vine growing in the open air is introduced into a hot-house during winter, its leaves will be developed, and there will be a vigorous motion of fluids in it, although in the other branches there is no circulation. Hales and Duhamel noticed the effect of the sun in promoting the movement of the sap in the Vine and Maple. Moisture and warmth appear to cause the most vigorous movement of the sap.*

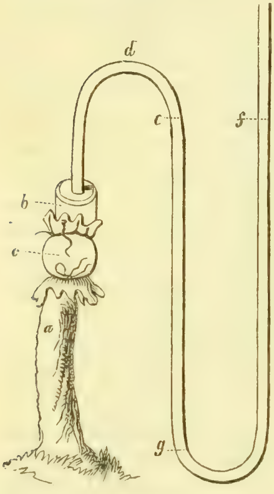

Fig. 1164.

754. The force with which the sap ascends in the stem was measured by Hales by means of an apparatus such as is represented in Figure 1164. A bent tube, *f d b*, was firmly attached to a stem, *a*, the top of which had been cut off, and the force of the sap was estimated by the rise of the mercury previously introduced into the tube, so as to fill the curvation between *e* and *f*. On 6th April he cut off a Vine, 2 feet 9 inches from the ground, and fixed on it the mercurial gauge, and he found the following results :—

Date of Experiment.	Rise of Mercury in Inches.
April 7, 11 A.M.	17.
,, 11, 7 A.M.	24¼, sunshine.
,, 14, 7 A.M.	20¼.
,, 14, 9 A.M.	22½, warm sunshine.
,, 14, 11 A.M.	16½.
,, 16, 6 A.M.	19½, rain.
,, 17, 11 A.M.	24¼, rain, and warmth.
,, 17, 7 P.M.	29½, Do.
,, 18, 7 A.M.	32½.

Fig. 1164. Instrument used by Hales to ascertain the force of ascent of the sap. A bent glass tube, *f g e d*, is attached to the upper part of a cut Vine stock, *a*, by means of a copper cap, *b*, which is secured by a lute and a piece of bladder, *c*. The level of the mercury at the commencement of the experiment is marked by the letters *e* and *f*. The sap as it rises in the stem of the Vine passes into the tube, so as to press the mercury down in the limb, *e*, and up in the limb, *f*.

* Hales, Vegetable Statics, p. 115. Duhamel, la Physique des Arbres, ii. 258.

From this time till May 5th the force gradually decreased. The force of the sap in another experiment was equal to 38 inches of mercury, which Hales states is nearly five times greater than the force of the blood in the crural artery of a horse, and seven times greater than the force of the blood in the same artery of a dog.* Brucke† found that in a Vine, the spring sap, having a specific gravity of 1.0008, raised a column of mercury to the height of $14\frac{1}{2}$ inches, and therefore exerted a pressure equal to that of a column of water 195 inches high. In another experiment sap of specific gravity 1.0009 raised the mercury to the height of $17\frac{1}{2}$ inches.‡

755. Recapitulation of the principal facts connected with the general course of the sap :—

1. There is still much doubt as to the exact course of the sap in plants, more especially as regards the tissues through which it is conveyed.
2. In cellular plants the sap has no definite course, but seems to pass from cell to cell through every part of the tissue.
3. In vascular plants a definite course is followed by the sap in its progress, the liquid sap being contained in cells and woody tubes, while gaseous matters are contained in the fibro-vascular tissue.
4. Watery fluids are taken up by the cells at the extremity of the root; they are conveyed to the stem, and finally reach the leaves, whence they are diffused through the plant.
5. In a dicotyledonous tree the crude sap appears to ascend through the cells, pleurenchyma, and intercellular spaces of the new wood, until it enters the leaves.
6. In the leaves the sap is exposed to the action of air and light, and is thus elaborated so as to be fitted for the formation of various secretions.
7. From the leaves there appears to be a descent of elaborated sap, more especially towards the exterior of the stem.
8. There is also a general diffusion of elaborated sap through the different parts of the plant.
9. The causes which operate in the progression of the sap are endosmose as a propelling force, chemico-vital actions in the cells and vessels, capillarity, and the transpiration of the leaves as an attracting force under the influence of light.
10. The absorption of fluids by the roots and the transpiration by the leaves in healthy plants must always correspond.
11. Heat, light, and moisture have a powerful effect on the motion of the sap.
12. The force with which the sap ascends is very great; in some instances it raised mercury in a tube to the height of 38 inches.

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* Hales, Vegetable Statics, p. 105-107.

† Brucke, Poggendorff Annalen der Physik, lxiii.

‡ For fuller remarks on the movement of the sap, consult Cotta, Naturbeobachtungen uber der Bewegung des Saftes. Duhamel's Physique des Arbres. Girou de Buzareingues sur le Mouvement des Fluides dans les Plantes—Ann. des Sc. Nat. 2d ser. Bot. v. 226. Matteucci, on the Physical Phenomena of Living Bodies—Trans. by Pereira, p. 75. Schleiden's Principles of Botany—Translated by Lankester, p. 515. The movements of fluids and granules in individual cells and vessels have already been noticed under Rotation and Cyclosis, at pages 414 and 422.

CHAPTER VIII.

PHYSIOLOGY OF THE FLOWER.

I. FUNCTIONS OF THE FLORAL ENVELOPES.

1. CHANGES IN THE CONTENTS OF THE FLORAL TISSUES.

756. The appendages of the flowers which assume a green colour perform the same functions as leaves, giving out oxygen under the influence of light. The cells of the floral leaves or bracts, and of the calycine leaves or sepals, commonly contain chlorophyll, which is produced under the agency of light by a process of deoxidation, carbon being fixed and oxygen separated. The bright-coloured parts of flowers do not appear to decompose carbonic acid; on the contrary, they exhale this gas. The petals of flowers, according to Garreau, are usually covered with a fatty matter over the whole surface, and hence they have not the property of absorbing water. But if they are washed with soap, then with ether and distilled water, they become endosmotic and absorb fluids. The petal of Pæony absorbed no distilled water in thirty-six hours; when washed with soap and ether, absorption took place, which was increased when the epidermis was removed.

757. The corolla is associated with the thalamus or receptacle in producing abundance of starch, which is changed into sugar during flowering, so as to afford nutriment to the stamens and pistils. While the calyx and green parts of the flower are concerned in the elaboration of the juices under the influence of light, the corolla is more immediately concerned in the protection of the internal organs, in the formation of coloured juices, and in the production of amylaceous and saccharine matters.* The quantity of starch accumulated in the receptacles of flowers is often large. This is well seen in Compositæ, such as the Artichoke and Thistle (Fig. 1165). The amylaceous matter during flowering in these plants becomes saccharine, and is absorbed by the flowers for their nourishment. The state of such receptacles alters during flowering. They are first amylaceous, then

* Dunal, sur les Fonctions des Organes Floraux colorés et glanduleux, Paris 1829.

saccharine, and finally become dry. In the case of the Artichoke the receptacle and bases of the phyllaries or scaly bracts are used as food in the young state, but when flowering has proceeded they no longer yield nourishment. What is commonly called *the choke* in the Artichoke is the young unexpanded flowers. So also in the Dandelion, the receptacle is at first succulent, but after flowering it becomes juiceless. Many plants which accumulate starch and nutritive matter in their stems, roots, and leaves, part with these stores of nourishment when flowering proceeds, and change their character. Thus the succulent roots of the cultivated turnip, beet, and carrot become comparatively dry and fibrous, and the leaves of cabbage lose much of their tenderness, when the flowering stems are developed. The active juices of plants are hence frequently best collected before flowering.

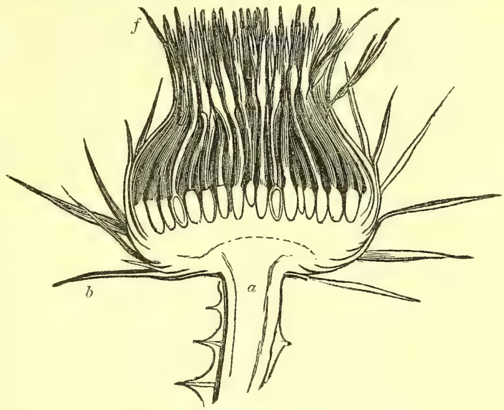

Fig. 1165.

2. ABSORPTION OF OXYGEN AND EVOLUTION OF CARBONIC ACID.

758. The flower, according to Saussure,* in the exercise of its functions, absorbs oxygen gas, and gives out carbonic acid. In his experiments he placed plants in a closed receptacle of air, of which they only occupied the 200th part, and measured the quantity of oxygen absorbed, comparing it with that of the volume of the flower experimented on taken as unity. The duration of the experiment, in each case, was 24 hours, the external temperature varying from 64.4° to 77° Fahrenheit.

Name of Species.	Oxygen absorbed by the Flowers.
Passiflora serratifolia	18.5
Cucurbita Pepo, Gourd, male flower	12
Matthiola incana, Stock	11

Fig. 1165. Head of Scotch Thistle (*Onopordum Acanthium*) cut vertically, showing the receptacle, *a*, to which the phyllaries, *b*, and flowers, *f*, are attached. This receptacle contains much starchy matter, which, as the flowers are developed, is changed into grape-sugar.

* Saussure, de l'Action des Fleurs sur l'air et de leur Chaleur Propre—Ann. de Chimie et de Phys. xxi. 279. See also Saussure, Recherches Chimiques sur la Végétation, p. 133.

Name of Species.	Oxygen absorbed by the Flowers.
Typha latifolia, Great Reed-Mace	9.8
Castanea vulgaris, Chestnut	9.1
Polyanthes tuberosa, Tuberose	9
Daucus Carota, Carrot	8.8
Hibiscus speciosus	8.7
Tropæolum majus, Indian Cress	8.5
Hypericum calycinum, large flowered St. John's Wort	7.5
Cobæa scandens	6.5
Lilium candidum, White Lily	5.
Cucurbita Pepo, Gourd, female flower	3.5

759. This absorption of oxygen is carried on by the coloured corolla, along with the essential organs of reproduction.* The quantity of oxygen absorbed is much greater when the stamens and pistil are perfect than when they are abortive or wanting. A perfect flower, with the latter organs present, took up more oxygen than one which had become double by the more or less complete conversion of the stamens and pistil into petals. Thus—

Common Stock,	Single Red,	consumed	11	vol. of oxygen.
,,	Double	,,	7.7	,,
Common Tuberose,	Single	,,	9.	,,
,,	Double	,,	7.4	,,
Indian Cress	Single	,,	8.5	,,
,,	Double	,,	7.25	,,

760. In proportion to their volume the essential reproductive organs absorb more oxygen than the entire flowers :—

NAMES OF SPECIES.	Flowers entire. Oxygen absorbed.	Essential organs. Oxygen absorbed.
Common Stock	11.5	18
Indian Cress	8.5	16.3
Gourd, male flower	7.6	16.
Large-flowered St. John's Wort	7.5	8.5
Cobæa scandens	6.5	7.5
Hibiscus speciosus	5.4	6.3

761. More oxygen is consumed by the male flower than by the female :—

Oxygen consumed	by male flower of Gourd in 10 hours	7.6
Do.	by female	3.5
Do.	by Stamens separately	11.7
Do.	by Styles and Stigmas separately	4.7

* The organs of plants which consume most oxygen are those which wither most quickly, viz. the stamens, styles, and petals.

Oxygen consumed by large Reed-Mace in 24 hours, inflorescence consisting of one male and one female Spike	. . . .	9.8
Do. by male Spike alone	. . .	15
Do. by female Spike alone	. . .	6.2
Oxygen consumed by panicles of male flower of Indian Corn in 24 hours	. . . .	9.6
Do. by female flowers and their sheath	.	5.2

3. EVOLUTION OF HEAT DURING FLOWERING.

762. At the same time that oxygen is absorbed there is a conversion of starch into grape sugar, an evolution of carbonic acid gas, and in many instances a very marked elevation of temperature, caused by the combination between the carbon of the flower, and the oxygen of the air. The starch, which is stored up in the receptacle and at the base of the petals, by passing into the state of dextrin and grape sugar, becomes fitted for vegetable nutrition. At the same time important purposes are served in the economy of the plant. Thus the saccharine and honey-like matter which often collects in the cup of the flower, and sometimes in special pits or depressions, as in Crown Imperial (Fig. 1166), and Asarabacca (Fig. 1167), attracts bees and various insects, which are thus made instrumental in scattering the pollen. According to Vaucher, the saccharine matter is applied to the stigma and other parts of the pistil, so as to favour the application and bursting of the grains of pollen.

763. An evolution of heat takes place during flowering; but from the large surface exposed, it seems to be in most instances carried off by the atmosphere as soon as it is developed. Cases occur, however, in which the temperature can be noted. Thus the flower of a Cistus (Fig. 529, p. 205) showed a temperature of 79°, while that of the air was 76°, and those of a Geranium 87° when the air was 81°. Otto ascertained that the flowers of Victoria regia at Hamburg (Fig. 235, p. 107) gave out heat when the anthers were mature. In one instance when the temperature of the hot-house was 70.7° F., and that of the tank 69.1°, that of the Victoria about seven o'clock in the evening was 80.3°; on another occasion, while the air was 72.5°, and the tank 69.5°, the Victoria was 105.1°. M. Teysman at Burtenzorg, in Java, has observed an elevated temperature in the male cone of Cycas circinalis; the time when it was observed being between 6 and 10 P.M.* By means of an air thermometer Saussure found the flowers of Polyanthes tuberosa $\frac{1}{2}$°, those of Bignonia radicans 1°, those of Cucurbita Pepo 1° to 3° F. above the temperature of the air; while Mulder found the flower of Cereus grandiflorus 1° to 2° F. warmer than the atmosphere.

* De Vriese, observations upon the elevated temperature of the male inflorescence of Cycadaceous plants—Hooker's Kew Miscellany, iii. 186.

764. The most marked instances of the evolution of heat, however, occur in the blossoms of plants belonging to the natural order Araceæ (Fig. 1168). In them the inflorescence consists of a thick fleshy spadix (Fig. 1170) containing much starch, and bearing numerous male and female organs, *a* and *b*, enclosed in a large sheathing bract or spathe (Fig. 1169, *s*). The production of heat during the expansion of the spathe of Arum italicum was observed by Lamarck in 1777.* Senebier† found that the temperature of Arum maculatum (Fig. 1168) rose to

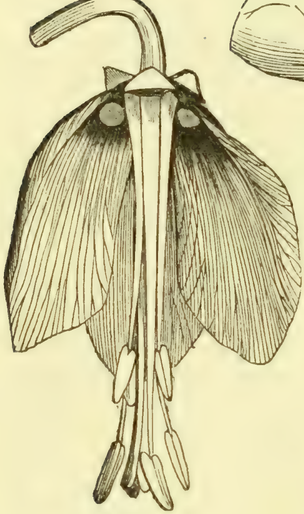

Fig. 1166.

Fig. 1167.

15.5° F. above that of the air, and Dutrochet‡ measured it from 25° to 27°. Schultz§ noticed the heat of Caladium pinnatifidum 9° F. above that of the atmosphere; and Goeppert|| states that the tempe-

Fig. 1166. Flower of Crown Imperial (*Fritillaria imperialis*) laid open, showing the pits or depressions at the base of the petals (leaves of perianth), in which honey-like matter is secreted. The saccharine matter is formed from starch.

Fig. 1167. Asarabacca (*Asarum europæum*), the flowers of which have depressions on the inner and basal portion of the perianth containing saccharine matter.

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* Lamarck, Encyclopedie methodique, Bot. iii. 8.

† Senebier, Physiol. Végét. iii. 314.

‡ Dutrochet, Comptes Rendus, 1839, 695. See also Saussure, on Arum maculatum—Ann. de Chimie et de Phys. xxi. 284; also Treviranus, in Tiedemann Zeitschrift für Physiol. iii. 257.

§ Schultz, Die Natur der lebendigen Pflanze, ii. 185.

|| Goeppert, ueber warme Entwickelung in der lebenden Pflanzen, Wien. 1832.

rature of the spadix of Arum Dracunculus rose to 31.5° F. above that

Fig. 1168.

Fig. 1170.

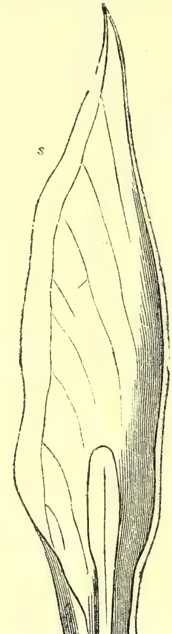

Fig. 1169.

of the air surrounding it. Brongniart in 1834 found the temperature

Fig. 1168. Cuckow-pint (*Arum maculatum*), belonging to the natural order Araceæ. It is one of the plants which is remarkable for the production of heat in certain circumstances during flowering.

Fig. 1169. Spathe, *s*, or floral leaf enclosing the spadix or organs of reproduction of Arum. There are numerous male and female flowers on a common receptacle, which contains much starch.

Fig. 1170. Spadix of Arum, showing the female flowers, *a*, the male, *b*, the abortive flowers, *c*, and the club-shaped extremity, *d*, of the spadix. The spadix is succulent, and contains much starch.

of Colocasia odora* 19.8° F. above the air of the conservatory in which the specimen grew. Van Beek and Bergsma noticed the heat of the same spadix 129° when that of the air was 79°. In the Isle of France, Hubert† states that a thermometer placed in the centre of five spadices stood at 131° F., and in the centre of twelve at 142½°, while the temperature of the air was only 74.75°. De Vriese says that from the computation of several hundred observations the maximum has varied from 48° to 57° F.

765. Dutrochet's examination of the spadix of Arum maculatum gives the following results :—‡

DATE AND HOUR.	Deviation of Thermo-electric Needle.	Heat of Spadix above Air.	Temperature of Air.
May 2. 4 P.M. .	64°	17.6° F.	59.9° F.
„ 5.30 „ .	65	18.7	60.2
„ 6.30 „ .	58	12.5	60.2
„ 7 „ .	55	10.6	60.0
„ 8 „ .	44	6.3	59.5
„ 9 „ .	30	3.4	59.0
„ 10 „ .	19	2.1	58.6

From these observations it appears that the maximum of temperature in the spadix occurred at 5.30 P.M., one hour and a half after the complete opening of the spathe, and that the heat was 18.7° above that of the surrounding air. On the 3d of May Becquerel's thermo-electric needle applied to the same plant remained at zero till mid-day, and then began to deviate to the opposite side, indicating that the spadix had then become colder than the air around. This deviation of the needle reached 4°, which implied that the temperature of the spadix was about ½° below the temperature of the air. On the 4th of May another specimen of Arum maculatum came into flower, and was experimented on. The heat at 2.30 P.M. was 14° above the air, the needle showing a deviation of 60°.

766. The seat of the highest temperature changes during flowering. When the spathe opens, the staminal organs show the greatest heat; and after the pollen is discharged, their temperature falls, and the part of the spadix above them grows warm. Hubert states that the outer surface of the spadix is that in which the temperature is principally developed. The male organs of the Arum are also shown to have a higher temperature than the female. Dutrochet made the

* Brongniart, sur le Colocasia odora, &c.—Nouv. Ann. du Mus. iii. 145. See figure and description of this plant, which is called Fragrant Indian Kale, in the Botanical Magazine, Fig. 3935.

† Hubert, in Bory de St. Vincent, voyage dans les quatre Iles principales de la mer d'Afrique, ii. 68. See also Journal de Physique, lix. 281.

‡ Dutrochet, Recherches sur la Chaleur propre du Spadice de l'Arum maculatum à l'epoque de la floraison—Ann. des Sc. Nat. 2d ser. Bot. xiii. 65.

following observations on the heat of the female flowers of Arum maculatum :—

DATE AND HOUR.	Deviation of Thermo-electric Needle.	Heat of Female Flowers above Air.	Temperature of Air.
May 4. 2.45 P.M.	22°	2.5° F.	58.1° F.
„ 3.30 „	18	2	58.1
„ 4.45 „	16	1.8	58.1
„ 5.45 „	13	1.4	58.1
„ 7.15 „	11	1.2	57.7
„ 9 „	8	0.9	57.3
„ 10 „	6	0.6	57.2
May 5. 6 A.M.	18	2	57.2
„ 7 „	26	2.9	57.2
„ 8 „	28	3.1	57.7
„ 9 „	24	2.7	58.4
„ 10 „	17	1.9	59
„ 11 „	15	1.6	59
„ 12 noon	14	1.5	59
„ 1 P.M.	13	1.4	59
„ 2 „	12	1.3	59
„ 3 „	9	1.0	59.3

767. There is also exhibited during flowering a daily maximum and minimum of temperature, which, however, do not appear to occur at regular periods. In the case of Arum maculatum, Dutrochet found the maximum temperature in the morning, while Senebier noticed it after 6 in the evening. In Colocasia odora, Brongniart found the maximum at 5 P.M.; Vrolik and De Vriese, as well as Van Beek and Bergsma, at 3 P.M.; Hasskarl, in Java, at 6 A.M.; Hubert, in Madagascar, after sunrise.* In the gardens of Paris, Amsterdam, and Leyden, Colocasia odora attains its maximum temperature at noon. The production of heat in Arum italicum, according to Saussure, attained its maximum from 4 to 7 P.M. In an experiment with Colocasia, the first flower began to expand on 4th March, but it was not till the 6th that the escape of pollen began, and the increase of temperature was perceptible to the touch. While the temperature of the air was 73.4° F., that of the spadix was 86°. The heat of the flower gradually diminished, and in the evening its temperature was the same as that of the stove. The plant, however, regained its temperature next day at the same hour, 2 P.M., and for four days it continued, though with gradually decreasing intensity, to present a similar phenomenon, when the flower finally faded.

768. Brongniart gives the following results of his observations

* Mohl, on the Vegetable Cell, by Henfrey, p. 102. Consult also Brongniart—Nouv. Annales du Museum, tom. iii. 145; Vrolik and De Vriese—Ann. des Sc. Nat. 2d ser. v. 134, and xi. 65; Van Beek and Bergsma, Obs. Thermo-elect. sur l'elevation de temp. des Fleurs de Colocasia odora.

on Colocasia odora as regards the time and degree of maximum heat :—

DATE OF OBSERVATION.	Hour of Max. Temperature.	Temperature of Air.	Temperature of Spadix.	Temperature above Air.
Spathe opened March 14.	3¼ P.M.	76.1° F.	84.2° F.	8.1° F.
15.	4¼ „	75.2	93.2	18
Pollen discharged, 16.	5 „	74.8	93.2	18.4
Pollen discharged, 17.	5 „	75.2	95	19.8
Pollen discharged, 18.	11 A.M.	80.6	95.3	14.8
19.	10 „	77.9	82.4	4.5

The rise of temperature bore an evident relation to the development of the stamens and the emission of the pollen, and after the latter had taken place, the temperature fell, and the spadix withered.*

769. Vrolik and De Vriese record the following experiments, in the Botanic Garden at Amsterdam, on a plant of Colocasia odora (Caladium odorum), at the time when the anthers began to open :—

Experiment on 23d June 1838.

Hour.	Temp. of Air.	Temp. of Spadix.	Temp. above Air.	Hour.	Temp. of Air.	Temp. of Spadix.	Temp. above Air.
12.45 P.M.	64° F.	74.5° F.	10.5° F.	4 P.M.	64.4° F.	68° F.	3.6° F.
1.5 „	64.4	76.4	12	5 „	64.4	66.9	2.5
2 „	64.9	78.9	14	6 „	64.4	66.3	1.9
3 „	64	79.8	15.8	7 „	64.4	66	1.6
3.30 „	64	73.4	8.4	8 „	64.4	66	1.6
Continuation of Experiment, 24th June. Pollen discharged.							
11 A.M.	64.9° F.	68° F.	3.1° F.	3 P.M.	60° F.	77° F.	17° F.
12 noon	65.6	69.9	4.3	4 „	59	75.3	16.3
1 P.M	66.9	75.9	9	5 „	65.6	73	7.4
2 „	62.9	78	15.1	6 „	65.6	69.8	4.2
2.30 „	60	79.7	19.7	7 „	65.6	68	2.4
Continuation of Experiment, 25th June.							
1 P.M.	69.2° F.	82° F.	12.8° F.	2.30 P.M.	68° F.	82° F.	14° F.
1.30 „	69.2	84	14.8	3 „	68	80.9	12.9
2 „	68.1	82.5	14.4	4 „	68	78	10

The maximum occurred on the 24th, between 2 and 3 in the after-

* Brongniart, sur le Colocasia odora, et sur l'Elevation de Temperature de sa fleur.—Nouv. Ann. du Mus. d'Hist. Nat. iii. 145.

noon, at which time the temperature of the spadix was nearly 20° F. above that of the air in the conservatory.*

770. Garreau† gives the following tabular view of observations made at Lille on the heat given out by the spadix of Arum italicum. The experiment was conducted on 8th June 1851, the atmospheric temperature being 66.2° F. :—

Hours of the Paroxysm.		Heat of Spadix above Air.	Mean Heat.	Oxygen consumed.	Volume of Oxygen consumed, the Organ being taken as unity.
				Cubic cent.	
1st Hour	2 h. 30 m. 3 30	5.0° F. 10.0	7.5° F.	75	16.5
2d Hour	3 30 4 30	10.0 15.8	12.9	95	21.1
3d Hour	4 30 5 30	15.8 19.4	17.6	125	27.7
4th Hour	5 30 6 30	19.4 11.8	15.6	85	18.9
5th Hour	6 30 7 30	11.8 6.4	9.1	55	12.2
6th Hour	7 30 8 30	6.4 3.2	4.8	25	5.5

The mean heat per hour was 11.2° F., the mean of the oxygen consumed 76.6, and its mean volume, when compared with the organ as unity, was 16.9. The oxygen consumed during the 6 hours of the paroxysmal heat was 460 cubic centimetres, and that consumed during the 18 succeeding hours was 230, making in all, in 24 hours, 690 cubic centimetres. The quantity of oxygen consumed increased with the temperature. Thus in three distinct experiments the results were—

No. 1.	Mean heat,	9.9° F.	Oxygen consumed,		16.1	cubic cent.
No. 2.	—	11.2	—	—	16.9	—
No. 3.	—	13.1	—	—	17.3	—

Garreau says that the nature of the surface of the spadix of Arum seems to facilitate absorption. It consists of numerous projecting cells, giving a velvety appearance to the organ, with two or three open stomata. Saussure found that the blossom of Arum maculatum, when cold, consumed five times its volume of oxygen, but when warm, thirty times. In a flower during the paroxysm, he found that the spathe consumed five times its volume of oxygen, the bare portion of the spadix 30 times, and the part covered with flowers 132 times.

* Vrolik et De Vriese, sur l'Elevation de Temperature du Spadix d'un Colocasia odora.—Ann. des Sc. Nat. 2d ser. Bot. v. 134, and xi. 65.

† Garreau, Relation entre l'Oxygène et le Spadice de l'Arum italicum.—Ann. des Sc. Nat. 3d ser. Bot. xvi. 253.

771. The relation which the evolution of carbonic acid bears to the heat produced is thus shown by Dutrochet :—

NAME OF ORGAN.	Mean Temp. above Air in 12 Hours.	CO_2 evolved in 24 Hours.
		Cubic centimetres.
Spathe of Arum maculatum . .	0.06° F.	4.0
Spadix of do. . .	18.00	38.0
Male organs of do. . .	12.00	135.0
Female organs of do. . .	2.7	10.0
Female flower, Gourd	0.16	7.6

The quantity of carbonic acid evolved is in direct proportion to the oxygen absorbed, and the degree of chemical action which takes place determines the amount of heat.

772. The presence and contact of oxygen gas is necessary for these phenomena. When the spadix of an Arum is put into oxygen gas, the heat is developed rapidly and powerfully, the maximum difference between the heat of the oxygenated spadix and another in the air varying from 5° to 12° F.; and when the spadix is placed in carbonic acid gas or nitrogen, the evolution of heat ceases. The production of heat is prevented by covering the spadix with olive oil, grease, tallow, honey, or starch.*

4. PERIODS OF FLOWERING—FLORAL CALENDAR.

773. The age at which different species of plants produce flowers varies. Some spring from seed and produce flowers in the course of a single year and die, others produce flowers the second year after germinating and then decay, while a third set continue to flower for many years in succession. Hence the division into annual (☉), biennial (♂), and perennial (♃) plants. In some cases flowering is long delayed, and when it does occur the development of the flowering stalk takes place with great vigour and rapidity, and the plant dies after producing fruit and seed. Species of Agave exhibit this phenomenon. Thus the flowering-stalk of Agave geminiflora (Littæa geminiflora) in the garden at Nymphenburg grew 13½ feet from 14th August to 10th December 1842. In the Royal Garden at Kew in 1844 Agave vivipara (Fourcroya gigantea) produced a flowering stem which at first grew at the rate of 2 feet in 24 hours; in two months the stalk attained the height of 26 feet. A plant of Agave fœtida, which had vegetated in the Jardin des Plantes in Paris for nearly a century, and during that period had scarcely shown any signs of increase, during a warm summer began to exhibit symptoms of flowering. In 87 days

* Vrolik and De Vriese, in Ann. des Sc. Nat. 2d series, xi. 77.

the flowering-stalk grew 22½ feet. The flowering-stalk of Agave americana has been known to acquire a height of 30 feet in the space of 30 to 40 days.

774. Any cause, whether natural or artificial, which retards flowering, is attended with results of a similar kind more or less marked. When fruit trees have been in a non-flowering condition, they sometimes suddenly produce abundance of blossoms. A season in which blossoming has been scanty is often succeeded by one in which it is profuse. When the flower-buds are taken off early, it sometimes happens that an annual plant, such as Mignonette, is rendered biennial or perennial. The tree Mignonette is produced in this way. When plants grow in a rich soil it sometimes happens that, in place of producing flowers, they develope branches and leaves luxuriantly. In these instances cutting the roots, pruning the branches, taking a ring of bark out of the stem so as to retard the descent of sap, and transplanting into poor soil, frequently cause the plants to flower. Injuries inflicted on forest trees late in the season sometimes give rise to autumn flowering. When a branch is grafted on a vigorous stock it often happens that its flowering is accelerated. By this process a check is put to luxuriant branching, and the sap of the old stock stimulates the young graft or scion.

775. The different periods of the year in the various countries and climates of the globe are marked by the flowering of certain species of plants. Each climate has its peculiar floral calendar. Thus in Scotland we have the Winter Aconite (Eranthis hyemalis) and the Snow-drop (Galanthus nivalis) flowering in February, the Primrose (Primula vulgaris) in March, the Cowslip (Primula veris) and Daffodil (Narcissus Pseudo-Narcissus) in April, the Hawthorn (Cratægus Oxyacantha) in May, numerous successive species expanding their blossoms during each month of summer, the Ivy (Hedera Helix) flowering in September, and the autumn Crocus (Colchicum autumnale) pushing up its flowering-stalks in October. Every month and every week has thus its peculiar flowers. The expansion of certain flowers indicates the revival of vegetation after winter in temperate and cold regions, and after the dry season in warm countries. The time of expansion of the flowers of the same species in different countries gives indications in regard to the climate, and the difference of seasons in the same locality is also marked by the dates at which the same species flower.* The registration of the periodical phenomena of flowering or florescence is suggested by the British Association as one of the points to be attended to in determining the nature of different seasons.† In 1829 Schubler states that the Lily of the Valley (Convallaria majalis) flowered at Rome on the 26th April, at Tubingen on 10th May, at

* Linnæus gives a Floral Calendar for Upsal in Philosoph. Botanica, Stockholm, 1751, p. 272. See also Naturalist Calendar, in White's Selborne, 369.

† British Assoc. Reports for 1850, p. 338. Tables are given of the plants to be observed in regard to their periods of foliation, defoliation, and flowering.

Berlin on 17th May, and at Greifswald on 10th June. According to Berghaus the same species flower at Zurich 6 days later than at Parma, at Tubingen 13 days later, at Jena 17, at Berlin 25, at Hamburg 33, at Greifswald 36, and at Christiania 52. The Almond is said to flower at Smyrna early in February, in Germany at the beginning of April, and in Christiania not till the commencement of June. There is thus periodicity in flowering as regards the seasons, and plants retain the tendency to expand their flowers at a definite period of the year even when transported to countries where the seasons are reversed. In these circumstances they do not immediately accommodate themselves to the opposite conditions of the seasons in which they are placed, but for a while continue to show symptoms of flowering at the usual time to which they were accustomed in their native clime. Some varieties flower earlier than others of the same species. This has been noticed in the case of species of Thorn, Horse Chestnut, and many other plants. By means of slips taken from such plants gardeners perpetuate early flowering varieties.

776. Mr. M'Nab has for several years marked the periods of flowering of the same species in the same exposure in the Edinburgh Botanic Garden, and thus he has shown the difference in the seasons. The following is an example of his tables :—

NAME OF SPECIES OR VARIETY.	DATE OF FLOWERING.		
	1852.	1851.	1850.
Rhododendron atrovirens .	Jan. 14	Jan. 2	...
Garrya elliptica	" 20	" 14	Dec. 24
Rhododendron Nobleanum .	" 23	Feb. 2	...
Geum pyrenaicum . . .	" 23	Jan. 20	March 22
Erica herbacea	" 24	" 16	...
Corylus Avellana	" 25	" 16	Feb. 16
Azara dentata	" 26	...	...
Alnus glutinosa	" 27	Jan. 13	...
Galanthus nivalis	" 28	" 17	Feb. 11
Knappia agrostidea . . .	" 31	" 28	" 22
Daphne Mezereon	" 31	" 28	" 22
Eranthis hyemalis . . .	" 31	" 15	" 14
Cornus mascula	Feb. 2	Feb. 14	...
Symphytum caucasicum .	" 2	Jan. 23	March 14
Galanthus plicatus . . .	" 3	" 28	Feb. 14
Crocus susianus	" 3	" 26	" 16
Helleborus lividus . . .	" 3	" 11	March 19
Sisyrinchium grandiflorum .	" 3	" 27	" 12
Potentilla Fragariastrum .	" 5	" 26	Feb. 5
Helleborus odorus	" 10	" 20	" 14
Helleborus orientalis . . .	" 14	...	...

NAME OF SPECIES OR VARIETY.	DATE OF FLOWERING.		
	1852.	1851.	1850.
Arabis albida	Feb. 15	Feb. 7	Feb. 21
Symphytum tauricum . .	„ 16	„ 6	...
Crocus vernus and varieties	„ 18	„ 3	„ 26
Primula denticulata . . .	„ 19	„ 15	„ 23
„ nivalis	„ 20	March 16	March 1
Symplocarpus fœtidus . .	„ 20	Feb. 4	Feb. 18
Leucojum vernum	„ 21	Jan. 20	„ 18
Arabis precurrens	„ 21	Feb. 1	„ 24
Anchusa sempervirens . .	„ 21	„ 14	„ 26
Tussilago alba	„ 27	Jan. 26	March 12
„ nivea	„ 27	„ 28	„ 2
Pulmonaria angustifolia .	March 1	...	...
„ mollis	„ 2	Feb. 7	„ 11
Adonis vernalis	„ 6	„ 18	„ 16
Dondia Epipactis	„ 8	Jan. 4	„ 2
Nordmannia cordifolia . .	„ 10	Feb. 20	Feb. 28
Narcissus pumilus . . .	„ 11	March 5	March 4
Erythronium Dens Canis .	„ 12	„ 1	„ 11
Aubretia grandiflora . . .	„ 18	„ 1	„ 24
Acacia affinis (open wall) .	„ 20	„ 16	„ 22
Hyacinthus botryoides . .	„ 20	„ 11	„ 18
Scilla bifolia coerulea . .	„ 20	„ 6	„ 13
„ „ alba	„ 21	„ 4	„ 14
Ribes sanguineum (first flower opened) . .	„ 21	„ 5	„ 11
Hyoscyamus Scopolia . .	„ 25	Feb. 24	„ 1
Draba azoides	„ 26	March 14	„ 15
Anemone hortensis . . .	„ 27	„ 28	April 6
Saxifraga crassifolia . . .	„ 27	„ 4	March 20
Scilla bifolia, rubra . . .	„ 28	„ 17	„ 25
Narcissus Pseudo-Narcissus	„ 28	„ 27	„ 24
Puschkinia scilloides . .	„ 28	„ 1	„ 25
Corydalis solida	„ 28	„ 19	„ 16
Iberis sempervirens . . .	„ 28	Feb. 10	„ 9
Asarum Europæum . . .	„ 29	„ 10	„ 7
Anemone nemorosa . . .	„ 30	March 9	„ 24
Corydalis nobilis	„ 31	„ 16	„ 22
Orobus vernus	„ 31	Feb. 17	Feb. 23
Scilla sibirica	April 1	March 26	April 6
Narcissus moschatus . . .	„ 1	„ 26	March 24
Dalibarda geoides . . .	„ 2	April 3	„ 30
Hyoscyamus physaloides .	„ 2	March 28	„ 30
Omphalodes verna . . .	„ 2	„ 10	„ 22
Fritillaria imperialis . .	„ 3	„ 13	„ 20
Hyoscyamus orientalis . .	„ 5	„ 28	April 1

777. Temperature is a most important agent in causing plants to flower, but in each species the range of flowering-temperature is definite. A high temperature, in the case of plants belonging to cold regions, often makes them produce leaves in place of flowers, or if flowers are produced, they drop off and are abortive. Fruit trees of temperate regions, when grown in tropical countries, are frequently unproductive. In cultivating plants in hot-houses, it is of importance to regulate the temperature, and at the same time to attend to the state of moisture and ventilation, if we wish the plants to flower properly.

5. VIGILS OF PLANTS—SLEEP AND AWAKING OF FLOWERS.

778. There are differences in regard to the hours of the day at

Fig. 1171.

Fig. 1172.

which flowers expand. Some open at dawn of day, others a few hours

Fig. 1171. Head of flower of the Common Marigold (*Calendula officinalis*), belonging to the Compositæ which close their florets in the evening. The outer florets, or those of the ray, cover those of the centre or disk, and thus protect them. The same thing takes place in the Daisy.

Fig. 1172. A species of Star of Bethlehem (*Ornithogalum umbellatum*), which closes its flowers about 11 A.M., and is hence called Lady-Eleven-o'Clock. The flowers come off from the common rachis in a corymbose form. The bulb, *a*, is scaly, and produces small bulbs or cloves in the axil of the scales. This bulb is supposed to be the *Chirionim* or cab of Doves' Dung mentioned in Scripture as being sold during the famine in Samaria for a large sum.—2 Kings vi. 25.

later, others at mid-day, others in the evening, and a few after darkness has come on. Roemeria violacea expands its blossoms early in the morning, and the petals have generally fallen off two or three hours before noon. Many Composite plants (Fig. 1171) show a remarkable tendency to open and close their florets. Species of Goat's-beard (Tragopogon) receive the common name of *go-to-bed-at-noon* on account of closing their florets at mid-day. Œnothera biennis is called Evening Primrose from opening its flowers in the evening.

Fig. 1174.

Fig. 1173.

Fig. 1175.

779. The vigils of plants attracted the attention of Linnæus, and he constructed what he called a Floral Clock, in which the hours of the day were indicated by the opening of certain flowers, and which were hence called horological. The following is a specimen of such

Fig. 1173. One of the Cichoraceous plants, the Chicory (*Cichorium Intybus*), which opens its flowers early in the morning. It is a Composite plant. The root yields chicory, which is often mixed with coffee.

Fig. 1174. Scarlet Pimpernel (*Anagallis arvensis*), which opens its flowers about 8 A.M., and closes them during gloomy weather and rain. It is called Poor Man's Weather-glass.

Fig. 1175. A Ficoid plant (*Mesembryanthemum falciforme*), the flowers of which open and close under the influence of light and darkness.

an arrangement of flowers, in which the hours indicate the periods of waking from sleep—it is given by De Candolle* from observations made at Paris:—

	Hours of Waking.
Ipomœa purpurea	2 A. M.
Ipomœa Nil (Fior de Notte) and Calystegia sepium	3-4 A. M.
Tragopogon, and some other Cichoraceæ, Matricaria suaveolens	4-5 A. M.
Papaver nudicaule and most Cichoraceæ (Fig. 1173)	5 A. M.
Ecbalium Elaterium, Lapsana communis, and some Cichoraceæ, Convolvulus tricolor	5-6 A. M.
Hypochæris maculata, several species of Solanum, Convolvulus siculus	6 A. M.
Species of Sonchus and Hieracium	6-7 A. M.
Species of Nymphæa, Nuphar, Lactuca, and Camelina, Prenanthes muralis	7 A. M.
Mesembryanthemum barbatum, Specularia Speculum, Cucumis Anguria	7-8 A. M.
Anagallis arvensis (Scarlet Pimpernel), (Fig. 1174)	8 A. M.
Nolana prostrata	8-9 A. M.
Calendula arvensis	9 A. M.
Arenaria rubra	9-10 A. M.
Mesembryanthemum nodiflorum	10-11 A. M.
Ornithogalum umbellatum (Fig 1172), (Lady-Eleven-o'Clock)	11 A. M.
The greater part of the Mesembryaceæ (Fig. 1175), Passiflora cærulea	12 A.M.
Scilla pomeridiana (at Montpelier), Pyrethrum corymbosum	2 P. M.
Silene noctiflora	5-6 P. M.
Œnothera biennis	6 P. M.
Mirabilis Jalapa	6-7 P. M.
Lychnis vespertina	7 P. M.
Cereus grandiflorus, Mesembryanthemum noctiflorum, Œnothera tetraptera and suaveolens	7-8 P. M.

780. Fritzsch has paid particular attention to the opening and closing of flowers, and gives the results of observations made at Prague, in Bohemia. He states that these phenomena are rarely momentary, but that they are slow and continuous processes, which at all hours of the day are in varying degrees of intensity. He examined 140 species of plants belonging to 29 natural orders, and found that the phases exhibited by flowers in regard to sleeping and waking are influenced by light, by temperature, and more especially by insolation or exposure to the direct rays of the sun. They are also, in a certain degree, dependent on colour. These facts will be illustrated in the succeeding remarks taken from a translation of Fritzsch's paper.†

781. Table showing the commencement of sleep and waking in different species:—

* De Candolle, Physiologie Végétale, ii. 484. See also Linnæus—Philos. Bot. Ed. Vindòbon, 1763, p. 278, and Vigiliæ Florum Solarium—Philos. Bot. p. 273.

† Fritzsch, Resultate mehrjährige Beobachtungen uber jene Pflanzen deren Blumenkronen sich täglich periodisch Offnen und Schliessen—Translated in Journ. of Hort. Soc. of London, viii. 1.

Hours.	Commencement of Sleep. No. of Species.	Awaking. No. of Species.	Hours.	Commencement of Sleep. No. of Species.	Awaking. No. of Species.
0.5 P.M.	7	1	0.5 A.M.	0	0
2.5 „	16	1	2.5 „	1	3
4.5 „	24	0	4.5 „	0	12
6.5 „	25	2	6.5 „	2	34
8.5 „	6	0	8.5 „	1	28
10.5 „	2	0	10.5 „	1	2

From this table it appears that the hour 6 P.M., at which the greater number begin to close, is twelve hours distant from that, 6 A.M., at which the greater number begin to expand. The duration of sleep varies from 10 to 20 hours, the mean being about 14.

782. Although there seems to be no time of day when the blossoms of certain plants do not open, yet in the greater number of cases they are closed soon after sunset. The number of species which begin to awake increases slowly at the early hours of the morning, then more rapidly from 2 A.M. to 7 A.M., and decreases again rapidly after mid-day. After that hour only those species open which are night-bloomers. With the exception of a few hours about midnight there is no hour of the day at which blossoms do not begin to close; there are, however, only a few about mid-day, from which time the number increases, reaching its maximum at 6, and then again decreasing.

783. When blossoms begin to open after the cessation of sleep, the change usually takes place in the first instance slowly, then more rapidly, and, as it approaches its maximum, there is another retardation. In a few plants only the complete expansion lasts an hour, more commonly not so much; they then begin to close again, at first slowly, afterwards more rapidly, and, as they approach the maximum of approximation of their petals, the progress is again slow. The flower remains many hours in a more or less closed condition, until the time returns for a new cycle of phases. The state of expansion of the corolla varies. In some cases the limb spreads out at a right angle with the tube, in other cases the angle is less, while in some the limb is turned down so as to form an oblique angle with the tube. Estimating the angular value of the degree of expansion as follows:—

	Angular value of phase.	Corresponding angle.		Angular value of phase.	Corresponding angle.
Perfectly closed	0	0°	Half reflected	150	135°
Half open	50	45°	Completely reflected	200	180°
Completely expanded	100	90°			

Fritzsch obtains the following results:—

Minimum in 17 species	0	Maximum in 16 species	81-90
„ 28 „	1-10	„ 13 „	91-100
„ 18 „	11-20	„ 4 „	101-110
„ 5 „	21-30	„ 8 „	111-120
„ 10 „	31-40	„ Barkhausia fœtida	121-130
„ 4 „	41-50	„ Solanum vulgare	131-140
Maximum in Crocus vernus	31-40	„ Scorzonera hispanica	141-150
„ 4 species	41-50	„ Tigridia pavonia	180
„ 10 „	51-60	„ Pyrethrum corymbosum	190
„ 14 „	61-70		
„ 15 „	71-80		

784. The time of the greatest expansion of the flowers varies in different species. In general the number of species whose blossoms attain the maximum of their phase increases from sunrise to mid-day, and then decreases till sunset. None of the day-bloomers are open till 7 A.M., or later than 5 P.M. A similar law seems to hold good with the night-bloomers, which generally seem to open their corolla fully towards midnight, while at mid-day they are completely closed.

Table showing the time of the greatest expansion of the flower.

Time of greatest Expansion.	No. of Night Bloomers.	No. of Day Bloomers.	Time of greatest Expansion.	No. of Night Bloomers.	No. of Day Bloomers.
0.5 P.M.	0	27	0.5 A.M.	1	0
2.5 "	0	13	2.5 "	0	0
4.5 "	0	4	4.5 "	0	0
6.5 "	0	0	6.5 "	0	1
8.5 "	0	0	8.5 "	0	16
10.5 "	2	0	10.5 "	0	26

Thus at the inferior culmination of the sun the night-bloomers are most expanded; the expansion decreases as the sun approaches the horizon; at sunrise they close, when the day-bloomers commence their phases. The day-bloomers are most expanded at mid-day, and closed again towards sunset, when the night-bloomers in turn recommence their course.

785. In those blossoms which are fully expanded in the morning, the duration of expansion is short. In those blossoms which expand in the afternoon, the condition of waking is limited by the length of time the sun is above the horizon. In those blossoms which are fully expanded in the night, the duration of sleep is shortest.

Mean Duration of Sleep in Flowers which open at different times of the day :—

Morning-bloomers (41 species) 14.8 hours.	Afternoon-bloomers (27 species) 12.9 hours.
Mid-day-bloomers (15 species) 14.2 hours.	Night-bloomers (3 species) 11.8 hours.

Those blossoms which are fully expanded in the morning open in general more rapidly than they close, while in those which open in the afternoon the contrary law prevails.

786. While the time of sleep of plants is in close connection with the apparent daily course of the sun, the degree of expansion depends on the temperature of the air and various meteoric conditions, as well as on insolation or exposure to the direct rays of the sun. Hoffmann states that heat is the cause both of the awakening and the sleeping of plants, and that light only enters into those effects in so far as it contains heating rays.* The temperature at which flowers begin to

* Hoffmann, uber der Pflanzenschlaf, Giessen, 1850. Recherches sur le sommeil des Plantes—Ann. des Sc. Nat. 3d ser. Bot. xiv. 310. See also Bot. Gazette, May 1851, and Dutrochet, du Reveil et Sommeil de Fleur—Ann. des Sc. Nat. 2d ser. Bot. vi. 177.

expand varies, and the time of the year has therefore a marked influence :—

Temp. Fah. at which Species begin to expand.		Mean Time of Observation.
38.75°	Two species . . .	April 3.
43.25	Five „ . . .	April 18.
47.75	Nine „ . . .	May 18.
52.25	Sixteen „ . . .	June 16.
56.75	Fourteen . . .	July 5.
61.22	Six „ . . .	July 12.
66.75	Malva Alcea . . .	July 7.

787. The following table indicates the temperature at which the greatest degree of expansion of the flowers take place :—

Temp. Fahr.		Mean Time of Observation.
47.75°	Mirabilis Jalapa (night-bloomer)	
56.75	Erodium cicutarium . .	May 6.
	Lychnis vespertina (night-bloomer)	
61.25	Four species	Aug. 10.
	Funkia japonica (night-bloomer)	
	Œnothera biennis (night-bloomer)	
65.75	Three species	July 2.
70.25	Eleven „	May 27.
74.75	Thirteen „	May 30.
79.25	Fifteen „	June 26.
83.75	Twenty „	June 29.
88.25	Thirteen „	July 13.
97.25	Echinocactus Ottonis . .	July 15.
106.25	Carlina acaulis . . .	Sept. 1.

The night-bloomers reach the maximum of expansion at from 47.75° to 61.25° ; the day-bloomers from 79.25° to 88.25°.

788. The temperature at which all motion in the corolla ceases varies, as seen by the following list :—

In three species, motion	ceased at	74.75° F.
In three „	„	83.75
In five „	„	88.25
In four „	„	92.75
In seven „	„	97.25
In Commelina cœlestis	„	101.75

Thus some flowers cannot bear a temperature of 74.75°, while others can endure a temperature of 100° and more.

789. Plants, in ordinary circumstances, require the light of the sun in order to awake from sleep, either directly by insolation, or indirectly by diffusion in the atmosphere. Some are so sensitive that they begin to expand the moment the sun's rays illuminate the higher regions of the atmosphere. As the intensity of light increases, the number of species which expand their blossoms increases. The

number of species increases as the hour approaches at which insolation (exposure to the direct rays of the sun) ceases. No blossom closes before the insolation begins, for even those flowers which usually close before mid-day remain for some hours open when exposed to the direct rays of the sun.

790. Exposure to artificial light causes some flowers to expand. The flowers of Crocus have opened under the light of an Argand lamp, those of Gentiana verna expanded fully when exposed to the light of a gas-burner. Gloomy weather and rain cause flowers to close. Those which are very sensitive to such influences are called meteoric. There is a periodicity in flowering which is not easily interrupted. If a plant is accustomed to flower in daylight at a certain time, it will still make an effort to expand its flowers at the wonted time even when confined in a dark room; showing that light is not the only cause of the expansion. De Candolle made experiments on the effects of light and darkness in flowering. He kept plants in two cellars, one warmed by a stove and dark, and the other lighted by lamps. On some plants, as Convolvulus arvensis and Cneorum, the artificial light had no effect; they still followed the clock hour in their opening and closing. Other plants expanded their blossoms slowly. Night-bloomers appeared disturbed both by perpetual light and perpetual darkness. In either condition they accelerated their movements so much that in 6 days they had gained half a day, and thus exchanged night for day as their time of opening.

791. As regards the connection between the colour of flowers and their expansion, Fritzsch says that yellow blossoms possess the strongest tendency to contract and expand, then follow white, red, and blue. Of the species examined, the following are the relative numbers:—

Colour of Flower.	No. of Species showing Movements of Flower.	Per Centage of Species Examined.
Yellow	39	42.5
White	22	23.8
Red	19	20.9
Blue	12	12.9

The following are the temperatures at which different-coloured flowers expand their blossoms:—

Colour.	Temp. at which Flowers Wake from Sleep.	Temp. at which Flowers attain Greatest Expansion.	Temp. at which Flowers Lose all Motion.
White and Red	51.125°	75.65°	88.7°
Blue and Yellow	51.125	78.8	93.65

792. The direction and position of the flowers on their stalk appear in some cases to be controlled by the sun's rays. This is particularly the case in Composite plants. The capitula of some of them are erect during the day, and droop at night. Species of Hypochæris are said to incline their heads towards the quarter of the heavens in which the sun is shining. The name Sun-flower (Helianthus, Girasole) was given

to a genus of Composite plants on account of the supposed influence of the sun on the direction of their heads.* In Victoria regia there is a spontaneous motion of the flower and the flower-stalk, the cause of which appears to be very obscure. It was observed by Paxton, and is thus described by the Hon. Mr. Chitty, as having been seen by him and Dr. M'Nab in Jamaica. On the 8th September at 6 A.M. the apex of the flower was seen pointing to the north-west. As it rose more above the water, it was seen gradually to wheel round by the west, and south, and north, to west again. The peduncle, which was several inches longer than was necessary to elevate the flower to the surface of the water, had now a spiral twist. At half-past 3 P.M. on the same day the flower was pointing north-west, while Mr. Chitty was inspecting it in that position, it suddenly and quickly wheeled round the quarter of a circle, namely, from north-west to north-east. On the following day the same phenomenon was noticed, the flower being rolled from north-east to north. The phenomenon seemed to be connected with the spiral twisting of the peduncle, and probably may be traced to the action of light and heat.

793. Melampyrum pratense, arvense, and sylvaticum, according to Vaucher, turn their flowers towards the light, which is not the case with Melampyrum cristatum. The flowers of some species of Narcissus incline towards the light by a double movement, that of the pedicel, which bends, and that of the peduncle, which twists. During maturation the pedicel and the capsule become erect, but the peduncle remains twisted. Occasionally movements of irritability are observed in petals. Morren observed them in the labellum of some Orchids, such as Megaclinium falcatum,† and they have been noticed also in the stalk of the labellum of Drakea elastica, which bends in a hinge-like manner when irritated. The petals of Gentiana sedifolia close when touched.

6. COLOURS OF FLOWERS.

794. The Colours of Flowers naturally attract the attention of all, and their varied hues are in an especial manner an object of interest to the florist. These colours usually reside in the corolla, but in the case of many plants, especially Monocotyledons, they occur both in the calyx and corolla (perianth); and in some instances, as in Salvia and Amherstia, the bracts are highly coloured. The changes produced by culture on the colours of many plants are familiar to every one, and they may be well illustrated in the case of the Tulip and Dahlia, the flowers of which are naturally of a yellow colour, but in the hands of the florist assume all varieties of red, white, and yellow. From its variable nature, colour is not taken much into account by the prac-

* This turning to the sun has given rise to the name of Girasole Artichoke (Helianthus tuberosus, a kind of Sunflower), and the name has been corrupted to Jerusalem Artichoke.

† Morren, on Megaclinium falcatum, in Mém. de l'Acad. de Bruxelles, xv.

tical botanist in the determination of the species of flowering plants. It is chiefly in Cryptogamic plants, such as Fungi and Sea-weeds, that this character is regarded of value. It is probable, however, that too little attention has been paid to this subject, owing to the want of an accurate nomenclature, such as has been adopted by Werner in the characters of minerals. Henslow long ago suggested a method by which a correct and comprehensive nomenclature might be established for defining colours in plants. His scheme is a modification of one suggested by Mirbel, and consists in referring all natural colours to certain absolute tints or shades, determined according to fixed rules. Thus, he refers all colours to different degrees of mixture between three colours called primary. They may be assumed, for instance, to be red, blue, and yellow, or purple, orange, and green. If we take red, blue, and yellow, then a mixture of red and blue makes purple; of red and yellow makes orange; of blue and yellow makes green; and innumerable binary compounds may be made by uniting the primaries, two and two, in different proportions. Numerous shades also may be obtained between the deepest that can be found and the faintest, by diluting each colour to a greater or less extent. Thus, he divides a circle into three equal parts, and places blue, red, and yellow respectively in each of the divisions. Around this circle a second is described, and divided into six equal compartments, containing respectively the three primaries, and also those three binaries which are exactly intermediate between them, viz., orange (red and yellow), purple (blue and red), and green (blue and yellow). Another circle, containing twelve equal compartments, is now described round the last, and in these are placed the last six colours, together with six new ones formed by uniting each contiguous pair in the same way as before. Another circle would contain twenty-four colours, and so on; each fresh addition being always formed from the combination of two contiguous colours in a former circle, and between which it is exactly intermediate; and the whole being reduced to a uniform shade in depth of tint.*

795. In this way every conceivable binary compound or pure colour might be formed. But as the colours in contiguous compartments will differ less and less from each other as the circles extend, Henslow thinks that a third circle of twelve colours will be sufficient

* Henslow remarks, If the three colours, purple (B + R), orange (R + Y), and green (B + Y), or any other three taken at equal intervals round a circle constructed on the above principle, had been assumed as our three primaries, and these had been combined two and two, we should have obtained all the pure colours as before, and among them the three former primaries (blue, red, and yellow), under the character of binary compounds. This will be apparent, when we recollect that the union of three primaries such as blue, red, and yellow (B + R + Y), in equal proportions forms white light with the colours of the spectrum, and a grey or neutral tint when material colours are employed.

Green + Orange = (B + Y) + (R + Y) = (B + R + Y) + Y = White + Yellow—the latter giving the colour.

Orange + Purple = (R + Y) + (B + R) = (B + R + Y) + R = White + Red.

Green + Purple = (B + Y) + (B + R) = (B + R + Y) + B = White + Blue.

—Henslow's Principles of Descriptive and Physiological Botany, p. 195.

to give a series which can be easily appreciated, and these he calls fundamental or basial colours. They would stand thus—

B = Blue.
2 B + R = Bluish-purple or purplish-blue.
B + R = Purple.
2 R + B = Reddish-purple or purplish-red.
R = Red.
2 R + Y = Reddish-orange or orange-red.
R + Y = Orange.
2 Y + R = Yellowish-orange or orange-yellow.
Y = Yellow.
2 Y + B = Greenish-yellow or yellowish-green.
Y + B = Green.
2 B + Y = Bluish-green or greenish-blue.

Henslow then proceeds to point out the importance of constructing a chromatometer or measurer of colours, on such principles as to enable the botanist to have a uniform standard to appeal to. There seems to be no doubt that this might be accomplished with benefit to science. The range of colours in species might thus be correctly defined, and an accurate nomenclature established, which is a great desideratum.

796. We now proceed to consider the colours presented by flowers, and more especially the changes which they undergo by cultivation. These changes, although they appear to be endless, are really limited in their extent. In reference to their colours, flowers are divided by De Candolle* into two series—1. Those having *yellow* for their type, and which are capable of passing into red and white, and never into blue. 2. Those having *blue* for their type, and capable of passing into red and white, but never into yellow. The first series is called *Xanthic*, the second *Cyanic*. The following is a tabular view of the two series, green being considered as an intermediate state of equilibrium between the two :—

Red Orange-red Orange Yellow-orange Yellow Yellow-green	Xanthic Series.
Green. Colour of Leaves.	
Blue-green Blue Blue-violet Violet Violet-red Red	Cyanic Series.

* De Candolle, Physiologie Végétale, ii. 906. See also, Schubler and Funk, Untersuchungen ueber die Bluthenfarben, Tubingen, 1825.

Or the table may be given thus :—

	Green.		
Cyanic Series.	Blue-green	Yellow-green	Xanthic Series.
	Blue	Yellow	
	Blue-violet	Yellow-orange	
	Violet	Orange	
	Violet-red	Orange-red	
	Red.		

Green, which is made up of blue and yellow, is the centre whence the two series diverge, and they meet again in red.* It would appear that all flowers capable of changing colour, do so in general by rising or falling in the series to which they belong. Thus in the Xanthic series, the flowers of the Marvel of Peru may be yellow, orange-yellow, or red; those of the Austrian Rose, orange-yellow or orange-red; those of the Indian Cress vary from yellow to orange or orange-red; those of the garden Ranunculus pass through every gradation in the series from red to green. In the Cyanic series, the Anemone varies from blue to violet and red; the Hyacinth from green to red, through all the gradations; Lithospermum purpuro-cæruleum, and many Boraginaceæ, from blue to violet-red; the Hydrangea from rose colour to blue; and the ligulate flowers of the China Aster from violet-blue to violet-red and red.

797. These rules cannot be said perhaps to be universally applicable. They appear, however, to be very general, and they are useful in enabling us to predict the possible varieties of colour in the flowers of the same species. To the Xanthic series belong Adonis, Aloe, Cactus, Camellia, Cytisus, Dahlia, Lysimachia, Mesembryanthemum, Œnothera, Oxalis, Potentilla, Ranunculus, Rose, Tulip, Verbascum, &c. As examples of the Cyanic series may be mentioned Anagallis, Campanula, Epilobium, Geranium, Globularia, Hyacinth, Phlox, Polemonium, Nemophila, Scilla, Vinca, &c. Some exceptions occur to the rule laid down: thus, while Hyacinths are in general blue, red, or white, some varieties assume a pale yellowish hue; the yellow Auricula of the Alps, although it does not become pure blue, exhibits occasionally a violet hue; the flowers of Myosotis versicolor change from yellow to pale blue.

798. The original colour of the Tulip is yellow, and although by cultivation it is made to assume all the varieties of colour in the yellow series, we do not find it becoming blue. Such is also the case with the common Dahlia and the Rose. No one has succeeded in getting a blue variety of either of the latter. The Geranium, on the other hand, although it presents all shades of blue, red, and white, does not become yellow. There seems thus to be a certain limit in the range of colour which a species can be made to assume. These remarks

* Morot, Recherches sur la Coloration des Végétaux—Ann. des Sc. Nat. 3d ser. Bot. xiii. 160.

apply only to the change of colour in a given species. They will not apply in all cases to every species of a genus. Thus, while most of the Gentians belong to the blue series, and do not become yellow by cultivation, there is a yellow species of the genus (Gentiana lutea) which never changes into blue. Such is also the case in the genera Aconitum, Linum, Sonchus, &c. Again, we find certain plants exhibiting, in the same flower, blue and yellow colours. This is seen in Dendrobium sanguinolentum;* also in Pansies, and in many other parti-coloured flowers, as in Convolvulus tricolor, and in species of Myosotis, which have a yellow zone round the corolline tube, while the upper part is blue. In these last mentioned cases each of the coloured portions of the flower vary in general only in their proper series—the part which is yellow never becoming truly blue, nor the blue yellow. The florets of the ray of Composite plants often exhibit blue colours, while those of the disc are yellow. The law by which the changes of colour are regulated has not been ascertained, and it is impossible, in the present state of our knowledge, to predict what colour a florist's flower will assume. The different rays of light have different effects as regards colours. It would appear, also, that the nature of the soil sometimes alters colours. Thus, Hydrangea hortensis (Hortensia speciosa) produces blue in place of pink flowers, when planted in some kinds of bog earth and of yellow loam.

799. The colours of flowers often appear to depend on the state of oxygenation of the juices.† Certain flowers have a pale hue when first produced, and change under the influence of sunlight: thus Cheiranthus Chamæleo has at first a whitish flower, then a citron-yellow, then red or slightly violet; the petals of Stylidium fruticosum are pale yellow at first, then lightish rose-coloured; the flowers of Œnothera tetraptera are first whitish, then rose-coloured or nearly red; the corolla of Cobæa scandens is greenish-white the first day, and violet the day following; the flowers of Hibiscus mutabilis appear in the morning of a white colour, towards mid-day they become flesh-coloured, and at night they are red. The central portion of the floral leaves (bracts) of Hakea Victoria is during the first year yellowish-white; during the second, golden-yellow; during the third year, orange; and during the fourth, blood-red. The common pink Phlox is said, early in the morning, to have a lightish blue colour, which alters as the sun advances, and becomes pink. The colours of many Boraginaceous flowers are first pink and then blue. In Phaseolus Caracalla the white changes to yellow, having originally been violet. Changes in oxygenation are said to cause these variations in the colours. In Phlox it has been supposed that some substance is present which becomes blue by the non-elimination of oxygen during the night;

* Botanical Register, January 1843.

† The effect of oxygenation on the flowers of plants is very marked: thus the juice of Socotrine Aloes, when it exudes, is first violet, and next becomes brown; so also that of Œnanthe crocata, which is first colourless, then brown. Certain Fungi (species of Boletus), when bruised, assume a blue colour from oxygenation of their juice.

and as the oxygen is given out during the day, the blue colour disappears; while the red, which had been partially discharged by the same cause, is restored as the oxygen is exhaled.

800. Injury to the petals, during the process of decay, causes the colours of flowers to change. The white flowers of Camellia japonica, when bruised, assume a brown colour, in consequence of an alteration in their colouring matter, those of Bletia Tankervilleæ and of Calanthe veratrifolia change into blue. The yellow flowers of Melampyrum become black on drying, and so do the purple flowers of Lathyrus niger. The yellow ligulate flowers of Hieracium staticifolium, and of some other yellow Cichoraceous plants, and the yellow flowers of some Leguminosæ, such as Lotus, become greenish-yellow on drying; the blue flowers of Ipomœa Learii in drying become red, while those of Campanula become whitish.

801. The colours of flowers depend on a substance different from chlorophyll. The colouring matter is usually of a fluid nature, and has not the composition of chlorophyll. The colours are, however, influenced by light, although in different ways. Marquart thinks that there is a peculiar matter called Anthocyane or Anthokyan, which is the colouring matter of blue, violet, and red flowers, and another called Anthoxanthin, the colouring matter of yellow flowers. Orange flowers contain both. Feeble acids colour anthocyan violet, while energetic acids colour it red. Concentrated sulphuric acid colours anthoxanthin indigo-blue and then purple, by taking away the elements of water.*

802. Professor Hope† made experiments on the coloured and colourable matters of the leaves and flowers of plants. He thinks that there resides in the same parts of plants, in addition to the chromule or coloured matter, some substance probably destitute of colour, which becomes red by the action of acids, and yellow or green by the action of alkalies. This substance he denominates Chromogen, and he considers it as consisting of two distinct principles, one which forms the red compound with acids, and which he calls Erythrogen; and another which affords a yellow compound with alkalies, which he calls Xanthogen. Leaves, in addition to green chromule or chlorophyll, contain Xanthogen, and some of them (excepting those which have some tint different from the green), contain Erythrogen. White flowers contain Xanthogen, but no Erythrogen; such is also the case generally with yellow flowers, while red and blue flowers contain both Xanthogen and Erythrogen. Litmus is a solitary example of a substance abounding largely in Erythrogen, but containing no Xanthogen.

803. In 1831, Kohler, of Tubingen, published an Inaugural Dissertation, in which he gave the results of some investigations made

* Marquart, Die Farben der Blüthen, Bonn. 1835. On the Colours of Flowers—Edin. New Phil. Journ. xx. 429.

† Hope, Observations on the Coloured and Colourable Matters in the Leaves and Flowers of Plants—Proceedings of the Roy. Soc. of Edin. 21st March 1836. Also Ellis's description of a Plant Case, in Loudon's Gardener's Magazine, xv. 495.

by himself and Schubler, relative to the colour of the flowers in different families of plants. They examined the relations of the flowers of 4200 plants belonging to 27 different natural orders and tribes, of which 20 were dicotyledonous and 7 monocotyledonous. The dicotyledons belonged to orders and tribes represented by the following genera:—Jasmine, Nightshade, Gentian, Borage, Heliotrope, Lysimachia, Primrose, Polemonium, Convolvulus, Harebell, Violet, Butterwort, Vine, Madder, Rose, Ranunculus, Poppy, Water-lily, Figwort, Wallflower. The monocotyledons belonged to orders and tribes represented by the following genera:—Lily, Hemerocallis, Amaryllis, Squill, Iris, Smilax, and Indian-shot. The monocotyledons examined had generally a greater tendency to flowers of the white and yellow-red series of tints than the dicotyledons, while blue flowers were more frequent in the latter.

804. The following table is given of the distribution of colours in these natural orders:—

Colour of Flower.	In 4200 Species.	Mean of 1000.	Colour of Flower.	In 4200 Species.	Mean of 1000.
White .	1193 .	284	Green .	153 .	36
Yellow .	951 .	226	Orange .	50 .	12
Red .	923 .	220	Brown .	18 .	4
Blue .	594 .	141	Black .	8 .	2
Violet .	307 .	73			

Hence it would appear that in the species examined, white was the most extensively distributed colour; and that among the other coloured flowers, yellow, red, and blue were of more frequent occurrence than the three intermediate tints (violet, green, and orange). Of the three primary colours, yellow was most abundant, blue the rarest, while of the three intermediate colours violet was the most frequent. It is doubtful whether a truly black colour exists in flowers. The darkest tints, as in the flower of the Bean, are of a deep brown hue.

805. Different colours prevail in different natural orders, as seen by the following table:—

100 Species.	White.	Red.	Violet.	Blue.	Green.	Yellow.	Orange.
Water-lily family .	46	11	—	14	—	28	—
Rose „ . .	40	32.2	0.5	—	—	52.2	—
Borage „ . .	35	10	9	28	3	13	0.5
Primrose „ . .	27	41	7	6	1.5	15	9.7
Convolvulus „ . .	27	39	10	12	—	7	2.4
Ranunculus „ . .	19	16	4	15	2	42	0.5
Campanula „ . .	10	5	21	58	—	3	0.7
Poppy „ . .	7	38	9	—	—	36	7

Thus the Water-lily and Rose families contained the greatest number of white-flowered species, the Poppy and Campanula tribes the fewest. Primroses and Convolvuluses were richest in red, Campanulas in blue, and Ranunculuses in yellow.

806. It would appear that certain districts are occasionally characterised by the prevalence of flowers of a particular colour. It is said that in New Guinea and Papua there is a great proportion of white flowers. Hinds says that out of 50 species examined by him there were 12 blue, 23 yellow, and 15 white. Brown and yellow Papilionaceæ abound in many parts of Australia. In Central America, 10° north latitude, and in a similar parallel to New Guinea, the series of colours, according to Hinds, were 12 blue, 30 yellow, and 8 white; and in a high northern latitude, 57°, there were 26 blue, 13 yellow, and 11 white.

807. The arrangement of coloured flowers in the parterre is a matter deserving the attention of gardeners.* Chevreul has written very fully on the subject. He states that an important principle is to combine such colours as produce white light. Thus red, blue, and yellow form, by their union, a white ray. Hence flowers of these colours may be, with propriety, placed together; or a flower of one of these primary colours may be combined with one whose colours is made up of the other two in the shape of a binary compound. Thus, red agrees well with green, which is made up of yellow and blue. This may be seen in the case of the scarlet Pelargonium, where the colour harmonizes with its own green leaves, or with the green of other plants around it; so also in the case of red Dahlias. Again, blue harmonizes with orange compounded of yellow and red, as may be illustrated by a combination of the Brachycome iberidifolia with Erysimum Perofskianum. Yellow harmonizes with violet, composed of blue and red, as seen in the petals of Pansies. To produce the best effect the colours should be as nearly as possible of the same tone.

808. In cases where colours do not agree, placing white between them restores the effect. White is said to come in best in the complimentary arrangement of blue and orange, and worst in that of yellow and violet. The primary colours, red, yellow, and blue combined in pairs, give a better effect than a combination of one primary colour with one binary colour containing that primary one.

Thus,	Red and yellow	are better	than	Red and orange.
,,	Yellow and blue	,,	,,	Yellow and green.
,,	Blue and red	,,	,,	Blue and violet.
,,	Red and blue	,,	,,	Red and violet.
,,	Blue and yellow	,,	,,	Blue and green.
,,	Yellow and red	,,	,,	Blue and violet.

Where a primary colour, and a binary one containing the primary are combined, the brighter the tint of the binary the better.

* M'Intosh, Book of the Garden, i. 593.

809. Chevreul has given the following illustrations of the mode of arranging flowers as regards their colours :—

1. White Arabis, Saxifraga crassifolia, and Caucasian Doronicum.
2. Saxifrage, Doronicum, Arabis, and Purple Honesty.
3. Blue Hyacinth, yellow Narcissus, repeated ; or Hyacinths alone, white and red repeated ; or white, blue, white, red, &c., repeated.
4. Iberis sempervirens, and Alyssum saxatile repeated ; Iberis, Phlox varia (purple), Anemone pavonina (red), or Anemone appenina (sky-blue).
5. White and blue Periwinkles, white and blue Violets, mixed along with common Anemones.
6. Cydonia Japonica, rising as a bush in a bed of Violets.

Kemp says that to produce strong and striking effects there must not be merely a tolerable collection of plants mixed together and disposed so as to give variety and contrast of colour, but groups of particular kinds should be planted in permanent places.*

810. Dr. Hope examined the effect of sulphurous acid on the colours of flowers. It did not affect white flowers, nor did it decolorize any of the yellow flowers submitted to its action ; of thirty or forty red flowers it decolorized all, with the exception of two or three ; of twenty blue flowers only two, Commelina cærulea and Centaurea Cyanus (Fig. 392, p. 163), resisted its blanching powers. It decolorized some of the orange-coloured flowers, but rendered others of them of a bright yellow ; it decolorized all the purple flowers that were tried, except purple Centaurea Cyanus, which it rendered blue, and purple Scabiosa atro-purpurea, which it reddened.†

7. ODOURS OF FLOWERS.

811. The odours of flowers, as well as their colours, vary much.‡ The sources of odours in flowers are very obscure. They are often traced to the presence of fragrant volatile oils or resins. The effluvia are of such a subtle nature as to elude chemical analysis. They are usually developed under the influence of sunshine, but in certain instances odours are emitted during the absence of light. Some flowers are only odoriferous in the evening. This is the case with Cestrum nocturnum, with several species of Catasetum and Cymbidium, and with Lychnis vespertina. Certain flowers, such as Hesperis tristis, and Nyctanthes arbor tristis, receive their specific names (tristis, sad) from giving out their fragrance only at night. Morren states that

* Kemp, on the laying out of a small garden.

† Hope, on Coloured and Colourable Matters in Flowers—Proceedings of Edin. Roy. Soc. March 21, 1836. Sulphurous acid, whether employed in its gaseous or liquid form, did not decolorize the chlorophyll of leaves.

‡ The study of the odour of flowers has received the name of Osphresiology.—See Cloquet sur les odeurs, Paris, 1815.

the flowers of Habenaria bifolia, near Liege, which are quite scentless during the day, give out a pleasant penetrating aroma in the evening, usually about 11 P.M. He found that the perfume manifested itself at twilight, exhibited the greatest energy at the time when the darkness of night prevailed, and decreased with the dawn. Two racemes of flowers of this Orchid were placed in two cylindrical glasses filled with water, in which the plants were totally submerged. One glass was placed in the sun, the other in the shade. As evening came on a delicious aroma became evident, and was emitted during the night, but disappeared at sunrise. This leads, Morren thinks, to the conclusion that the odour depends on some physiological cause, and not on evaporation of particles, nor the accumulation of them in the parts of the plants where they have their origin. He found that aromatic Orchids, such as Maxillaria aromatica, lost their perfume in half an hour after the application of the pollen had been artificially made, and that the unfertilized flower retained its odour long. According to Recluz, the flowers of a plant called by him Cacalia septentrionalis are odoriferous when the sun shines upon them, but when the sun's rays are intercepted by artificial means, even by interposing the hand, the odour disappears. The odour returns when the sun's rays are admitted.*

812. Trinchinetti† divides odoriferous flowers into two classes:—

1. Those in which the intermission of odour is connected with the opening and closing of the flower, and in this class there are two sub-divisions.
    - *a.* Flowers which are closed and scentless during the day, and are open and odoriferous at night; such as Mirabilis Jalapa, M. dichotoma, M. longiflora, Datura ceratocaula, Nyctanthes arbor tristis, Cereus grandiflorus, C. nycticalus, C. serpentinus, Mesembryanthemum noctiflorum, and some species of Silene.
    - *b.* Flowers which are closed and scentless during the night, and are open and odoriferous during the day; such as Convolvulus arvensis, Cucurbita Pepo, Nymphæa alba, and N. cærulea.
2. Flowers which are always open, but which are odoriferous at one time and scentless at another. Under this class there are two sections.
    - *a.* Flowers always open, and only odoriferous during the day; such as Cestrum diurnum, Coronilla glauca, and Cacalia septentrionalis.
    - *b.* Flowers always open, and only odoriferous at night; such as Pelargonium triste, Cestrum nocturnum, Hesperis tristis, and Gladiolus tristis.

813. The exudation of odours by nocturnal flowers sometimes takes place in a peculiarly intermittent manner. Thus in the night-blooming Cereus (Cereus grandiflorus) the flowers are fragrant only at inter-

* Recluz, de l'effet des rayons solaires sur la fleur du Cacalia septentrionalis—Journal de Pharmacie, 1827, p. 216.

† Trinchinetti, de odoribus Florum—Vide Morren, Rapport sur le Mémoire de M. Trinchinetti Acad. Roy. de Bruxelles, tom. vi.

vals, giving out puffs of odour every half hour, from eight in the evening till midnight. Morren states that on one occasion the flower began to expand at six o'clock in the evening, when the first fragrance was perceptible in the hot-house. A quarter of an hour afterwards the first puff of odour took place, after a rapid motion of the calyx; at 6.23 there was another powerful emanation of fragrance; by thirty-five minutes past six the flower was completely open; at a quarter to seven the odour of the calyx was the strongest, but modified by the petals. After this time the emanations of odour took place at the same periods as before.* The odours of flowers have frequently peculiar effects on nervous individuals, particularly when the odours are connected with the presence of hydrocyanated oils. The odour of some flowers is remarkably overpowering, and that of others, such as Stapelias or Carrion flowers (Fig. 1176), is very offensive.

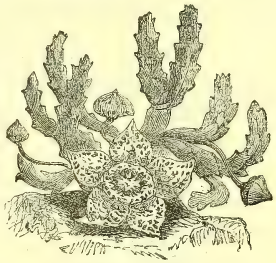

Fig. 1176.

814. Observations have been made by Kohler and Schubler in regard to odoriferous flowers, as occurring in species belonging to the natural orders already noticed when speaking of colours. They have arranged the coloured flowers which they examined according to their odoriferous qualities, and according to the nature of their odours:—

COLOUR.	Species.	Odoriferous.	Odours agreeable.	Odours disagreeable.
White . .	1193	187	175	12
Yellow . .	951	75	61	14
Red . . .	923	85	76	9
Blue . . .	594	31	23	7
Violet . .	307	23	17	6
Green . . .	153	12	10	2
Orange . .	50	3	1	2
Brown . .	18	1	0	1

Of the white-flowering plants examined a large number were odoriferous, and the great majority of the odours were agreeable; while of the orange and brown-coloured flowers a smaller proportion were odoriferous, and the odours were generally fetid. The Monocotyle-

Fig. 1176. One of the Carrion flowers (*Stapelia variegata*), belonging to the natural order Asclepiadaceæ. It receives its English name on account of the fetid odour of its dark brown flowers. The odour attracts flies.

* Morren, Observations sur l'Anatomie et la Physiologie de la fleur du Cereus grandiflorus, in Bull. de l'Acad. Roy. de Bruxelles, tom. v. See also Fleming on the Temperature of the Seasons, p. 93.

dons examined were found to contain 14 per cent. of odoriferous species, while the Dicotyledons only contained 10 per cent. In the case of the natural orders examined the colours were associated with the odours as follows:—

NATURAL FAMILY.	Prevailing Colours.	Odoriferous Flowers per cent.
Water-lily family .	White and yellow	22
Rose " . .	Red, yellow, and white	13.1
Primrose " . .	White and red	12.3
Borage " . .	Blue and white	5.9
Convolvulus " . .	Red and white	4.13
Ranunculus " . .	Yellow	4.11
Poppy " . .	Red and yellow	2
Campanula " . .	Blue	1.31

815. Recapitulation of the principal points connected with the functions of the floral envelopes :—

1. The floral envelopes which are of a green colour perform the same functions as leaves —decomposing carbonic acid and giving out oxygen.
2. The bright-coloured floral envelopes, along with the receptacle, usually evolve carbonic acid.
3. The starch stored up in the corolla and receptacle is converted into grape-sugar.
4. While this change is taking place in the starch, oxygen is absorbed, and carbonic acid is exhaled.
5. Single flowers absorb more oxygen than double flowers, on account of the presence of the organs of reproduction, more especially of the stamens.
6. Flowers, at the time when the essential organs are fully developed, give out a certain amount of heat, which is due apparently to chemical changes going on in the cells.
7. In ordinary cases the heat is carried off rapidly by the air, and cannot be easily detected.
8. But in the case of certain plants, especially species of Araceæ, the elevation of temperature is very marked, the maximum varying from 10° to 50° F. or more above the surrounding air.
9. The maximum of temperature in the Araceæ occurs at different periods of the day—frequently between 3 and 6 P.M.
10. The temperature bears a relation to the quantity of oxygen consumed, as well as to the carbonic acid evolved.
11. The phenomenon of the production of heat requires the presence of oxygen. It is not exhibited when the plants are placed in nitrogen or carbonic acid gas, nor when the parts are covered with oil.
12. The periods of flowering vary, and hence plants are divided into annual, biennial, and perennial.
13. When flowering takes place after having been long delayed, either naturally or artificially, it frequently proceeds with great vigour and rapidity.
14. Injuries done to plants often cause them to flower.
15. The different periods of the year at which plants flower have given rise to the construction of floral calendars.

16. The climate of different countries and the nature of the seasons may be in some degree determined by the florescence or flowering of certain species of plants.
17. The registration of such periodic phenomena is important in botanical geography.
18. Plants expand their flowers at particular periods of the day, and hence floral clocks have been formed in which the hours are marked by the flowering of certain species of plants.
19. The vigils of plants, or their sleeping and awaking, depends in a great measure on temperature and light.
20. Some flowers are diurnal or day-bloomers, opening during light, others are nocturnal or night-bloomers, opening at night.
21. The mean duration of sleep in plants is about 12 or 14 hours.
22. The state of the expansion of the corolla varies in different instances, and the temperature required in day and night-bloomers for the maximum expansion is different.
23. Artificial light will cause the expansion of certain blossoms.
24. Meteoric flowers are those which close during cloudy or wet weather.
25. Differently coloured flowers seem to possess different degrees of irritability. Yellow are said to possess the strongest tendency to close and expand, then follow white, red, and blue.
26. The position of flowers on the stalk is sometimes influenced by the light of the sun. At other times there seems to be a peculiar twisting of the peduncle and turning of the flower, which cannot be traced to direct solar influence or insolation.
27. The colours of flowers have not been well defined, and there is necessity for a good nomenclature of plant-colours.
28. Colour is not employed in botanical characters, except in some of the lower tribes of plants.
29. The colours of flowers are ranged in two series—the Cyanic or blue, and the Xanthic or yellow.
30. Each of the series diverges from green as a centre, and after passing through different shades of colour, they unite again in red. In both the series red and white occur.
31. A species belonging to the blue series may exhibit all shades of white, purple, and violet, but it does not become pure yellow. A species belonging to the yellow series may exhibit all shades of white and orange, but it does not become pure blue.
32. This law refers to single species, and not to the different species of a genus, some of which may be yellow, and others blue.
33. Parti-coloured flowers exhibit colours in both series, but the colours in such cases are usually defined, and do not change into each other.
34. The arrangement of coloured flowers in the garden, so as to produce harmony, is of importance. The complementary colours, or those required to make up white light, such as blue, yellow, and red, contrast best. White often relieves the effect when there is a want of harmony.
35. The chromule or colouring matter of flowers differs from chlorophyll, and it is supposed by some to be formed of two colourable principles, one being the colouring matter of yellow flowers, and the other that of blue and red flowers.
36. There are certain prevailing colours in different natural orders, and the flora of a district or country is sometimes marked by the prevalence of certain colours.
37. The odours of flowers vary much, and depend on very subtle matters beyond the determination of the chemist.
38. Some plants give out their odours during day, others during night; and occasionally the odours are given off in puffs at short intervals.
39. The colours of flowers appear to be in some way associated with odours. Dark brown flowers have often a very disagreeable odour.
40. Some natural orders contain many odoriferous species, others do not contain any.

II. FUNCTIONS OF THE ESSENTIAL ORGANS OF REPRODUCTION.

1. BRIEF HISTORICAL SKETCH OF THE SUBJECT.*

816. The idea of the existence of separate sexes in plants was entertained in early times, long before separate male and female organs had been demonstrated. The production of Dates in Egypt, by bringing two kinds of flowers into contact, proves that in very remote periods some notions were entertained on the subject. Female Date Palms (Fig. 1177) only were cultivated, and wild ones were brought from the desert in order to fertilize them. Herodotus informs us that the Babylonians knew of old that there were male and female Date-trees, and that the female required the concurrence of the male to become fertile. This fact was also known to the Egyptians, the Phœnicians, and other nations of Asia and Africa. The Babylonians suspended male clusters from wild Dates over the females; but they seem to have supposed that the fertility thus produced depended on the presence of small flies among the wild flowers, which, by entering the female flowers, caused them to set and ripen. The process was called palmification. A similar statement was made in regard to the Fig. The process of caprification, or bringing wild Figs in contact with cultivated ones, so as to cause the latter to ripen soon, is mentioned by Aristotle, who observed that a certain insect was generated on the flowers of the Caprifig (wild Fig), which, having become a fly, entered the unripe fruit of the domestic Fig, and caused it to set.† Theophrastus,‡ who succeeded Aristotle in his school in the 114th Olympiad, frequently mentions the sexes of plants, but he does not appear to have determined the organs of reproduction. Pliny,§ who flourished under Vespasian,

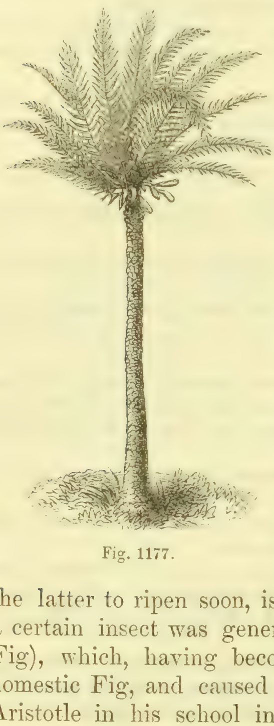

Fig. 1177.

Fig. 1177. Date Palm (*Phœnix dactylifera*), bearing fruit at the upper part of the stem, where the crown of leaves is formed.

* For full details connected with the history of Embryogeny up to 1770, see Alston's Dissertation on the Sexes of Plants, in Edin. Physical and Literary Essays and Observations, i. 228.

† Gasparrini, on the Caprification of the Fig, translated in Journ. Hort. Soc. Lond. iii. 185.

‡ Theophrastus, De Historia et de Causis Plantarum, lib. i. c. 22, ii. c. 8 and 9, and iii. c. 9.

§ Plinius, Hist. Naturalis, lib. xiii. c. 4.

speaks particularly of a male and female Palm, but his statements were not founded on any real knowledge of the organs. From Theophrastus down to Cæsalpinus, who died at Rome in 1603, there does not appear to have been any attention paid to the reproductive organs of plants. Cæsalpinus* had his attention directed to the subject, and he speaks of a halitus or emanation from the male plants causing fertility in the female.

817. Grew, in a paper on the Anatomy of Plants, read before the Royal Society in November 1676, seems to have been the first who really observed the functions of the stamens and pistils. Up to this period all was vague conjecture. Grew speaks of the *attire*, or the stamens, as being the male parts, and he mentions having spoken of the subject to Sir Thomas Millington, Savilian Professor at Oxford, who entertained the same opinion. Grew says that "when the attire or apices break or open, the globules or dust falls down on the seed-case or uterus, and touches it with a prolific virtue; not by entering bodily, or as to its gross substance, but only by communicating to it some subtile or vivific effluvia."† Ray‡ adopted Grew's views, and states various arguments to prove their correctness in the preface to his work on European Plants, published in 1694. In 1694, Camerarius,§ Professor of Botany and Medicine at Tubingen, published a letter on the sexes of plants, in which he refers to the stamens and pistils as the organs of reproduction, and states the difficulties he had encountered in determining the organs of Cryptogamic plants. In 1703, Mr. Samuel Morland,‖ in a paper read before the Royal Society, stated that the farina (pollen) is a congeries of seminal plants, one of which must be conveyed into every ovum or seed before it can become prolific. In this remarkable statement he seems to anticipate in part the discoveries afterwards made as to pollen tubes, and more particularly the views promulgated by Schleiden. In 1711, Geoffroy,¶ in a memoir presented to the Royal Academy at Paris, supported the views of Grew and others as to the sexes of plants. He states that the germ is never to be seen in the seed till the apices (anthers) shed their dust; and that if the stamina be cut out before the apices open, the seed will either not ripen, or be barren if it ripens. He mentions two experiments made by him to prove this—one by cutting off the staminal flowers in Maize, and the other by rearing the female plant of Mercurialis apart from the male. In these instances most of the flowers were abortive, but a few were fertile, which he attributes to the dust of the apices having been wafted by the wind from other plants.

818. Linnæus was the next botanical author who took up the subject of the sexes of plants, and he may be said to have opened a new

* Cæsalpinus, De Plantis, lib. i. c. 3.

† Grew, Anatomy of Vegetables, p. 171.

‡ Ray, Historia Plantarum, p. 18.

§ Camerarius, Epistola de Sexu Plantarum, Tubing. 1694.

‖ Morland, Observations on the parts and use of the Flower in Plants—Phil. Trans. for 1703, xxii. p. 1474.

¶ Geoffroy, Observations sur la Structure et l'Usage des principales parties des Fleurs, in Mém. de l'Acad. Roy. Franc. for 1711, p. 272.

era in the history of Botany. He first published his views in 1736, and he thus writes—"Antheras et stigmata constituere sexum plantarum, a palmicolis, Millingtono, Grewio, Rayo, Camerario, Godofredo, Morlando, Vaillantio, Blairio, Jussievio, Bradleyo, Royeno, Logano, &c., detectum, descriptum et pro infallibile assumptum; nec ullum, apertis oculis considerantem cujuscunque plantæ flores, latere potest."* He divided plants into sexual and asexual, the former being Phanerogamous or flowering, and the latter Cryptogamous or flowerless. In the latter division of plants he could not detect stamens and pistils, and he did not investigate the mode in which their germs were produced. He was no physiologist, and did not promulgate any views as to the embryogenic process. His followers were chiefly engaged in the arrangement and classification of plants, and while descriptive Botany made great advances, the physiological department of the science was neglected. His views were not, however, adopted at once by all, for we find Alston stating arguments against them in his Dissertation on the Sexes of Plants. Alston's observations were founded on what occurred in certain unisexual plants, such as Mercurialis, Spinach, Hemp, Hop, and Bryony. The conclusions at which he arrives are those of Pontedera,† that the pollen is not in all flowering plants necessary for impregnation, for that fertile seeds can be produced without its influence.‡

819. Soon after the promulgation of Linnæus' method of classification, the attention of botanists was directed to the study of Cryptogamic plants, and the valuable work of Hedwig on the reproductive organs of Mosses made its appearance in 1782.§ He was one of the first to point out the existence of certain cellular bodies in these plants which appeared to perform the functions of reproductive organs, and to them the name of antheridia and pistillidia were given. This opened up a new field of research, and led the way in the study of Cryptogamic reproduction, which has since been much advanced by the labours of numerous botanical enquirers (p. 321, note).

820. The interesting observations of Morland, already quoted, seem to have been neglected, and no one attempted to follow in the path which he had pointed out. Botanists were for a long time content to know that the scattering of the pollen from the anther, and its application to the stigma, were necessary for the production of perfect seed, but the stages of the process of fertilization remained unexplored. The matter seemed involved in mystery, and no one attempted to raise the veil which hung over the subject of Embryogeny. The general view was, that the embryo originated in the ovule, which was in some obscure manner fertilized by the pollen.

* Linnæus, Systema Naturæ, 1748, p. 216; Philosophia Botanica, 1751, p. 91; Vid. etiam Wahlborn, Sponsalia Plantarum, in Linn. Amœn. Acad. i. 61-109.

† Pontedera, Anthologia.

‡ Alston, in Physical and Literary Essays, i. p. 318.

§ Hedwig, Fundamentum Hist. Nat. Muscorum Frondosorum, Lipsiæ, 1782; Theoria Generationis et Fructificationis Plantarum Cryptogamicarum, Petropoli, 1784, et Lipsiæ, 1798.

821. In 1815, Treviranus* roused the attention of botanists to the development of the embryo, but although he made valuable researches, he did not add much in the way of new information. In 1823, Amici † discovered the existence of pollen-tubes, and he was followed by Brongniart ‡ and Brown.§ The latter traced the tubes as far as the nucleus of the ovule. These important discoveries mark a new epoch in Embryology, and may be said to be the foundation of the views now entertained by physiologists, which have been materially aided by the subsequent elucidation of the process of cytogenesis, or cell-development, by Schleiden, Schwann, Mohl, and others. The whole subject has been investigated recently with great assiduity and zeal by physiologists, both as regards Cryptogamous and Phanerogamous plants. The formation of germinal vesicles in the ovule, and the development of the embryo in flowering plants, have been fully considered by Schleiden, Mirbel, Mohl, and others; the embryogenic process in Coniferous plants and in the higher Cryptogams by Hofmeister, Suminski, and Mettenius; and that of the lower Cryptogams by Thuret, Decaisne, and Tulasne. We have thus been enabled to come to certain general conclusions on this obscure subject, and future observers have been directed in the proper path of investigation.

2. SEXUALITY OF PLANTS. MATURATION OF THE ORGANS CONCERNED IN REPRODUCTION; AND CHANGES PRECEDING THE DEVELOPMENT OF THE EMBRYO.

822. In flowering plants the organs concerned in reproduction are the stamens and pistils, while in flowerless plants, organs called antheridia and archegonia, as well as peculiar cells, exist, which appear to perform this function. As regards the former class of plants, many proofs have been given that the pollen discharged from the anthers must be applied to the stigmatic surface of the pistil in order to produce perfect seed. Among the best evidences of the functions of the stamens and pistil in flowering plants, are those derived from species in which these organs are separated, and in which, when contact is carefully prevented, no seed is produced. A Palm (Chamærops humilis, *var.* elata) which still exists at Leyden,|| and which, in the days of Clusius, produced pistilliferous flowers but no fruit, was impregnated by pollen from a staminiferous plant, and immediately perfected

* Treviranus, von der Entwicklung des Embryo, &c. Berlin, 1815.

† Amici, Observations Microscopiques sur le Pollen—Atti della Soc. Italian. xix., trad. in Ann. des Sc. Nat. 1st ser. ii. 65. See also Amici, sur la Mode d'Action du Pollen sur le Stigmate, in Ann. des Sc. Nat. 1st ser. xx. 329.

‡ Brongniart, Mém. sur la Génération et le Développement de l'Embryon dans les Végétaux Phanerogames, in Ann. des Sc. Nat. 1st ser. xii. 14, 145, 225. See also xxiv. 113.

§ Brown, on the Organs and Mode of Fecundation in Orchideæ and Asclepiadeæ, in Linn. Trans. xvi. 685.

|| This Palm is upwards of 250 years of age, and is noticed and figured by Dr. Neill in his Horticultural Tour in Holland, &c. p. 156.

seed. Similar observations have been made in Edinburgh upon the same species of Palm, as well as on the Pitcher-plant (Fig. 1178). In plants such as Cucumbers, gardeners are well aware of the necessity of applying the male to the female flowers in order to get fruit; and the production of hybrid plants, by applying the pollen of one plant to the pistil of another, is also an evidence of the uses of these organs. Experiments of this kind require much caution to avoid fallacy arising from pollen being wafted from a distance, so as to cause female plants to produce fruit. Moreover, it sometimes happens that in plants usually producing pistilliferous flowers only, stamens are developed. This has occurred frequently in Chamærops humilis, *var.* elata, the arborescent form of the European Fan Palm, in the Edinburgh Botanic Garden. Such a case might have been considered, by careless observers,

Fig. 1178.

Fig. 1179.

Fig. 1180.

as an instance of a female plant producing fertile seed without the action of pollen. When flowers are completely double, that is, when the stamens and pistils are entirely converted into petals, no seed is produced. Occasionally, however, in flowers apparently double, a single stamen may exist, with sufficient pollen to fertilize the plant, or the pistil may be perfect, so that pollen from other plants may affect it, and lead to the production of perfect seed.

Fig. 1178. Flowering stalk of the Pitcher-plant (*Nepenthes distillatoria*), with its folded leaves in the form of ascidia (pitchers). The plant is diœcious, male flowers being produced on one plant as above, and female on a separate plant. By taking the pollen of the one and applying it to the pistil of the other, fertile seeds were produced many years ago in Edinburgh, for the first time in Britain.

Fig. 1179. Male (staminiferous) flowering plant of Hemp (*Cannabis sativa*).

Fig. 1180. Male and female flowers of Hemp (*Cannabis sativa*). 1. Male flower, with reflexed perianth and five stamens. 2. Cluster of female flowers of the Hemp, enclosed by bracts. It has been said that the female flowers have produced perfect seed without the application of pollen.

823. In certain cases, it has been stated that perfect seed has been produced without the agency of pollen. Pontedera and Alston brought forward supposed instances of this in Hemp (Figs. 1179 and 1180), Mercurialis, and Spinach, and similar statements were made by Bernhardi* in regard to these plants, as well as Lychnis dioica, and by Fresenius in regard to Datisca cannabina. Mr. Smith† of Kew mentions a Euphorbiaceous plant, Cœlobogyne ilicifolia, in which he states that perfect seeds were produced without the presence of pollen. Liebmann‡ notices a similar occurrence in a species of Cycas in the Botanic Garden of Copenhagen, and Gasparrini§ asserts that Figs developed in summer never contain male flowers, and yet produce seeds which contain an embryo. All these cases require further investigation. Richard, Desfontaines, and others, by careful experiments, found that no perfect seeds were produced in Hemp when the males were carefully excluded. It frequently happens that in monœcious and diœcious plants, male organs are produced among female flowers in a very obscure form. Even in the animal kingdom statements were at one time made in regard to the productiveness of females without contact with males. Such observations were found to be incorrect, and proceeded entirely from the difficulty of detecting the male organs. Thus in the Tunicata it was supposed that ovaries only were present, but subsequently testes were found; it required microscopic examination to detect the presence of testes in the same mass with the ovaries. In the case of the Fig, Gasparrini detected at the upper part of the nucleus of the ovule certain cells, which he called pollinides (pollinii), filled with a semi-fluid granular matter, which might probably serve the purpose of pollen.|| A similar structure was noticed by Gasparrini in some Oranges with plurality of embryos. In the case of Cœlobogyne it has been stated that the glands of the bracts contain a viscid fluid, which may perhaps be employed in fertilization. These glands are considered by many as produced by a deduplication or chorization of the anthers. These anomalous cases require examination, and at all events, they are not such as to overthrow the opinion as to the necessity of the application of pollinic matter of some kind to the stigma in order to produce a fertile seed. In all investigations of this kind, it must also be remembered that the only test of true fertilization is the production of a germinating embryo, for the mere swelling of the ovary and of the ovule may take

* Bernhardi, ueber Bildung von Samen ohne Vorhergegange Befruchtung, in Otto und Dietrich Allgem. Garten Zeit. 1839; sur la Formation des Graines sans Fecondation, in Ann. des Sc. Nat. 2d ser. xii. 362. See also Annals of Nat. Hist. vii. 166.

† Smith, Notice of a Plant which produces perfect seeds without any apparent action of pollen on the stigma, in Trans. Linn. Soc. xviii. 510; Annals of Nat. Hist. iv. 68.

‡ Liebmann, concerning the Impregnation of Cycadeæ, in Proceed. of Scandin. Nat. at Copenhagen in 1847. See Proc. Linn. Soc. March 5, 1850.

§ Gasparrini, Ricerche sulla Natura del Caprifico et de Fico, &c. Napoli, 1845. Sur quelques points de Physiologie relatifs au Figuier et au Caprifiguier, in Ann. des Sc. Nat. 3d ser. Bot. xi. 365. See also Journal Hort. Soc. Lond. iii. 185.

|| Gasparrini, sur l'Origine de l'Embryon dans les Graines des Plantes Phanerogames—Ann. des Sc. Nat. 3d ser. v. 206, xi. 365.

place without impregnation. Thus a specimen of Carica Papaya (Fig. 1181) was fertilized in the Edinburgh Botanic Garden by pollen from another species of the same genus, and fruit was produced with fertile seed; and the same plant produced next year large fruit without any application of pollen, but the seed was not perfect. Henslow has conjectured that cases where fertile seed is stated to have been formed without the action of pollen, may be analogous to what is seen in Aphides, where one impregnation is sufficient to produce eight or ten generations.

824. In Phanerogamous plants provision is made for securing the application of the pollen to the stigmatic portion of the pistil or to the ovule. The relative lengths of the stamens and pistils, in erect and pendulous flowers, are varied on this account, and the mode in which the anthers open is also made subservient to the same end (p. 231). In the case of some plants, the elastic filaments are bound down by the floral envelopes until such time as the pollen is ripe, and then they are set free so as to scatter the pollen with great force. This phenomenon is seen in the common Nettle (Urtica dioica), and in the

Fig. 1181.

Fig. 1182.

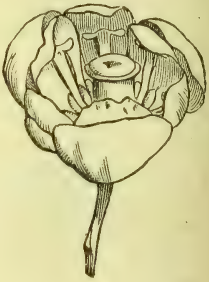

Fig. 1183.

Pellitory of the wall (Fig. 1182). Elastic filaments occur also in Cornus canadensis. In this plant the corolla of each flower consists of four segments, which are for some time folded over the other floral organs, and meet in a central point. Towards their tips arises a long spine or hair. The stamens are four in number, and are kept in a very acutely bent position towards the pistil by the corolla. The base of each petal, as well as the angle of inflection of each filament, has

Fig. 1181. Papaw-Tree (*Carica Papaya*), bearing fruit. The tree is Dichogamous, that is, has separate male and female flowers. A plant in the Botanic Garden did not produce fruit until fertilized by pollen artificially applied. But after the first application, the fruit continued to swell for a second year, although it did not produce fertile seed.

Fig. 1182. Male flower of Pellitory (*Parietaria officinalis*), having four stamens with incurved elastic filaments, and an abortive pistil in the centre. When the perianth expands, the filaments are thrown out with force, so as to scatter the pollen on the female flowers in the vicinity. The same thing occurs in the Nettle, as shown in Figure 628, p. 229.

Fig. 1183. Flower of the Barberry (*Berberis vulgaris*), the stamens of which are irritable, and move towards the pistil when touched at their base. The irritability resembles that of the Sensitive plant, and is ascribed to turgescence in certain cells, and contraction in others.

an elastic joint, and when the hairs or spines at the apex are slightly touched, the corolla flies back, and the stamens, freed from restraint, start up and scatter the pollen. This elastic state is probably owing to turgescence of the cells on one side of the filament, as well as to the temporary restraint caused by the perianth. In the species of Kalmia a similar phenomenon is observed, the anthers being held for a time in little pouches or sacs of the corolla, and then moving with a jerk towards the pistil.

825. In the Barberry (Fig. 1183) and Mahonia, the filaments are very irritable on their inner surface, at the point where they join the receptacle, and when touched in that situation they move towards the central organ. The motion, like that of the leaves of the Sensitive plant, seems to be connected with a small cellular swelling or gland at the base. In species of Stylidium (Fig. 1184), the stamens and

Fig. 1184.

Fig. 1185.

pistil are united in a common column, which is jointed and irritable, and which, when touched at the joint, passes with force and rapidity from one side of the flower to the opposite one, so as to burst the anthers and scatter the pollen on the central stigma. The stamens of the common Rock-rose (Helianthemum vulgare), and of species of Cistus (Fig. 1185), exhibit movements which are apparently connected with the application of the pollen. Morren has remarked also sensi-

Fig. 1184. A species of Stylewort *(Stylidium tenuifolium)*, which displays irritability in its reproductive column. 1. Plant, with its narrow leaves and numerous flowers, from each of which a column projects formed by the united stamens and pistil. 2. Flower separated, showing calyx, corolla, and column; at the extremity of the latter the anther lobes are placed, surrounding the stigma in the centre. 3. A similar flower, showing the column in the act of passing from one side of the flower to the other.

Fig. 1185. Flowering stem of a species of Rock-rose (*Cistus creticus*), the stamens of which display irritability when touched.

tiveness in the andrœcium of Cereus grandiflorus and of Sparmannia africana. In the flowers of species of Indigofera the carina is held up by the alæ by means of hook-like processes, and when the wings separate, the carina falls down towards the pedicel, exposing the essential organs, and probably thus contributing to the application of the pollen. In species of Grevillea the styles are curved, and have their stigmatic surface contained within the tips of the perianth, in which place the sessile anthers lie; and it is only after the perianth expands, and the pollen has been ripened and applied, that the style becomes straight, so as to project to a considerable length above the flower. A similar occurrence is met with in many Proteaceæ. In the Grass of Parnassus (Parnassia palustris), and in Rue (Figs. 1186 and 1187), the stamens move forward in succession towards the pistil.

826. Insects are sometimes employed in scattering pollen. The bees in collecting the honey secreted at the base of the petals are

Fig. 1186.

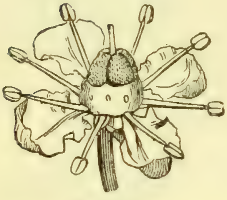

Fig. 1187.

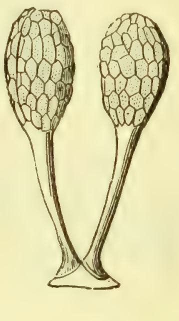

Fig. 1189.

Fig. 1188.

made instrumental in applying the pollen to the stigma. In Orchids (Fig. 1188), in which the anthers are placed on the upper part of a column with the stigmatic surface separated from them, and the pollen is in masses (Fig. 1189), the agency of insects seem to be required for fertilization. The flowers of these plants exhibit remarkable animal forms, probably with the view of attracting insects. It has been remarked that in Orchids the forms of the perianth resemble

Fig. 1186. Flower of the Grass of Parnassus (*Parnassia palustris*), the stamens of which move in succession towards the pistil, in order to scatter their pollen. In the Figure, some stamens are seen applied to the pistil, and others removed from it.

Fig. 1187. Flower of Rue (*Ruta graveolens*), in which there is a successive movement in the stamens towards the pistil.

Fig. 1188. Flower of an Orchid called Twayblade (*Listera ovata*), in which the pollen forms masses easily removable by insects, and thus applied to the stigmatic surface.

Fig. 1189. Pollen masses of an Orchid, united to a gland at their base. These masses are easily detached from the anther by insects, and are thus applied to the stigma.

those of the insects belonging to the native country of the plant. The flowers also secrete a large amount of saccharine matter, and are odoriferous ; their pollen-masses are very easily detached, and are very adhesive. All these circumstances seem to be connected with their mode of impregnation. In Asclepiadaceæ, which have also peculiar pollinia (Fig. 1190), insects are attracted by the odour of the flowers (sometimes very fetid, as in Stapelia, p. 547), as well as by saccharine matter. In various species of Birthwort (Figs. 1191, 1192, 1193), in which the essential organs are contained in a tubular perianth, insects are employed to effect the application of the pollen. Species of Tipula enter the expanded portion of the perianth, and then crawl down through the long tube to the cavity at the base con-

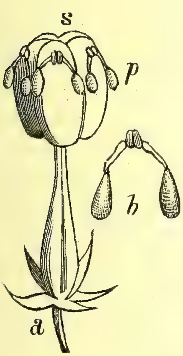

Fig. 1190.

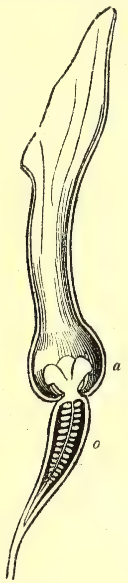

Fig. 1192.

Fig. 1191.

taining the stamens and pistil. On attempting to return they are prevented from getting out by numerous hairs pointing downwards, which act like a trap. While moving about in the lower chamber, the insects spread the pollen when ripe, and afterwards when the flower fades they escape.

827. Pollen grains in general require to be protected from the

Fig. 1190. Pistil of one of the Asclepiadaceæ, with the calyx and flower-stalk, *a*, the pollen-masses, *p*, adhering to the stigma, *s*. Pollen-masses, *b*, separated with the gland uniting them.

Fig. 1191. Separate flower of Common Birthwort (*Aristolochia Clematitis*), formed by a single perianth enclosing the stamens and pistil at its base. The inside of the tubes of the perianth is lined with stiff hairs pointing downwards, which allow the entrance of an insect called Tipula pennicornis, but prevent its exit until the pollen has been scattered on the stigma, and the flower has withered.

Fig. 1192. Section of a flower of Birthwort, showing the stamens and pistil, *a*, at the bottom of the perianth and surmounting the ovary, *o*.

direct action of moisture, which causes them to burst prematurely. The closing of flowers during rain accomplishes this object. In the Daisy and other Composite plants the outer florets close over the inner ones, and thus prevent injury from wet. When plants grow in water the pollen is sometimes of a peculiar nature, and the anthers are placed along with the pistils in a covering to protect them from the effects of moisture. This is seen in the Sea-wrack (Zostera marina), the pollen of which has a filamentous appearance. In other aquatics, as Water-lilies (Fig. 1194), Victoria (Fig. 235, p. 107), Hottonia and Lobelia, the peduncles rise above the water at the time when the flowers are developed. In an aquatic plant called the Water-soldier (Stratiotes aloides), the whole plant floats in the water, and sends down roots into the mud below. The Duck-weeds (species of Lemna), also produce their essential organs on floating leaves, while their roots hang in the water (Fig. 1195). In Vallisneria (Fig. 1196), the female plant, *b*, sends up a long spiral peduncle, which sometimes increases in length 14 inches during twenty-four hours, and which enables the flower to appear above water, and to be accommodated to its depth, at the same time that the root remains attached to the mud below; the male plant, *a*, on the other hand, is detached from the bottom of the water, floats on the surface, and there perfects its pollen, which is ultimately wafted on the pistilliferous plant. A similar phenomenon is exhibited by an African plant called Lagarosiphon muscoides. The Vallisneria, as grown in an aquarium in the stove of the Edinburgh Botanic Garden, did not display this phenomenon fully as regards the male flower. The plant produced its flowers at the bottom of the tub, and its pollen rose to the surface of the water, buoyed up apparently by a small collection of air which enabled it to float. The pollen came up for several days in large quantity.

828. The fertilizing power of the pollen is retained for a different length of time in different species of plants. According to Kölreuter and Gærtner, the pollen continued fresh in some species of Tobacco only for 48 hours; in Datura Stramonium, D. Tatula, and D. ferox, and in Lychnis dioica, for 2 days; in Hibiscus Trionum and the Clove-pink for 3 days; in Lobelia syphilitica and L. splendens for 8 or 9 days; in Wallflower for 14 days; in Orchis abortiva for 2 months.* The pollen of the Date, Cannabis, Tea, and Camellia, have been kept fresh for a year. Morren states that the pollen of Candollea was fertile for one year, and Michaux mentions the pollen of Chamærops humilis and of the Date as having been used successfully after 18 years. Pollen may be carried to a distance and retain its fertilizing power. Dates at St. Helena were fertilized by pollen brought from trees growing on the Continent of Africa. The pollen of some plants may be sent to a distance in a letter, and after many months be capable of acting on the stigma.

* Gærtner, Befruchtung der Gewächse. Stuttgart, 1844. Kölreuter, Vorlaufige Nachricht von einigen, das Geschlecht der Pflanzen betreffenden Versuchen 1761-1766.

829. The quantity of pollen produced in some cases is enormous. In the case of Firs and Pines (Figs. 1197, 1198, 1199), this seems to

Fig. 1193.

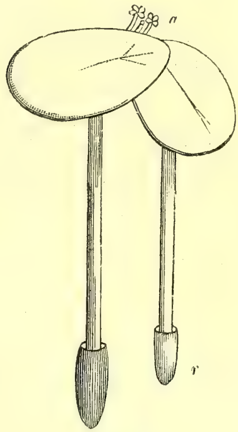

Fig. 1195.

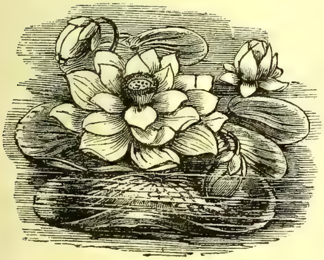

Fig. 1194.

Fig. 1196.

be connected with the fact that the cones or female organs are separate

Fig. 1193. Flowering-stalk of Common Birthwort (*Aristolochia Clematitis*). Fertilization is effected by insects.

Fig. 1194. Water-Lotus (*Nelumbium speciosum*), the flower of which appears above water, and thus the pollen is prevented from being injured by moisture. The fruit of the plant is supposed to be the Pythagorean Bean.

Fig. 1195. Plants of the Lesser Duckweed (*Lemna minor*), which float on the surface of ponds. The naked flowers, *a*, are borne upon the green leaves and appear above the water; while the roots, *r*, with their sheathed points, hang in the water.

Fig. 1196. Male and female plants of Vallisneria spiralis. *a*, the male plant, which is detached from the mud at the bottom of the water, and rises to the surface so as to mature its pollen and scatter it; *b*, the female plant, which remains fixed in the mud, and sends up a spiral peduncle, which uncoils according to the depth of the water, and bears the pistilliferous flowers above the water, so as to allow the pollen to be wafted upon them.

from the staminal clusters, and that, moreover, the leaves are usually evergreen, and thus present an obstacle to fertilization. The yellow powder in Pine forests falls to the ground in vast quantity, and it is sometimes carried by the winds to a great distance, so as to fall in the form of what have been called *sulphur showers*. Many instances are given of coloured rain containing pollen grains. On 17th April 1850, at 11 A.M., a yellow-coloured rain fell at the Mumbles, near Swansea, the sky being at the time bright and free from clouds. The spots of rain when fresh were of an ochre-yellow, and the colour remained for many days notwithstanding heavy showers. The sediment was examined and found to consist chiefly of pollen grains, probably those of a species of Salix. Among the grains were also spores resembling those of Cladosporium. Two instances of coloured rain are recorded by Professor Bailey, one of which occurred at Troy, New York, and the other

Fig. 1198.

Fig. 1197.

Fig. 1199.

in the harbour of Pictou.* The matter at Pictou was the pollen of the Scotch Fir (Pinus sylvestris), that at Troy consisted chiefly of the pollen of some Cupuliferous plant.

830. Morren counted the number of pollen grains in a plant of Cereus grandiflorus which grew in the stove of the Botanic Garden of Liege. He found that in each flower there were 500 stamens, and as 40 flowers were produced, the total number of stamens on the plant

Fig. 1197. One of the Conifers. A variety of the Spruce Fir. The tree bears male flowers in clusters, and female flowers in cones.

Fig. 1198. Stamen of a Fir, showing the grains of pollen, *pol*, which are abundant and discharged by the separation of the valve, *val*.

Fig. 1199. Female flowers of a Fir arranged in a cone, the scales of which are bracts covering the ovules.

* American Journal of Sciences and Arts, 1842. See also Hassall on the Pollen Granule—Annals of Nat. Hist. viii. In the Museum of Economic Botany at Edinburgh, there is a specimen of Coniferous pollen which fell in a shower at Thibedeau, 70 miles west of New Orleans, presented by Dr. Traill.

was 20,000, and of pistils 40, each having 24 stigmas. Each anther contained 500 pollen grains, and hence the total number of grains in each flower was 250,000, and upon the entire plant 10,000,000. A single plant of Chinese Laburnum (Wistaria sinensis) produced 675,000 flowers containing 10 stamens each, or 6,750,000 in all, and these contained 27 billions of pollen grains. In a single blossom of Leontodon Taraxacum Hassall counted 243,000 ; a flower of Pæony furnishes on an average 174 stamina, each containing 21,000 granules, giving a total of 3,654,000. In an entire Rhododendron plant the pollen grains amounted to 72,620,000. These numbers, great though they be, sink into insignificance when compared with the myriads produced

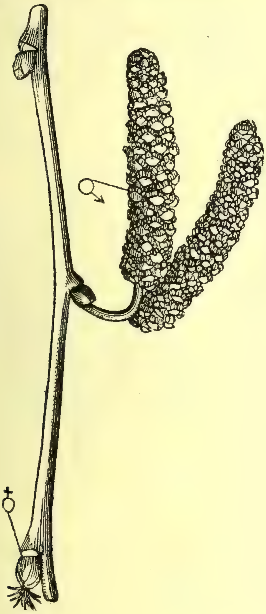

Fig. 1200.

Fig. 1201.

by a single forest tree. A Bulrush gave 144 grains by weight of pollen.* De Vriese, in speaking of a specimen of Cycas circinalis, states that the male cone was 0.450 metres long, and 0.200 broad; the number of scales was 3500, and the surface of each four square centimetres, the whole sums of the organs which compose the cone being thus = 14,000 square centimetres. The under surface

Fig. 1200. Flowering branch of Hazel (*Corylus Avellana*), bearing male spikes, ♂, and female spikes, ♀. These are produced before the leaves, so as to allow the pollen to reach the pistils.

Fig. 1201. Male flowers of a Willow (*Salix*), which are produced before the leaves and on a separate plant from the female flower.

* Hassall, on the Pollen Granule—Annals of Nat. Hist. viii. 108.

of the scales was covered with unilocular anthers to the number of 400, the total number of anthers being estimated at 1,400,000. Each anther contained several thousand grains of pollen, which were developed with great rapidity.* In many catkin-bearing plants, which are monœcious or diœcious, the pollen is abundant, and the essential organs are developed before the leaves are produced. Examples of this occur in the common Hazel (Fig. 1200), and in Willows (Figs. 1201, 1202).

831. Observations have been made by Gærtner and Kölreuter as to the quantity of pollen required to fertilize the ovules. One grain, or at most three, are sufficient to impregnate the ovule of Mirabilis longiflora and M. Jalapa. In a single flower of Hibiscus Trionum, Kölreuter counted 4863 pollen grains, and he ascertained that 50 or 60 were sufficient to fertilize all the ovules in the ovary, usually

Fig. 1202.

Fig. 1203.

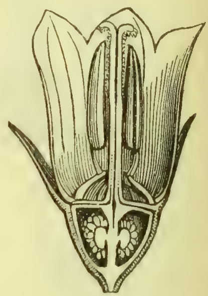

Fig. 1204.

amounting to 30; when fewer grains were employed, impregnation was not complete; thus 25 grains only impregnated from 10 to 16 ovules. In most cases the pollen of a single fertile anther is sufficient for the perfecting of the ovules, and the additional anthers are produced with the view of insuring the result. Morren states, that in the flower of Cereus grandiflorus he found 150,000 grains of pollen out of 250,000 which had not been applied to the stigma, while the number of ovules in each ovary was about 30,000.

832. During the evolution of the stamens and the maturation of the pollen, the pistil undergoes changes, more especially as regards

Fig. 1202. Female flowers of a Willow (*Salix*), which are also produced in the early part of the season before the leaves, and are on a separate plant from the male flowers.

Fig. 1203. Style of a species of Bellflower (*Campanula*), covered with hairs, which collect the pollen.

Fig. 1204. Flower of a species of Bellflower (*Campanula*), with the stamens applied to the hairs of the style so as to scatter the pollen.

* De Vriese, observations on Cycadaceous Plants, in Hooker's Kew Miscellany, ii. 186.

the stigma, which becomes enlarged, lax in its texture, and covered with a viscid secretion. The secretion is stated by Aldridge* to have acid qualities at some period of its formation, but, according to Vaucher, it is saccharine, and resembles that formed by the nectariferous glands of petals. In species of Campanula, such as C. Medium, rapunculoides, Trachelium, and rotundifolia, during the discharge of the pollen, the style, which is covered with hairs (Fig. 1203), elongates, and in its upward progress brushes the pollen from the anthers (Fig. 1204). The hairs which collect the pollen apply it to the stigma, the branches of which, *s*, are at first erect, and afterwards, by changes in their cells, become revolute. The hairs occasionally appear double, from their extremities being drawn within the lower part of their tubes after performing their functions.† Brongniart looks upon these hairs as mere pollen collectors,‡ but others look upon them as directly concerned in fecundation. Hassall thinks that in Campanulaceæ and Compositæ not only the true stigma, but also that portion of the style which is covered with hairs, is essentially concerned in fecundation.§

833. In Goldfussia (Ruellia) anisophylla, Morren noticed that the style has a curved stigmatic apex, which gradually becomes straightened so as to come into contact with the hairs of the corolla on which the pollen is scattered.|| The stigma in species of Mimulus, Diplacus, and Bignonia is bilamellar, and the two lamellæ close when touched with pollen or any extraneous body.¶ It is said that in some species of Cactus and Passion-flower the styles move towards the stamen. In order that impregnation may take place, the stigma must be in a proper state to receive the pollen. Gærtner says that a fresh cut style in which the stigma is removed will not do for this purpose. In rare instances, as in the Sea-pink (Armeria maritima), the conducting tissue of the style becomes elongated, so as to pass into the ovary (Fig. 1205), and ultimately comes into contact with the ovule, when impregnation takes place (Fig. 1206).

834. Before the process of impregnation, certain changes also take place in the ovule. The relative position of its parts is frequently altered, so that the micropyle is brought near to the placenta (Fig. 1207). Moreover, one of the central cells becomes much enlarged and developed, so as to form the embryo-sac (Fig. 1208, *s*). Occasionally this sac becomes so enlarged as to appear on the outside of the ovule, as in Avicennia.** At the end of this sac, next to the micro-

* Aldridge, on the Structure and Functions of the Pollen, in Lond. Journ. of Bot. iv. 86; also on the use of Pollen in Natural Classification, in Lond. Journ. of Bot. i. 575.

† Wilson, on the Pollen-Collectors of Campanula, in Hooker's Journal, ii. 183.

‡ Brongniart, sur les Poils Collecteurs des Campanules, et sur la Mode de Fecondation de ces Plantes, in Annales des Sc. Nat. 2d ser. xii. 244, trans. in Ann. of Nat. Hist. v. 380.

§ Hassall, on the functions performed by hairs on the stigma in Campanulaceæ and Compositæ—Ann. of Nat. Hist. viii. 84.

|| Morren, sur le Mouvement et l'Anatomie du Style du Goldfussia anisophylla—Bull. de l'Acad. Roy. de Bruxelles, tom. vi.

¶ Braconnot, sur l'irritabilité du stigmate des Mimulus, in Ann. de Chim. et de Phys. xxix. 333.

** Griffith, on the Ovule of Santalum, &c.

pyle, several delicate free nucleated cells are produced, to which the name of embryo-vesicles or germinal-vesicles has been given (Fig. 1209, *c*). In this way the ovule is prepared for the action of the pollen, and for the production of the embryo plant.

835. The essential organs, when performing their active functions, absorb much oxygen and evolve carbonic acid. At the same time they acquire a certain elevation of temperature. This has been already noticed when speaking of the floral envelopes. The time of the emission of pollen seems to be that at which the maximum heat is produced, and the stamens have a higher temperature than the pistil.* When the stamens and pistil are mature the anther bursts (Fig. 1210), and scatters the pollen, *p*, on the stigma (Fig. 1211, *stig*). There it is detained, and is acted on by the viscid secretion, by means of which tubes are developed from the intine (Figs. 1212 and 1214, 2). This is a sort of germination of the pollen cell. These tubes pierce the stigmatic tissue, and convey the fovilla (Fig. 1213) through the canal of the style to the ovule. In Figure 1214, 1, the

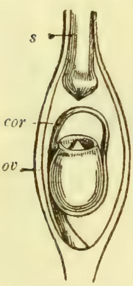

Fig. 1205.

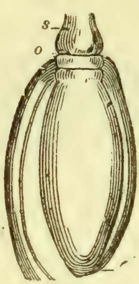

Fig. 1206.

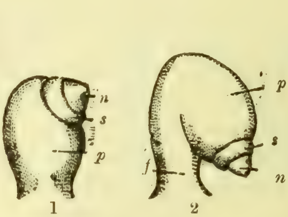

Fig. 1207.

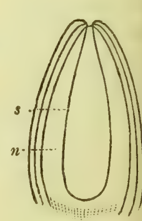

Fig. 1208.

ovary, *o*, with the ovule, *n*, and embryo-sac, *v e*, is represented; the pollen, *p*, is applied to the stigma, *stig*, and its tubes, *t p*, pass through the conducting tissue of the style, *styl*, to reach the embryo-sac.

836. The emission of tubes sometimes commences half a minute after the pollen has been applied to the stigma; in other cases, as in Mirabilis Jalapa, it takes from 24 to 36 hours. In the Larch Geleznoff says that the tubes do not emerge for 35 days. Pollen tubes may be seen easily in species of Gesnera, by gently scraping off from the stigma the pollen which has been in contact with it for 48 hours. They may also be detected in the Crocus vernus when a portion of

Fig. 1205. Ovary, *ov*, of Sea-pink (*Armeria maritima*), in which the ovule is suspended by a curved cord, *cor*, and the conducting tissue, *s*, of the style elongates in a downward direction.

Fig. 1206. The ovule of the Sea-pink further advanced, showing the conducting tissue, *s*, of the style in contact with the foramen of the ovule, *o*, and pushing aside the cord.

Fig. 1207. The ovule of Celandine (*Chelidonium*), with its primine, *p*, secundine, *s*, and nucleus, *n*, projecting through the foramen, which is slightly turned round in 1, and completely turned in 2. By this change in the position of the ovule the foramen is brought near the placenta, and the pollen tubes reach it more easily; *f*, the funiculus or umbilical cord.

Fig. 1208. Ovule of Polygonum, showing the embryo-sac, *s*, developed in the midst of the nucleus, *n*.

* See remarks on this subject at pages 522, 523, and 526.

the stigma is gently pressed in water between two plates of glass until it is transparent. Colocasia odora is another plant in which pollen tubes are readily detected penetrating the tissue of the stigma. In the common species of British Orchis they may be traced without much

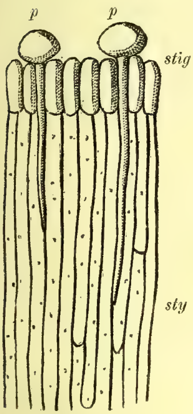

Fig. 1211.

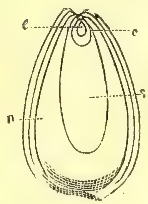

Fig. 1209.

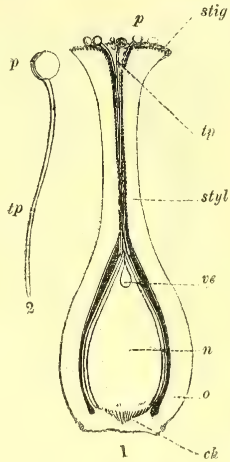

Fig. 1214.

Fig. 1210.

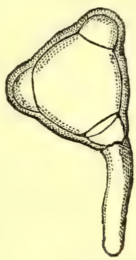

Fig. 1212.

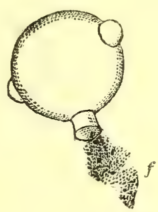

Fig. 1213.

difficulty to the foramen of the ovule. The tubes may be recognized by their opaque granular contents, and their small size compared with

Fig. 1209. Ovule of Polygonum, showing the nucleus, *n*, and the embryo-sac, *s*, containing a vesicle or germinal cell, *c*, formed before impregnation. This cell, after fertilization, developes the first embryonal cell, *e*.

Fig. 1210. Stamen, *s*, of Wallflower (*Cheiranthus*), scattering the pollen, *p p*, from the anther, *a*.

Fig. 1211. Grains of pollen, *p p*, applied to the viscid cellular stigma, *stig*, of Frogsmouth (*Antirrhinum majus*). The style, *sty*, is laid open to show the pollen tubes passing down to the ovary.

Fig. 1212. Grain of pollen of the Evening Primrose (*Œnothera*), showing a pollen tube partially developed.

Fig. 1213. Spherical grain of pollen of the Cherry (*Cerasus*), showing a pollen tube formed by the intine, with its extremity ruptured, so as to discharge fovilla, *f*.

Fig. 1214. Pistil and pollen of Polygonum. 1. Stigma, *stig*, with pollen grains, *p*, adherent to it, sending tubes, *tp*, down the conducting tissue of the style, *styl*; the ovary, *o*, containing the ovule with its covering and central cellular mass or nucleus, *n*, containing a rudimentary embryo-sac, *ve*, in which ultimately the embryo is developed. The base of the ovule attached to the placenta is marked by the chalaza, *ch*. 2. Pollen grain, *p*, separated, with pollen tube, *tp*.

the rest of the tissue in the style. In Digitalis purpurea the diameter of the pollen tube is 1-166th of a millimetre, in Orchis Morio 1-180th, in Wallflower 1-280th, and in Common Shepherd's Purse 1-332d.

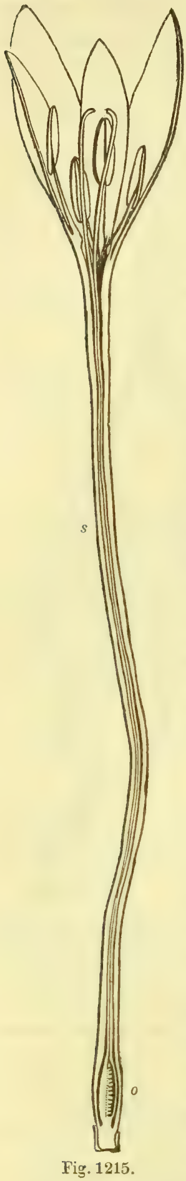

Fig. 1215.

837. The length to which the tubes extend is often very great. In Cereus grandiflorus, Morren estimated that the tubes when they reached the ovary extended as far as 1150 times the diameter of the pollen-grain ; in Crinum amabile, Hassall says they reach 1875 times the diameter of the grain, in Cleome speciosa 2719 times, in Oxyanthus speciosus 4489 times, and in Colchicum autumnale (Fig. 1215) 9000 times.* The length of time which the pollen tube takes to traverse the conducting tissue of the style varies. The time does not always correspond with the comparative length of the style. In some short-styled plants the time taken is very long, while in the case of the long-styled Cereus grandiflorus and Colchicum autumnale a few hours is sufficient. In the style of the former, 9 inches long, the end of the pollen tube, according to Schleiden, reached the ovule in a few hours ; in that of the latter (Fig. 1215), 13 inches long, in about 12 hours. In other plants weeks sometimes elapse before the tube traverses a short distance. In the case of some Coniferous plants, as Pinus sylvestris, Pineau states that a year elapses before the tubes reach the embryo-sac.

3. VIEWS OF EMBRYOGENY OR EMBRYO-DEVELOPMENT.

838. The mode in which the embryo or young plant is produced in the seed is a subject of great physiological interest. It has engaged the attention of many eminent botanists in Germany, France, Italy, Russia, Britain, and India, and within the last thirty years has called forth able papers from the pens of Amici, Brongniart, Brown, Schleiden, Mirbel, Spach, Meyen, Mohl, Unger, Hofmeister, Muller, Tulasne, Griffith, Henfrey, and others.† Notwithstanding all that has been done, however, there are still difficulties connected with vegetable embryogeny, and additional microscopic researches are required for the full elucidation of the subject. When we reflect on the

Fig. 1215. Flower of Meadow-saffron or autumn Crocus (*Colchicum autumnale*), with its very long style, *s*. The pollen-grains applied to the stigma give out tubes, which extend to 9000 times the diameter of the grain before they reach the ovary, *o*. This is often accomplished in 12 hours.

* Hassall, on the Pollen Granule—Annals of Nat. Hist. viii. 92, and ix. 544.

† See references to the works and papers of these authors in the notes to this section.

nature of the inquiry, the minuteness of the tissues to be examined, the difficulty of tracing microscopic morphological changes, and the many sources of fallacy to which such researches are exposed, it is not a matter of surprise that many conflicting opinions have been brought forward. Amidst the multiplicity of views which have been promulgated, there appear to be some facts sufficiently established, and indications have been given of the proper method in which future researches ought to be conducted, in order to arrive at satisfactory results.

A. *Formation of the Embryo in Cryptogamous or Acotyledonous Plants.*

839. In the simplest Cryptogamic plants, composed of a single rounded cell, as in the Yeast plant (Fig. 1061, p. 360), and the Red-snow plant (Fig. 1062, p. 360), the processes of reproduction and nutrition cannot be separated. The same cell appears to perform both functions. At a certain period of growth divisions take place in the cell-contents, and by the bursting of the parent cell germs are discharged which are capable of producing new individuals. As we ascend in the scale the plants become more complex. In place of one cell they consist of several united together either in a single or branched linear series, and combined both end to end and laterally, so as to form cellular expansions. In this state the nutritive and reproductive cells are often separate and distinct, as may be seen in common Mould (Fig. 1068, p. 362), and in Fungi generally. In Confervæ (Fig. 1083, p. 411) and in Diatomaceæ (Fig. 1077, p. 408) the existence of reproductive cells with distinct functions have been observed. In many of them we perceive at certain stages of growth cells united by a process of conjugation,* the result of this union being the production of a cellular embryo or spore (Fig. 1216, *c*). This conjugation is a very interesting process, and tends to throw light on the subject of reproduction throughout the whole vegetable kingdom. The cells in these plants have in their interior a granular endochrome, which appears to have different functions in the different cells. When certain cells are brought into contact, tubes are emitted which unite the two (Fig. 1216, *b*), the endochromes come into contact, and the result is the formation of a spore, the mixed

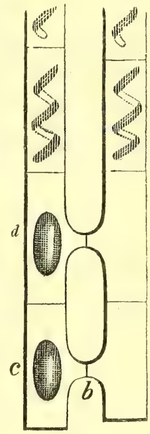

Fig. 1216.

Fig. 1216. Filaments of Zygnema, with conjugating cells. The tubes uniting two cells are seen at *b*, and similar tubes connect two upper cells, *a* and *d*. The contents of the cells intermingle, and spores or sporoid embryos, *c* and *d*, are produced. The upper cells, in which there is no conjugation, retain their usual contents; while some of the lower cells have lost their contents, and spores are produced in others.

* The name Conjugatæ is given to species of Zygnema, Tyndaridea, Mougeotia, Staurocarpus, &c., on this account.

endochromes being surrounded with a proper membrane. Sometimes the contents of one cell considered as the male pass into the other in which the spore is produced, as in Zygnema (Fig. 1216), and sometimes the contents of both cells unite, and the spore is produced in the tube between them, as in Diatoms. The occurrence of this process in Diatomaceæ, as observed by Thwaites,* and confirmed by Smith and others,† favours the view that these organisms belong to the vegetable kingdom.‡

840. In many of the Confervæ, however, spores appear to be produced without the conjugation of separate filaments. In such instances it is conjectured that different cells in the same filament perform different functions, and are so placed that at a certain period their contents by coming into contact develope a germ. The same filament may thus contain both male and female cells; although botanists as yet have not been able to show the difference between them. In some species of Meloseira the endochrome at each end of the cell appears to have a different property, and mixture takes place in the cavity of a single frustule. In this case there is a movement towards the centre of the cell when the spore is formed.

841. Proceeding to other divisions of Acotyledons, we find different kinds of reproductive organs, which can, however, only be observed at certain periods of development, and frequently cannot be seen after the embryo has been fully formed. In the same way as in the flowering plants, when the seed has been ripened the stamens have generally withered and fallen off, and sometimes also the style and stigma. It is of importance, therefore, in all investigations into Cryptogamic reproduction, to examine the plants at their early period of growth. The reproductive organs have received different names in different natural orders of Cryptogams. They are generally called antheridia and archegonia or pistillidia, from their supposed analogy to anthers and pistils. The antheridia contain sperm-cells, in each of which is a moving ciliated phytozoon, spirillum, or spermatozoid (Fig. 1000, p. 335), and the pistillidium or archegonium contains a germ-cell or embryonal-cell, which produces a germinating body (Fig. 1011, p. 340).§

* Thwaites, on Conjugation of the Diatomaceæ—Annals of Nat. Hist. xx. 9, 343. Thwaites has seen conjugation in Eunotia (Epithemia) turgida, Cocconema lanceolatum, Gomphonema minutissimum or curvatum, also in species of Meloseira, Orthoseira, Aulacoseira, Dickieia, and Schizonema.

† Smith, on British Diatomaceæ; on Conjugation of Closterium Ehrenbergii, in Annals of Nat. Hist. 2d ser. v. i. Morren, sur les Closteries, in Ann. des Sc. Nat. 2d. Ser. Bot. v. 257.

‡ Besides this process of conjugation, by means of which a cellular embryo is formed, some of these plants have a power of merismatic or fissiparous division (Fig. 1077, p. 408), by which cells are separated, capable of independent existence. This may be compared to the process of budding, and is thus distinct from fecundation. When plants are propagated readily by the process of gemmation or budding, they frequently do not produce reproductive germs. This is true of all tribes of plants, both Phanerogams and Cryptogams.

§ In order to see the phytozoa of Sea-weeds, such as Fucus serratus, in motion, it has been recommended to gather the fresh plant in winter or early spring, when showing orange-coloured receptacles, to remove it from the water, and to leave it to dry partially. As the surface dries there exude from the pores of the receptacle drops of a thick orange-coloured liquid, which, on being placed under the microscope and moistened with salt water, will be found to be composed of antheridia, from which issue innumerable spermatozoids, which move about. To see the moving spermatozoids

842. Spermatozoids are considered as analogous in their function to the spermatozoa of animals. In the case of animals, these spermatozoa have been traced by Dr. Henry Nelson in many instances to the ovum. Newport* has determined that in regard to certain animals (such as Amphibia), the presence of active spermatozoa is absolutely necessary to impregnate the ovum, and that impregnation is effected by simple impact. He has noted the time necessary to complete the operation, and has observed the internal changes that immediately take place in the body of the nucleus; and he has found that the spermatozoa, after producing this effect by simple external contact, become inert, and lose all power of motion. Spermatozoids have in like manner been traced to the archegonia, or the cells in which the rudimentary embryo is formed. Hofmeister states that he has often seen spermatozoids swimming about around the archegonium, in longitudinal sections of the involucres of Jungermannieæ; he has also seen them in a motionless state after the rudiment of the fruit began to be developed. Similar observations have been made in regard to Mosses and Ferns; and Suminski is disposed to think that the extremity of a spermatozoid in Ferns is developed as an embryonic cell, in the same way as Schleiden thinks the end of the pollen tube constitutes the first cell of the embryo in flowering plants. After the application of the contents of the antheridia to the archegonia, a cellular body is produced in the latter, which may be called a sporoid embryo. This cell may be discharged at once, or it may go through certain phases of existence without being separated from the plant on which it is produced. The spore or sporoid embryo is often provided with cilia, which enable it to move about in fluid until it becomes attached to rocks or other bodies, when it begins to sprout (Fig. 1036, p. 350).

843. In Algæ and Characeæ, antheridia containing sperm-cells (Figs. 1217 and 1218) have been found, as well as sporangia. Tulasne has detected them in Fungi, and Itzigsohn has observed them in Lichens, such as Cladonia alciornis and Borrera ciliaris. Leighton has noticed peculiar motions in the spores of Lichens—the movements continuing for hours after the spores are set free. The spore-fruits or capsules of Hepaticæ are preceded by minute cellular organs called

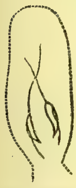

Fig. 1217.

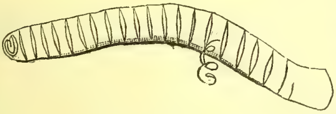

Fig. 1218.

Fig. 1217. Antheridium of a Sea-weed (*Fucus serratus*), containing phytozoary cells.

Fig. 1218. Filament from the globule of Chara, consisting of numerous phytozoary or sperm-cells. A spermatozoid is seen escaping from one of them.

in Ferns, take the very young prothallium, which is easily procured in the case of spores germinating on damp pots in fern-houses, and place it under the microscope between thin plates of glass, moistened with water.

* Newport, on the Impregnation of the Ovum in Amphibia—Phil. Trans. for 1851, p. 169. See also Barry—Phil. Trans. 1843, p. 33.

archegonia (Fig. 1220) and antheridia (Fig. 1219), containing cells with spiral filaments, spirilla, or spermatozoids. The spermatozoids enter the archegonia, and thus a cell is produced, from which the spore-fruit or capsule, a distinct body, is produced (Fig. 1221, *s*), constituting the second generation. In Jungermannieæ, as well as in Marchantieæ, reproductive organs have been detected. Thus in Jungermannia bicuspidata (Fig. 1222), there is represented at *a* an archegonium containing an unimpregnated germ-cell, and at *b* an archegonium containing an impregnated germ-cell, which is the rudimentary fruit. The germ-cell, after fertilization, shows two nucleated cells, *c*, and from it, as a second generation, the fruit-bearing stalk is produced. Around the orifice of the canal leading to the germ-cell and rudimentary fruit are seen numerous spermatozoids, *s s*, which have been discharged from the antheridia.


Fig. 1219.

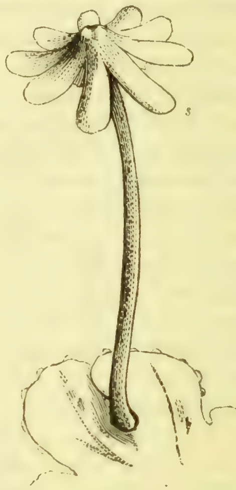

Fig. 1221.

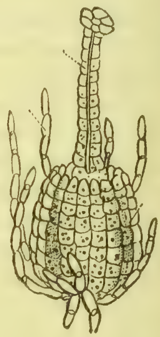
Fig. 1220.

844. In Mosses there is a free germ-cell (embryonal-cell) at the base of the archegonium. Spermatozoids, from the sperm-cells of the antheridium (Fig. 1223), reach it in all probability, and then it is developed into the sporangium or spore-case (Fig. 1224), which is the second generation of the plant, according to some authors. The spores produce the leafy plant (Fig. 999, p. 335), bearing antheridia and archegonia. In Figure 1225 is shown the confervoid prothallium, *p*,

Fig. 1219. Antheridium of Liverwort (*Marchantia*) discharging its sperm-cells, that is, cells containing spermatozoids.

Fig. 1220. Pistillidium or archegonium of Liverwort (*Marchantia*), containing in its interior a cell, which is impregnated by the spermatozoids of the antheridium.

Fig. 1221. Thallus of Liverwort (*Marchantia polymorpha*), bearing a stalked fruit, *s*, which is the product of the impregnated cell of the archegonium. The receptacle at the apex of the stalk bears on its under surface sporangia containing spores and elaters. The spores, when germinating, produce a thallus, on which antheridia and archegonia are formed.

of a Moss produced from the spore, and bearing buds, *a*, *b*, which produce leafy individuals with organs of reproduction. After the contact of these organs, a single cell of the archegonium is developed into the complete fruit (theca or sporangium) which is often borne upon a stalk (Fig. 1224). The complete fruit contains spores, which, when discharged, again develope the foliaceous plant. Bruch and Schimper* say that Mosses having antheridia and archegonia upon the same stem always bear fruit, and that in diœcious Mosses the capsule is not

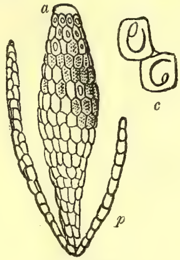

Fig. 1223.

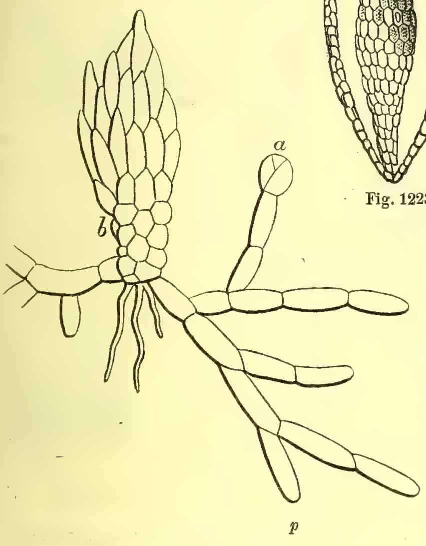

Fig. 1225.

Fig. 1224.

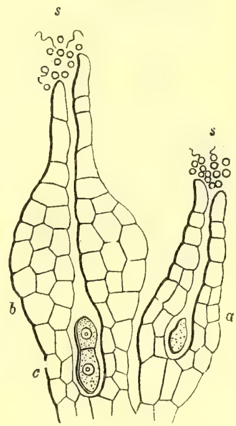

Fig. 1222.

developed unless the plants bearing sperm-cells and those producing germ-cells are in proximity.†

Fig. 1222. Archegonia of Jungermannia bicuspidata. *a*, Unimpregnated archegonium, with a tube leading to a cavity, near the base of which is a cell. *b*, Archegonium after impregnation, with the cell divided into two nucleated portions. This double nucleated body is the rudiment of the fruit-bearing stalk. At the apex of the canal leading to the cell are seen spermatozoids, *s s*.

Fig. 1223. The male organs of a Moss (*Polytrichum*). *a*, Antheridium containing sperm-cells, two of which are seen at *c*. These sperm-cells contain spermatozoids, which are discharged so as to impregnate the archegonium. Surrounding the antheridium there are filaments or paraphyses, *p*.

Fig. 1224. Sporangium of a Moss (*Polytrichum*), supported on a stalk. This stalked sporangium is produced by the impregnated cell of the archegonium. It constitutes the second generation.

Fig. 1225. Prothallium, *p*, of a Moss (*Funaria hygrometrica*), consisting of a congeries of cells arranged in a filiform manner. This prothallium originates from the spore, and bears a bud, *a*, and a young stem, *b*, from the base of which roots proceed. This stem bears antheridia and archegonia. An impregnated cell in the archegonium produces the stalked theca or sporangium.

* Schimper, Recherches Anatomiques et Physiologiques sur les Mousses, Strasburg, 1848.

† Spirilla or spermatozoids have been found in many Mosses, as in species of Sphagnum, Polytrichum, Splachnum, Bryum, and Hypnum. In the antheridia of Polytrichum each cell contains a single spirillum, which shows rapid gyrations.

845. In leafy Mosses and Jungermannieæ there is also an increase by buds. The confervoid filament produced by the spore gives origin to a number of buds (Fig. 1225), whence leafy stems proceed, and these leafy stems also produce buds or gemmæ, called innovations. There is thus a multiplication by reproduction and by gemmation, as in other plants. Thwaites thinks that the theca of Mosses and its contents are due to impregnation; that the spore-mass in the theca is equivalent to the embryo, which divides by gemmation (sporangial or embryonic gemmation) into a number of separate individuals or sporules; that these sporules give origin to other gemmæ, which arise

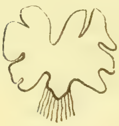

Fig. 1226.

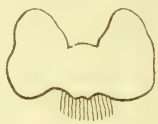

Fig. 1227.

Fig. 1230.

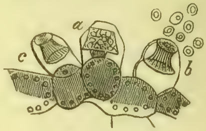

Fig. 1229.

Fig. 1228.

Fig. 1232.

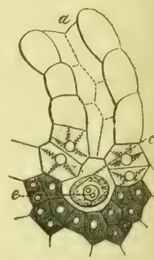

Fig. 1231.

from the confervoid filament or mycelium of the Moss in its early state (mycelial gemmation); and that a third gemmation (or gemmation

Fig. 1226. Prothallium of a Fern. It is a flat cellular expansion of a green colour, lobed at the margin, and with roots proceeding from its lower surface. On it are produced antheridia containing spermatozoids, and archegonia.

Fig. 1227. Prothallium of a species of Pteris, with two lobes and with roots proceeding from one side. The name of prothallus and of pro-embryo is also given to these thalloid expansions.

Fig. 1228. Cellular prothallium of a Fern (*Pteris longifolia*), produced by a spore, *s*, and giving off a root, *r*, at one end. It consists of numerous cells, and it gives origin to antheridia, and pistillidia or archegonia.

Fig. 1229. Antheridia from the prothallium of the Common Brake (*Pteris aquilina*). *a*, An unopened antheridium; *b*, antheridium bursting at the apex, and discharging free cellules, each containing a spermatozoid; *c*, antheridium after the discharge of the cellules.

Fig. 1230. A spermatozoid with cilia, discharged from a cellule in the antheridium of the Forked Spleenwort (*Asplenium septentrionale*).

Fig. 1231. Archegonium of the Forked Spleenwort (*Asplenium septentrionale*) immediately after impregnation. *a*, Canal leading to the ovule or large cell, *c*, at the base of the archegonium; *e*, nucleated embryonic cell, whence the sporangiferous frond proceeds. Spermatozoids from the antheridium reach the canal of the archegonium, and impregnate the ovule.

Fig. 1232. Young plant of a Fern (*Pteris paleacea*), showing the commencement of the sporangiferous frond, *f*, arising from the impregnated ovule in the archegonium; the prothallium, *p*, being still attached.

proper) is the production of gemmæ or innovations after the Moss is fully developed.*

846. In Ferns the prothallium, pro-embryo, or prothallus (Figs. 1226 and 1227), bears antheridia and archegonia at the same epoch. It is produced from the spore, and consists of cells, as shown in Figure 1228. The antheridia occur on the under surface of the prothallium, and they consist of a cellular papilla having a central cavity (Fig. 1229, *a*). This cavity contains free cellules, which are discharged by a rupture at the apex, *b*, and these little cellules, in bursting, give exit to a ciliated spiral filament or spermatozoid (Fig. 1230), which swims actively in water, advancing with a rotatory motion through the water when seen under the microscope. The archegonia (Fig. 1231) exist on the under side of the prothallium, near the notch of the border (Fig. 1227). They are less numerous (varying from three to eight), and consist of cellular papillæ formed by ten or twelve cells. They are larger than the antheridia, and have a central canal, *a*, leading down to a large globular cell, *c*, (called by some ovule) imbedded in the substance of the prothallium or pro-embryo, and containing the embryo germ, *e*. This canal is closed at first, and then opens. In the globular cell at the bottom of the archegonium, a free cell is first formed, which, it is supposed, is reached by the spermatozoids. Mercklin † says that he has seen spermatozoids in the canal of the archegonium of Ferns. Suminski ‡ thinks that the end of a spermatozoid is developed into the embryo-cell. After a time this cell divides, and is gradually converted into an embryo, with a bud above and a radicle below, from which the regular leafy stem of the Fern grows (Fig. 1232, *f*). The life of the sporangiferous plant is indefinite, as in Tree Ferns, while the prothallium is usually of very short duration. Thus in Ferns the spores contained in the sporangium form the prothallus (Fig. 1228) without impregnation, and this latter process is necessary for the development of the germ (Fig. 1231, *e*), which gives rise to the leafy sporangiferous stem or frond; while in Mosses the spore forms the prothallus and the leafy stem without impregnation, and this operation only causes the development of the stalked theca, or spore-producing part of the plant (Fig. 1224). Hofmeister says that in Mosses the archegonium or rudiment of the fruit is like the ovule in Ferns; it contains a cell which becomes blended with the stem at one end (below), and forms a sporangium at the other end. Equisetaceæ (p. 330) resemble Ferns in their reproduction and alternation of generation. Thuret found sperm-cells in the young state of the fronds of Equiseta. §

* Thwaites conjectures that the tetraspores of Florideæ (Fig. 1035, p. 349), and the opseospermata of Chætophoreæ, and the terminal spore of Vaucheria (Fig. 1037, p. 350), are true gemmæ.

† Mercklin, Beobachtungen an dem Prothallium der Farrnkräuter, St. Petersburg, 1850.

‡ Lezczyc-Suminski, Entwickelungs-geschichte der Farrnkräuter, Berlin, 1848. See Annals of Nat. Hist. 2d ser. iv. 339.

§ Thuret, sur les Anthéridies des Fougères, in Ann. des Sc. Nat. 3d ser. Bot. xi. 5. Mettenius, Beiträge zur Botanik, 1850, p. 22. Milde, de Sporarum Equisetorum Germinatione, in Linnæa for 1850, 545. Milde, ueber Antheridien bei keimenden Equiseten, in Bot. Zeit. for 1850, viii. 448.

847. Hofmeister and Mettenius* have examined the reproduction of Club Mosses (Lycopodiaceæ), and have detected antheridia and archegonia. They find that the small spores of Lycopods discharged from the antheridia (Fig. 1233) do not produce new plants, but have an office analogous to that of the pollen, namely, to effect the fertilization of a germ produced by the large spore (Fig. 1235). The small spores contain cellules with spiral filaments or spermatozoids (Fig. 1234, *c*); the other spore emitted from the oophoridium or sporangium (Fig. 1235) is much larger than the pollinic spore, and is the ana-

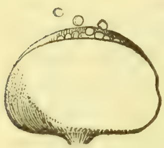

Fig. 1233.

Fig. 1234.

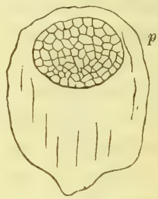

Fig. 1236.

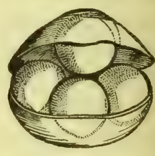

Fig. 1235.

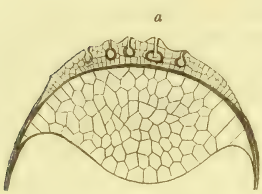

Fig. 1237.

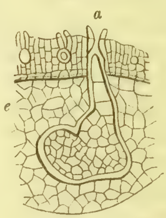

Fig. 1238.

Fig. 1239.

logue of the ovule. The large spore forms a cellular prothallium in its interior (Fig. 1236, *p*), on which archegonia are developed.†

Fig. 1233. Antheridium of a Club Moss (*Lycopodium*), containing small spores, which are cells containing spermatozoidal cellules, as seen in Figure 1234.

Fig. 1234. Small spore (pollinic spore) of a Lycopod (*Selaginella helvetica*), bursting and discharging cellules, *c*, containing spermatozoids.

Fig. 1235. Oophoridium or sporangium of a Club Moss (*Lycopodium*) opening, and showing four large spores in its interior. These large spores or ovules contain a cellular prothallium in their interior, bearing archegonia.

Fig. 1236. Large spore discharged from the oophoridium of a Lycopod (*Selaginella Mertensii*), with the outer coat removed to show the young cellular prothallium, *p*, at the upper end.

Fig. 1237. Vertical section of the prothallium and upper half of a large spore of a Lycopod (*Selaginella denticulata*). There are several archegonia, and in one of them, at *a*, there is a central free cell, whence the leafy frond ultimately proceeds.

Fig. 1238. Vertical section of a small portion of the prothallium and upper part of the large spore of a Lycopod (*Selaginella denticulata*), showing the embryo, *e*, developed from a central cell of one of the archegonia, *a*, carried down by the growth of the suspensor, so as to be imbedded in the cellular tissue at the upper part of the spore.

Fig. 1239. The small spore of a Rhizocarp (*Pilularia globulifera, Pillwort*). The inner coat is protruded, and the outer coat has burst, so as to discharge cellules containing spermatozoids. Some of the spermatozoids are separate, and are seen coiled up in a spiral form.

* Mettenius, Beiträge zur Botanik, Heidelberg, 1850.

† Muller, on the Development of Lycopodiaceæ, in Bot. Zeitung, trans. in Ann. of Nat. Hist. 1st series, xix. 27. See also Henfrey, in Garden Companion for May 1852, p. 70.

The process of impregnation is supposed to take place here by the spermatozoids of the small spores coming into contact with the large spore, after the coat of the large spore has burst at its apex, so as to expose the cellular prothallium and its archegonia (Fig. 1237, *a*). The free central cell of the archegonium then enlarges, divides, and elongates into a filament, which grows down into the prothallium (Fig. 1238). A suspensor is thus formed, at the end of which is the embryo, *e*, imbedded in the cellular tissue at the upper part of the large spore. The embryo finally produces its radicle and its bud, which is developed as the leafy frond. In Rhizocarps* the antheridia are sacs containing small spores, which emit cellules with spermatozoids (Fig. 1239). The large spores contained in the sporangia of Rhizocarps (Fig. 1240) produce first a prothallium like that of Lycopods, in which archegonia appear (Fig. 1241). The prothallium usually developes only one central archegonium. To this the spermatozoids get access, and then the development of the embryo takes

Fig. 1240.

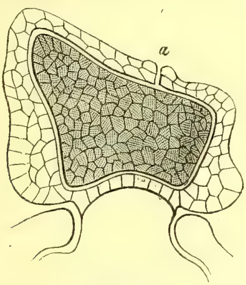

Fig. 1242.

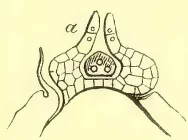

Fig. 1241.

place, as seen in Figure 1242, where the cellular embryo within the prothallium has attained a large size.†

Fig. 1240. Large spore of a Rhizocarp (*Marsilea, Pepperwort*), which contains a cellular prothallium bearing archegonia. The mammillary projection is the point whence the gemmation of the embryo proceeds after impregnation.

Fig. 1241. Vertical section of prothallium of a Rhizocarp (*Pilularia globulifera*), containing a central archegonium, *a*, before impregnation.

Fig. 1242. Archegonium, *a*, of a Rhizocarp (*Pilularia globulifera*) cut vertically after impregnation, showing the prothallium, with the embryo in its interior in an advanced state. This embryo gives origin to the leafy stem.

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* Mettenius, Beiträge zur Kenntniss der Rhizocarpeen, Frankfurt, 1846. Nægeli, sur la Propagation des Rhizocarpées, in Ann. des Sc. Nat. 3d ser. Bot. ix. 99.

† For full details relative to Cryptogamic Reproduction, the student may consult the following works:—Agardh, sur la Propagation des Algues, in Ann. des Sc. Nat. 2d ser. v. 193. Lehrbuch der Botanik. Berkeley and Broome, on the conversion of Asci into Spores in Fungi —British Assoc. Proc. 1851, p. 70. Cohn, on Hæmatococcus—Nova Acta, xxii., and on Stephanophæra, in Ann. Nat. Hist. 2d ser. x. 401. Derbes et Solier, sur les Organes Reproducteurs des Algues, in Ann. des Sc. Nat. 3d ser. xiv. 261. Hassall, on British Fresh-water Algæ. Hedwig, Theoria Generationis et Fructificationis Plantarum Cryptogamicarum. Henfrey, on the Reproduction and supposed existence of Sexual Organs in the higher Cryptogamous Plants, in Report of British Assoc. for 1851, p. 162. On the Reproduction of the Higher Cryptogamia and Phanerogamia, in Ann. of Nat. Hist. 2d ser. ix. 441. Hofmeister, vergleichende Untersuchungen der Keimung, Entfaltung und Fruchtbildung

B. *Formation of the Embryo in Phanerogamous or Cotyledonous Plants.*

848. In these plants we meet with conspicuous organs of reproduction in the form of pollen-bearing stamens and ovule-producing pistils. In some instances these organs are obscure or abnormally developed, and hence apparently has arisen the idea that perfect seeds have been produced without the action of pollen. These cases have already been noticed at page 555. The anomalies occur in unisexual plants, in regard to the impregnation of which there is great likelihood of erroneous observation. Believing that nothing has yet transpired to prove that pollinic and ovular cells are not concerned in Phanerogamous reproduction, we now proceed to trace the steps of this process first in Gymnospermous, and then in Angiospermous Phanerogams.

a. EMBRYOGENY IN GYMNOSPERMOUS PHANEROGAMS.

849. In Gymnospermous plants, such as Coniferæ (Fig. 1243) and Cycadaceæ (Fig. 1244), impregnation is effected by direct contact between the pollen and the ovule. There is no true ovary bearing a stigma. In the Coniferæ the scales covering the seeds are either reckoned as bracts or as expanded ovarian leaves (Fig. 1245). In Cycadaceæ the naked ovules are produced on the margin of modified leaves. In both these orders it is usual to meet with more than one embryo in the perfect seed. In the Coniferæ there is also a peculiar delay in the production of the embryo, after the contact of the pollen. The phases through which the embryo passes in the seed may be reckoned as somewhat similar to those observed in the case of Lycopodium. Brown long ago noticed in the albumen of Coniferous seeds, semicylindrical bodies, three to six in number, which he called corpuscles (Fig. 1248, *d*). They are arranged in a circle near the

höherer Kryptogamen, Leipzig, 1846. Ueber die Fruchtbildung und Keimung der höherer Kryptogamen, in Bot. Zeitung for 1849, vii. 793, translated in Botanical Gazette, ii. 70. Itzigsohn, de l'existence des Spermatozoides dans certaines Algues d'eau douce, in Ann. des Sc. 3d ser. xvii. 150. Kaulfuss, das Wesen der Farrnkräuter besonders ihrer Fruchtheile, &c. Leipzig, 1827. Leszczyc-Suminski, sur le développement des Fougères, in Ann. des Sc. Nat. 3d ser. Bot. xi. 114. Milde, zur Kenntniss der Equiseten in Nova Acta Nat. Curios. xxiii. part ii. 557; zur Entwickelungs-geschichte der Equiseten und Rhizokarpen—Nova Acta, xxiii. part ii. 613. Pringsheim, Entwickelungs-geschichte der Achlya prolifera, in Nova Acta, xxiii. part i. 395. Ralfs, on the British Desmidieæ. Schacht, Beiträge zur Entwickelungs-geschichte der Farrnkräuter, in Linnæa for 1849, 753. Ueber Antheridien der Lebermoose, in Botan. Zeitung for 1852, x. 153. Siebold, sur les Plantes et les Animaux unicellulaires, in Ann. des Sc. Nat. 3d series, xii. 138. Thuret, sur les Anthéridies des Fougères, in Ann. des Sc. Nat. 3d ser. xi. 5. Sur les Zoospores des Algues et les Anthéridies des Cryptogames, in Ann. des Sc. Nat. 3d series, Bot. xiv. 214, and xvi. 5. Tulasne, sur l'Appareil Reproducteur dans les Lichens et les Champignons, in Ann. des Sc. Nat. 3d ser. xv. 370. Hist. Organog. et Physiol. des Lichens, in Ann. des Sc. Nat. 3d ser. xvii. 153; and Comptes Rendus, 1851. Unger, sur les Anthères des Mousses, et sur les Animalcules Spermatiques qu'elles contiennent, in Ann. des Sc. Nat. 2d ser. xi. 257. Sur les Animalcules Spermatiques des Plantes, in Ann. des Sc. Nat. 2d ser. xi. 271. Valentine, on the Development of the Theca, and on the Sexes in Mosses, in Linn. Trans. xvii. 465. Wigand, zur Entwickelungs-geschichte der Farrnkräuter, in Bot. Zeit. Jan. and Feb. 1849; and Ann. des Sc. Nat. 3d ser. Bot. xi. 126.

apex, and differ from the mass of the albumen in colour as well as consistence. In Pinus sylvestris and P. austriaca the number of corpuscles are three to five, in Abies balsamea and pectinata three in

Fig. 1243.

Fig. 1244.

general, and in Abies canadensis, Taxus, and Juniperus, four, rarely five or more. In each of these corpuscles there is a distinct embryonal funiculus. These funiculi often ramify, and each of their ramifications terminates in the rudiment of an embryo (Fig. 1251, 2). The corpuscles in Pinus are not developed, according to Brown, until the spring, or even beginning of summer of the year after flowering.* In Cycadaceæ the enlargement of the fruit, the consolidation of the albumen, and the complete formation of corpuscula in its apex, are wholly independent of male influence, as Brown has proved in cases where pollen could not have been applied, namely, in Cycas and Zamia, producing female flowers in England at a time when male flowers were not known to exist in the country.†

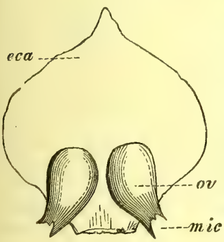

Fig. 1245.

Fig. 1243. A Coniferous tree, the Stone-pine, which belongs to the Gymnospermous division of Phanerogams, the seeds being naked, that is, not contained in an ovary with a stigma. The seeds are in cones.

Fig. 1244. A Cycadaceous plant (*Cycas revoluta)*, belonging also to the Gymnospermous division. The seeds are produced on the edge of abnormal leaves.

Fig. 1245. Pistillate flower of a Pine, consisting of a scale, *eca*, which is a hardened bract, and two ovules, *ov*, attached to its base; *mic*, the foramen of the ovule. The ovules are naked, not being contained in a true ovary.

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* Brown, on the Plurality and Development of Embryos in the Seeds of Coniferæ—Brit. Assoc. Tran. 1834. Annals of Nat. Hist. 1st ser. xiii. 368. Annales des Sc. Nat. 2d ser. xx. 193.

† Brown, on Female Flowers of Cycadeæ and Coniferæ, Appendix to Capt. King's Voy. 1826, ii. 536—Brit. Assoc. Report, 1835, p. 596. Ann. des Sc. Nat. viii. 211.

850. Mirbel and Spach* examined the seed of the Yew, and found that the ovule at first appeared as a mere bag of mucilage containing rudiments of cells which arrange themselves in a honeycomb manner. After impregnation, active changes begin in the primitive cells. They send out tubes which pass irregularly into the cavity of the young seed, and after ceasing to lengthen form cells at their extremity, which are the rudiment of the embryo. The tubes act as suspensors and finally disappear, while the cells at the end multiply and form the embryo with its cotyledons.

851. The subject has been recently examined with great care by Hofmeister,† and the following are his views. The ovule of Conifers consists of a short nucleus inclosed in a single integument, and having a large micropyle (Fig. 1246). In the delicate cellular nucleus there is developed an embryo-sac, *b*, sometimes more than one, as in the Yew tribe. The pollen grains enter the large micropyle and come into contact with the nucleus, and then send their tubes into its apex (Fig. 1247, *c*). This process sometimes requires several weeks or

Fig. 1246.

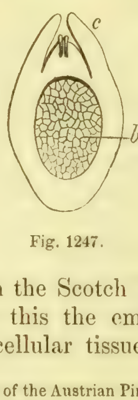

Fig. 1247.

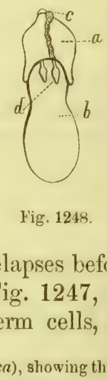

Fig. 1248.

months. Pineau says, that in the Scotch Fir a year elapses before the tubes reach the sac. After this the embryo-sac (Fig. 1247, *b*), becomes gradually filled with cellular tissue or endosperm cells, and at

Fig. 1246. Vertical section of the ovule of the Austrian Pine (*Pinus austriaca*), showing the nucleus, *a*, consisting of delicate cellular tissue containing deep in its substance an embryo-sac, *b*, formed before impregnation by the coalescence of a vertical series of a few cells. The micropyle, *m*, is very wide, and through it the pollen-grains come into contact with the summit of the nucleus, into the substance of which they send their tubes.

Fig. 1247. Vertical section of the ovule of the Scotch Fir (*Pinus sylvestris*) in May of the second year, showing the enlarged embryo-sac, *b*, full of endospermal cells, and pollen-tubes, *c*, penetrating the summit of the nucleus after the pollen has entered the large micropyle of the ovule.

Fig. 1248. Vertical section of the embryo-sac, *b*, and of part of the nucleus, *a*, of the ovule of the Weymouth Pine (*Pinus Strobus*). At the micropylar end of the embryo-sac, two cells called corpuscles, *d*, have made their appearance. Each of these is at first separated from the inner surface of the micropylar end of the sac by a single cell, which afterwards divides into four, leaving a passage from the surface of the sac down to the corpuscle. The pollen-grain, *c*, on the summit of the nucleus, then sends down a tube which perforates the embryo-sac, and reaches the corpuscle through the intercellular canal.

* Mirbel et Spach sur l'Embryogenie des Pinus Laricio et sylvestris, des Thuya orientalis et occidentalis, et du Taxus baccata, in Ann. des Sc. Nat. 2d ser. xx. 257.

† Hofmeister, vergleichende Untersuchungen der Keimung, Entfaltung und Fruchtbildung höherer Kryptogamen und der Samenbildung der Coniferen, Leipsic, 1851. See Henfrey's Report in Brit. Assoc. Report for 1851, p. 122. See also Henfrey on the Reproduction of the Higher Cryptogamia and Phanerogamia, in Annals of Nat. Hist. 2d ser. ix. 441.

the same time enlarges. This development of endosperm cells occupies frequently a long time, especially in the Abietineæ, which require two years to ripen their seeds. After the embryo-sac has become filled with cellular tissue, certain cells at the micropylar end of the sac enlarge and form the corpuscles of Brown, the secondary embryo-sacs of Mirbel and Spach (Fig. 1248, *d*). Each corpuscle is at first separated from the inner surface of the embryo-sac by a simple cell, which afterwards divides into four by the formation of two vertical septa crossing each other ; then a passage is formed between the inner angles of these cells leading to the corpuscle. In the cavity of each corpuscle free cells appear. After the corpuscles become evident, the pollen tubes resume their growth, pass through the tissue of the nucleus, and reach the outside of the embryo-sac, one over each corpuscle. The tubes then perforate the membrane of the embryo-sac, reach the canal between the four cells, and come into contact with the corpuscle. (Fig. 1248, *d*). A cell at the lower end of the corpuscle then enlarges, and forms the embryonal vesicle. A free cell in the vesicle divides into

Fig. 1249.

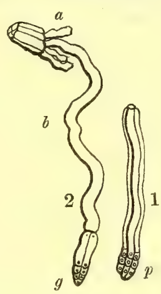

Fig. 1251.

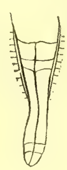

Fig 1250.

eight cells by vertical and transverse septa, and these together constitute a short cylindrical cellular body (Fig. 1249), the *pro-embryo*, as it is called by Hofmeister. The four lower cells of this pro-embryo, by the elongation of the upper ones (Fig. 1250), are finally pushed into the substance of the nucleus. The four elongated pro-embryonic cells (Fig. 1251, 1) now appear as isolated suspensors (Fig. 1251, 2), and the cell at the end of each suspensor becomes an embryo, *g*. There are thus four times as many rudimentary embryos as there are corpuscles. Usually one of these only becomes developed as the embryo of the ripe seed.

Fig. 1249. Nucleated cells of what Hofmeister calls the pro-embryo, in the ovule of the Weymouth Pine (*Pinus Strobus*). The cells are pushed downwards into the cellular tissue of the nucleus by the elongation of the upper cells, which finally form the suspensor.

Fig. 1250. The same pro-embryonic body in the ovule of the Weymouth Pine, with the lower cells pushed farther down by the elongation of the upper suspensory cells.

Fig. 1251. Suspensors taken from the ovule of the Weymouth Pine (*Pinus Strobus*). In No. 1 the four suspensors are united. They form a cylinder composed of four elongated cells, and at the end, *p*, are seen some of the lower nucleated cells of the pro-embryo. In No. 2 the suspensors have separated, three of them, *a*, are cut off, and the remaining one, *b*, is connected with the embryo, *g*, at its extremity.

852. Pineau* thinks that when the pollen tube comes into contact with the corpuscle, it bursts so as to discharge its fovilla into the corpuscle. According to Geleznoff† the embryo is formed by a cellule which originates in the end of the pollen tube, and passes through an orifice into the corpuscle. Schacht also advances a similar opinion. He says that the pollen tube in such plants as Taxus, Pinus, and Abies, enters the corpuscle, and fills it either entirely or partially with cellules, these cellules being always in the interior of the pollen tube, and forming the rudiment of the embryo.‡

853. The view which seems to be supported by the best physiologists is thus given by Henfrey. In Conifers and Cycads, which embrace Gymnospermous plants, the pollen grains are applied to the micropyle of the ovule, without the intervention of a stigma; they then traverse the cells of the nucleus, and reach the embryo-sac. The endospermal cells which fill this sac develope corpuscles consisting of an enlarged cell surmounted by four others, which leave a canal between them leading to the large cell. Henfrey thinks that this resembles the Archegonia of Selaginella and Ferns. The pollen tube enters the canal between these cells, and impregnates the large cell of each corpuscle, just as the spermatozoid acts in the case of Ferns. The large central cell then produces four suspensors, each of which presents at its extremity a rudimentary embryo, only one of which becomes fully developed. The growth of the suspensors down from the central cell, Henfrey thinks, is analogous to the growth of the suspensor in Selaginella and Isoetes. We observe a marked development of endospermal cells extending over a considerable period, and thus making an evident interval between the entrance of the pollen tubes and the production of corpuscles. Henfrey is disposed to look upon the endospermal cellular development as analogous to the prothallium produced within the large spore of Lycopods, and which in other Cryptogams, such as Ferns, is not produced within the spore, but grows out from it in the form of a green expansion bearing both archegonia and antheridia.§

b. EMBRYOGENY IN ANGIOSPERMOUS PHANEROGAMS.

854. In regard to Phanerogamous Angiosperms, when the pollen grains are discharged from the anther, they are applied to the stigmatic surface of the pistil, and the viscid fluid there secreted causes a

* Pineau, sur la formation de l'Embryon chez les Conifères, in Ann. des Sc. Nat. 3d ser. Bot. xi. 83.

† Géléznoff, sur l'Embryogenie du Meleze—Bull. Soc. Nat. de Moscow, xxii. and Ann. des Sc. Nat. 3d ser. xiv. 188.

‡ Schacht, Entwickelungs-geschichte des Pflanzen-embryon, Amsterdam, 1850.

§ For a full view of the analogies between reproduction in Cryptogams and Gymnosperms, see Henfrey's Paper already referred to. See also Corda, Beiträge zur Lehre von der Befruchtung der Pflanzen in Nova Acta, xvii. 599, for an account of the Embryogenic process in Pinus Abies.

rupture of the extine and the protrusion of the intine in the form of a tubular prolongation, which gradually elongates as it proceeds down the loose conducting tissue of the style. At the period of impregnation, Griffith noticed an oscillatory movement in the pollen tubes of Dischidia.

855. There were formerly differences of opinion as to the mode in which the influence of the fovilla was conveyed to the ovules. Hartig* maintained that in many instances the tube did not reach the ovule, but that the fovilla during the latter part of its course was conducted by the tissue of the style. Brongniart also thought that the pollen tubes burst at their lower end, and that the fovilla was conveyed by the conducting tissue to the ovules. Almost all physiologists, however, of the present day believe that the closed extremity of the pollinic tube sooner or later comes into contact with the ovule. In some cases it appears to be met by a tubular prolongation from the ovule itself. Meyen noticed in Phaseolus and in Alsine media, and Griffith† in Santalum album, that the apex of the embryo-sac is very much prolonged upwards so as to meet the pollen tube. Professor Dickie‡ observed similar ovular tubes in the case of Euphrasia officinalis and Odontites, Narthecium ossifragum and Veronica. In Eyebright (Euphrasia) the ovule-tube is less than 1-3000th of an inch in diameter.

856. When the pollen-tube reaches the ovule it proceeds through the foramen or micropyle so as to come into contact with the embryo-sac (Fig. 1208, *s*, p. 566). Consequent on this is the development of the cellular embryo. The determination, however, of the steps of the embryogenic process has given rise to disputes among physiologists. Some maintain that the end of the pollen-tube enters or introverts the embryo-sac, and becomes the rudimental cell of the embryo, others, that the tube merely comes into contact with the sac, in which a germinal vesicle has been previously formed ready for impregnation. Much has been done of late years to clear up the difficulties of this controverted matter, and there seems to be now a more general agreement among physiologists in regard to the principal facts of embryogeny.

857. In the year 1837 Schleiden advanced a view of embryogeny which has received a few supporters. He states that a cell of the nucleus is developed into the embryo-sac (the quintine of Mirbel), seen in Figure 1252, *s*, and that this occurs in all Phanerogamous plants;§ that the embryo-sac contains a substance which is gradually transformed into cellular tissue, and which ultimately constitutes (when not

* Hartig, Neue Theorie der Befruchtung der Pflanzen.

† Griffith, on the Ovule of Santalum album, in Linn. Trans. xviii. 59; on the Ovulum of Avicennia, in Linn. Trans. xx. 1; on the Development of the Ovulum, Notulæ in Plantas Asiaticas, 1847, p. 133.

‡ Dickie, on the Physiology of Fecundation in Plants, in Annals of Nat. Hist. 1st ser. xvii. 5; on the Ovule of Euphrasia officinalis, in Ann. of Nat. Hist. 2d ser. i. 260.

§ Schleiden examined at least 500 plants of the most different families (about 150), and states that he never failed, at least in the earlier stages, to extract the embryo-sac in whole or part. The demonstration of the sac, he says, is easiest in New Zealand Flax (Phormium tenax), the Almond tribe, Water-lilies, and some of the Cucumber tribe.

absorbed by the growth of the embryo) the endosperm or albumen; that the pollen tube can be traced from the stigma to the micropyle

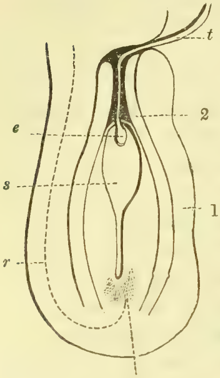

Fig. 1252.

in a very large number of plants, and that in Helianthemum dentatum he has not unfrequently extracted the pollen-tube free, in unbroken continuity, from the pollen-grain to the ovule; that the tube next reaches the embryo-sac, *s*, the walls of which it presses in before it, and thus becomes surrounded by it, although in reality external to it, like the intestines and their peritoneal covering; that in some instances it causes absorption of the walls of the sac and enters it, and that the end of the pollen-tube, *e*, forms the rudiment of the embryo or the germinal vesicle, in which cells are developed from cytoblasts, while a portion of variable length, at the upper part of the tube, remains as the suspensor or embryophore. He applies these views to cases of polyembryony, as occurs in Coniferæ and Cycadaceæ, as well as in the Mistleto and other plants, and considers that the plurality of embryos depends on more than one pollen-tube having entered the foramen of the ovule.* These opinions were adopted by Wydler † and Geleznoff, ‡ and of late they have been supported by Schacht,§ who also states that the pollen-tube occasionally branches, so that one tube may give origin to several embryos.

858. The views of Schleiden, when first propounded, stimulated all vegetable physiologists. The facts were new, and seemed to upset all former ideas as to the nature of the stamens and pistils. Mirbel and Spach, Meyen, Amici, Hofmeister, Muller, Tulasne, and others, entered the field, and the result has been that Schleiden's opinions have not been confirmed. These authors agree in tracing the pollen tube downwards to the ovule, and they maintain that in the embryo-sac there exists one or more vesicles before impregnation, and that one of these vesicles, after the impact of the pollen tube with the embryo-sac, becomes altered and enlarged, so as to form the rudiment of the embryo.

Fig. 1252. Ovule of Philydrum lanuginosum, shortly after impregnation, according to Schleiden The pollen-tube, *t*, has reached the foramen (micropyle), and has passed through the ovular canal to the nucleus and embryo-sac, *s*; it has entered the latter either by perforating its walls or by introverting them. The end of the pollen-tube, *e*, according to Schleiden, constitutes the first cell of the embryo. 1, the primine; 2, the secundine; *ch*, the chalaza; *r*, the raphe.

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* Schleiden, einige Blicke auf die Entwickelungs-geschichte der Veget. Organism—Wiegmann, Archiv. 1837. Um Bildung des Eichens, und Enstehung des Embryos bei der Phanerogamen—Nova Acta, xix. part 1, 27. Sur la formation de l'Ovule et l'Origine de l'Embryon dans les Phanérogames, in Annales des Sc. Nat. 2d ser. xi. 129. Recherches sur la Phytogensie, in Annales des Sc. Nat. 2d ser. xi. 242 and 362, translated in Taylor's Scientific Memoirs, ii. 281.

† Wydler, sur la formation de l'Embryon, in Annales des Sc. Nat. 2d ser. xi. 142.

‡ Gélézuoff, ueber die Bildung des Embryo, in Bot. Zeitung, 1843, 841. Bullet. of Imp. Nat. Hist. Soc. of Moscow, xvi.

§ Schacht, Entwickelungs-geschichte des Pflanzen-Embryon, Amsterdam, 1850.

859. In 1839, Mirbel and Spach* examined the embryogeny of grasses, and especially of the Indian Corn (Zea Mais) a monœcious grass, and they were led to contradict the views of Schleiden, and to maintain that he had mistaken a cell of the ovule for the extremity of the pollen-tube. They showed that before the pollen was ripe, a cell was developed in the ovule, which they called the primary utricle, and that this came into contact with the pollen-tube, so as to produce the embryo. Giraud† and Wilson‡ made similar observations on the formation of the embryo in Indian Cress (Tropæolum majus), and both are opposed to Schleiden's views. Meyen§ published a series of observations on various species of Mesembryanthemum, especially M. pomeridianum, in which he noticed an adhesion between the pollen-tube and embryo-sac, a discharge of part of the contents of the former without any entrance of the tube into the sac, and the formation of a germ-vesicle which gradually elongated by the production of cells, and ended in a globular body which formed the embryo.

860. In 1847, Amici, on examining Cucurbita Pepo, stated that he found a hollowing out of the nucleus or central part of the ovule, in such a way as to form a sac, in which there existed an embryonic or germinal vesicle before the application of the pollen. He traced the pollen-tube down the style to the ovule, so as to come into contact with the vesicle. In this stage a penetration of fluids took place, and thus the act of fecundation was accomplished. The embryonic vesicle after this increased, the development of cells took place at its base, that is, opposite to the part where the pollen-tube exerted its influence, the pollen-tube disappeared, and finally the vesicle became full of parenchyma in which the embryo was developed. In Orchis Morio he traced in the same way the pollen-tube (Fig. 1253, *t*) to the upper portion of the embryo-sac, *e*, where the germinal vesicle had been previously formed. Imbibition of fluid then took place between the end of the tube and vesicle, giving rise to the development of the embryo at the lower end of the vesicle, and the elongation of the upper part in the form of a confervoid filament, which acted as a suspensor of the embryo.||

861. Hofmeister,¶ in 1847, examined the mode of fecundation in species of Œnothera, Godetia, and Boisduvalia, and the result of his researches was, that he found an embryo-sac containing at first numerous granules from 1-3500th to 1-3000th of a line in diameter,

* Mirbel et Spach, sur l'Embryogenie Végétale, in Annales des Sc. Nat. 2d ser. xi. 200 and 381.

† Giraud on Vegetable Embryology, in Ann. of Nat. Hist. 1st ser. v. 225. On the Origin and Development of the Embryo in Tropæolum majus, in Linn. Trans. xix. 161, Ann. Nat. Hist. ix. 245.

‡ Wilson, Researches in Embryogeny, Phytologist, i. 625, 657, 731, 849, 881.

§ Meyen, on the Act of Impregnation, and on Polyembryony, Berlin, 1846. Translated in Taylor's Scientific Memoirs, iii. 1. Also, sur la fecondation des Végétaux, Annales des Sc. Nat. 2d ser. xi. 312.

|| Amici, sur la Fecondation des Orchidées, in Ann. des Sc. Nat. 3d ser. vii. 193, from Parlatore Giorn. Bot. Ital. Ann. 2.

¶ Hofmeister, sur la manière dont s'opere la fecondation chez les Œnotherées, Bot. Zeitung, Nov. 1847; Ann. des Sc. Nat. 3d ser. Bot. ix. 65. Die Enstehung des Embryo der Phanerogamen, Leipsic, 1849; also in Annales des Sc. Nat. 3d. ser. xi. 375.

floating in a viscid mucilaginous fluid (protoplasm); in the midst of this granular matter certain nuclei appeared, which developed cells varying in number from one to three or more (Fig. 1254, *v*). These nucleated cells appeared before impregnation; one of them became pyriform, and touched the membrane of the embryo-sac by its conical extremity, while its other extremity hung free in the embryo-sac. This cell is the germinal vesicle—the embryonary vesicle of Amici. The pollen-

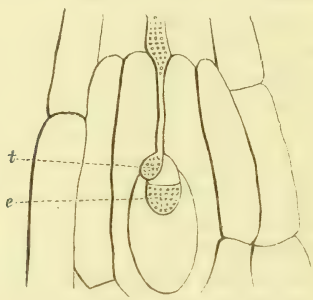

Fig. 1253.

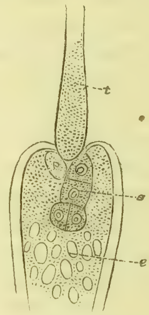

Fig. 1254.

tube, in passing through the micropyle, is often contracted in its diameter. The end of it is expanded when it reaches the embryo-sac, to which it is applied either at the apex or near it (Fig. 1254, *t*). Sometimes the end of the tube, still closed, introverts the sac, as seen in the Figure, or even perforates it, so as to come into contact with the germinal vesicle. In either case an endosmotic action takes place between the contents of the tube and the sac or the vesicle. In consequence of this action, cell-formation begins in one, rarely more germinal vesicles. The vesicle increases, and is transformed into a compound cellular mass, which Hofmeister calls the pro-embryo. This divides into two by the formation of a septum; the upper part elongates, and forms a septate cellular suspensor, *s*, while the lower portion becomes globular, divides into four, and is developed as the embryo, surrounded by endospermal cells, *e*.

862. In 1848, Mohl* confirmed the researches of Amici in his examination of the Orchis Morio. In this plant he traced the formation

Fig. 1253. Section of ovule of an Orchis (*Orchis Morio*), showing the pollen tube passing through the endostome, and reaching the embryo-sac in the nucleus. The closed and enlarged end of the tube, *t*, is applied to the sac, in which a vesicle had been previously formed. Transudation of fluids takes place, and the embryo, *e*, is developed at the lower end of the germinal or embryonal vesicle while the upper part of the vesicle elongates, and forms a confervoid suspensor.

Fig. 1254. Section of the ovule of Œnothera, showing the pollen tube, *t*, with its enlarged extremity applied to the end of the embryo-sac, and introverting it slightly; the germinal vesicle in the sac has been impregnated, and has divided into two parts, the upper part forming a confervoid septate suspensor, *s*, and the lower dividing into 4 parts, which form a globular mass—the rudimentary embryo, surrounded by endospermal cells, *e*.

* Mohl, sur le développement de l' Embryon dans l'Orchis Morio, Bot. Zeitung, 1847, and in Ann. des Sc. Nat. 3d ser. ix. 24.

of the embryo-sac and embryonic vesicle, and the descent of the pollen tubes. The ovule arises from the placenta as a projecting cell, which by division becomes a cellular papilla (the nucleus) having a central cell (embryo-sac) surrounded by a simple cellular layer. The two coats grow over this, and by the greater elongation of one side the ovule becomes anatropous. The nucleus loses its cellular coat by absorption, and finally consists simply of an embryo-sac. In the apex of this sac, at the time when the pollen falls on the stigma, three cellules (embryonal vesicles) make their appearance. The pollen tubes pass down the style and finally reach the placenta, and enter, either singly or more than one, the micropylar canal of the ovule, and come into contact with the embryo-sac on the outside, close to the place where the embryonal vesicles lie. The pollen tube does not penetrate the sac. After this, one of the embryonal vesicles begins to swell, divides by a septum into two, the upper cell grows out in a filamentous form through the micropyle, while the lower cell enlarges and divides repeatedly, so as to form a cellular globule, the embryo. The filamentous prolongation, apparently analogous to the suspensor, withers. Mohl concludes by stating that he differs from Schleiden in his views, and that he considers the pollen grain not as a plant ovum, but as the male fertilizing organ. In the protaplasm of the embryo-sac, according to him, nuclei appear before the pollen tube reaches the sac, and thus give rise to the formation of germinal vesicles, one of which, after impregnation, gives origin to the embryo.

863. Muller,* in 1848, examined the development of the vegetable embryo in Orchis Morio, Monotropa Hypopitys, Begonia cucullata, Elatine Alsinastrum, and Epilobium angustifolium. The conclusions at which he arrives are, that the pollen tube is applied to the embryo-sac for the purpose of supplying to it, by a process of endosmose, the fertilizing or fecundating matter which is contained in the tube ; that the embryo takes its origin in a cytoblast, and not in the extremity of the pollen tube. Unger,† in 1849, made the embryo of the Hippuris vulgaris an object of study, and traced in this plant the various stages of embryo growth. His results are similar to those just noticed, and are at variance with the views of Schleiden.

864. Tulasne‡ is the next vegetable embryologist who entered the field. His researches were carried on in 1849, and had reference principally to the natural orders Scrophulariaceæ, Halorageaceæ, Campanulaceæ, and Cruciferæ. He confirms in most particulars the observations of Amici, Hofmeister, Mohl, and Muller. In Cruciferæ and Scrophulariaceæ there is a large embryo-sac (Fig. 1255) in the midst of a cellular nucleus. At the upper part of the embryo-sac embryonal vesicles are produced, *b ;* and in the lower and middle

* Müller, sur le Développement de l'Embryon Végétale—Ann. des Sc. Nat. Bot. 3d ser. ix. 33.

† Unger, Die Entwickelung des Embryo von Hippuris vulgaris, in Mohl et Schlechtendal, Bot. Zeit. vii. 329.

‡ Tulasne, Etudes d'Embryogenie Végétale, Ann. des Sc. Nat. 3d ser. Bot. xii. 21.

part of the sac a number of free cellules, *c*, called endospermal cells (in which the albumen or endosperm is formed). The pollen tube, *a*, penetrates the apex of the cellular nucleus, and reaches the embryo-sac at a point removed from the vesicles. The impregnated embryonal vesicle, *b*, is next divided into two parts by a septum, the upper part being elongated into a cylinder, the suspensor, while the lower division, *d*, forms the embryo. The embryo then developes its different parts, the two cotyledons and the radicle with the first bud or plumule (Fig. 1257). In some plants, as Cruciferæ, the endosperm preceding the embryo is entirely absorbed, so that the seed is

Fig. 1255.

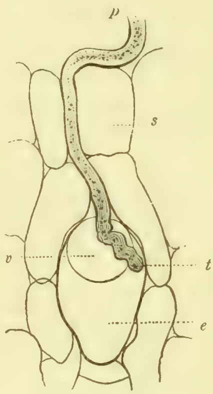

Fig. 1258.

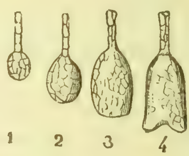

Fig. 1257.

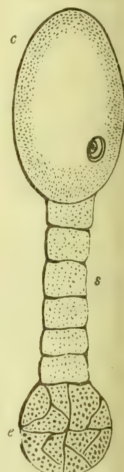

Fig. 1256.

exalbuminous; in others it remains in the form of albumen surrounding the embryo. In Nymphæa the endospermal cells remain as albuminous matter inside the sac, and there is also a layer of albumen (exosperm) formed by the nucleus outside the sac.

865. Henfrey* has made observation on the ovule of Orchis Morio,

Fig. 1255. Section of part of the ovule of a species of Speedwell (*Veronica triphyllos*), shewing the pollen tube, *a*, passing through the cellular tissue of the nucleus, and reaching the embryo-sac, which contains the rudimental embryo, *d*, attached to the sac by its suspensor, *b*, and endospermal cells, *c*, at the lower part of the sac.

Fig. 1256. Embryo of the Whitlow-grass (*Draba verna*), with its suspensor. The embryo, *e*, consists of a globular mass of cells, which shows the original four divisions. The suspensor, *s*, consists of a linear series of cells, developed from the upper part of the germinal vesicle, and terminated by a large nucleated cell, *c*.

Fig. 1257. The embryo in different stages of development. 1. Embryo in young state as a globular mass at the end of a suspensor. 2 and 3. Embryo more advanced. 4. Embryo showing the division into two cotyledons.

Fig. 1258. Section of ovule of an Orchid (*OrchisMorio*), showing the inner coat or secundine, *s*, the pollen tube, *p*, passing through the endostome to reach the nucleus of the ovule, with the embryo-sac, *e*. The end of the pollen tube, *t*, is applied to the outside of the sac, in which there is a single germinal vesicle or embryonal vesicle, *v*, which ultimately forms the embryo and its suspensor.

* Henfrey on the Ovule of Orchis Morio, in Linn. Trans. xxi. 7.

and states that the embryo is really produced by the ovule itself; that the germinal vesicle (Fig. 1258, *v*) exists within the embryo-sac, *e*, before the pollen exerts its influence; that the pollen tube, *p*, penetrates the coats of the ovule to reach the embryo-sac, to which its extremity, *t*, is applied; and that the passage of the pollinic fluid through the intervening membranes impregnates the germinal vesicle, and determines its development into an embryo; that the germinal vesicle divides into two cells (Fig. 1259, *v*), the upper forming an articulated Conferva-like filament (Fig. 1260, *f*), which grows out from the sac, the lower enlarging so as to fill the sac and form the embryo (Fig. 1260, *g*). Dr. Cobbold* has come to similar conclusions from the examination of the embryogenic process in Orchis mascula.

866. Dr. Sanderson made observations on Hippuris vulgaris,† the result of which is that he adopts more or less completely the views of Amici and Hofmeister, in opposition to those of Schleiden. He finds the embryo vesicle developed in the interior of the embryo-sac (Fig. 1261) before impregnation. The vesicle consists at first of a single

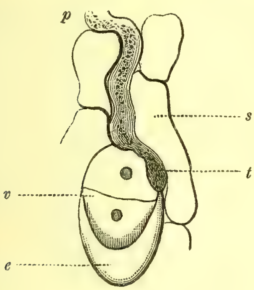

Fig. 1259.

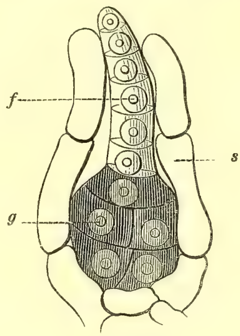

Fig. 1260.

elongated cell attached to the free extremity of the embryo-sac. After impregnation the vesicle is transformed into a spheroidal cell, which is divided into two by a transverse septum; the upper portion elongates and forms a septate confervoid filament (Fig. 1262, *f*), the suspensor; while the lower assumes a spheroidal form, the embryo-globule (Fig. 1262, *e*), and subsequently divides into four. Cells are produced in this globule, and finally the embryo is developed from it. He divides the essential phenomena of the embryogenic process in Phanerogamous

Fig. 1259. Section of a portion of the ovule of Orchis Morio, showing the pollen tube, *p*, passing through the endostome, or foramen, in the secundine, *s*, and the extremity of the tube, *t*, applied to the embryo-sac, *e*, which contains the impregnated vesicle, *v*, now divided into two nucleated cells by a transverse septum.

Fig. 1260. Embryo of Orchis Morio in a more advanced state. The germinal vesicle, in the sac surrounded by the inner coat, *s*, is divided into two portions, *g*, the embryo globule, or the rounded mass of nucleated cells which form the embryo, and the confervoid nucleated filament, *f*, which constitutes the suspensor.

* Cobbold on the Embryogeny of Orchis mascula, in Quart. Journ. of Microscop. Science, i. 90.

† Sanderson on the Embryogeny of Hippuris vulgaris, in Annals of Nat. Hist. 2d ser. v. 259.

Angiosperms into three classes. 1. The development of the embryo-sac, or the separating and setting apart of a cell of the female organ for reproductive purposes. 2. Changes which take place in the cavity of the sac previous to impregnation. These consist in the development of a vesicle (probably always from a cytoblast) at the micropylar end of the sac, and of endospermal cells which serve a temporary purpose of nutrition. The vesicle (called embryo-vesicle, or germ vesicle) contains a fluid granular protoplasm. 3. Changes which take place in the embryo-sac after the act of impregnation, in other words, after the pollen tube has been brought into contact with the embryo-sac, and an interchange of their contents has taken place. These changes consist

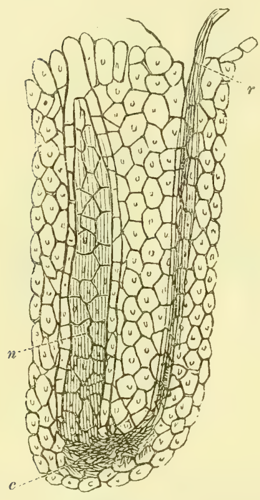

Fig. 1261.

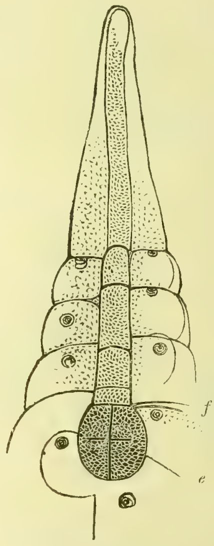

Fig. 1262.

in the enlargement and division of the vesicle into two parts by a transverse septum; the multiplication of cells so as to form a confervoid filament, and the development by endogenous cell-production (usually at the lower part of the filament, sometimes in the centre), of a globular body, which constitutes the future embryo.

867. Sanderson remarks that although in general but little benefit is to be derived from analogies drawn between the animal and vege-

Fig. 1261. Ovule of the common Mare's-tail (*Hippuris vulgaris*), with the raphe, *r*, proceeding from the hilum to the chalaza, *c*, the nucleus, *n*, containing the elongated embryo-sac in which the germinal vesicle is formed.

Fig. 1262. Embryo of the common Mare's-tail (*Hippuris vulgaris*), after impregnation. The vesicle has divided into two portions, the lower forming a globular cellular mass, the rudimental embryo, *e*, the upper forming a confervoid filament, the suspensor, *f*, which proceeds upwards in the elongated embryo-sac, part of which is seen at the apex. Nucleated cells surround the sac, and there are nucleated cells in the embryo.

table kingdoms, and in many instances such analogies lead to erroneous conclusions,* yet as, in the present instance, they seem to be pretty evident and well marked, it may not be uninteresting to consider their general outline. They are contrasted in the following way :—

I. Individualization of a cell of the female organ for reproductive purposes.

Animal.	Vegetable.
Ovulum.	Embryo-sac.

II. Changes in this cell before impregnation by development of nucleus and nucleolus.

Animal.	Vegetable.
Germinal vesicle, or germinal spot.	Embryo vesicle, or germinal vesicle, and cytoblast.

III. Changes in this cell after the act of impregnation.

Animal.	Vegetable.
1. Development of 2 cells from germinal spot.	1. Division of 2 cells in embryo vesicle.
2. Further multiplication of cells within the germinal vesicle, which become ultimately absorbed. (Cleavage of yelk mass.)	2. Multiplication of cells in embryo vesicle, which become ultimately absorbed.
3. Conversion of yelk mass into the embryo, or development of embryo on its surface.	3. Conversion of contents of embryo vesicle into the embryo.

868. The following may be given as a *Resumé* of the facts ascertained relative to the process of impregnation in Angiospermous Flowering plants. The pollen grains are applied to the stigmatic portion of the pistil, and by the action of the viscid secretion of the stigma a sort of germination commences—often in a few minutes, sometimes not for many hours, by means of which minute tubes are developed from the inner lining of the grains. These tubes, by continuous growth at their ends, are elongated, and pass through the conducting tissue of the style into the ovary—attaining, in some long-styled plants, a length exceeding the diameter of the grain many thousand times. Before the tubes reach the ovary the ovules have undergone changes in their interior; the embryo-sac has become enlarged, so as sometimes to occupy nearly the entire nucleus, as in Orchidaceæ and Compositæ, and occasionally, as in Santalum, Osyris, and Avicennia, to project out of the micropyle in the form of an ovular tube or bag.†

* Dr. Sanderson remarks, that the terms placenta and ovule apply to organs in plants which are not the analogues of organs so called in animals. The terms, as applied botanically, are misnomers.

† Griffith states that in Osyris, Santalum, and Avicennia the embryo-sac, after the application of the pollen, enlarges, so as to be on the outside of the nucleus or body of the ovule—Linn. Trans. xx. 1.

The protoplasmic matter contained in the embryo-sac immediately before impregnation becomes altered, so as to produce endospermal cells. Nuclei appear in the protoplasm at the upper end of the sac next the micropyle. These nuclei, which are usually three, give origin to as many cells, which are termed the germinal or embryonal vesicles, and which are essential for the formation of the embryo.* The pollen tube, subsequent to this, reaches the upper part of the embryo-sac, after penetrating through the micropyle and any nuclear cells that may lie between it and the sac.

869. On reaching the embryo-sac the pollen tube is either arrested or it elongates still more, so that its swollen extremity penetrates laterally between the embryo-sac and the surrounding cellular tissue, or in certain rare instances (as in Narcissus poeticus, Digitalis purpurea, and Campanula Medium) introverts the embryo-sac, and even penetrates it (as in Canna), so as to come into contact with the germinal vesicles. When the end of the tube comes into contact with the sac, it is probable that there is a transudation of the fluid matter of the fovilla, which passes through the membrane of the pollen tube, through the embryo-sac, and through the wall of the germinal vesicle, and thus impregnation is effected. After reaching the sac, the pollen tube begins to decay; its contents acquire a granular, half-coagulated aspect; and it finally disappears by absorption. It usually happens that only one germinal vesicle is impregnated, and in the progress of its subsequent growth it causes absorption of the others; sometimes, however, several are impregnated, and thus there may be a plurality of embryos formed (polyembryony). The impregnated vesicle enlarges, acquires an ovate, cylindrical, or clavate form, constituting the pro-embryo of Hofmeister. The vesicle divides in all cases by a transverse partition into two cells, one above the other; the lower of these produces cellular tissue in its interior, and is sometimes at once transformed into the embryo. At other times, and more frequently, there is a successive production of cells in the pro-embryonic body, so that the upper division of the vesicle forms a confervoid-like filament, the suspensor, while the lower is transformed into a globular cellular mass, which is the rudiment of the embryo. The suspensor is sometimes of great length; thus, in Draba verna, it is three times the length of the embryo, and in Gnetum it is three and a half to five inches in length, while the whole seed is only one inch long. It is attached to the radicular end of the embryo, while the cotyledons are formed at the opposite side. In monocotyledons a single sheathing cotyledon is developed; in dicotyledons two opposite leaves, and after their formation the apex produces the terminal bud or plumule. The embryo is thus suspended in an inverted manner in the seed. In the progress of development a marked division takes

* In Lychnis Githago there is only one vesicle; in Funkia cærulea four or more; and in Canna one vesicle displaces the rest before impregnation.

place below the radicular extremity and the suspensor, and the latter finally shrivels.

General Conclusions in regard to the Embryogenic Process.

870. Such, then, are the most important views relative to vegetable embryogeny, and we are enabled, from the observations which have been made, to draw the following conclusions on the subject:— In all divisions of the vegetable kingdom impregnation seems to consist in the contact of two cells having different contents. In the lowest class of plants two of the cells of the filaments conjugate; in the higher Cryptogamics, antheridian cells emit spermatozoids, and these come into contact with an archegonial cell or ovule, which either forms at once a separate embryo, or gives rise to the formation of a spore-bearing frond; in Gymnosperms the pollen cells are applied directly to the ovule, and send short tubes into the nucleus which reach the ovular reproductive cell or embryo-sac; and in Angiosperms the pollen sends its tubes through the stigma and style before reaching the ovule and its cell.

871. In Angiospermous flowering plants there are stamens containing pollinic cells, and pistils containing ovular cells; these two cells are united by the pollen tube; this tube reaches the embryo-sac with its vesicles and endospermal cells; after the impregnation of a germinal vesicle the formation of the embryo and its suspensor proceeds at once by merismatic division; the plant undergoes all its metamorphoses in the ovary, and separates finally as a rudimentary perfect individual; the embryo is either monocotyledonous or dicotyledonous.

872. In Gymnospermous flowering plants there are stamens, containing pollinic cells, and cones, or modified branches, bearing ovular cells; these two cells come into direct contact; the pollen, after reaching the nucleus of the ovule through the large micropyle, remains for a long time before the pollen tube is formed; this tube (after many months) passes through the upper part of the nucleus to the embryo-sac, containing corpuscles and endospermal cells; after this a cell of the corpuscle becomes developed by merismatic division into the embryo and suspensor; the embryo is either dicotyledonous or polycotyledonous.

873. In vascular Cryptogamous flowerless plants, such as Lycopods, organs are produced which contain bodies equivalent to pollen-cells, and there are also other organs (sporangia or oophoridia) containing large spores, which are equivalent to ovular cells; the larger spores contain endospermal cells in the form of a cellular prothallium; the prothallium bears archegonia (corpuscles), which, after impregnation by spermatozoids from antheridian cells, give rise to the cellular body, whence a sporangiferous individual arises; the antheridia

and archegonia are not placed together on a prothallium. In other vascular Cryptogamous flowerless plants, such as Ferns and Equisetums, the spore-cases (sporangia) enclose spores which contain a rudimentary prothallium, only developed during germination, and producing both antheridia and archegonia; the spermatozoids of the former impregnate a vesicle or cell of the latter, which then gives origin to the sporangiferous individual representing the stem, leaves, and cones of Gymnosperms. In cellular plants the union of two cells, either directly or by the intervention of a tube, gives rise to the formation of a spore or sporoid embryo.

4. HYBRIDIZATION, OR THE PRODUCTION OF HYBRIDS IN PLANTS.

874. In connection with the subject of fertilization, the production of hybrids or mules deserves attention. When the pollen of one species is applied to the stigma of another species, so as to effect fecundation, the seeds thus formed give rise to individuals which are intermediate in their characters between the two parents. The plants produced by this heterogeneous fertilization are called hybrids or mules. A true hybrid is a cross between two species, but the term is often applied to crosses between mere varieties, races, or sub-species. The latter sort of crosses have been occasionally denominated sub-hybrids in order to avoid confusion. In hybridizing it is necessary to bring together species which are allied, as, for instance, the species of the same genus, or those of allied genera. It is not, however, easy to determine the plants which can produce hybrids. Many plants which seem to be nearly allied do not inoculate each other. Sageret failed in his endeavours to fecundate an apple tree by a pear tree, and no one has succeeded in getting hybrids between the gooseberry and currant, nor between the strawberry and raspberry. The statements in regard to the intermixture of the orange and pomegranate, and of roses and black currants, are not founded on facts. Sometimes we meet with hybrids between different genera, and such have been called Bigeners. Kölreuter obtained them among the Malvaceous genera, also between Papaver and Glaucium; Gærtner between Datura and Hyoscyamus, and Nicotiana; Wiegmann between a garden bean and a lentil. In these instances the breed is monstrous and sickly, and is usually of very short duration. Occasionally, however, in the case of genera nearly allied, the hybrids are more permanent, as in the plant called Bryanthus erectus, which is a hybrid between Rhodothamnus Chamæcistus and Phyllodoce cærulea.*

875. It is not common to meet with hybrids in a wild state, because there is a much greater likelihood of the pistil being impregnated by the pollen of the anthers beside it, than by that from a distance; and if fecundation has taken place, then pollen applied from

* Paxton's Flower Garden for Sept. 1850, pl. 19.

other sources has no effect. De Candolle* gives a list of about forty natural hybrids between species of Ranunculus, Anemone, Hypericum, Scleranthus, Potentilla, Geum, Medicago, Galium, Centaurea, Cirsium, Stachys, Rhinanthus, Digitalis, Verbascum, Gentiana, Mentha, Polygonum, Quercus, Salix, and Narcissus. Lindley mentions Cistus Ledon as being constantly produced in nature between C. monspessulanus and C. laurifolius; and Cistus longifolius between C. monspessulanus and C. populifolius; Saxifraga luteo-purpurea and S. ambigua, between S. aretioides and S. calyciflora.† Diœcious plants, in which male and female flowers are on separate individuals, seem to be liable to produce hybrids, and hence perhaps the difficulty of determining the species of Willows. Hybrids are constantly produced artificially by gardeners, in order to improve the characters of the flowers or of the fruit.

876. It has been found that for successful hybridizing the pollen must be in perfection, and the stigma also must be fully developed. There appears always to be a preference for its own pollen on the part of the stigma. When strange pollen is applied, even in the case of species which hybridize, it does not act so effectually on the ovules as the pollen belonging to the flower. Hybrid fecundation then is usually less complete than natural fecundation. Gærtner found that out of nineteen flowers of Nicotiana Langsdorfii fecundated by N. marylandica, and out of fourteen fecundated by N. paniculata, he succeeded only in five, and in nine of the same species fecundated by N. quadrivalvis, only one was successful. The capsule of Nicotiana macrophylla contains 2416 perfect seeds, while this species fecundated by N. quadrivalvis contained only 658. The capsule of Papaver somniferum contains 2130 seeds, but when fecundated by Glaucium luteum, only six were perfect. Dichogamous plants, that is, those in which the sexes are separate, are not so susceptible of the influence of strange pollen. This seems to be a provision to guard against hybridity in such cases. Hybrids are more common in polyspermous genera than in those in which the seeds are few.

877. When impregnation takes place between two pure species the characters of the parents never remain pure and unaltered in the formation of the hybrid. In general every part of the new production is modified, so that it presents a decided difference from either of the parents, though resembling the one more than the other. Sometimes the influence of the male predominates, sometimes that of the female. In Digitalis it is said that the influence of the female plant prevails, in Nicotiana that of the male. Herbert says, that in hybrid Amaryllises the flowers and organs of reproduction partake of the character of the female parent, while the foliage and habit, or the organs of vegetation, resemble the male. Fries Morel says that hybrid Carnations resemble the female parent in form, and the male in colour. In a hybrid between Phyllocactus crenatus (female), and Cereus speciosissi-

* De Candolle, Physiol. Végét. ii. 707.

† Lindley, Introduction to Bot. vol. ii. p. 243.

mus (male), the stem, and in some respects the flowers, were those of crenatus, and the colour that of speciosissimus. The male gave colour and changed somewhat the form of the flower, while the female gave general habit. The specific differences, according to Gærtner, of nearly allied species, appear more distinct in the hybrids to which they give rise, than in the pure species. Thus Lobelia cardinalis, fulgens, and splendens, which are very nearly allied, give totally distinct hybrids when united with Lobelia syphilitica. On the other hand, Nicotiana magnifolia, macrophylla, marylandica, and petiolata, give identical hybrids when impregnated with N. glutinosa. The supposed species in this latter case are probably therefore mere forms. Hybrid types are considered as depending on the specific distinction of species, and not on any external influences.

878. Hybrids occur in which the characters of the parents are intimately blended, so that it is impossible to say to which there is a greater resemblance. Sometimes the number of the organs is curiously intermediate; thus Cucubalus has three stigmas, and Lychnis five, and a hybrid between them has four. Again, hybrids occur in which one part or other approaches the paternal or maternal form, though the characters of the parent never pass altogether pure into the new organism. Lychnis vespertino-diurna, a hybrid between the two species whose name it bears, has no perfect diurnal sleep as in L. vespertina, but the petals roll back slightly when the sun shines or the weather is hot; the hybrid resembles vespertina in its small leaves, diurna in the vital phenomena; vespertina in its large flowers, and straight blunt stigmas, diurna in the pubescence; vespertina in the more pyramidal fruit, and also in the size and colour of the seeds. There is a third set of hybrids in which there is resemblance to one of the parents, whether male or female, so decided, that the agreement is at once perceptible and beyond doubt.

879. In certain circumstances we find the typical forms which are combined in the hybrid separated so as to appear in the same individual. Thus a hybrid* between Cytisus Laburnum and Cytisus purpureus, called Cytisus Adami or Red Laburnum, occasionally has branches, some of which bear the flowers of the male, and others those of the female parent. Sageret mentions a case of a hybrid sprung from a female Chinese Melon and a male Market Melon, in which, of two branches exactly opposite each other, one bore nothing but the latter Melon, whilst the other branch bore a cross between both Melons.†

880. Thwaites observes that the fertilization of the ovule consists in the union of a part of the contents of a pollen-grain with certain matter contained in the germinal vesicle, and that the embryo origi-

* This hybrid is by some attributed to the grafting of Cytisus purpureus on Cytisus Laburnum, and not to fertilization; and Herbert thinks that a combination between the cells of each of the plants may be considered as originating it.

† Sageret, Mém. sur les Cucurbitacées, et sur la production des Hybrides, Paris, 1826-27.

nates from the mixed substance; and he thinks that this is confirmed by what takes place in hybridization—the hybrid plant owing its existence to an endochrome made up of a portion of the endochromes of each of the parent plants, and the proportion varying in different ovules. The ovules of Fuchsia coccinea, impregnated by the pollen of Fuchsia fulgens, produce plants of every intermediate form between these two species—some resembling the one and others the other species, but the majority partaking of the characters of both. The variations are referred to the different proportions in which the endochromes are mixed. One of the hybrid seeds produced twin plants which were dissimilar.*

881. Hybrids, although they may be fertile at first, rarely continue so for many generations.† Herbert mentions hybrid Narcissuses which never produced seed.‡ The non-production of fertile seeds in some plants has led to the idea that they are mules. The cause of sterility in mules has not been fully ascertained. Henslow could not find in a hybrid Digitalis any structural changes which could account for barrenness. It may be that the pollen is not perfect in its development. In many hybrids there occur monstrosities in the pollen granule. Thus in the pure species of Fuchsia each granule is furnished with either two or three pollen-tubes; while in the pollen of F. Standishii a hybrid between F. fulgens, whose grains of pollen have but two tubes, and another species the granules of which have three, great confusion prevails—some of the granules having two or three tubes like the type, while others have four tubes. Many appear abortive, consisting only of extine, and no fovilla. This will account for the seeds of hybrid species being so frequently unproductive, since they either have not received the influence of the degenerated pollen at all, or have done so in an imperfect manner. It would be interesting to know if sterile hybrids wanted some peculiar matter in their fovilla, in the same way as sterile mules among animals have no spermatozoa.

882. Hybrids may be fertilized by pollen taken from one of the parents, and then their offspring approaches in character to that parent. Hybrids impregnated for a third or fourth time with the pollen of the original male plant, approach more and more to the male type. Such is also the case when the impregnation is effected by pollen taken from the original female type, but in this instance the change is usually more slow. Gærtner, to whom we are indebted for most of these remarks on hybridity, gives a tabular view of the number of impregnations requisite to complete changes of species by hybridization. He produced hybrids between the two species named, and then, by using the pollen of the original male or female parent, he found that in

* Thwaites, on Diatomaceæ, in Ann. Nat. Hist. 2d ser. i. 163.

† Although hybrids have generally little tendency to reproduce themselves by generation, and usually die out, still there are certain supposed hybrids which continue to propagate themselves. Sageret, for instance, thinks that the Colza is a hybrid between the Cabbage (Brassica oleracea), and the Turnip (Brassica Napus).

‡ Bot. Register, Aug. 1843.

progress of time the species are brought back to the male or female type. By this means he ascertained the following facts :—

Aquilegia atro-purpurea became	. .	A. canadensis in	3	generations.
A. canadensis	„ . . .	A. atro-purpurea	4	„
A. canadensis	„ . . .	A. vulgaris . .	4	„
Dianthus arenarius . .	„ . . .	D. Caryophyllus .	5-6	„
———— . .	„ . . .	D. pulchellus .	5-6	„
———— . .	„ . . .	D. chinensis . .	5-6	„
———— . .	„ . . .	D. superbus . .	5	„
Dianthus Armeria . .	„ . . .	D. deltoides . .	5-6	„
——— barbatus . .	„ . . .	D. Carthusianorum	3-4	„
———— . .	„ . . .	D. chinensis . .	5	„
Geum urbanum . . .	„ . . .	G. rivale . . .	4	„
Lavatera pseudolbia . .	„ . . .	L. thuringiaca .	4	„
Lychnis diurna . . .	„ . . .	L. vespertina .	4	„
——— vespertina . .	„ . . .	L. diurna . . .	3	„
Œnothera nocturna . .	„ . . .	Œ. villosa . . .	4	„
——— villosa . .	„ . . .	Œ. nocturna . .	4-5	„

These observations relative to hybrids, must not be considered as in any way favouring the erroneous and unfounded statements made in regard to the conversion of one species into another of a very different structure, as of Oats into Rye, Rye into Bromus secalinus, Bromus sterilis into Hordeum murinum, Brassica Rapa into Thlaspi arvense, Thlaspi arvense into Camelina sativa or Capsella Bursa pastoris.*

883. Hybridizing is an important horticultural operation. By it the gardener endeavours to increase the size of flowers, to improve their colour, to approximate their forms to some assumed standard of perfection, to enlarge the foliage as in esculents, to render tender plants hardy, to heighten the flavour of fruits, and to exchange early for late varieties. The changes produced by muling on the size and colour of the blossoms are very remarkable. By inoculating Cereus speciosissimus with C. grandiflorus, we find that the *immediate* result is a seedling whose flowers are ten inches in diameter. The hues resulting however from the union are not necessarily intermediate. Blue and yellow do not produce green, as proved by a hybrid between Verbascum phœniceum and V. phlomoides. By muling, beautiful varieties have been produced between Rosa indica and R. moschata, Azalea pontica and A. nudiflora coccinea, Rhododendron arboreum and R. caucasicum, Catawbiense, ponticum and campanulatum ; between Rhodothamnus Chamæcistus and Phyllodoce cærulea,† Veronica fruticulosa and saxatilis, Cereus speciosus and speciosissimus ; also between species of Fuchsia, Mahonia, Potentilla, Pelargonium, Cal-

* For fuller remarks on hybridization, see the translation of Gærtner's Paper on Muling in Vegetables, in Journ. of Hort. Soc. of Lond. vi. p. 12.

† Mr. Isaac Anderson, a successful hybridizer, states that the hybrid between these two genera can only be produced by taking the pollen of Rhodothamnus and applying it to the stigma of Phyllodoce. He has constantly failed in impregnating the pistil of the former with the pollen of the latter.

ceolaria, Viola, Dahlia, Erica, Narcissus, and numerous others. In the case of Rhododendrons, gardeners have been able to secure the fine colour of the Indian R. arboreum with the hardiness of the American species. By inoculating the common Heartsease with the large-flowered Pansy of the Altai mountains, a degree of vigour has been infused into the former which we could not hope to obtain by ordinary means. The fine varieties of Pelargonium have been obtained, by cultivation and by hybridizing, from the small-petaled Pelargonium of the Cape. Fruits and culinary vegetables are sometimes improved by hybridity. These hybrids cannot be continued from seed. They must be propagated by offsets or cuttings. The effect of hybridizing or crossing is very marked in the case of certain Cereal plants. Mr. Maund has done much in this way, and has in some instances produced important varieties. These were shown at the Great Exhibition, along with others, from Mr. Raynbird.

884. This subject has important bearings on the origin and limitation of species. If, as some old authors supposed, there were only a few species originally formed, and all the rest are the result of hybridization, there would be no limit to the production of species, and no permanence in their characters. This opinion, however, is not supported by facts. It is believed that the types of all the species now on the globe were originally placed on it, and have given origin to offspring like themselves, capable of reproducing the species. We have already mentioned that hybrids are rare in a wild state, and they are seldom permanent and fertile, and they have always a tendency to revert to one of the original types.*

885. Recapitulation of the chief facts connected with Embryogeny :—

1. The existence of separate sexes in plants was conjectured in early times, but the organs of reproduction in flowering plants were not discovered till 1676 by Grew.
2. Linnæus made these organs the foundation of his sexual system of classification.
3. Hedwig discovered sexual organs in Mosses, and such organs have now been demonstrated in other Cryptogamous plants.
4. The stamens containing pollen, and the pistils containing ovules, have been proved to perform the function of reproduction in flowering plants.
5. Some anomalous cases have occurred in which perfect seed was produced apparently without the presence of pollen, but these require confirmation.
6. The pollen must be discharged from the anther and brought into contact with the stigma, in order that an embryo plant may be formed.
7. Various means are taken to accomplish this, such as elasticity and irritability of the stamens, winds, and insects.
8. Pollen can retain its vivifying power sometimes for a long time, and may thus be carried to a distance without injury to its properties.

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* For farther observations on Hybridization, the student may consult the following papers:—Gærtner, Versuche ueber die Bastarderzeugung im Pflanzen-reich, &c., in König. Holländ. Acad. der Wissenschaften, Stuttgart, 1849—trans. and abridged by Berkeley, in Journ. of Hort. Soc. Lond. v. 156. Herbert on Hybridization among vegetables, Journ. Hort. Soc. Lond. ii. 1. Kölreuter, Vorlauf. Nachricht von einigen das Geschlecht der Pflanzen betreff. Versuchen, &c., Leipzig, 1761-1766. Standish and Noble on Hybrid Rhododendrons in Journ. Hort. Soc. Lond. v. 271.

9. The quantity of pollen produced is much greater than is actually required for the impregnation of the ovules, with the view of ensuring fertilization.
10. In some cases where stamens and pistil are on different parts of a plant, or on different plants, the leaves are not produced until after impregnation, so as to allow the pollen and ovules to come into contact.
11. In some Evergreens, as Firs and Pines, the quantity of pollen produced is very large, and it is occasionally wafted by the winds to a distance so as to fall like a shower of sulphur.
12. The stigma is prepared for the reception of the pollen grains by the secretion of a viscid substance, which, besides detaining them, causes them to protrude tubes.
13. The style is also sometimes provided with hairs for the purpose of collecting and applying the pollen.
14. While maturation of the pollen is going on in the anthers, the ovules are also undergoing changes by which the foramen is brought near the placenta, and certain cells are developed in their interior for the purpose of embryogeny.
15. The ovular cells thus produced are the embryo-sac, and the germinal vesicles or nucleated cells in its interior, which are surrounded by parenchyma, called endospermal cells.
16. One of the nucleated germinal vesicles, after impregnation, is transformed into the embryo with its appendages, while the endospermal cells contain albumen.
17. In some of the lowest unicellular plants reproduction is carried on by one cell, probably by means of a difference in its contents.
18. In general, however, it may be said, that the act of impregnation consists in the union of two cells having different contents.
19. In some cellular plants, as Confervæ and Diatomaceæ, there is distinct conjugation or union of cells by means of an interposed tube, and the result of this is the formation of a cellular embryo.
20. In other Cryptogamic plants there are distinct sexual organs, namely, antheridia, containing phytozoary or spermatozoidal cells, and pistillidia or archegonia, containing ovular cells.
21. The antheridia discharge the phytozoa or spermatozoids, which reach the archegonia, and impregnate a germinal vesicle which ultimately gives rise to the embryo.
22. In Hepaticæ, antheridia and archegonia are produced on the thallus, and the impregnated cell of the latter gives rise to the spore-bearing stalk (the fruit or capsules).
23. In Mosses, antheridia and archegonia are borne on leafy stalks, and after impregnation the archegonial cell gives rise to the stalked theca or sporangium with its spores.
24. In Ferns and Equisetums, the antheridia and archegonia are produced on a cellular prothallus which is developed during the germination of the spores, and after impregnation the archegonial cell gives rise to the sporangiferous frond or stalk.
25. In Lycopods and Rhizocarps, there are antheridian cells with spermatozoids, and large spores or ovules, containing archegonia on a cellular prothallus in their interior, and after impregnation the archegonial cell gives origin to a sporangiferous frond.
26. In Gymnospermous or naked-seeded flowering plants, there are stamens containing pollen, and ovules supported on cones or altered branches, and in them the pollen enters the large micropyle of the ovule without the intervention of stigma and style.
27. When the pollen reaches the nucleus of the naked ovule it remains long dormant, and after many weeks and months sends out a tube which reaches the embryo-sac and impregnates a corpuscle.
28. One of the cells of the corpuscle then takes on an active function, and developes the embryo with its suspensor in the midst of endospermal cells.
29. There is frequently a plurality of embryos in Gymnosperms, owing to the impregnation of several vesicles in an ovule.
30. In Phanerogamous flowering plants stamens are present, containing pollen cells, and pistils containing ovular cells.

31. In these plants the pollen tube passes through the stigma and the conducting tissue of the style until it reaches the foramen (micropyle) of the ovule.
32. In some instances a tube is prolonged upwards from the ovular walls, or from the embryo-sac, to meet the pollinic tube.
33. The pollen tube passes into the micropyle and reaches the embryo-sac contained in the upper part of the nucleus.
34. Schleiden thinks that the end of the pollen tube introverts the embryo-sac, and in some cases perforates it, and that it becomes the first cell of the embryo.
35. Almost all physiologists, particularly Amici, Hofmeister, Mohl, and Tulasne, agree in thinking that Schleiden was mistaken in regard to the extremity of the pollen tube, and they believe that the embryo is formed from a distinct cell previously existing in the embryo-sac.
36. In some instances the pollen tube indents the embryo-sac, at other times it perforates it, and comes into actual contact with a cell contained in the sac.
37. In the embryo-sac there are produced before impregnation certain cells, often three, called germinal or embryonary vesicles, only one of which in general is impregnated by the pollinic fluid, which transudes through the membrane of the pollen tube and the walls of the embryo-sac and vesicle.
38. After impregnation, the vesicle divides by a transverse septum into two parts, the upper portion forming a confervoid partitioned filament or suspensor, and the lower becoming filled with cells constituting the rudimentary embryo.
39. The suspensor is attached to the part which forms the radicle of the embryo, and at the opposite end one or two cotyledons are produced, enclosing the first bud or plumule.
40. An embryo is usually produced in each ovule (monembryony), but when more than one germinal vesicle is impregnated there is a plurality of embryos (polyembryony).
41. When the pollen of one species is applied to the pistil of another species, we occasionally find seeds produced which give rise to individuals intermediate between the two parents; these individuals are called hybrids or mules.
42. In order that hybridizing may be successful, the species must be allied in certain particulars; hybridization cannot be practised indiscriminately.
43. Hybrids are rarely fertile, or at all events rarely continue fertile for any length of time; they have a tendency to die out or to return to one of the parent types.
44. Hybrids may be fertilized by pollen taken from one of the parent types, and they then approach more and more to the type whence the pollen was taken.
45. A plant has a preference for the pollen from its own species, and hence hybrids are rare in nature, and there is no evidence of true species being produced by hybridity.
46. Hybrids are not always strictly intermediate between their parents; sometimes the characters of the male parent, at other times that of the female prevail.
47. By hybridizing we endeavour to improve the size, form, and colour of flowers, to produce hardy varieties, and to heighten the flavour of fruit.

CHAPTER IX.

PHYSIOLOGY OF THE FRUIT.

886. While the object of fecundation is to develope the embryo in the seed, it causes at the same time changes in the pistil. The stigma and style become dry, and either fall off, as in the Peach (Fig. 770, p. 264), Orange, and Nut, or are persistent, as in the Poppy (Fig. 808, p. 273), Mangosteen, Clematis (Fig. 836, p. 281), and in many pods (Fig. 825, p. 278). The pericarp in some instances becomes swollen, even although the ovule is not fecundated. In such cases the fruit is abortive in as far as reproduction is concerned, although it may be valued for domestic purposes. Many of the best Oranges and Grapes contain no perfect seeds, and the fruit of the Banana (Fig. 873, p. 290), Plantain, Bread-fruit (Fig. 783, p. 268), and Pine-apple (Fig. 882, p. 293), is most palatable when it is seedless. The age of trees seems to have an influence over the production of seeds. In the case of the Orange, it is said by Bullar that old trees often produce seedless fruit. The fruit during its growth attracts nourishment from the surrounding parts, and it is of importance that it should receive a large supply of elaborated sap.

887. In their natural state some plants exhaust themselves in the production of fruit, and die after one year, if annuals, or after two, if biennials. Sometimes fruiting is long delayed, and ultimately takes place vigorously and abundantly. This is observed in plants such as the American Aloe, which only fruits once after many years, and then dies. The division of plants into Monocarpic and Polycarpic is founded on their times of flowering and fruiting. The former are such as flower and fruit only once in their life and then die. This may take place at the end of one year, two years, or many years. The latter are such as flower and fruit many times in the course of their lives. A plant which has been prevented by an inclement season from perfecting its fruit, will often bear a large quantity the following season, if genial. An annual, by being prevented from fruiting, may be made to endure for two or more years. The increased vigour of perennials enables them to withstand the exhaustion induced by fruiting.

888. In the case of cultivated plants, where the object of the gardener is to have a supply of good fruit, many artificial means have been adopted to promote the development and maturation of the pericarp. The application of manure to the soil, by increasing the vigour of the plants, aids in this matter; also checking the branches by judicious pruning, so as to cause a great flow of sap to the fruit; and cutting a ring of bark from the branches, so as to produce accumulation of sap above the wound. In ringing the bark, care must be taken to make the cut so that the two lips of the wound may reunite in the course of a few months. If the cut is large, then the branch may be destroyed. It is prudent not to ring the bark of the main stem, but only that of branches; and the wound should be covered with grafting-clay and damp moss, so as to allow the healing process to go on. Checking the roots has an important influence on the production of fruit. Mr. Bellamy, in an excellent garden at Starcross, in Devonshire, although he had abundance of fruit, could not succeed in producing Greengages. He took three of his trees and conveyed them to his estate in Dorsetshire, a cold, bleak, chalky, mountainous district, exposed to north, north-west, and easterly winds, where scarcely a blade of grass appeared till May. The second year after transplantation, the trees bore abundantly the finest fruit imaginable. This they continued to do for three years, and then ceased. Mr. Bellamy removed them again, and again they bore fruit. Ever after he planted out ten trees every year, keeping up a stock of forty, and never after wanted abundance of Greengages. The check given to the root produced fruit in place of wood.

889. When fruit sets in large quantity, it is prudent to thin it early, and thus allow only a moderate quantity to come to perfection. As the sap is distributed to the whole fruit, this operation will permit more nourishment to go to that which remains. By judicious thinning, although the quantity of fruit is diminished, its quality is much improved. In this way the size and flavour of Peaches, Nectarines, Apricots, Grapes, and other cultivated fruits, are increased. If plants are permitted to bear fruit when very young, it often fails to come to maturity. This is the case in the Melon, for instance, if the fruit is allowed to form at a very early period of the life of the plant; whereas, if the plant is not allowed to bear fruit till the leaves are fully formed and the sap has accumulated, the fruit rapidly swells, and arrives at great perfection.

890. The pericarp sometimes preserves its green colour and leafy aspect, as in the Pea, and continues to act as leaves do—decomposing carbonic acid during daylight, and giving out oxygen. According to Saussure and Couverchel, all fruits in a green state perform this function of deoxidation.* Saussure states that green sour Grapes, while growing on the Vine, and exposed to the sun in close vessels, give

* Saussure, Recherches Chimiques sur la Végétation. Couverchel, Mémoire sur la Maturation des Fruits, in Ann. de Chimie et de Physique, xlvi. 147.

out oxygen. Sometimes the cells of the pericarp become hardened and thickened by the deposit of lignine, and the seed-vessel becomes dry, assuming a white or brown colour. In these circumstances its active vital functions cease, and it no longer produces any marked effect on the air. In other instances the pericarpial cells contain matters which, in the progress of maturation, undergo chemical changes, so that the fruit becomes succulent, and its epicarp assumes various tints of red, yellow, and blue. As transpiration and evaporation take place from the surface of succulent fruits, the fluids in the outer cells become thickened, and thus promote the endosmotic action between them and the cells containing thinner liquids. In this way the fruit swells considerably. When the fruit has attained its full size the stalk dries up, and may be easily detached from the plant; at the same time waxy matter is deposited in the cuticle, which prevents the drying process from going on rapidly.

891. During their early state pulpy fruits are tasteless or slightly bitter, and they have at that time the structure and chemical constitution of leaves. In their second stage of development they acquire a sour taste from the production of acids, such as malic acid in the Apple and Gooseberry, tartaric acid in the Grape and Tamarind, citric acid in the Lemon, Orange, Red Currant, and Cranberry. In the third stage, or that of ripening, the acids diminish in quantity, they are more fully neutralized by the alkalies present in the fruit, and are partially decomposed; the cellulose forming the walls of the cells and vessels is also transformed, and along with the gum is converted into grape sugar. Saccharine matter may be formed from the acids in the fruit, by the addition of the elements of water, and the separation of oxygen. Thus citric acid, $C_{12}\ H_8\ O_{14}$ with the addition of 6 equivalents of water, and the separation of 6 equivalents of oxygen, gives $C_{12}\ H_{14}\ O_{14}$ the equivalent of crystallized sugar.* During these changes there is a loss of watery fluid, a slight increase of temperature, and an evolution of a small quantity of carbonic acid. Dutrochet says that during the ripening of a Pear, the mean temperature during 12 hours was 0.07° F., and the quantity of carbonic acid evolved in 24 hours varied from 0.5 to 0.7 per cent; a Plum in similar circumstances showed a mean temperature of 0.11°, and gave out in 24 hours 1.6 of carbonic acid. Saussure and Couverchel state that Grapes, Apples, and Pears, when separated from their respective plants, and kept at a temperature of about 60° F., gave out carbonic acid. Fremy found that ripe fleshy fruits gave out a large quantity of carbonic acid when boiled in a saline solution.†

* The formation of sugar from acids is thus shown by Professor Gregory in his Hand-book of Organic Chemistry, p. 460:—

Acid employed.	Water added.	Oxygen separated.		Crystallized sugar.
Citric, $C_{12}\ H_8\ O_{14}$	+ 6 HO.	O_6	=	$C_{12}\ H_{14}\ O_{14}$.
Malic, 3 ($C_8\ H_4\ O_{10}$)	+ 16 HO.	O_{18}	=	2 ($C_{12}\ H_{14}\ O_{14}$).
Tartaric, 3 ($C_8\ H_6\ O_{12}$)	+ 10 HO.	O_{18}	=	2 ($C_{12}\ H_{14}\ O_{14}$).

† Fremy, Recherches Chimiques sur la Maturation des Fruits, in Comptes Rendus, xix. 784.

892. Berard, in a memoir presented to the French Academy of Sciences,* gives the following analysis of succulent fruits in different stages of maturation :—

CONSTITUENTS.	Melting Peaches.		Duke Cherries.		Red Currants.		Greengage Plums.		Apricots.		
	Green.	Ripe.	Green.	Ripe.	Green.	Ripe.	Green.	Ripe.	Green.	More advanced.	Ripe.
Albuminous matter	0.41	0.93	0.21	0.57	1.07	0.86	0.45	0.28	0.76	0.34	0.17
Chlorophyll	0.27	Red colouring matter	0.05	Red colouring matter	0.03	Red colouring matter	0.03	0.08	0.04	0.03	0.10
Ligneous matter (Cellulose and Lignin)	3.01	1.21	2.44	1.12	8.45 (Including	8.01 seeds).	1.26	1.11	3.61	2.53	1.86
Gum and Dextrin	4.22	4.85	6.01	3.23	1.36	0.78	5.53	2.06	4.10	4.47	5.12
Sugar	0.63	11.61	1.12	18.12	0.52	6.24	17.71	24.81	trace	6.64	16.48
Malic Acid	1.07	1.10	1.75	2.01	1.80	2.41	0.45	0.56	2.70	2.30	1.80
Citric Acid	—	—	—	—	0.12	0.31	—	—	—	—	—
Lime	0.08	0.06	0.14	0.10	0.24	0.29	trace	trace	trace	trace	trace
Water	90.31	80.24	88.28	74.85	86.41	81.10	74.57	71.10	89.39	84.49	74.87
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Berard, Mémoire sur la Maturation des Fruits, in Ann. de Chimie et de Physique, 2d series, xvi. 152, 225

893. The changes which take place during ripening are thus shewn to consist chiefly in a diminution of the quantity of water and of ligneous matter, and an increase in the quantity of sugar. The changes in these ingredients are thus tabulated :—

NAMES OF FRUITS.	WATER.		SUGAR.		LIGNEOUS MATTER.	
	Unripe.	Ripe.	Unripe.	Ripe.	Unripe.	Ripe.
Melting Peaches .	90.31	80.24	0.63	11.61	3.01	1.21
Duke Cherries .	88.28	74.85	1.12	18.12	2.44	1.12
Red Currants . .	86.41	81.10	0.52	6.24	8.45 including	8.01 seeds.
Greengage Plums	74.57	71.10	17.71	24.81	1.26	1.11
Apricots . . .	89.39	84.49	trace and then 6.64	16.48	3.61	1.86
Jargonelle Pears .	86.28	83.88	6.45	11.52	3.80	2.19

894. Berard thinks that these changes in fruits depend essentially on the action of the oxygen of the air. Fleshy fruits, he says, may be preserved with little alteration for many weeks in vacuo, in nitrogen, and in hydrogen gas; Peaches, Plums, and Apricots, may be kept from twenty to thirty days, and Pears and Apples for three months, in a sealed bottle, containing a little sulphate of iron, lime, and water, which remove the oxygen of the air. Fremy found that the ripening of the fruit was arrested by covering it with varnish, which he supposes to act partly by preventing the access of air, and partly by stopping the transpiration, and thus checking the flow of sap into the fruit.* Couverchel says that the sugar of fruits is formed by the action of organic acids on the gum, dextrin, and starch; while others think that the cellulose and lignin are also transformed into sugar by the action of acids. The formation of sugar in the fruit, according to Fremy, is checked by watering the tree with alkaline solutions, or by causing the fruit-bearing branches to absorb these solutions. The diminution of the sour taste in ripe fruits is due in part to the neutralization of the acids, and in part to chemical changes in them. When green fruits are cooked, similar changes take place in their ingredients, by which the acid and gummy matters are converted into sugar.

895. Certain fruits, more especially those belonging to the natural orders Pomaceæ and Ebenaceæ, after being ripe, undergo a series of chemical changes when pulled and allowed to remain in a room at a moderate temperature. The austerity of Medlars is diminished under this process, to which the name of bletting (French, *blette*) is given

* Comptes Rendus, xix. 784.

by Lindley. It is a stage intervening between what is commonly called ripeness and decay. The chemical changes, as shewn in the table, consist in a loss of weight, in consequence of a separation of water and a diminution in the quantity of saccharine and ligneous matter. There is a slight increase at the same time in the albuminous matter and in the malic acid.

INGREDIENTS.	JARGONELLE PEARS.		
	Unripe.	Ripe.	Bletting.
Albuminous Matter	0.08	0.21	0.23
Chlorophyll	0.08	0.01	0.04
Ligneous Matter (Cellulose and Lignin)	3.80	2.19	1.85
Gum	3.17	2.07	2.62
Sugar	6.45	11.52	8.77
Malic Acid	0.11	0.08	0.61
Lime	0.03	0.04	trace
Water	86.28	83.88	62.73
	100.00	100.00	76.85

896. During the maturation of certain fruits, oily and aromatic substances are produced which give a peculiar flavour. In fruits which form jellies, there is developed a gelatinous matter, to which the name of Pectic acid is given. The production of this acid has been particularly examined by Fremy.* He states that a substance called Pectose, insoluble in water, alcohol, and ether, accompanies cellulose in the pulp of green fruits, and of certain roots, as Carrots and Turnips. By the simultaneous action of acids and heat it is transformed into Pectine, which is soluble in water, and which is developed in ripe fruits. The malic and citric acids of fruits seem to operate along with heat in converting pectose into pectine, and its various modifications, such as metapectine and parapectine. By means of another substance, called Pectase, which acts as a ferment, pectine is converted into pectosic and pectic acids. These various substances are found in the gelatinous matter of succulent fruits, and the following is their composition :—

Pectine, $C_{64}\ H_{40}\ O_{56}$, 8HO.
Pectosic acid, $C_{32}\ H_{20}$, O_{28} 3HO.
Pectic acid, $C_{32}\ H_{20}\ O_{28}$, 2HO.

The pectase of fruits, during its solution, reacts on the pectine, produced by the action of acids on pectose, and transforms it into gelatinous pectic acid. Fremy formed a jelly by introducing pectase into

* Fremy, Mémoire sur la Maturation des Fruits, in Ann. de Chimie et de Physique, 3d ser. xxiv. 5; also in Journ. de Chimie Médicale for 1845, p. 132.

a solution of pectine. Vegetable jellies are also formed by pectosic acid.

897. According to Dutrochet,* there is in green fruits during their active growth a certain amount of specific heat, which can be detected by means of Becquerel's thermo-electric needle. The following table shows the amount of this specific heat :—

NAME OF FRUITS.	Deviation of Becquerel's Needle.	Proper Heat of Fruit.	Temp. of Air.
Green Pear	1°	0.10° F.	57.2° F.
Green Apple	$1\frac{1}{3}^{\circ}$	0.14°	63.5°
Green Plum	$1\frac{1}{2}^{\circ}$	0.16°	64.4°
Green Peach	$1\frac{1}{3}^{\circ}$	0.14°	63.1°
Green fruit of Ribes Uva-crispa . . .	1°	0.10°	57.2°
Green fruit of Liriodendron tulipifera	$1\frac{2}{3}^{\circ}$	0.18°	69.8°
Green cone of Abies alba (Michaux), .	$1\frac{2}{3}^{\circ}$	0.18°	71.6°
Green fruit of Datura Stramonium, eight days after flowering . . .	$1\frac{1}{3}^{\circ}$	0.14°	64.4°
Green fruit of Papaver somniferum, two days after flowering	2°	0.21°	67.1°

898. The greater number of plants ripen their fruit considerably within a year from the time when the flower expands, and some require only a few days for the purpose. Some trees, as certain species of Oak, require eighteen months; Juniper fruit, and cones of the Firs, the fruit of some American Oaks, and of the Metrosideros of New Holland, hang above twelve months; and the Cedar requires twenty-seven months to mature its fruit or to bring its seeds to perfection. The Orange presents a singular phenomenon in respect to maturation of its fruit. This is generally looked upon as ripe at the end of the first year; but it often happens in the south of Europe that, in order to obtain Oranges of the best quality, the fruit is allowed to remain for a second summer on the tree. It is not easy then to say what is the real term of maturation in this fruit in its natural state. Discussions have arisen as to the time when the fruit of the cereal plants is most productive to the farmer. Many think that Wheat ought to be cut before the fruit reaches perfect maturity, inasmuch as it then yields most flour. When allowed to remain till fully ripe, then the outer covering or bran thickens at the expense of the flour. Such is also said to be the case in Oats. About a fortnight before ripening is said to be the proper time for cutting corn, as the skin is then thinner, the grain fuller, the bushel heavier, and the yield of flour greater.

899. The following table† will give some idea of the diffe-

* Dutrochet, sur la chaleur des êtres vivans à basse temperature—Ann. des Sc. Nat. 2d ser. xiii. 65.

† De Candolle, Physiologie Végétale, ii. 568.

rent periods required for the maturation of the fruit in different plants:—

Periods which elapse between flowering and the maturation of the fruit.

13 days, Setaria viridis.
14 — Digitaria sanguinalis, Avena pratensis.
16 — Festuca ovina, Briza media.
17 — Aira cæspitosa, Bromus cristatus.
18 — Avena elatior, Festuca sylvatica.
19 — Glyceria aquatica, Hordeum pratense, Medicago sativa.
20 — Dactylis glomerata, Milium effusum, Lolium perenne, Triticum repens.
21 — Poa alpina, Onobrychis sativa.
22 — Cynosurus cristatus, Aira flexuosa.
23 — Trisetum flavescens.
24 — Festuca glabra, Poa cristata.
25 — Alopecurus pratensis, A. alpinus, Avena pubescens, Festuca arundinacea, Nardus stricta.
27 — Bromus sterilis, Holcus mollis, Agrostis vulgaris, Festuca loliacea.
28 — Festuca fluitans.
30 — Alopecurus agrestis.
31 — Agrostis canina, A. stricta, Cynodon Dactylon, Phalaris canariensis.
37 — Festuca dumetorum.
41 — Stipa pennata, Molinia cærulea.
43 — Holcus lanatus, Sanguisorba canadensis, Trifolium pratense, Bunias orientalis, Arundo colorata.
45 — Elymus arenarius, Elymus geniculatus, Phleum pratense, Beckmannia erucæformis, Poa fertilis, P. pratensis.
51 — Cynosurus cæruleus.
52 — Trachynotia cynosuroides.
53 — Anthoxanthum odoratum.
57 — Holcus odoratus.
2 months, Strawberry, Elm, Cherry, Raspberry, Euphorbia Esula, Spiræa Filipendula, Potentillas, Poppies.
3 — Reseda Luteola, Prunus Padus, Cotoneaster, Celandine, Lime-tree.
3 to 5 — Apple, Plum, Sloe, Beech, Walnut.
4 — Horse-chestnut, Hawthorn, Roses.
5 — Birch, Alder.
5 to 6 — Vine, Pear.
6 — Chestnut, Medlar, Hazel, Almond, Hippophæ.
7 — Olive, Savin, Daphne Laureola, Quercus Robur.
8 to 9 — Colchicum autumnale, Mistleto.
10 — Pinus Laricio.
11 — Most Pines.
12 — Most Mosses, some Conifers.

900. The period in which fruits ripen is materially accelerated by an increase of temperature, and their flavour is also improved. Hence

the use of putting fruit under glass, or on slates of a dark colour, or wrapping it up in thin bags. The maturation is also accelerated by removing a ring of bark from the branch or stem, which leads to an accumulation of descending sap above the cut. This is practised in vineyards in France on a large scale, and by this operation the ripening of grapes is accelerated twelve or fifteen days. De Candolle mentions a Vine near Geneva which never produced fruit till this operation was performed. When fruit-trees belonging to a cold climate are transferred to a hot one, it frequently happens that no fruit is produced; the leaves become luxuriant, and the flowers, if they expand, are abortive. A high temperature sometimes seems to cause the production of unisexual male flowers only. Hence plants in hot-houses when over-stimulated by continued heat, are often abortive. They require a season of rest or repose in order to perform their functions properly.

901. The various kinds of edible fruits require different climates in order to attain perfection. Thus the Apple and Pear succeed best in the middle temperate climes, Peaches and Oranges require warm temperate regions, while Bananas, Bread-fruit, and Mangos demand tropical heat. Three of the finest known fruits are the Pine-apple, which attains perfection in Guayaquil, the Cherimoya, on the slopes of the Andes, and the Mangosteen, in the Indian Archipelago. It has been remarked, in regard to native fruits, that white berries are commonly sweet, red ones sour, blue have a sour mixed with a sweet flavour, and black are either almost tasteless or poisonous. The seeds of many fruits, such as the Apple and Pear, have a tendency to sport, as it is called, when highly cultivated. By the art of horticulture the native Crab-apple and Pear have been made to produce all the esteemed varieties of the present day. These varieties are propagated by the process of grafting, to be afterwards described. By making slips of improved kinds grow on well-grown stocks, vigour is imparted to them, and the maturation is accelerated.

902. Recapitulation of the chief facts connected with the physiology of the fruit :—

1. Fruit is produced after fecundation, and is not perfect unless it contains seeds capable of germinating.
2. Some fruits which are valued for domestic purposes do not produce seeds, owing to imperfect impregnation, and probably depending in some measure on the age of the plants and their cultivation.
3. Fruiting has a tendency to exhaust the plant; annuals die after performing this function.
4. If a plant is prevented one season from producing fruit, it frequently furnishes a large supply the following year.
5. The operations of pruning, ringing the bark, and checking the roots, often make fruit-trees productive.
6. Cultivated fruits are much improved in quality by judicious thinning at the early stage of growth.
7. Green-coloured fruits, particularly when they retain their leafy character, decompose carbonic acid under the agency of light, and give out oxygen.

8. Hardened Pericarps, which are often of a brown or whitish colour, cease to perform active functions.
9. Succulent fruits often assume tints of yellow, red, or blue, and they seem to give out carbonic acid during their maturation.
10. Fleshy or succulent fruits during ripening exhibit an increase of temperature, and lose their austerity and sourness by the conversion of cellulose, dextrin, and acids into grape sugar, as well as by the neutralization of their acids.
11. Succulent fruits swell by an endosmotic action in their cells; those near the surface losing fluid by transpiration, and thus having their contents thickened, which circumstance causes a flow of less dense fluids from the internal parts.
12. The transpiration is often ultimately checked by the deposit of waxy matter in the cuticle.
13. During the maturation of fleshy fruits there is a loss of water, a diminution of cellulose and lignin, and an increase of saccharine matter.
14. Some austere fruits, when taken from the tree in an apparently ripe state, undergo farther changes when kept in a moderate temperature; these changes consist chiefly in a loss of water, and a diminution in the quantity of ligneous matter, and of sugar. This process has been called bletting.
15. Green fruits contain pectose, which, by the aid of heat and acids, is transformed into pectine, and during maturation pectine is converted into pectosic, pectic, and metapectic acids, which give the jellying quality to fleshy fruits.
16. In green fruits there is a certain amount of proper heat, seldom exceeding one-tenth of a degree.
17. The time required for the maturation of fruit varies much; in grasses the time which elapses between flowering and the ripening of the fruit varies from thirteen to forty-five days; while in other fruits several months are required, and in some instances a year or more.
18. The ripening of fruit is accelerated by heat, and by various horticultural operations.
19. Different fruits are adapted to different climates; in tropical regions, where fruits are best fitted for the well-being of man, they are produced in great abundance.
20. Fruits are much improved by high culture, and by the process of grafting on approved stocks.

CHAPTER X.

PHYSIOLOGY OF THE SEED.

I. MATURATION OF THE SEED, AND MODES IN WHICH SEEDS ARE SCATTERED AND DEPOSITED IN THE SOIL.

903. The production of an embryo is the object of fertilization. In the case of flowering plants this embryo is contained in the seed, in which it attains a certain degree of development. In these plants after impregnation the ovule undergoes evident changes. The embryo plant enlarges, attracts nourishment from the surrounding tissues, and either absorbs all the contents of the ovule, or becomes surrounded by a store of perisperm (albumen), which is deposited within or on the outside of the embryo-sac (Fig. 908, p. 302), or in both situations (Fig. 907, p. 302). The nucleus of the ovule is either absorbed or becomes filled with various azotized and unazotized matters, while the coats (especially the outer one) become denser and firmer, and the foramen is closed. Lignin is often deposited on the walls of the cells of the episperm. The seed by means of these changes is rendered more fit to resist vicissitudes of temperature and other accidents which might injure the vitality of the embryo.

904. An aperispermic embryo (Fig. 923, p. 305) has all the nutriment contained in its own substance, especially in its cotyledons, and when the coats of the seed are removed the embryo alone is found within. A perispermic embryo has a separate store of nutriment beside it, and when the seed-coats are taken off the embryo is found surrounded more or less completely by this nutritive matter or perisperm (Fig. 908, p. 302). The perisperm consists of amylaceous, gummy, and saccharine matters, with oils, resins, nitrogenous substances, and certain salts, such as phosphates, sulphates, and chlorides. The presence or absence of perisperm seems to be connected with the mode in which the seed germinates, and the nature of the perisperm varies according as the seeds sprout rapidly or lie long dormant in the soil. The store of nourishment laid up in the seed is greater than the embryo requires in ordinary circumstances. When the perisperm is not allowed to be fully formed before the seed is detached from the plant, it sometimes happens that owing to the soft and succulent condition of

the albumen, the embryo sprouts rapidly. In such cases, however, the embryo does not germinate vigorously, and is apt to fail from want of a due supply of nutriment. Some seeds continue to be of a soft texture, while others assume a stony hardness, as is the case in the Date (Fig. 786, p. 269), and in the Ivory Palm. Some ripe seeds are of greater specific gravity than water, and sink when thrown on it. In other instances, especially when air is contained in the envelopes, as in the Indian Cress, the seeds float in water.

905. When the seed is ripe, it is either discharged from the seed-vessel, or the fruit remains indehiscent, and falls with the seed still contained in it. Fleshy fruits, such as Apples and Peaches, fall from the tree when ripe, and their succulent portion serves as nutriment for the young embryo while sprouting. Many dry fruits, especially such as are monospermal, fall along with the seed which they enclose. In the cereal grains the pericarpial covering and the integument of the seeds are incorporated (Fig. 848, p. 283), and in the fruit of Labiatæ and Boraginaceæ (Fig. 838, p. 281) these two coverings continue attached when the seed is ripe. In Compositæ (Fig. 494, p. 197) and Valerian (Fig. 497, p. 198) the hairy calyx remains attached to the fruit, so as to be the means of dispersing it along with the contained seed, and in samaroid fruits (Fig. 850, p. 284, and 851, p. 285) there are winged appendages for the same purpose. In the case of the Dandelion (Fig. 495, p. 198), the receptacle, which is at first succulent and flattened, becomes dry and convex, and the phyllaries, which are erect, become deflexed, so as to allow the fruit to be easily scattered. Other dry fruits dehisce in various ways, as already mentioned (p. 271, *et seq.*), so as to scatter the seeds. The opening of the seed-vessels takes place either as the result of a drying process, as in Mahogany, or from the effects of moisture, as in species of Mesembryanthemum (Figs. 1085 and 1086, p. 411), and in the pod of Anastatica hierochuntina, commonly called the Rose of Jericho (p. 411).

906. Some plants are called Hypocarpogean, because their fruit is subterranean—that is, it is either produced on peduncles underground, or, after being ripened in the air, is pushed into the soil by a curvation of the fruit-stalk. The fruit of Colchicum autumnale (Fig. 641, p. 232) is situated underground in the first instance at the base of the long tube of the flower. Vicia amphicarpos and Lathyrus setifolius *var.* amphicarpos produce fruit both on aerial and subterranean branches. Arachis hypogæa, called Earth-nut, produces on its aerial branches abortive flowers, while on those underground it developes perfect pods. Many aquatic plants which flower in the air deposit their fruit in the mud at the bottom of the water, as is the case in Vallisneria (Fig. 1094, p. 415), and in Trapa (Fig. 314, p. 134). The peduncle of Linaria Cymbalaria at the time of flowering is straight and short, but it afterwards elongates and curves irregularly, until it comes to a fissure in the rock or wall on which it grows; there it inserts the capsule, which subsequently allows the seeds to escape.

The peduncle of Cyclamen (Fig. 469, p. 193) curves in a similar way, so as to place the seed-vessels in the earth. The extremity of the peduncle of Trifolium subterraneum is provided with a hard point, by means of which, after its curvation, it penetrates the soil and deposits its pods. Seeds are sometimes provided with hairy and winged appendages, as seen in the case of Cotton, Willow (Fig. 896, p. 297), Asclepias (Fig. 895, p. 297), Pine (Fig. 893, p. 297), Mahogany, and Bignonia, for the purpose of being wafted to a distance by the agency of winds. The seeds of plants valuable as food have been dispersed by man over various quarters of the globe. Streams also convey to a distance the seeds of plants which grow on their banks. The pulpy covering of some fruits renders them fit for the food of birds and other animals, and when the seeds are hard and enclosed in a stony endocarp, they may escape the action of the gastric juice, and be deposited in a state fit for germination.

907. Seeds are scattered in such a way as to reach the soil best fitted for their growth, whether the plants are terrestrial or aquatic. Provision is made for the propagation of the species by the production of a large number of seeds, so as to make up for the loss occasioned by decay, or by the seeds being eaten by animals. The number of seeds produced by the Seje Palm is 8000, by the common Spear-thistle (Carduus lanceolatus) 24,000, by the oriental Poppy (Papaver orientale) 32,000, and by the Tobacco-plant (Nicotiana Tabacum) 40,000 or more. Some common weeds spread very rapidly in gardens in consequence of the number of their seeds. A writer in the Gardener's Chronicle estimates that the common Groundsel (Senecio vulgaris) ripens about 52 seeds in each head of flowers, and produces about 40 heads or 2080 seeds; the Dandelion ripens about 135 seeds in each head, of which it produces about 20, or 2700 seeds; the Sow-thistle (Sonchus oleraceus) ripens about 230 seeds in each head, and produces about 48, thus yielding 11,040 seeds per plant, and the annual Spurges (species of Euphorbia) form about 180 seed-vessels, each containing 3 seeds, and therefore produce about 540 seeds per plant. Taking, then, a single plant of each of these species, we find that they will together produce 16,380 seeds, which after germination will cover about 3½ acres of land at 3 feet apart. This statement shows the importance of eradicating such weeds before they ripen their seeds.

II. GERMINATION OR SPROUTING OF THE EMBRYO PLANT.

908. Germination is the term applied to the sprouting of the embryo when placed in circumstances favourable for its growth. In the case of flowerless plants a cell or spore separated from the parent plant is developed into a new organism, while in flowering plants an embryo

plant already in a certain stage of development within the seed, begins to send out first its root, and then its cotyledons and primary stem-bud. In the case of the latter class of plants, germination may be defined the act by which the fecundated embryo of a seed leaves the state of torpor in which it has remained for a longer or shorter period, starts into life, as it were, comes out from its envelope, and sustains its existence until such time as the nutritive organs are developed.

1. REQUISITES FOR GERMINATION.

909. In order that germination may go on, certain conditions are necessary. The most important of these requisites are moisture, a certain temperature, and air. The absence of light is also favourable for the process, and, according to some, electricity promotes it. In general, seeds do not sprout until they are placed in the position which the plants are subsequently to occupy. Occasionally, however, seeds begin to germinate before being detached from the plant, as in the case of the Mangrove tree (Fig. 123, p. 53). Instances are given of the seeds of Poppy, and of those of the Lemon, Papaw, and Gourd, germinating in their seed-vessels, and we often find Coco-nuts germinating during their transport from their native country to Britain. In such cases there is a sufficient supply of nourishment for the embryo in its early state.

910. A certain amount of moisture is required for germination. If seeds are kept in a dry state they can be preserved for a long time without sprouting.* Water is required for the solution of the nutritive matter of the seed, as well as for exciting the endosmotic action of the cells. No circulation nor movement of fluids can take place in the seed until water is taken up. The nourishment of plants is absorbed chiefly in a liquid state. Seeds imbibe a large quantity of water, and in so doing their cells become much distended. By this means they are enabled to burst the hard endocarpial coverings which often surround them, as in the case of what is called stone-fruit. De Candolle says that a Haricot or French bean, weighing about $7\frac{1}{3}$ grains, absorbed about $10\frac{1}{2}$ grains of water during germination, and another, weighing $4\frac{1}{3}$ grains, absorbed $6\frac{1}{2}$ of liquid. In countries in which dry seasons occur, germination is for a time checked, but when the wet season arrives, the seeds sprout with great rapidity and vigour.

911. The amount of heat required for the development of the embryo varies much. Some seeds, as those of plants belonging to cold regions, require a moderate temperature, others belonging to hot countries demand an elevated one. It may be said in general that a temperature varying from 60° to 80° F. is the most favourable for

* Saussure, de l'influence du dessechement sur la germination de plusieurs graines alimentaires Genève, 1828.

germination.* In cold regions the spores of Cryptogams germinate at a very low temperature. In other instances germination proceeds at high temperatures. Dr. Hooker states, that on the edges of hot springs in the valley of Soane in India, the temperature of which was sufficient to boil eggs, there occurred sixteen species of flowering plants —Desmodium, Oldenlandia, Boerhaavia, some Compositæ, Grasses, and Cyperaceæ. He also mentions Ranunculus sceleratus as growing in the vicinity of hot springs near Monghyr in India, at a temperature of 90°. According to Andrejewskyi the following plants grow, watered by the hot springs of Abano—Althæa rosea, Hypericum perforatum, Ajuga Chamæpitys, Sedum acre, Spergula arvensis, Arenaria rubra, Mentha arvensis, Adiantum Capillus Veneris, and some Mosses; Ulva labyrinthiformis, Conferva alba, C. anonyma, C. Aponitana, and C. capillacea were found growing in water at temperatures varying from 112° to 146° F. On the edge of the boiling springs in New Zealand Colenso mentions that Ferns (as Pteris Brunoniana), Carices, and Compositæ flourished luxuriantly. Forster, who sailed with Captain Cook, found the ground near a volcano in the Island of Tanna so hot as to raise Fahrenheit's thermometer to 210°, and at the same time this spot was covered with flowers. A hot spring in the Manilla Islands, which raises the thermometer to 187°, has plants flourishing in it and on its borders. In hot springs near a river of Louisiana, with a temperature varying from 122° to 145°, Confervæ, herbaceous plants, shrubs, and trees flourish. A species of Chara has been found growing and reproducing itself in one of the hot springs of Iceland, which boiled an egg in four minutes, and various Confervæ have been seen in the boiling springs of Arabia and of the Cape of Good Hope.

912. The necessity of air for germination was demonstrated by Ray, Boyle, and others before the chemical composition of the atmosphere was discovered. Scheele, Senebier,† and Saussure showed that the presence of oxygen gas was required in order to aid in the changes which take place in the seed. When seeds were placed in an atmosphere of hydrogen, nitrogen, and carbonic acid, they did not germinate. When they are buried deeply in the soil, so as to be deprived of the access of air, they do not grow. In such circumstances, when the soil is turned up so as to bring the seeds near the surface, germination often commences. In this way seeds, which have been long dormant, spring up on the embankments of railways, and white Clover frequently appears when the soil is stirred. Some substances which supply oxygen, as weak solutions of chlorate of potass and of oxalic acid, are said to be useful in promoting germination. Chlorine acts in the same way by decomposing water and setting oxygen free.

913. Seeds germinate more rapidly in shade than in light, and in diffuse daylight more quickly than when exposed to the direct solar

* Edwards et Colin, de l'influence de la Température sur la Germination, Paris, 1834.
† Huber et Senebier, sur l'influence de l'Air dans la Germination.

rays.* Boitard sowed Auricula seeds in three flower-pots, one covered with a transparent glass bell-jar, the second with a bell-jar of ground glass, and the third with a bell-jar enveloped in black cloth. In nine days the latter had sprouted ; those under the ground glass germinated on the 12th day; and those under the transparent glass jar had not germinated by the 15th day. In these experiments, however, if the sun was shining, temperature might have something to do with the result. Experiments have been made as to the effects of different rays on germination. Senebier sowed Lettuce seeds in several small cups. One of the cups he left exposed to light and air; another he placed in darkness, and a third he confined under a large glass vessel, whose bottom was thrust so far up into its body as to leave a hollow space 9 or 10 inches in height, and 4 or 5 in width; this vessel was then filled with water, through which the light that fell on the seeds beneath necessarily passed; a fourth cup was placed in a similar vessel which contained yellow fluid; a fifth beneath a similar vessel filled with red fluid; and a sixth under one that contained fluid of a violet hue. Through these fluids the yellow, red, and violet rays were respectively transmitted, while the others were for the most part intercepted. He found that the plants illuminated by the yellow rays grew most rapidly in height; next those in the violet rays; afterwards those in the red; the plants which grew in light transmitted through water were still smaller, and approached in size to those which vegetated in the open air, while those in perfect darkness attained the greatest height of all. These last plants perished on the 8th day, those in the yellow light on the 9th day, while all the others continued to vegetate. At the end of about five weeks, the plants under the red vessel were 4 inches 9 lines in height; under the violet vessel 3 inches 3 lines; under the water vessel 2 inches 10 lines; and those in the open air 1 inch and 3 lines. The leaves of plants in the red light were smaller than those of plants in the violet, and than the leaves of plants grown under the water-glass, or in air. Those exposed to the yellow were at first green, and then became yellow; those in red light appeared green, and preserved a tinge of that colour; those in the violet were quite green, and their colour augmented with their age; while those in darkness had no colour. Thus the violet rays acted powerfully in giving the green colour, but they did not act in the same manner as regards the growth and development. Senebier concluded that the height and size of a plant was proportionate to the intensity of the illumination, while its verdure depended more on the quality of the rays.

914. Hunt made experiments on the effects of coloured rays on the germination and growth of plants.† He passed the sun's rays through variously coloured glass, such as deep red glass coloured by oxide of gold, deep yellow glass prepared with the glass of antimony, red lead,

* Senebier, Mém. Physico-Chimiques, iii. 41. Saussure, Recherches Chimiques sur la Végétation, 23.

† Hunt, on the Chemical Action of Solar Radiations—Brit. Assoc. Report for 1850, p. 137.

and oxide of iron, deep blue glass coloured with cobalt, as well as through coloured solutions. He concluded that the process of germination and budding is essentially influenced by the chemical principle actinism, transmitted through the blue media. While the rays connected with blue light promoted germination, the luminous yellow rays impeded it. He found also that the decomposition of carbon is peculiarly due to the luminous principle, and hence that the formation of wood in plants is a function of their vitality excited by light; that the development of the flower is due to a delicate balance of the forces actinism and light, since we find that both the luminous and chemical agencies are very active during the process; and that the ripening of the fruit and the perfecting of the healthful conditions of the seed are due to a combination of the calorific and chemical forces—as evidenced in the so-called parathermic rays. From these facts it appears that the germination of seeds in the spring, the flowering of plants in summer, and the ripening of fruits in autumn, are dependent on the variations in the amount of actinism or chemical influence, of light and of heat at those seasons. He has suggested a kind of glass, coloured pale green with oxide of copper, as being the best for conservatories, and this has been adopted in the construction of the Palm-house at Kew.

915. Some have supposed that electricity promotes germination and growth. The subject was brought into notice so far back as 1746, when Mr. Maimbry at Edinburgh announced that electrified plants grew more rapidly and vigorously than those that were not so treated. About the same time the Abbé Nollet stated that electrified seeds germinated with increased facility, and he was supported by Bertholon and Jalabert. The Rev. E. Sidney has lately maintained that electricity produces a marked effect on growing plants, that their pointed leaves withdraw it from the air with great rapidity, and that during a highly electrical state of the atmosphere the growth of some young shoots is promoted. In the process of germination this agent seems to act to a certain extent. Solly, however, thinks that the influence of electricity on the growth of plants, so far as it can be determined, is very small.*

916. Dr. Antisell of Dublin says, that as atmospheric electricity is positive in its character and that of the earth negative, any body serving as a point of discharge for these two kinds, receives a shock which, in the case of a growing tree or plant, would be a stimulus to its growth if the shock is gentle, while it would be fatal if the shock was severe, as in thunder-storms. So long as the earth and the atmosphere are in equilibrio, the results of electricity on vegetation are not striking, but, should any disturbing cause arise, they become evident. One of these causes is evaporation of water. Rapid formation of clouds in the tropics always precedes thunder-storms; the electricity of the atmosphere accumulating round these clouds and discharging on the nearest objects. The issue tube of a steam-engine is a ready yielder of elec-

* Solly on the Influence of Electricity on Vegetation—Journ. Hort. Soc. Lond. i. 81, and ii. 42.

tricity. When water is evaporated there is always electrical disturbance. When evaporation is slow, the disturbance is slight but constant, and acts on vegetation. Hence, in countries where evaporation takes place from a large supply of moisture, vegetation is rapid and luxuriant. This depends, he thinks, partly on the moisture, and partly on electricity developed during evaporation. Showers are much more efficacious than water supplied artificially. Negative electricity is said to be favourable in a peculiar degree to vegetable growth. Every shower of rain conveys a quantity of electricity to the herbage it wets. Every operation of burning produces electricity. When wood is burned it becomes negative, while the carbonic acid arising from it is positive. Decomposition of carbonic acid in the leaf produces a like change; the oxygen which escapes being positive, while the cells in which the change takes place are negative. Dr. Forster a few years ago announced remarkable effects from the transmission of the galvanic influence through fields of Cereal grains, and recommended what he called a system of electro-culture, by means of wires passed from plates of zinc and copper round the fields. Dr. Fyfe examined the system recommended by Forster, and was not able to detect any evident results on crops. The apparatus which had been suggested was found not to produce any current of electricity, no effect being visible on the electrometer.*

917. While moisture, heat, air, and darkness, are favourable to germination, it is of importance that these requisites should be properly supplied. In nature seeds are sown in the earth to a moderate depth, so as to be excluded from light, and at the same time to be acted on by air, moisture is supplied by rains and dews, and a certain temperature is given. Such is the plan which we ought to imitate in garden and field operations. In order that seeds when scattered may be placed at a proper depth, the soil must be properly ploughed and pulverised. The preparation of the soil materially promotes germination; when properly ploughed the seeds sink to the same depth throughout the field. The pulverising of the soil is much promoted by the action of frost, which causes the clods to break up. The exposure of the soil to the action of the air is another important object in ploughing. The greatest surface is exposed by ploughing when the turf lies at an angle of 45°, and the turf will lie in this position when its depth is to its breadth, as about 7 to 10. The advantage of equal machine-sowing is, that the seeds germinate about the same time, and the crop is also all ripened at once, and the diminution in the quantity of flour caused by allowing some part of it to remain long in a ripe state is avoided. When seed is sown broadcast by the farmer, a certain quantity remains uncovered even after harrowing, and hence it does not germinate freely. This may be one reason why dibbling is more successful as regards the number of seeds which ger-

* Fyfe, Experiments on Electro-culture, in Trans. Ed. Soc. of Arts, iii. 100.

minate, and why with a smaller expenditure of seed an equal return is made.

2. DEPTH OF SOIL REQUIRED FOR GERMINATION. EFFECTS OF DRAINING.

918. The experiments made in regard to the depth at which seeds should be placed, agree in showing the advantage of shallow sowing. Petri gives the following as the result of his experiments on sowing rye :—

Depth at which the Rye was sown.	Number of grains that germinated.	Period at which the plants appeared above ground.
½ inch.	7 eighths	11 days.
1 —	the whole.	12 —
2 —	7 eighths.	18 —
3 —	6 eighths.	20 —
4 —	one-half.	21 —
5 —	3 eighths.	22 —
6 —	1 eighth.	23 —

The following are the experiments of Burger with Maize or Indian Corn :—

Depth at which Seeds were sown.	Period at which they came up.	Depth at which Seeds were sown.	Period at which they came up.
1 inch	8½ days	3 inch . . .	12 days
1½ „	9½ „	3½ „	13 „
2 „	10 „	4 „	13½ „
2½ „	11½ „	5½ and 6 . . .	17½ „

The more slightly the seed is covered by the earth, the more rapidly the bud makes its appearance, and the stronger afterwards is the stalk. The deeper the seed lies, the longer the shoot remains before it comes to the surface. Ugazi, from observations made in Bavaria, gives half an inch and one inch as being the best depths at which ordinary cereal grains, as well as Peas, Millet, Maize, Buckwheat, and Lentils, should be sown in argillaceous soils, while two to three inches is the depth proposed in sandy soils.* Large seeds must be placed deeper than small ones.

919. Experience proves, that stirring the soil, so as to insure a loose surface, is highly beneficial to growing crops. Air is thereby enabled to act more perfectly upon the substances from which plants derive their nourishment; and in dry weather the escape of moisture is prevented. When the surface is compact, the sun's rays dry the ground to a greater depth than when it is loose. When the particles

* Bulletin des Sciences Agricoles.

of the soil are in close contact, the uppermost, parched by the heat of the sun, draw humidity from those immediately under them, and these again from others still lower. On the contrary, when the surface is loose and well pulverised, it may lose its moisture rapidly and become very dry; yet, from imperfect adhesion with the inferior portion, the latter cannot readily communicate its moisture. In short, the loose soil at the top becomes an interposing medium which protects the under stratum from the drying effects of the sun.*

920. In order that land may be productive in the case of cultivated grains, moisture must be supplied in proper quantity, and a certain amount of heat must be imparted to the soil. This is accomplished by the operation of draining, which has been carried to great perfection of late. Much injury is inflicted on the soil by stagnant water. The land is rendered cold, inasmuch as the sun's rays, in place of being expended in heating the soil, are absorbed by the water, the temperature of which is not raised so rapidly as that of the earth or of the air. There is thus a great loss of heat. Moreover, by the exclusion of air there is often an imperfect decay of vegetable and animal matters in the soil, so that acids are produced which are deleterious and hurtful to vegetation. Superabundant moisture also acts prejudicially on the climate of a country, and it injures plants by rendering them weak and dropsical. The importance of giving bottom heat to plants cannot be too strongly insisted on.

921. The object of draining is not so much to get rid of the water, as to make it percolate freely through the whole of the soil, laterally as well as perpendicularly, and thus obtain from it the nutriment in the shape of ammonia, carbonic acid, &c., which it contains. As the water disappears, air occupies its place, and hence drained soil is aërated. Mr. Smith of Deanston had the merit of reducing thorough draining to a system. His system consisted in forming parallel drains of from 2½ to 3½ feet in depth in the furrows between the ridges, at such short intervals as to insure the speedy removal of all superfluous water, whether derived from rain or from springs. The parallel drains are made so as to cut the different strata of the land perpendicularly to the line of strike, whilst the main or leading drains run across the direction of the dip, and are about 6 inches deeper than the parallel drains.† The effects of draining are both mechanical and chemical. It gives rise to improved efficiency in ploughing, harrowing, and weeding, besides saving seed. It also aids the fertilizing power of manures, ameliorates the climate, raises the temperature of the soil, accelerates the harvest, and improves the herbage and other crops. The economical advantages of draining are thus summed up by Johnston:—1. Stiff soils are more easily and more cheaply worked. 2. Lime and manures have more effect, and go further. 3. Seed-time and harvest are earlier and more sure. 4. Larger crops are reaped, and of better quality. 5. Valuable crops of Wheat and Turnip are made to grow where scanty

* Gardener's Chronicle, Sept. 15, 1841. † Smith, Remarks on Thorough Draining, 1844.

crops of Oats were formerly the chief return. 6. Naked fallows are rendered less necessary, and more profitable rotations can be introduced. 7. The climate is improved, and rendered not only more suited to the growth of crops, but more favourable to the health of man and animals.*

922. Drained land in summer is from 10° to 20° warmer than water-logged land. Professor Schubler states that the loss of heat caused by evaporation in undrained lands amounts to $11\frac{1}{4}$° to $13\frac{1}{2}$° F. Parkes says that in draining the Red Moss near Bolton-le-Moor the thermometer in the drained land rose in June 1837 to 66° at seven inches below the surface, while in the neighbouring water-logged land it never rose to above 47°. In the London Horticultural Society's Garden the mean temperature of thoroughly-drained soil at one foot below the surface, in the month of July, is 63°.49; and if we take water-logged land to be the same as spring water, 47°, then there is a gain of $16\frac{1}{2}$°. Experiments have been made which show that in peaty soil saturated with water, the addition of boiling water to the surface will not raise the temperature to any depth in the soil, so that wet land will thus remain cold in spite of all the warm rain that falls. This is not the case with drained soil where there is a constant percolation.

923. The depth of drains, and their distance from each other, must be regulated by the nature of the soil, and of the subsoil. Mr. Smith says that where you meet with a hard bottom, you must go down till you meet with a good one, but you must never allow depth to compensate for width. Drains should of course never be shallower than the known depth to which the roots of annuals descend. In impervious soils, Smith says that 15 to 18 feet is a good working distance for drains. In extremely stiff clay, drains do not seem sufficiently to dry the land when first made; the improvement in these cases is gradual, and may take several years, but the result is certain. Drains in these soils should be $2\frac{1}{2}$ to $3\frac{1}{2}$ feet deep. In very light soils the distance between the drains may be from 30 to 40 feet, and the depth at least 30 inches. By making deep, and at the same time efficient drains, we increase the quantity of soil available for the purposes of plants. In the case of deep-rooted plants, it is essential that water should be removed from the lower as well as from the upper portion of the soil.

924. Drains must be kept clear, otherwise their good effects will be lost. Occasionally they become choked up, the roots of plants getting access to them (see page 428). All that can be done to prevent this, is to make deep drains, and not to allow them to pass near trees; also to keep the land clean. Shallow drains are more likely to be affected because the roots reach them more easily. The trees liable to send in roots are Ash, Sycamore, Alder, Poplar, Willow, Lime, Elm, Privet, and Laurel; these trees form fibrous roots with great rapidity. Clean land, with annual crops, will be little liable to have the drains choked in this way, because the roots of annuals are

* See Johnston's Lectures on Agricultural Chemistry, 550.

usually not deep, and if they get into drains they will quickly die. Docks, Thistles, Burdocks, Plantains, Bistorts, and Dandelions, are very injurious when in the vicinity of drains.

3. VITALITY OF SEEDS, AND MODES OF PRESERVATION.

925. Some seeds must be sown immediately after they are ripe, otherwise they lose their vitality, and decay. This is the case with the seeds of Magnolia, Coffee, Clove, and with those of an oily and mucilaginous nature. Even though the germinating power is lost, the seeds may be in a state fit for food. The seeds of the double Coco-nut (Lodoicea Seychellarum), when carried from the Seychelles Islands to the Maldives, and those of Entada (Pursætha) scandens, when borne by the gulf-stream from the Antilles to the outer Hebrides, are to all appearance fresh, although they will not sprout when planted. Wheat which had been placed in wooden casks, well pitched and secured against the influence of the weather, in 1548, made excellent bread at Zurich in 1799, although it did not germinate. Seeds with very delicate integuments can seldom be kept longer than a few weeks or months, while hard and bony seeds have been known to germinate after the lapse of many years. Certain seeds are known to retain their germinative powers for a long time. The seeds of Cucumber have germinated after seventeen years, those of Colsa and Malva crispa after eighteen, of Althæa rosea after twenty-three, Maize after thirty, Haricots, or French beans, after thirty-three, Melons after forty-one.* For sixty years a bag of seeds supplied the Jardin des Plantes annually with Sensitive plants. Haricots taken from the Herbarium of Tournefort, and which were at least one hundred years old, were found to germinate, as were also seeds of Hieracium, fifty years old, from Fries' Herbarium. Grains of Rye have been found fertile after one hundred and forty years.

926. The subject of the Vitality of Seeds has engaged for ten years the attention of a committee of the British Association, and from time to time reports have been issued. Experiments have been made on seeds illustrating nearly three hundred genera, and upwards of seventy natural orders. It was found that the seeds of Allium fragrans, Camassa esculenta, Pinus Pinea, Lupinus grandifolius, Galega sibirica, Cassia canarina, Clarkia elegans, &c., germinated after a period varying from ten to nineteen years; those of species of Malva, Hibiscus, Crotalaria, Hedysarum, Phaseolus, Dolichos, Tamarindus, and Eucalyptus, &c., retained their vitality for twenty or thirty years; while seeds of species of Colutea and Coronilla germinated after forty or fifty years. It would appear, in general, from the experiments, that the seeds of Leguminous plants retain their vitality for a long time. †

* Lefebure, sur la Germination des Plantes, Strasburg, 1804. Gerardin, sur la proprieté des Graines de conserver longtemps leur vertu germinative, Paris, 1809.

† See Summary of Experiments in British Association Report for 1850, p. 162.

927. Seeds placed in particular circumstances have retained their vitality for a great number of years, and even for centuries. Savi saw for ten years young Tobacco plants continue to spring up in his garden from seed which had been sown naturally. All the young plants were regularly rooted out, and yet the supply continued for the length of time mentioned; showing that many seeds remained dormant, and only appeared as the soil was turned up and exposed to air. Duhamel noticed the re-appearance of Datura Stramonium, after twenty-five years, in a ditch which had been filled up and afterwards cleared. Miller noticed Plantago Psyllium grow in a ditch at Chelsea which had been newly cleared, and where it had never been known to grow in the memory of man. Mr. Vernon Harcourt mentions the following instance of delayed germination. A field was prepared for white Carrots; the Carrots were sown, but the season being very dry they did not grow. The ground was, however, soon covered with a crop of white Turnips, which had been sown eight years before. The Turnip seed had been carried down by rains below the ordinary depth of ploughing, and beyond the reach of atmospheric influence, and there they remained in a condition which artificial preservation finds it difficult to imitate, being neither parched up by too much heat, nor decomposed by stagnant moisture, until they were brought by the subsoil plough to the surface, where their vital powers were stimulated to action.

928. Lindley mentions the germination of Raspberry seeds found in 1834 or 1835 in an ancient barrow (tumulus) near Maiden Castle, along with coins of the Emperor Hadrian. The seeds were in the cavity of the abdomen of a skeleton found in a coffin thirty feet below the surface, and may have been 1600 to 1700 years old. Mr. Kemp details a case of prolonged vitality in seeds found at the bottom of a sand-pit twenty-five feet in depth. The plants produced were Polygonum Convolvulus, Rumex Acetosella, and a variety of Atriplex patula. From various circumstances he concludes that they were deposited there at a time when a lake was formed in the course of the Tweed, about a quarter of a mile from Melrose; and as no lake existed in the time of the Romans 2000 years ago, he concludes that the seeds were very ancient. They are of a farinaceous character.* Desmoulins gives the following instance of seeds retaining their vitality for a long period in particular circumstances. In the spring of 1834 a proprietor of land in the neighbourhood of Bourdeaux having caused a piece of ground to be dug over to a considerable depth for the purpose of planting a vineyard, discovered a good many tombs, most of which presented this remarkable peculiarity that the head of the skeleton deposited therein rested on a heap of apparently well-preserved seed. The graves, from various collateral circumstances, were proved to be of Roman origin, and were referred to the third or fourth century of the Christian era. The seeds were carefully collected and sown, and on germination were found to be chiefly Heliotropium europæum, Me-

* Kemp, on the Vitality of Seeds, &c., in Ann. of Nat. Hist. 1st ser. xiii. 89.

dicago lupulina, and Centaurea Cyanus. The facts of this case establish the position that certain kinds of seeds, if entirely excluded from the agents needful for vegetation, or rather, if shielded from the combination of influences requisite for germination, will maintain their vital property uninjured for the space of fifteen or sixteen centuries, and display it afresh when placed in favourable circumstances.* Burroughes found that seeds of Centranthus ruber, taken from an ancient coffin in Wymondham Abbey, germinated.†

929. In Stirlingshire germinative seeds of the Corn Marigold (Chrysanthemum segetum) were found under six or seven feet of peat moss. When new land is turned up it frequently happens that seeds spring up which have lain long dormant. White Clover (Trifolium repens) appears in these circumstances. In the fens of Cambridgeshire, after being drained and ploughed, large crops of Sinapis arvensis and alba are said to spring up. When certain marshes in Zealand were drained, Carex cyperoides was observed to grow in abundance, although not previously known in the neighbourhood. Fumaria micrantha has been known to appear in large quantity on newly stirred ground near Edinburgh. After extensive conflagrations plants often make their appearance which had not been previously seen in the neighbourhood. In Newfoundland, after a fire in the forests, the ground has become covered with a luxuriant growth of Raspberry bushes, succeeded by a thick wood of Birch, although previously to the fire nothing but Fir and Spruce had been seen for miles. The virgin forests of Brazil (Mattos Virgens), when destroyed by fire, are succeeded by plants of a totally different kind. Such forests are called Capoeiras. After the great fire of London, Ray states that Sysimbrium Irio came up in great profusion.

930. It is not easy to account for the manner in which the vitality of many seeds is thus preserved. Uniform temperature, moderate dryness, and exclusion from light and oxygen, appear to be essential requisites. If the temperature is elevated, and moisture and oxygen are present, then germination commences. The vitality of seeds in certain favourable circumstances may thus be preserved for a very extended period, but it is by no means easy to imitate these conditions. The statements made in regard to the preservation of Mummy Wheat have not been confirmed by careful observation. Even in the cases which appeared to be conclusive, fallacies have been detected. Thus Mummy Wheat, supplied by Sir G. Wilkinson to various parties, was found in some cases to contain grains of Maize, a plant of the New World, which leads to the conclusion that in this case the grains had been tampered with. We have no evidence that the Wheat cultivated as Mummy Wheat was that deposited 3000 years ago in the Mummy-cases.

* Desmoulins, Notice sur des graines trouvées dans les tombeaux Romains, translated in Hooker's Companion to the Botanical Magazine, vol. ii. p. 293.

† Hooker's Companion to the Botanical Magazine, ii. 298.

931. Preservation of seeds in a germinating condition is a matter of importance in as far as the introduction of plants from abroad is concerned. Seeds brought from India to Britain round the Cape rarely vegetate freely, while those brought overland succeed well. Seeds are best transported in their pericarps. The flinty coatings of many foreign legumes will preserve the living germ for an indefinite period. Seeds of Coniferæ in a germinative state are often found in cones attached to the spray on which they grew, three or four years after the flowers that produced them had been dead. In preserving seeds an important requisite is to have them ripe and dry. Corn, pulse, and farinaceous seeds generally, will live for a long time if gathered ripe and preserved quite dry. Such seeds should be put into dry paper, and exposed during transportation to free ventilation in a cool place, as for instance in a coarse bag suspended to a nail in a cabin. Many seeds which cannot be transported when exposed to air, will retain their vital properties if buried in clay. Oily seeds, and those having much tannin in their composition, as Beech-Mast, Acorns, and Nuts, must not only be ripe and dry, but also must be excluded from the air. They are usually put into dry earth or sand pressed hard; or they are preserved in charcoal powder, and enveloped in tin or wax. Perhaps they might be preserved in hermetically sealed bottles full of carbonic acid. Exalbuminous seeds, and those having dense and fleshy albumen, bear transportation best.* Mr. M'Nab has suggested a mode of transmitting seeds by having a strong box about ten inches square, with the sides three quarters of an inch thick, in which alternate layers of earth and seeds are placed, the whole being firmly pressed together. In this way seeds have been sent by Dr. M'Nab from Jamaica to the Botanic Garden of Edinburgh, and nearly the whole of them germinated. On the arrival of such a box the layers of earth and seeds are taken out in succession and put into separate boxes. Wardian Cases (Fig. 1154, p. 484) may also be employed for the transmission of seeds in earth. The seeds will thus be brought frequently in a germinating condition.

932. Alphonse De Candolle finding that there have been fallacies in regard to the vitality of seeds, from not attending to the particular circumstances in which they have been preserved, made experiments on the subject by taking seeds of different natural orders, collected simultaneously in the same garden, transported and preserved in the same manner, sown in equal numbers, and in similar conditions of soil, humidity, and temperature.† The seeds were collected in the Florence Garden in 1831, and were sown on the 14th May 1846, being nearly 15 years old. He selected 368 species belonging to about 150 different

* Hooker, Remarks on the Transportation of Seeds, in his Paper on the Vegetation of the Galapagos Islands, in Linn. Trans. xx. 256.

† De Candolle, on the relative Duration of the Power to germinate in Seeds belonging to different natural Families, in Annales des Sc. Nat. 1st ser. Bot. xx. 38; translated in Annals of Nat. Hist. 1st ser. xx. 38.

genera, and 53 families. Twenty seeds of each were sown in peat mould in pots, and watered. The pots were kept under examination till autumn. The mean temperature in June, the period when several species sprung up, was 66.2° F., that of July 65.3° F., and the maximum reached 86° and 87.8° F. Out of the 368 species only 17 germinated; of the 17 species which came up, Dolichos unguiculatus was the only one that yielded more than one-half the seeds sown, viz., 15 out of 20, others had 1, 2, or 3 germinations in 20 seeds. Lavatera cretica approached nearest Dolichos, but there were only 6 out of 20 that germinated.

933. The natural families experimented on by De Candolle are classed as follows, commencing with those where the largest proportion of species preserved the power of germinating, and ending with those where ten or more species having been sown, none came up:—

NATURAL ORDERS.	No. of Species which germinated.	No. of Species sown.	Per cent. which germinated.
Malvaceæ	5	10	50
Leguminosæ	9	45	20
Labiatæ	1	30	3.3
Scrophulariaceæ	0	10	0
Umbelliferæ	0	10	0
Caryophyllaceæ	0	16	0
Gramineæ	0	32	0
Cruciferæ	0	34	0
Compositæ	0	45	0

The seeds of Malvaceæ and Leguminosæ excelled all the orders examined in the duration of the faculty of germination, while in Compositæ, Cruciferæ, and Gramineæ, the germinative power did not appear to last long.

934. Of the 368 species there were 357, the duration of which was known from Botanical works, and 11 doubtful. Of these 357 species there were—

		No. which germinated.	Per cent.
Annuals . . .	180 . .	9 . .	5.0
Biennials . . .	28 . .	0 . .	0.0
Perennials . . .	105 . .	4 . .	3.8
Ligneous . . .	44 . .	3 . .	6.7

Woody species seem to preserve the power of germinating longer than others, whilst biennials are at the opposite extreme. Perennials probably lose the power of germination more quickly than annuals. Large seeds appeared to De Candolle to preserve the power of germinating longer than small ones. The presence or absence of separate albumen did not seem to make any difference. Some albumens, such as those of Coffee and of Umbelliferæ, are difficult to preserve from special chemical conditions. Compositæ seem to lose their germinating power very early. From other experiments, De Candolle concludes, that the duration of the faculty of germination is frequently in an inverse proportion to the power of germinating quickly.

935. As regards spores, some of them seem to lose their vitality soon. Thus Thuret could only make fresh spores of Equisetums germinate. Others appear to retain the vital properties for a very long period. Ferns have been raised from spores taken from plants preserved in old Herbaria. Two plants of Gymnogramma Calomelanos were obtained in the Liverpool Garden from sowing spores which were taken from the Herbarium of Forster, and were about fifty years old. A similar power seems to reside in the spores of many of the lower Cryptogams, which are only developed in peculiar circumstances; as for instance in the spores of parasitic Fungi, which are constantly floating in the atmosphere, ready to germinate whenever they light on an appropriate nidus.

936. Various means have been adopted to make old seeds germinate. Otto of Berlin puts seeds into a bottle filled with a solution of oxalic acid, and allows them to remain till germination is observable (generally from twenty-four to forty-eight hours), and then sows them in the usual way. They are sometimes wrapped in a woollen cloth soaked in oxalic acid. Seeds from twenty to forty years old have been made to grow by this means, when they would not germinate in the usual way. Others propose a solution of chlorate of potash, or of chlorine, or a very weak solution of nitric acid, as a means of promoting germination (see page 616). Humboldt states that the seeds of the common Cress (Lepidium sativum) in a solution of chlorine germinated in six or seven hours, whereas in water germination did not take place for thirty-six or thirty-eight hours.*

937. Different seeds have different powers of resisting external influences. Cereal grains have been found by Edwards and Colin to bear a short exposure to 122° F. in water, 143°.6 in steam, and 167° in dry air, as well as a dry cold of 70° below the freezing point.† Thus these grains bear 21°.6 more in steam than in water, and 23°.4 more in dry air than in steam. Mr. Hemingway states that seeds of Elder (Sambucus nigra) germinated after being twice boiled in making wine, being present during the vinous fermentation, and remaining for twenty months in the dregs of the cask.‡ The seeds of Phytolacca decandra, and of the Raspberry, have been known to germinate after exposure for a short time to the heat of boiling syrup. Payen found that the sporules of Oidium aurantiacum bore a temperature of 221° to 248° F. even in moist air for half an hour without destroying their vegetating power.§

* Humboldt, Flora Fribergensis Subterranea, 1793, p. 156.

† Edwards et Colin, de l'influence de la temperature sur la Germination, in Annales des Sc. Nat. 2d ser. Bot. i. 257; sur la Végétation des Cereales sous de hautes temperatures, in Ann. des Sc. Nat. 2d ser. Bot. v. 1.

‡ Hemingway, on the Vitality of Seeds, in Ann. of Nat. Hist. 1st ser. viii. 317.

§ Payen, les temperatures que peuvent supporter les sporules de l'Oidium.—Ann. de Chim. et de Phys. xcix. 253.

4. LENGTH OF TIME REQUIRED FOR GERMINATION.

938. The time required for the germination of seeds depends greatly on the texture of their coats, as well as their age. Some exalbuminous seeds, such as Cresses, which are also very hygroscopic, sprout in twenty-four hours, others require many days, or even months. Hard seeds, such as those of some Palms, lie long dormant. The seeds of the Almond tree, which germinate in five or six days when sown immediately, require a year when kept till spring. Large seeds are slower in germinating than small ones, because they require more water, and their absorbing surface does not increase in proportion to their size. Seeds having an osseous or stony spermoderm, and those which are sown naturally while contained in a hard pericarp, as Nuts and Achenes, germinate more slowly than others. The germination may be expedited by thinning or chipping the envelope, so as to allow water to penetrate more easily. In seeds, however, which take a very long time to germinate, this procedure may cause them to decay. Many of the seeds enclosed in a hard shell or stone germinate in the midst of a decaying mass, which must contribute to the decomposition of the shell. Soaking hard seeds in water, or causing them to pass through the digestive canal of animals, greatly accelerates germination. The seeds of Hawthorn, and others of a similar nature, are thus often deposited by birds in peculiar localities in a state fit for immediate germination.

939. Alphonse De Candolle examined the germination of 863 species in the open air, and the following table shows the general results. In each of the orders there were a considerable number of species experimented on, and the epochs of the maximum of germination are stated in the order of their rapidity :—*

NATURAL ORDERS.	No. of Species.	Day on which the greater Number germinated.
Amaranthaceæ	28	6th to 8th day
Cruciferæ	55	8th day
Boraginaceæ	15	9th ,,
Caryophyllaceæ	40	9th ,,
Malvaceæ	25	10th ,,
Compositæ	160	11th ,,
Convolvulaceæ	12	11th ,,
Gramineæ	99	11th ,,
Plantaginaceæ	14	11th ,,
Polygonaceæ	22	12th ,,
Chenopodiaceæ	27	13th ,,
Valerianaceæ	18	13th ,,
Campanulaceæ	9	14th ,,
Labiatæ	21	14th ,,
Leguminosæ	122	14th ,,

* De Candolle, Physiologie Végétale, ii. 648.

940. Out of 379 seeds raised in a stove under the same circumstances, the results obtained by Alphonse De Candolle as to the date of germination were as follow :—

Seeds.	Day of Germination.	Seeds.	Day of Germination.	Seeds.	Day of Germination.	Seeds.	Day of Germination.
1	2d	15	8th	23	14th	1	23d
10	3d	17	9th	7	15th	2	25th
20	4th	41	10th	8	16th	4	26th
46	5th	17	11th	17	17th	15	27th
52	6th	20	12th	3	20th	13	28th
27	7th	17	13th	1	21st	3	30th

941. The experiments of Alphonse De Candolle give the following results as to germination at different temperatures :—*

NAMES OF SPECIES.	NUMBER OF DAYS REQUIRED FOR GERMINATION.	
	In the open air, 46.4° to 53.6° F.	In a stove, 64.4° to 77° F.
Erigeron caucasicum	10	2
Thlaspi ceratocarpum	8	4
Dolichos abyssinicus	10	3
Zinnia tenuiflora	11	5
—— coccinea	22	5
Grahamia aromatica	14	5
Solidago hirta	11	5
Lablab vulgaris	14	10
Anthemis rigescens	7	6
Rheum undulatum	8	7
Duvaua dependens	22	16

It is stated in Silliman's Journal that the Lima Bean, at a temperature of 88° in the shade, will appear above ground in 7 days; at a temperature of 62°, in 20 days. The Marrowfat Pea at 51° requires 19 days, while at 74° it requires only 11 days. The germination of Radishes varies with the temperature from 6 to 12 days.

942. The rapidity with which some annuals germinate in arctic regions when the heat of summer returns is very remarkable. They pass through their periods of germination, flowering, and fruiting in a very short period. Such is also the case in warm countries after the dry season. After the dry season in the Brazilian plains, and when

* De Candolle, Physiologie Végétale, ii. 649.

the first few showers have fallen, Gardner remarked that the annual Grasses pushed forth their blades with astonishing rapidity and vigour. Spruce states that on the sandy shores of the Amazon and Tapajoz, after the waters leave them, several small annual or rather ephemeral plants spring up. They start up from the sand, flower, and ripen their seeds in the course of a few days, and then wither. Amongst them are an Alisma, two or three Eriocaulons, a Xyris, and some minute Cyperaceæ.

5. CHEMICAL CHANGES DURING GERMINATION.

943. During the germination of seeds, alterations take place in the nature of their contents. When the embryo occupies the entire seed, changes occur in the cotyledons, by means of which nutritive matter is prepared; when there is a separate store of perisperm, its constituents are acted upon by moisture, heat, and air, so as to undergo chemical changes. Alterations take place in the azotized matter, and part of the fibrin gives origin to diastase, which acts as a ferment; acetic acid is also formed, and the starchy matter is converted into dextrin and grape-sugar. Thus insoluble matters are rendered soluble, and a large amount of saccharine matter is produced. At the same time there is an evolution of carbonic acid, in consequence of a combination between the oxygen of the air and the carbon of the seed, and as the result of this chemical action a certain amount of heat is developed.* The heat is carried off very rapidly by the soil in ordinary cases, so that it is difficult to ascertain its amount; but when seeds are laid in moist heaps the increase of temperature becomes apparent.

944. Saussure made experiments as to the changes produced on the air during germination.† He put 21 grains of Wheat soaked in water into a close vessel containing air, during 21 hours. They began to germinate at the end of 17 hours.

The Air before the Experiment contained—	Cubic Centimetres.	The Air after the Experiment contained—	Cubic Centimetres.
Nitrogen . . .	148.84	Nitrogen . . .	148.32
Oxygen . . .	39.86	Oxygen . . .	37.44
		Carbonic acid .	2.47
	188.7		188.23

Thus the Wheat diminished the atmosphere by 0.47 cubic centimetres; it formed 2.47 of carbonic acid, and removed 2.42 of oxygen and 0.52

* See Ingenhousz, Experiences sur les Végétaux, ii. 35, 37. Senebier, Physiol. Végétale, iii. 113. Saussure, sur la Végétation dans l'Air Atmospherique in Ann. de Chimie et de Phys. 1st series, xxiv. 139; also Recherches Chimiques sur la Végétation, p. 10. Goeppert, ueber warme entwickelung in der lebenden Pflanze.

† Saussure, sur l'Alteration de l'Air par la Germination, in Annales des Sc. Nat. 2d ser. ii. 270 also Mém. de la Soc. d'Hist. Nat. de Genève.

of nitrogen. Three seeds of Haricot (Phaseolus vulgaris), after being soaked in water, were enclosed in a vessel of air for 48 hours. They commenced germinating in 24 hours:—

Air before the Experiment.	Cubic Centimetres.	Air after the Experiment.	Cubic Centimetres.
Nitrogen . . .	151.41	Nitrogen . . .	150.44
Oxygen	40.24	Oxygen . . .	31.26
		Carbonic acid . .	9.53
	191.65		191.23

In this instance the air was diminished by 0.42 cubic centimetres, 9.53 of carbonic acid were formed, and 8.98 of oxygen and 0.97 of nitrogen disappeared. When the Beans were again soaked in water, and allowed to grow for 48 hours more in the same quantity of fresh air, until the radicles were from 16 to 27 millimetres in length, there were formed 15.94 cubic centimetres of carbonic acid, while 15.13 of oxygen and 0.81 of nitrogen disappeared. In the same way four seeds of the Bean (Faba vulgaris, equina) enclosed in air for 48 hours, gave the following results :—

Air before the Experiment.	Cubic Centimetres.	Air after the Experiment.	Cubic Centimetres.
Nitrogen . . .	210.26	Nitrogen . . .	209.41
Oxygen	36.29	Oxygen . . .	44.38
	266.55	Carbonic acid . .	11.27

Here 11.27 cubic centimetres of carbonic acid were produced, while 11.91 of oxygen and 0.85 of nitrogen disappeared.

945. Four Peas soaked in water were placed for 48 hours in oxygen gas, and the same number were placed in air during the same period. At the end of the experiment the radicles in oxygen were from 15 to 23 millimetres in length, those in the air from 12 to 19 :—

Gas before the Experiment.	Cubic Centimetres.	Gas after the Experiment.	Cubic Centimetres.
Oxygen . . .	194.7	Oxygen . . .	178
Nitrogen . . .	4.8	Carbonic acid . .	15
		Nitrogen . . .	4.7
	199.5		197.7

Air before the Experiment.	Cubic Centimetres.	Air after the Experiment.	Cubic Centimetres.
Nitrogen . . .	161.2	Nitrogen . . .	160.17
Oxygen . . .	43.1	Oxygen . . .	31.23
		Carbonic acid . .	11.7
	204.3		203.1

In the oxygen 15 cubic centimetres of carbonic acid were formed, and

16.7 of oxygen disappeared; while in the air 11.7 of carbonic acid were formed, and 11.87 of oxygen disappeared.

946. While Saussure states that a certain amount of nitrogen is absorbed during germination, Boussingault says that in his experiments with Trefoil and Wheat, there was neither gain nor loss of nitrogen.* Boussingault† gives the following results of experiments on the changes which take place in the elements of the seed during germination :—

	Weight.	Composition.			
	Grammes.	C.	H.	O.	N.
Seed before germination	2.405	1.222	0.144	0.866	0.173
Seed after germination	2.241	1.154	0.141	0.767	0.179
Difference	—0.164	—0.068	—0.003	—0.009	+0.006

The total loss during germination was 0.164 grammes, and of that 0.068 was due to loss of carbon.

947. In the malting of Barley these changes are well seen. The grain is steeped in water in the first instance, so as to soften and swell; it is then laid in heaps 30 inches deep for 20 or 30 hours. In this situation it becomes warm, and germination commences.‡ This is moderated by laying the grain in thin strata of a few inches thick, on large airy but shaded floors. There it remains 12 or 14 days, until germination is sufficiently advanced, being frequently turned in the meantime, in order to allow each grain to germinate equally, and to prevent entangling of the radicles of contiguous grains. During this process sugar is formed, which is intended for the nourishment of the young plants, and if left long it would all be absorbed. This is prevented and germination stopped by exposing the grain in a kiln to a temperature rising from 100° to 160° or more. Thus the grain is dried and its vitality destroyed.

948. During germination it is probable that there is a certain electric disturbance. Carpenter says, the conversion of the starch of the seed into sugar involves the liberation of carbonic acid, and of a small quantity of acetic acid. Now as all acids are negative, and as like electricities repel each other, it is probable that the seed is at that time in an electro-negative condition. Hence germination is said to be quickened by connecting the seed with the negative pole of a feeble galvanic apparatus, whilst it is retarded by being connected with the positive pole.§

* Boussingault, Recherches Chimiques sur la Germination, in Comptes Rendus, vi. 102.

† Boussingault, Economie rurale, i. 39.

‡ Goeppert states that seeds of different kinds, when made to germinate in quantities of about a pound in air of 48° to 66° F., showed temperatures varying from 66° to 120°.

§ Carpenter, Gen. and Comp. Physiology, p. 72.

6. GERMINATION OF ACOTYLEDONOUS, MONOCOTYLEDONOUS, AND DICOTYLEDONOUS PLANTS.

949. When the spores of the lower Acotyledonous plants germinate, they send out cellular processes of a more or less conical form, which serve the purpose of roots, and which often divide. These cellular prolongations may be formed from the entire walls of the spore, or from its inner covering. In Figure 1263 there is represented the spore of a cellular plant before germination, provided with four cilia. In Figure 1264 are seen the germinating spores of another cellular plant, in which the cilia have disappeared, while one end of the spore has elongated in a conical manner, *a*, and has finally divided into three, *b*. The protrusion of a similar ramified root-like process is well seen in unicellular plants (Fig. 1265).

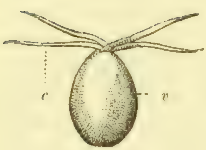

Fig. 1263.

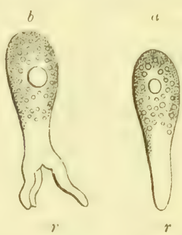

Fig. 1264.

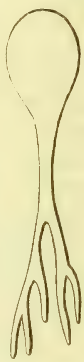
Fig. 1265.

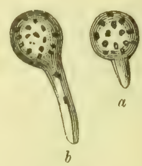

Fig. 1266.

950. The germination of the spores of Liverworts (Marchantia) exhibit a similar production of elongated conical processes (Fig. 1266). When these tubular prolongations protrude through the outer coat of a spore, they exactly resemble the pollen tube, which may be considered as the result of the germination of a single cell placed on the stigmatic surface—the soil fitted for its growth (Fig. 1211, p. 567). In Figure 1267, the spore of a Sea-weed (Fucus canaliculatus) is represented during germination, with its cellular roots protruded through

Fig. 1263. Spore, *v*, of an Algæ (*Chætophora*), before germination, provided with cilia, *c*, which lose their moveable properties and fall off when the spore begins to grow.

Fig. 1264. Germinating spores of a cellular plant (*Prolifera rivularis*). *a*, Spore giving out a conical root-like process, *r*, while the other extremity, containing a nucleus and granules, form a cellular frond. *b*, The same spore, with the root-like process, *r*, dividing.

Fig. 1265. A unicellular plant (*Botrydium granulatum*), germinating and giving off at the lower end of the cell ramifying processes which fulfil the functions of root-fibrils, while the upper part is the cavity in which fructification is produced.

Fig. 1266. Germinating spores of a species of Liverwort (*Marchantia polymorpha*), in different stages of growth. A small cellular protuberance first appears, *a*, which ultimately elongates, as seen at *b*. In the progress of development roots are produced, and a thalloid expansion bearing fructification.

the epispore. In the germinating spores already noticed, one part appears as a root-like portion, while the opposite end is developed as a thallus bearing fructification. While the germinating spores of Liverwort are shown in Figure 1266, the fully developed plant, with its thallus and fructification, is seen in Figure 1007, p. 337.

951. In the case of Fungi, there is produced a peculiar subterranean axis called mycelium or spawn, on which the fructification is ultimately developed (Fig. 1021, p. 345). This mycelium spreads equally on all sides from the original point of development. In this respect it is analogous to the thallus of Lichens. The more delicate the mycelium the quicker it grows, and the more easily the older portions perish. The circumference is often vigorous, while the central parts are dead or evanescent, so that the mycelium grows in the form of an increasing circle. Then, at the time of the formation of spores, numerous pilei arise from the outer part of the mycelium in the form of a circle or ring, and thus a fairy ring is formed; in the same way as in many Lichens, the thallus spreads in a circle, and at its extremities produces fructification or apothecia (Fig. 1013, p. 342). In many Parmeliæ and in Peltigenæ the growth and decay are slow, and they often vegetate and fructify perfectly towards the margin of the thallus, while the centre is entirely decayed. Even where the thallus is very persistent, the progress of vegetation and fructification from the centre to the circumference is distinctly visible. In old specimens the centre is usually free from apothecia (unless when a new superincumbent thallus has been formed after the decay of the old); then succeeds a ring of large, perfect apothecia, and then, near the margin of the thallus, a circle of young apothecia, which are younger in proportion as they are nearer the margin. A large fairy ring, formed apparently from many individuals of one species of Fungus disposed in a circle, really, then, constitutes the organs of fructification of a single individual only. Many obstructions occur to the development of such individuals, and hence the reason of their rare occurrence. Stones, stems of trees, insects, and unfavourable weather, all interfere with the progress of the mycelium. A fairy ring of Clavaria Botrytis has been noticed twenty feet in diameter, with tufts of fruit-bearing branches one or two inches distant from each other.

952. The spores of many of the lower Acotyledons, such as Fungi, are so minute as to be easily scattered by the wind, and thus they are sometimes developed in very anomalous situations. Spores sometimes find a nidus in diseased structures in man and animals. Thus, in the disease of the skin called Porrigo favosa, as well as in Mentagra and Aphthæ, peculiar cellular bodies are produced, which appear to be altered and metamorphosed vegetable forms. In the case of the silk-worm, a Cryptogam called Botrytis Bassiana is found in a disease to which they are liable, and which has been called Muscardine. Caterpillars exhibit occasionally germinating spores of species of Sphæria. Sphæria Robertsii grows on the larva of Hepialus virescens

in New Zealand (Figs. 1023 and 1024, p. 345). Other Sphærias are produced in similar situations. Mr. Jones Stephens has recently noticed one on the larva of a lamellicorn beetle from Bogota.* Species of Polistes are seen flying about in the West Indies with vegetable growths projecting from them. They are called vegetating wasps. Sporendonema muscæ is a vegetable form which grows on the body of a fly in the tropics. The spores of Fungi are diffused in the air, ready to alight on any body which can furnish a nidus for them. In this way various kinds of Mould are developed—the spawn or mycelium produced from the spore ramifying through the decaying matter, and sending up at intervals fructification. In some cases the mycelium becomes remarkably developed, and does not produce ordinary spore-bearing organs. Thus in vinegar and syrup a peculiar fungoid mass is often produced, which is probably a modified form of some kind of Mould. The Vinegar-plant seems to

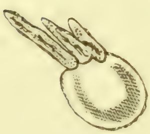

Fig. 1267.

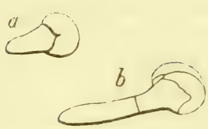

Fig. 1268.

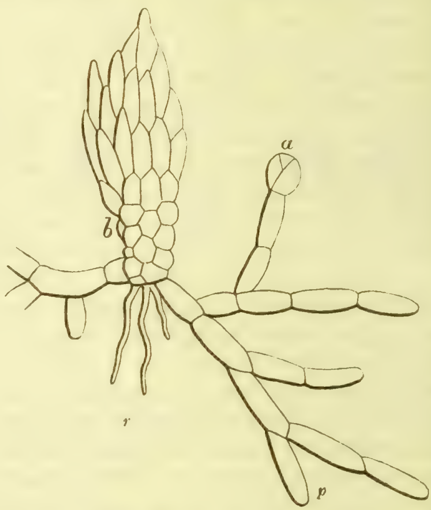

Fig. 1269.

be a peculiar mycelial development of the Mould called Penicillium glaucum. During the germination of the spores, certain changes are induced in the fluid surrounding them. Thus a saccharine solution is

Fig. 1267. Germination of spore of a Sea-weed (*Fucus canaliculatus*). Cellular filaments are seen bursting through the outer covering of the spore. These filaments appear to be formed by a prolongation of the inner coat of the spore.

Fig. 1268. Spore of a Moss (*Funaria hygrometrica*) germinating. The spore, *a*, gives out a cellular process, which elongates and divides, as seen at *b*. This produces the cellular prothallus.

Fig. 1269. The same Moss further developed, showing the cellular prothallus, *p*, or pro-embryo, with its roots, *r*, and buds, *a*, *b*, whence arise leafy stems bearing the organs of reproduction.

* See Hooker's Journal of Botany, iii. 77. Berkeley, on Entomogenous Sphæriæ, in Lond. Journ. Bot. ii. 205. Bennett, on Parasitic Vegetable Structures found growing on living Animals, in Trans. Roy. Soc. Edin. xv. 279. Goodsir, on Sarcinula, in Ed. Med. and Surg. Journ. No. cli. Also Ann. Nat. Hist. xi. 125.

converted into vinegar. The mycelium is sometimes formed in separate layers, which can be detached from each other, so as to form independent vegetating masses. The spores of a Fungus (Merulius lacrymans), when introduced into wood, germinate, and produce the disease called dry-rot.*

953. In higher Cryptogams the spore produces first a cellular prothallus, whence roots and reproductive organs proceed. In Mosses the germinating spore forms, in the first instance, a cellular prolongation, which becomes a conferva-like germ, whence buds arise, bearing the leafy plant with its fructification. This is shown in Figure 1268, where a germinating spore, *a*, of a Moss is seen protruding a cellular process, which elongates and divides, as seen at *b*, and finally, as

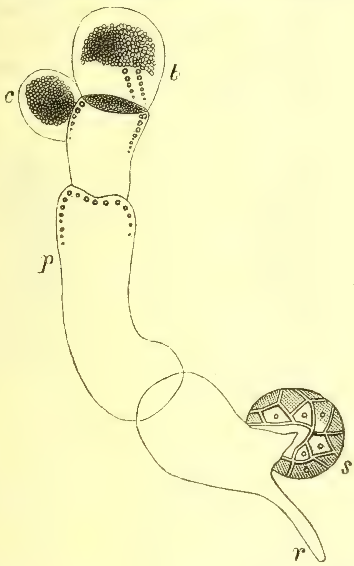

Fig. 1270.

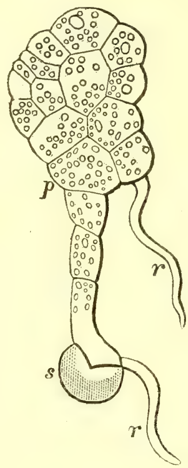

Fig. 1271.

shown in Figure 1269, forms a jointed cellular prothallus, *p*, whence buds are produced, *a*, *b*, bearing the leaves and the organs of repro-

Fig. 1270. Spore, *s*, of a Fern (*Pteris vittata*) germinating, and producing a cellular prothallus, *p*, which consists, in this early state, of five cells. Some of the cells, *b*, *c*, contain chlorophyll granules. A root, *r*, is produced from the lowest cell.

Fig. 1271. Spore of Fern (*Pteris serrulata*) germinating. The spore, *s*, gives rise to a cellular prothallus, *p*, whence cellular roots are given off, *r*, *r*. The prothallus bears the organs of reproduction, and gives origin to the sporangiferous frond. See also Figures 1226, 1227, and 1228, p. 574.

* Among the forms of Mould may be noticed—*Ascophora Mucedo*, on bread; *Mucor Mucedo*, on dried preserves; *Monilia*, on fruits; *Mucor herbariorum*, on dried plants; *Racodium*, in low cellars, as in the London Docks; *Penicillium glaucum*, common on organic substances—often growing on books, when exposed to moisture and a certain temperature; various species of *Myxotrichium*, *Chætomium*, *Oidium*, *Sporocybe*, and *Cladosporium*, on paper, linen, and parchment, according to the varying conditions of heat and moisture; *Onygena equina*, on the hoofs of dead horses; *Onygena corvina*, on the feathers of ravens; *Onygena felina*, on the dung of cats, &c.

duction. In Ferns the spore gives origin to a thalloid expansion, the prothallus, whence roots proceed, and ultimately the sporangiferous frond. In Figure 1270 there is represented the spore, *s*, of a Fern giving out a cellular prothallus. This prothallus enlarges, as seen in Figure 1271, gives out root-like processes, *r r*, and finally bears the organs of reproduction.*

954. The embryo of a monocotyledon has often at first sight no marked division of parts (Fig. 1272). There is seen a slight projection at one end, *r*, which ultimately forms the root, and a uniform conical mass, which consists of the cotyledon, *c*, with the primary bud and axis; at the lower part there is a slit, *s*, which, as germination proceeds, gradually opens, so as to allow the plumule to protrude. The enveloping body is the single cotyledon. The same appearance is presented in the embryo of a species of Pondweed (Fig. 1273). The general axis, *a*, gives off at one end a radicle, *r*, forming the root, while the cotyledon, *c*, at the other extremity, envelopes the

Fig. 1272.

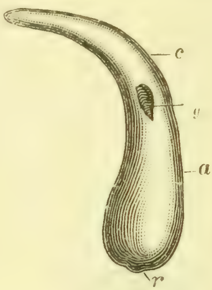

Fig. 1273.

Fig. 1274.

first bud or plumule, *g*, which, in germinating, protrudes through an opening or slit in the cotyledon.

955. In a monocotyledonous seed there is generally a supply of albumen, which is gradually dissolved and absorbed as germination

Fig. 1272. Embryo of a species of Arrow-grass (*Triglochin Barrelieri*), showing a uniform conical mass, with a slit, *s*, near the lower part. The cotyledon, *c*, envelopes the young bud, which protrudes at the slit during germination. The radicle is developed from the lower part of the axis, *r*.

Fig. 1273. Curved conical embryo of a species of Pondweed (*Potamogeton perfoliatus*). The axis, *a*, gives off at its lower extremity a radicular process, *r*, whence rootlets proceed, while the single cotyledon, *c*, envelopes the first bud, *g*, called gemmule or plumule, which in germinating protrudes through a slit or fissure.

Fig. 1274. Grain of Wheat (*Triticum*) germinating. The embryo lies at one side of the grain, *g*. The radicular portion of the embryo gives off rootlets, *r r r r r*, covered with cellular hairs. The principal root is the central one; the others being developed subsequently in succession. The roots pass through sheaths, *c c c*. The ascending axis, *t*, sheathed in the cotyledon, rises upwards. From the mode in which the roots proceed from an internal radicular axis, the embryo was called by Richard endorhizal.

* For further remarks on the germination of Ferns, see Henfrey, in the Gard. Mag. of Botany for 1851, p. 22; Lindsay, in Linn. Trans. ii. 93; Henderson, in Mag. of Zoology and Botany, i. 333; and Mac-Vicar, in Trans. of Roy. Soc. of Edin. x. 263. Also Suminski's work, and others referred to in the notes at pages 320 and 330.

proceeds. Sometimes the whole of the perisperm and its cells disappear; at other times, as in the seed of the Ivory Palm (Phytelephas macrocarpa), a portion is removed, and a sort of cellular skeleton is left within the seed. The radicular portion of the axis is more or less truncated, and sends off numerous rootlets, which pass through sheaths or coleorhizæ formed by the lower part of the axis. This is shown in the germinating grain of Wheat (Fig. 1274), in which the rootlets, *r*, are covered with cellular hairs for the purpose of absorption. The central root is first developed, and the others come off in succession as secondary rootlets. When there is no albumen present, the cotyledon is usually pushed upwards beyond the seed. Thus, in the common Horned Pondweed (Fig. 1275), the parts of the germinating embryo are a radicular portion, *r*, an axis or cauliculus, *a*, with a cotyledon, *c*, which is pushed upwards, and embraces the primary bud, *p*.

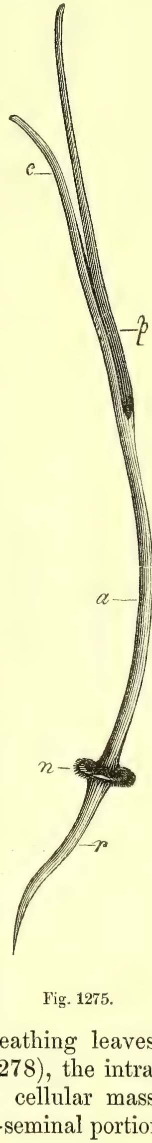

Fig. 1275.

956. In many perispermic monocotyledonous seeds the cotyledon is partly contained within the seed, and partly appears externally. That portion within the seed is called intra-seminal, and corresponds to the blade or lamina of the leaf; the narrow protruded portion, which varies much in length, represents the petiolary portion, which often ends in a sort of sheath embracing the axis. In Figure 1276, a representation is given of the seed of the Indian Shot in different stages of germination. A portion, *c*, of the single cotyledon remains within the seed, while another portion, *a*, protrudes, ending in a sheathing portion, *s*, which surrounds an axis, *t*, whence spring the radicles, *r r'*, which pass through sheaths, *col*, and a primary bud, *b*, which rises to form the stem. In Figure 1277 is seen the double Coco-nut germinating, with its long cotyledonary process, *c*, and the axis, whence proceeds the root, *r*, and the first bud of the stem, *a*. In the Date (Fig. 1279), the seed, *s*, gives exit to a long cotyledonary petiole, *b*, with its sheathing extremity; roots, *a*, proceed from the lower part of the axis, and the bud, consisting of sheathing leaves, *c d e*, from the upper part. In the Coco-nut (Fig. 1278), the intra-seminal portion of the cotyledon, *c*, becomes a large cellular mass, which gradually absorbs all the perisperm. The extra-seminal portion

Fig. 1275. Germination of the embryo of the Common Horned Pondweed (*Zannichellia palustris*). The radicular portion, *r*, is united to the ascending axis, *a*, at the column, or neck, *n*; the cotyledon, *c*, is pushed upwards, enclosing the primary bud or gemmule, *p*. The cotyledon in this case extends out of the seed. The embryo is aperispermic or exalbuminous.

protruded through the foramen and the hole in the endocarp is very short, and is connected with the axis, from which arises the plumule or first bud, *b*, and the radicles, *r*.

957. In Grasses, as shown in Figure 1280, the cotyledon, *c*, enlarges within the seed, and, on one side of the perisperm, roots, *r*, are protruded through sheaths, *co*, while the plumule, *g*, rises upwards,

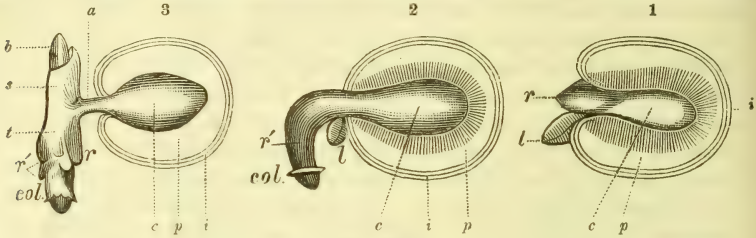

Fig. 1276.

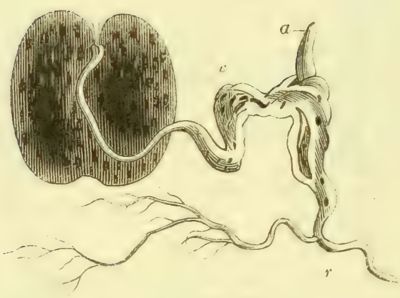

Fig. 1277.

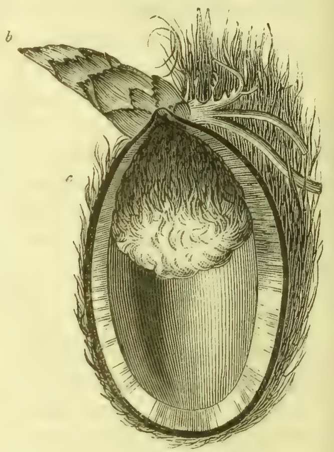

Fig. 1278.

consisting of sheathing leaves arranged alternately. The sheathing cotyledon, *c*, with the radicle and the plumule, are also represented in

Fig. 1276. The seed of the Indian Shot (*Canna indica*) in different stages of germination. The embryo is seen surrounded by the perisperm or albumen, *p*, which is enclosed within the integuments of the seed, or the general spermoderm, *i*. The micropyle is the point where the first part of the embryo protrudes, and the opening shows a lid-like process, *l*, which is raised in order to allow the passage of the germinating part. 1. The seed in its early germinating state, with the radicular axis, *r*, protruding, sheathed by the cotyledon. 2. The embryo enlarged and the perisperm diminished, the radicular portion, *r*', more fully protruded, and the radicle, coming through a sheath or coleorhiza, *col*. 3. The embryo still further increased, and the perisperm, *p*, diminished, a narrow portion of the cotyledon, *a*, protruded, ending in a sheathing portion, *s*, which embraces the axis, *t*, whence proceed the radicles, *r r*', passing through coleorhizæ, *col;* and the first bud of the ascending axis, plumule, *b*, ascending.

Fig. 1277. Double Coco-nut (*Lodoicea Seychellarum*) germinating. The embryo protrudes through the foramen of the seed, and through a hole in the hard pericarp. The long cotyledonary process, *c*, ends in an axis, whence proceed the radicle, *r*, and the first bud of the stem, *a*.

Fig. 1278. The Coco-nut (*Cocos nucifera*) germinating. The intra-seminal portion of the cotyledon becomes a large cellular mass, *c*. The protruded caulicular portion is short, and ends in the axis, whence proceed the first bud or plumule, *b*, and the radicles, *r*.

the Maize or Indian Corn, in Figure 1281. In the Quaking-grass (Fig. 1282) the cotyledon remains within the grain, *c*, and the axis elongates, bearing the leaves, *f g h i k;* while the first root, *a*, proceeds from the lower part of the axis, and subsidiary or secondary roots are given off from the leaves of the first bud. In all cases of monocotyledonous germination, after the radicles have descended into the soil, the plumule or first bud of the axis is developed, and the leafy stem is gradually formed. The leaves are usually alternate, and are often sheathing.

958. In dicotyledonous germination the radicle is protruded through the foramen of the seed, and then the cotyledons are either

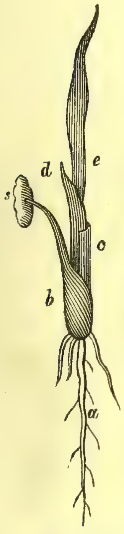

Fig. 1279.

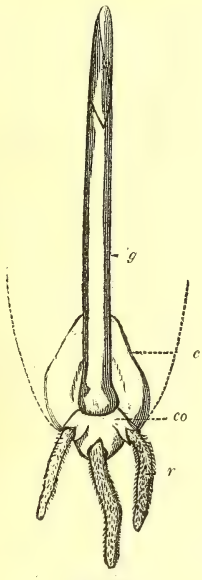

Fig. 1280.

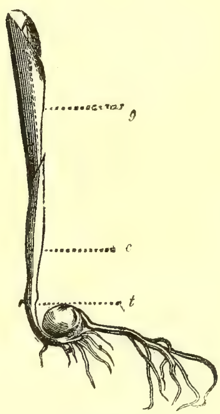

Fig. 1281.

protruded, so as to appear above ground as epigeal leaves of a green colour, or they remain within the covering of the seed as fleshy hypogeal lobes, containing much nutriment in their substance. The first kind of germination is seen in Figure 1283, where a French Bean is depicted producing its radicle, *r*, and its green epigeal cotyledons, *c c*,

Fig. 1279. Germination of the seed of the Date-palm (*Phœnix dactylifera*). The seed, *s*, containing a portion of the cotyledon inside (corresponding to the lamina of the leaf). The petiolary portion of the cotyledon, *b*, ending in a sheathing portion. The first root, *a*, and above it the other roots subsequently formed, as the leaves, *c d e*, are developed.

Fig. 1280. Grain of the Oat (*Avena*) germinating. The embryo lies on one side of the grain. The radicular portion gives off rootlets, *r*, covered with cellular hairs, which pass through sheaths, *co*. The single cotyledon, *c*, remains within the grain, and the plumule or first bud of the stem, *g*, is developed.

Fig. 1281. Grain of Maize or Indian Corn (*Zea Mais*) germinating. The roots proceed from the lower part of the axis, *t;* the single cotyledon, *c*, embraces the young ascending axis, whence arises the plumule, *g*.

which enclose the first bud or plumule, *g*; and the same thing is seen in Figure 1284, where the embryo of a Sycamore is seen with its radicular axis, *r*, giving origin to roots, its ascending axis, *a*, with the two cotyledons, *c c*, which are green, leafy, and epigeal, enclosing the first bud, *b*. The second kind of dicotyledonous embryo may be illustrated by the Bean and Pea (Fig. 1285), where the fleshy lobes, *c c*, which form the great bulk of the seed, are hypogeal, and are gradually absorbed during the growth of the plant. In the case of the Orange (Fig. 1286) the cotyledons, *c*, are hypogeal and fleshy, the radicle, *r*,

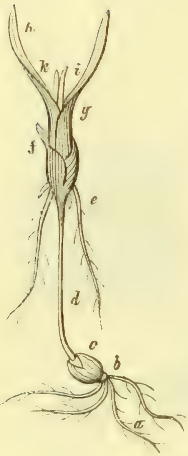

Fig. 1282.

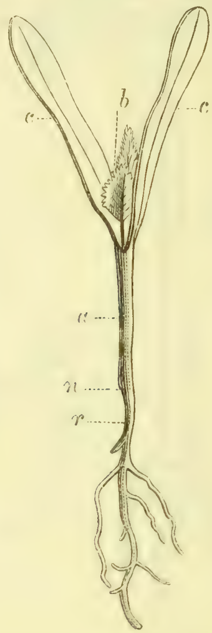

Fig. 1284.

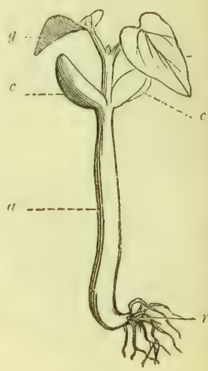

Fig. 1283.

passes downwards in a tapering manner, while the plumule, *p*, proceeds in an upward direction, bearing the leaves, *l l*.

Fig. 1282. Germination of the grain of Quaking-grass (*Briza media*). The grain, *c*, with its coverings and glumes, containing within it the single cotyledon; *b*, the truncated radicular axis, whence proceed the roots and rootlets, *a*; the elongating axis, *d*, with the first sheathing leaf, *f*, the second, *g*, the third, *h*, the fourth, *i*, and the fifth, *k*; other roots, *e*, proceeding from the bud with its leaves.

Fig. 1283. Dicotyledonous embryo of a French-bean or Haricot (*Phaseolus vulgaris*) germinating, showing the radicular portion, *r*, giving off roots, the portion of the axis (cauliculus), *a*, between the roots and the two leafy epigeal cotyledons, *c c*, and the primary bud or plumule, *g*, giving origin to the primordial leaves. The roots do not pass through sheaths, and the embryo is called by Richard exorhizal.

Fig. 1284. Dicotyledonous embryo of the Sycamore (*Acer Pseudo-Platanus*) germinating. The radicular portion of the axis, *r*, whence the rootlets proceed; *n*, the neck where the ascending and descending axis separate; *a*, the axis with the two leafy epigeal cotyledons, *c c*, between which is situated the primary bud, *b*, with the incipient primordial leaves.

959. The dicotyledonous seed is sometimes exalbuminous or aperispermic, as in the Pea and Orange, in which the fleshy cotyledons have a store of nutriment laid up in them for the growth of the embryo; at other times the seed is albuminous or perispermic, as in Castor oil and in the Dock (Fig. 914, p. 303), and then the nutriment is separate from the embryo, and is gradually dissolved and absorbed during germination. Sometimes the two cotyledons become united, and when the embryo germinates they appear as one; at other times divisions take place, so that the embryo becomes polycotyledonous, as in Firs (Fig. 1287). After the cotyledons have appeared they separate so as to allow the first bud, called plumule or gemmule, to be developed

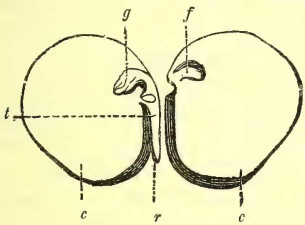

Fig. 1285.

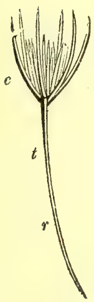

Fig. 1287.

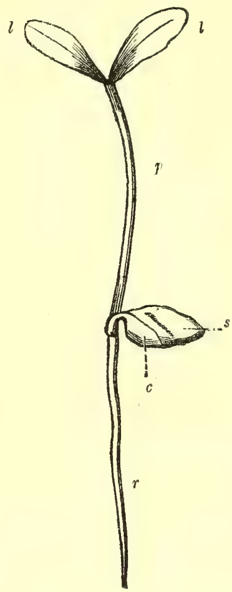

Fig. 1286.

between them (Fig. 1284, *b*). This bud forms the axis on which the leaves and flowers are produced. In proportion as the permanent leaves increase, the cotyledonary leaves (after acting as temporary organs of nutrition) wither and fall off, and if they are subterranean

Fig. 1285. Embryo of the Pea (*Pisum sativum*). The cotyledons, *c c*, or seed-lobes, are fleshy, and remain below ground, in other words, are hypogeal. The radicle, *r*, protrudes through the micropyle, and is the first portion of the embryo which appears during germination. The plumule, gemmule, or first bud, *g*, afterwards appears and rises upwards to form the ascending axis. The common axis, *t*, whence the radicle and plumule proceed, is united to the cotyledons by a short petiole, *f*, a small depression in one cotyledon, where the young bud, *g*, lay.

Fig. 1286. Seed, *s*, of the Orange (*Citrus Aurantium*) germinating. The fleshy cotyledons, *c*, within the spermoderm, the tapering radicle, *r*, the plumule, *p*, with the leaves, *l l*. The seed is exalbuminous, and the embryo exorhizal.

Fig. 1287. Young embryo of a Fir germinating, showing the common axis, *t*, whence proceeds the radicle, *r*, and the divided leafy epigeal cotyledons, *c*. The embryo is called olycotyledonous.

they are gradually absorbed. The leaves which are produced in succession sometimes differ in their form. Thus in Victoria regia the youngest leaf is linear and almost filiform, the next is hastate, the third sagittate, and the fourth is nearly ovate, with a deep incision at the base. The future leaves gradually assume a more or less circular form, generally with a distinct line showing the place of the union of the lobes.* The rate at which the axis increases varies according to the amount of temperature and moisture which is supplied.

7. DIRECTION OF GROWTH IN ROOTS AND STEMS.

960. Much obscurity exists as to the cause of the direction taken by the opposite extremities of the germinating plant, that is to say, of the downward growth of the root, and of the upward growth of the terminal bud. Mohl remarks—" To no phenomenon have we been rendered more indifferent, by having it daily before our eyes, than to the definite direction in which every part of a plant lies in reference to a perpendicular line; and yet in the circumstance that the stem grows upwards, the root downwards, and the leaf with its upper surface turned towards the sky, we behold a series of the most wonderful phenomena, the causal relations of which are unfortunately but too little understood."

961. Duhamel, Dodart, and others† attempted to explain the directions of the stem and root, by the influence of the darkness and the moisture of the soil on the latter, and the light and dryness of the air on the former. But this explanation has been shown to be unsatisfactory. For in all circumstances, whatever be the position of the seed and the media surrounding it, whether the seed germinates in earth, in water, or in air, in darkness or in light, still the radicle and plumule assume their normal direction. Johnson made a French Bean germinate in a tube filled in the upper part with wet earth, and in the lower with dry, and yet the radicle did not change its direction. When seeds are made to germinate on the surface of water, having a transparent tube below and an opaque one above, the radicles pass downwards to the transparent part, and the plumule upwards to the dark. When a seed is placed in wet earth or moss, and suspended in basket-work in the air, the root will proceed downwards into the air, showing that darkness and moisture will not account for its direction. Roots springing from aerial branches, as in the Screw Pine and Banyan, descend downwards in the air in the first instance, and many months elapse before they reach the soil.

962. It is curious, however, to remark in certain instances curvatures taking place in aerial roots, so that they come into contact with a supply of nourishment. Thus in a plant of Pandanus graminifolius, in the Botanic Garden of Edinburgh, in which roots spring from

* Hooker, Victoria regia, Lond. 1851.

† Duhamel, Physique des Arbres. Meese, sur l'Influence de la Lumière sur les Plantes, in Journ. de Physique, vii. 112.

branches at points six inches or more beyond the circumference of the tub in which the plant grows, there is a distinct inclination and curvation of the aerial roots, so as to reach the earth in the tub. Durand* says there is no evidence of roots seeking good soil and directing their growth in such a way as to reach the part whence most nourishment is to be derived. There is no doubt, however, that when roots do come into contact with moist soil containing much nutriment they grow very rapidly in that direction.

963. Knight attributes the direction of the stem and roots to gravitation, and the peculiar state of the contents of the tissues.† When the stem of a plant has a horizontal position, there is, he thinks, a gravitation of fluids towards the lower side, and as increased nourishment is thus given to that side, and as the stem enlarges throughout its substance, the cells swell and cause the end of the stem to point upwards. In the case of the root, the increase takes place at the extremity, and to this the fluids gravitate, so as to cause the point to descend. Knight performed the following experiments:—He caused Beans to germinate on the circumference of a horizontal wheel rotating rapidly, and he found that the radicles turned towards the periphery, while the plumules inclined towards the centre. When the wheel performed two hundred and fifty revolutions in a minute, the radicles pointed downwards about ten degrees below, and the plumules as many degrees above, the horizontal line of the wheel's motion—centrifugal force having made both to deviate 80° from the perpendicular direction each would have taken had it vegetated at rest. Seeds were also made to germinate on the circumference of a wheel to which a rapid vertical rotatory motion was given. The radicles, in this case, turned their points outwards from the circumference of the wheel, while the plumules took the opposite direction.

964. Knight supposed that there was a more or less liquid condition of the parts of the young plant, a difference in density of the parts, and a tendency in the denser parts towards the root. The beans on the vertical wheel were under the influence of the centrifugal force only, and their denser parts or roots pointed outwards from the circumference; while, on the horizontal wheel, the effect was intermediate between the centrifugal force and gravity. Dutrochet performed a similar experiment in regard to leaves, and he found that they were influenced by gravity, and turned their lower surfaces towards the periphery of the wheel. ‡

965. Dutrochet refers the phenomena to the different organization of the stem and root, and he traces the curvation of the stem upward, and of the root downward, to endosmose in the cells of these organs. He found that a plate cut longitudinally in the direction of a radius, from a herbaceous stem, and placed in water, curved so as to render

* Durand, sur la tendance des racines à chercher de bonne terre, &c. in Comptes Rendus, xxi. 987.
† Knight, on the Direction of the Radicle and Plumule during the Vegetation of Seeds.—Philos. Trans. 1806, p. 99, and Hort. Papers, p. 124.
‡ Dutrochet, Mémoires, ii. 54.

the outer part concave; while a similar plate, cut out of a young root, curved in the opposite way. These curvations he attributes to differences in the size of the cells. In the case of the young stem, the cells decrease in size, from the pith to the bark, while in the root the cortical cells are larger. These tendencies to curve exist in stems and roots, in consequence of the cells being full of fluids, and so long as the perpendicular position is maintained, the force of curvature in the different parts is kept in equilibrium. But when a stem or root is placed in an inclined position, the concentrated sap, by the force of gravity, flows to the lower side, and limits or weakens the endosmose exercised by the cells on that side, and thus they cease to counteract the tendency to incurvation on the upper side, which will be directed either upwards or downwards according to the situation of the different kinds of cells. When it takes place in a branch or stem in which there are large central cells, the curvation will be upwards, when in a root where the large cells are external, the curvation will be downwards. Thus Dutrochet refers all the movements in these organs to the soft parenchymatous cells, and the curvatures to the distention of cells on the side of the organ which becomes convex.*

966. Mohl says that both stem and root can only retain the perpendicular direction which they assume through the influence of gravity, when they are wholly removed from light, or light is freely admitted to all sides of them. If the light is admitted only to one side, then the axis becomes more or less inclined from its proper position. If light is admitted through a small aperture to a germinating plant, its stem curves towards the light. De Candolle's explanation that the curvation in plants exposed to light on one side, depended on the elongation of the cells on the dark side, and on the formation of carbon on the light side, so as to render it rigid, has not been confirmed by the observations of Dutrochet† and Gardner. Payer found that common Cress reared on moistened cotton in a room lighted by a single window, or in a box with a single aperture, instead of rising perpendicularly, as if it were growing in the open air or in complete darkness, inclined towards the light, at the same time preserving its straightness throughout, and forming an angle with the ceiling. On the contrary, when a growing plant which had been raised either in darkness or in the open air, and had taken a vertical direction, was placed in either of the above conditions, the young stem first became bent, and then inclined towards the light, in two distinct and successive phenomena; first, the lower part of the stem still retained its vertical position, while the upper part was more or less horizontal; second, the upper portion being a little straightened, and the lower a little inclined, the whole of the stem became straightened, and finally pointed in the direction of the light. Although a plant thus inclined itself to the side whence light proceeded, it did not seem to be necessary that the

* For remarks on this obscure subject, see Mohl on the Vegetable Cell, translated by Henfrey, p. 143.

† Dutrochet, sur la tendance des Racines à fuir la Lumière, in Ann. des Sc. Nat. 3d ser. Bot. ii. 96.

point of curvature should receive any portion of the rays of light. This bend did not remain in the young stem after the cause which produced it had been removed. The intensity of the curve differed in different circumstances. If, instead of a case with one aperture, young plants were placed in a box with two openings, and thus received light in two directions, peculiar phenomena occurred. If there were two apertures on one side of a box, so that the rays of light in passing through them formed an angle more or less acute with each other, and the light was of equal intensity, then the stem moved in the direction of the resultant or of the bisector of the angle. If the power of the two lights was unequal, either from a difference in the size of the apertures, or from shading, the stem curved towards the stronger light. If again the two apertures, in place of being on the same side of the box, were on opposite sides, and the intensity of the rays equal, the plant neither leaned to the one nor to the other.*

967. Macaire† found that while light caused the stems of plants to bend towards it, there was no attraction exerted by which the plant could be moved from its position. This he showed by the growth of Duck-weed, and of Peas, Beans, and Mustard seeds, placed on little floats of cork in water, to which light was admitted only on one side. There was no change of position in the Duck-weed, and no movement of the floats, although the stems bent towards the light. Macaire also states that the position of leaves is influenced by light. When he lighted a leaf from below, and threw a shade over the upper surface, it turned round. He reversed twigs, and found that a twisting of the leaves took place—the turning being quicker in cases where the two surfaces were of very different colours, one being a deep green, and the other pale. The leaves of the Raspberry twisted round in less than two hours. The twisting takes place sometimes in the blade, and at other times in the stalk. Leaves of Lilac and Polemonium cæruleum twisted back by a spiral curling of the limb; leaves of the Bean, Raspberry, Chestnut, Maple, Geranium, and Judas-tree, by the petiole. Leaves reversed under water, and with their petiole fastened in a hole, turned over by the blade. A leaf deprived of its petiole, and laid on the surface of water, with its lower surface towards the sun, rolled itself together like a ball, so as to expose its natural upper surface to the light, and hide the other. In a leaf placed under water on a float, the reversal occurred without any movement in the float.

968. Dutrochet, Payer, and Durand say that roots in general have a tendency to avoid the light. They showed this by experiments on Pothos digitata, and on various Cruciferous plants, such as Cabbage, Mustard, Radish, Stock, Colza, &c. Some roots, however, are said,

* Payer, Mém. sur la tendance des tiges vers la Lumière. Journ. de Pharm. et de Chim. 3d ser. iii. 136. See also his paper sur la tendance des Racines à fuir la Lumière, in Comptes Rendus, xvii. 1043.

† Macaire, sur la direction prise par les Plantes, in Bibliotheque Universelle de Genève xii. 331.

when grown in transparent glasses, to turn towards the light, such as the roots of Mirabilis Jalapa and Allium Cepa. But the correctness of the conclusions in these cases has been doubted by Macaire.* The Mistleto (Fig. 125, p. 53) seems to grow indifferently in all directions at the period of germination. The radicle always curves in such a way as to make its extremity touch the bark. Dutrochet says that the radicles of the Mistleto direct themselves toward the side which is most dark, and which in their ordinary vegetation is the trunk of the tree. He made the seeds germinate on the glass of a window of a room, some on the outside and others on the inside, and found that the latter directed their radicles inwards from the window, while those on the outside directed their radicles towards the glass of the window, as if to pass into the room or the darker part. The Mistleto, then, obeys the attraction of the branch on which it is parasitic, just as ordinary plants obey the attraction of the earth. Its roots descend towards the centre, while its stems grow perpendicular to the surface of the branch.

969. Observations have been made in regard to the effects of coloured rays on the direction of stems, leaves, and roots. The effects of the rays of the spectrum in causing flexion of plants were first noticed by Dr. Poggioli of Bologna. Gardner of New York says that all erect plants grown in darkness, when exposed to the influence of the solar spectrum, incline themselves towards the prism, and that this effect is produced by every variety of light, but in an especial manner by the indigo ray.† The force which constrains the movements of plants towards the light, according to him, has its maximum in the indigo ray. The bending towards that ray takes place often in a few hours, and sometimes exceeds 90°. The amount of light required for deflection is very small. He does not think that the chemical or heat-giving rays are the cause of the bending, but he attributes it to a modification of light. Dr. Gardner suggests that, as indigo light has a peculiar effect in governing the direction of the stems of plants (an action accomplished by light which is very feeble as compared with that of the yellow rays), the colour of the sky may regulate the upright growth of plants. As the blue rays do not cause in a marked degree the decomposition of carbonic acid, it is thought that Gardner's experiments contradict the views of De Candolle as to the bending of stems. When plants are exposed to the coloured rays of the spectrum, there is thus a flexion towards the light, and also a special movement towards the space illuminated by the indigo ray. Payer's observations corroborate those of Gardner as to effect of the

* Payer, sur la tendance des Racines à fuir la Lumière, in Comptes Rendus, xvii. 1043. Durand sur la tendance qui ont les Racines à fuir ou à chercher la Lumière, in Comptes Rendus, xxi. 1323. Brongniart et Dutrochet, Rapport sur la Mém. de Durand sur la fuite de la Lumière par les Racines, in Ann. des Sc. Nat. 3d ser. Bot. v. 65. Macaire, on the Directions assumed by Plants, in Phil. Trans. 1848, p. 253.

† Gardner, on the Action of Indigo Light in producing the Movements of Plants, in Lond. and Edin. Phil. Mag. xxiv. 6.

blue rays on the curvature of stems, and Dutrochet found that the red rays had also a slight effect.* Macaire made experiments as to the effect of different coloured rays in causing leaves which were reversed to turn into their proper position. While blue and violet rays (transmitted through glass of these colours) caused the reversal of the leaves, red rays had no effect. While in stems there is a flexion towards light, and especially towards the indigo ray, in roots, according to Dutrochet, there is a tendency to avoid the light, and a flexion to avoid the space illuminated by that ray. The movements of the roots are thus, generally speaking, the reverse of those of the stem.

970. The stems of plants undergo sometimes remarkable torsions on themselves, so as to give the axis a spiral form. Besides this, some plants have volubile stems, which twine in a spiral manner round supports. Others have spiral tendrils which twine in a similar manner. The summits of such stems, when separated from supports, exhibit also a revolutive motion. We have already seen that, as regards the tissues of plants, and the disposition of the leaves and of the parts of the flowers, there is a more or less complete spiral arrangement (p. 97). Dutrochet has paid particular attention to the torsions and twinings of stems, but he has not been able to give satisfactory explanations of them.† The volutions or twinings proceed in different directions in different plants. The following details are given by Dutrochet from observations made at temperatures varying from 62.6° to 66.2° F. The revolutions of the stems are, considered as respects an observer, supposed to be in the centre or axis round which the plant twines :—

NAME OF SPECIES.	Direction of the Volution.	Time required for a complete Volution.
Convolvulus arvensis . . .	Right to left.	9 to 10¼ hours.
Convolvulus sepium	Do.	15 to 18½ —
Phaseolus vulgaris	Do.	5½ to 8½ —
Cuscuta europæa	Do.	1½ to 2 —
Humulus Lupulus	Left to right.	20 to 23 —
Polygonum dumetorum . . .	Do.	3½ to 7¼ —
Lonicera Periclymenum . .	Do.	3½ to 5½ —
Tamus communis	Do.	9¼ —

In the case of Solanum Dulcamara, the stem twists in two directions;

* Dutrochet, de l'inflexion des Tiges Végétales vers la Lumière colorée, in Ann. des Sc. Nat. 2d ser. Bot. xx. 329.

† Dutrochet, des Mouvements revolutifs spontanés qui s'observent chez les Végétaux, in Ann. des Sc. Nat. 2d ser. Bot. xx. 306; sur la volubilité des Tiges des certaines Végétaux, in ibid. 3d ser. Bot. ii. 156. See also Braun, sur les torsions normales dans les Plantes, in Ann. des Sc. Nat. 2d ser. Bot. xii. 380. Johnson, on Divergence as the cause of motions in Plants, in Lond. and Edin. Phil. Mag. vi. 165, and vii. Knight, on the Motion of the Tendrils of Plants, in Phil. Trans. for 1812, p. 314.

the revolution from right to left was accomplished in $4\frac{1}{4}$ hours, that from left to right in $3\frac{1}{4}$. In the tendrils of plants similar movements

Fig. 1291.

Fig. 1289.

Fig. 1290.

Fig. 1288.

are observed (Figs. 1290 and 1291). In those of the Cucumber

Fig. 1288. Twining or volubile stem of the Hedge Bindweed (*Convolvulus* or *Calystegia sepium*). The volutions are from right to left, as regards a person supposed to be in the axis of the plant.

Fig. 1289. Twining or volubile stem of the Hop (*Humulus Lupulus*). The volutions are from left to right, as regards a person supposed to be in the axis of the plant. The free summit of the stem has a revolutive movement.

Fig. 1290. Melon (*Cucumis Melo*), with its curving tendril, *t*, which is a modification of a stipule.

Fig. 1291. Part of the stem of the Vine (*Vitis vinifera*), with its spiral tendril, *t*, which is a modified branch.

(Cucumis sativus) and Bryony (Bryonia alba), the movements of revolution take place in two opposite directions, not only in different tendrils, but also in the same tendril—one portion turning from right to left, and another from left to right. Plants turning from right to left (sinistrorsum) are marked). They occur among the Dicotyledonous orders Menispermaceæ, Leguminosæ, Convolvulaceæ, Acanthaceæ, Passifloraceæ, Apocynaceæ, Cucurbitaceæ, Malpighiaceæ, and Euphorbiaceæ. Those turning from left to right (dextrorsum) are marked (. They occur among the Dicotyledonous and Monocotyledonous orders Violaceæ, Caprifoliaceæ, Chenopodiaceæ, Polygonaceæ, Urticaceæ, Rubiaceæ, Dioscoreaceæ, Smilaceæ; as well as in Ferns among the Acotyledons.

971. Dutrochet distinguishes between the twining of a stem round a support, the revolutive movement of its free summit, and the torsion of a stem on its axis. He states also that the revolutive movement at the summit follows the direction of the twining of the stem, and is also in the same direction as the torsion of the stem itself. The direction of the spiral described by the leaves is the same as that of the revolutive movement of the summit of the twigs. The cause of these movements is very obscure. They are attributed to actions going on in the cells, which, by their distension or contraction, give rise to changes in the direction of the parts, in the same way as has been noticed in the case of sensitive leaves.

972. On reviewing all that has been stated on the subject of the direction taken by stems, leaves, and roots, we are disposed to think that the explanations are very unsatisfactory. While the facts are obvious, the cause is obscure. The experiments instituted do not suffice to prove that gravitation is the cause of the root penetrating the earth, for the portion of the plant which grows upwards is frequently the heaviest, and yet at the same time rises in a lighter medium. Moreover, the points of the roots have been found to penetrate to a certain extent into such a dense fluid as mercury.* Again, the mode of germination of the Mistleto and other parasites upon the stems of trees shows that the direction is governed by some more special influence than that of gravity. Henfrey remarks that "so far as we are in a position to tell, there is some definite, and as yet unknown, cause which makes the radicle first grow towards the earth or other source of nourishment, which it penetrates by elongation, a resisting point being offered by the weight of the seed or the earth covering it; and then, in its further growth downward, it requires a point of resistance to be afforded by the adhesion of the earth around the collar, ring, or neck of the root, since the elongation takes place in the structures just above the point of the root, thus exerting a pressure upwards and downwards, which if the upper part of the root be kept free, and the weight of the plant balanced, will cause the whole to rise bodily up-

* Payer, sur la tendance des Racines à s'enfoncer dans la terre, &c.—Comptes Rendus, xx. 1257. Durand, sur un fait singulier de la Physiologie des Racines, in Comptes Rendus, xx. 1257.

wards. Thus when seeds germinate in damp moss lying upon a hard surface, the elongation of the root will push the stem up through the moss, unless the root branches so as to get fixed down by entanglement among the loose matters. We may admit, therefore, that we are at present totally ignorant of the cause of the direction taken by roots —all the notions hitherto advanced having been purely speculative."*

973. Recapitulation of the chief facts connected with the physiology of the seed :—

1. After impregnation, the ovule enlarges, its foramen closes, and various azotized, unazotized, and inorganic matter are deposited in it.
2. The nutrient matter is either stored up in the embryo, more especially in its cotyledons, or it is laid up in the form of a separate perisperm or albumen surrounding the embryo.
3. The density of the perisperm is connected with the length of time required for germination.
4. When the seed is ripe it either falls to the ground along with the pericarp, or it is discharged from the seed-vessel in various ways.
5. In many succulent and monospermal pericarps there is no separation between the coverings of the seed-vessel and the seed until germination begins.
6. Some single-seeded pericarps have winged or hairy appendages, in order that they may be dispersed by the wind.
7. Many polyspermal seed-vessels open with elasticity, or by the agency of moisture, in order to scatter the seed.
8. In some instances fruits are hypocarpogean, in other words, ripen their seeds under ground.
9. Seeds are dispersed by the elasticity of their pericarps, or by the agency of winds, water, or animals.
10. Some seeds have winged or hairy appendages, so as to be wafted to a distance.
11. The propagation of the species is insured by the production of a large number of seeds.
12. Germination is the sprouting of the embryo plant when placed in circumstances favourable for its growth.
13. The requisites for germination are moisture, heat, and air. Darkness is also favourable to the process.
14. Moisture is required for the solution of nutritive matter, and for exciting the endosmotic action of the cells. It also causes the seed to swell, and enables it to burst its coverings.
15. A certain amount of heat is necessary for germination, varying in general from 60° to 80° F. Much depends on the climate in which the plant naturally grows. Some seeds bear a very high temperature, others a very low one.
16. Air, or rather oxygen, is required for germination. When seeds are buried deep and excluded from air, they do not germinate.
17. Seeds will not germinate in hydrogen, nitrogen, nor carbonic acid gas.
18. Germination takes place best in the shade, and the blue rays of light seem to act most beneficially in promoting the process.
19. Electricity has by some been considered favourable to germination. But the experiments in regard to electro-culture have not been successful.
20. In order that cultivated seeds may germinate well, they must be sown at equal depths in well pulverized and well drained ground.
21. Undrained land is cold, and does not supply the air and heat required for ordinary germination.

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* Henfrey on Germination, in Gardener's Mag. of Botany for 1851, p. 122.

22. The effects of draining are both mechanical and chemical. It gives rise to improved efficiency in ploughing and harrowing; it aids the effects of manures, it raises the temperature of the soil, ameliorates the climate, and accelerates harvest.
23. Drains should extend below the depth to which the roots of the ordinary cultivated plants penetrate, and their distance from each other may vary from 15 to 18 feet.
24. Drains must be kept pervious and protected against the entrance of roots.
25. The depth at which seeds ought to be sown is from half an inch to an inch. Shallow sowing enables the seeds to germinate rapidly and surely.
26. Some seeds require to be sown immediately after ripening, otherwise the embryo loses its germinating power.
27. Some seeds can be kept for a long time, and still retain their vitality.
28. Seeds buried in the soil often remain in a state fit for germination, and sprout when the earth is turned up, and when they are exposed to the influence of air, heat, and moisture.
29. Instances are given of the vitality of seeds being preserved for centuries in such circumstances.
30. The conditions in which seeds are preserved are not easily imitated.
31. It has not been proved that any true Mummy Wheat has germinated.
32. In transporting seeds it is requisite that they should be ripe and dry, and that they should be preserved in a dry and airy place.
33. Exalbuminous seeds, and those having a horny and dense albumen, seem to bear transportation best. Oily seeds must be excluded from the air.
34. Seeds can be transported successfully when placed in earth in alternate layers; the earth being pressed down.
35. The seeds of Leguminous and Malvaceous plants have been known to retain vitality long in ordinary circumstances.
36. The spores of Cryptogamic plants appear to retain their germinating power for a long period.
37. Chlorate of potass, oxalic acid, and chlorine have been used to accelerate the germination of old seeds.
38. The length of time required for germination varies from a few days or even hours to many weeks or months, according to the nature of the seed and the degree of temperature applied.
39. During germination the albuminous matter of the seed is dissolved, a ferment called diastase is produced, starch and dextrin are converted into grape sugar, some acetic acid is formed, oxygen is absorbed, heat is developed, and carbonic acid is evolved.
40. An acotyledonous spore during its germination, sends out cellular rootlike processes, and produces a thallus or frond, on which the organs of fructification are developed.
41. In the higher cryptogamic plants, as Mosses and Ferns, the spore produces at first a cellular prothallus which sends off rootlets, bears the organs of reproduction, and finally gives origin to the leafy sporangiferous frond.
42. A monocotyledonous embryo in germinating, emits from its radicular extremity rootlets which pass through sheaths or coleorhizæ, and sends out its plumule or gemmule enveloped in the single cotyledon, which splits at one side to allow the ascending axis to push forth.
43. Sometimes the laminar portion of the cotyledon remains in the interior of the seed, while a cotyledonary petiole is sent out, which ends in a sheath enveloping the young axis.
44. The intra-seminal portion of the cotyledon varies in size and form, and the extra-seminal part is sometimes much elongated.
45. A dicotyledonous embryo, in germinating, protrudes its radicle through the micropyle, while the two cotyledons either appear above ground as seminal leaves, or remain below ground as seminal lobes; the plumule or gemmule arises from between the cotyledons, and constitutes the first bud of the ascending axis.

46. The radicle of the embryo, in germinating, has a downward growth, while the plumule rises upwards.
47. The cause of the directions taken by these parts is not satisfactorily explained. Knight attempted to explain their direction by the law of gravitation in connection with the fluid matter contained in the cells of the embryo. Dutrochet endeavoured to account for the phenomena by the difference in the size of the peripherical and central cells, and the different curvatures thus caused.
48. Light has a powerful influence on the stem. When admitted on one side it causes the stem to bend towards it. Light causes the leaves, when reversed, to return to their normal position.
49. Roots appear to have a tendency to avoid the light. The root of the Mistleto during germination is directed towards some dark body, as the bark of a tree.
50. The blue rays of the spectrum appear to have the greatest effect in causing the bending of the stem, and the turning of leaves.
51. The torsions of certain stems upon themselves, their volutions round other bodies, and the revolutive movements of their free summits, are influenced by causes which are unknown. By some these phenomena are attributed to the influence of light, and to changes in the interior of certain cells, which thus cause curvation. There is a spiral tendency in all stem-growth, as shown by the spiral arrangement of the leaves and other organs.

CHAPTER XI.

PROPAGATION OF PLANTS BY BUDS AND SLIPS.

974. Besides the propagation by means of seeds containing an embryo, or by cellular spores, plants are also capable of extension by division. In unicellular plants, and others of the lowest class, it is common to find each cell possessing the power of producing a new individual, either by simple division or by the formation of a cellular bud. In higher plants this mode of propagation is carried out by means of an assemblage of cells, which are developed into an organ or bud of a more complicated nature, before it is detached. Multiplication by division of cells is very common among the lowest Algæ, such as Desmidiaceæ and Diatomaceæ (Fig. 1292). In the case of Lichens

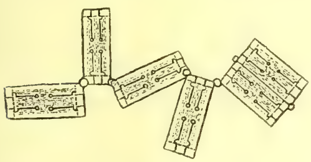

Fig. 1292.

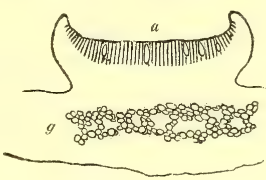

Fig. 1293.

(Fig. 1293) the thallus produces gonidia, *g*, which appear to be a collection of cellular buds capable of producing independent individuals. On the thallus of Liverworts (Marchantia) cup-like bodies (Fig. 1294, *g*) are produced containing gemmæ.* In Mosses the power of reproduction by gemmæ is very marked. Almost every cell of the surface of Mosses, according to Schimper,† is capable of giving origin to a

Fig. 1292. One of the Diatomaceæ (*Diatoma marinum*), a cellular Alga, which is propagated by division of cells, as shown in the Figure. The separate portions are called frustules, and when detached they form new individuals.

Fig. 1293. Vertical section of the thallus and fructification (Apothecium) of a Lichen. The thallus contains green active cells, called gonidia, *g*, which seem to be buds capable of propagating the plant. The apothecium, *a*, contains spore-cases, and spores which also reproduce the plant. The latter are produced by the agency of the sexes, while the gonidia are formed independently of impregnation.

* Mirbel, Recherches sur le Marchantia polymorpha.

† Schimper, Recherches Anatom. et Morphol. sur les Mousses.

leafy plant or innovation. The development of buds on the prothallus is also shown in Figure 1225, p. 573.

975. The higher classes of plants may be considered as consisting of numerous buds united on a common axis. These possess a certain amount of independent vitality, and they may be separated from the parent stem in such a way as to give origin to new individuals. In some instances buds are produced which are detached spontaneously at a certain period of a plant's life. The bulbils or bulblets of Lilium bulbiferum (Fig. 1295), Lilium tigrinum, Ixia bulbifera, and Dentaria bulbifera, are of this nature. The cloves formed in the axils of the scales of bulbs (Fig. 1172, *a*, p. 530), are gemmæ or buds which can

Fig. 1294.

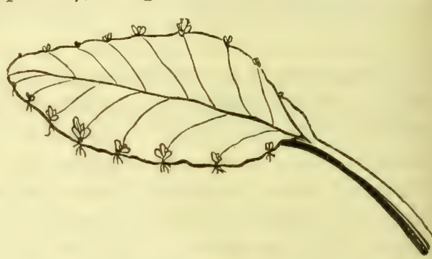

Fig. 1296.

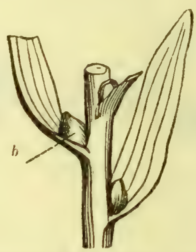

Fig. 1295.

be detached so as to form new plants. Such is also the case with corms, as in Colchicum (Fig. 159, p. 67). In these instances the buds are developed in the usual way in the axils of leaves or scales, that is to say, at the points where they join the stem. Some leaves naturally produce buds on their surface, as may be observed in Malaxis, Aspidium bulbiferum, and Nymphæa micrantha. Other leaves, when placed in particular circumstances, give rise to leaf-buds at their margin. Thus

Fig. 1294. A species of Liverwort (*Marchantia polymorpha*), with its green thallus, *t*, bearing a cup-like body, *g*, in which minute cells or free buds are seen. Besides these gemmæ there is also a stalked receptacle, *s r*, bearing organs of reproduction.

Fig. 1295. Stem of a bulbiferous Lily (*Lilium bulbiferum*), bearing bulbils or bulblets, *b*, in the axils of the leaves. These bulbils are easily-detached buds, which can propagate the plant.

Fig. 1296. Bud-bearing leaf of Bryophyllum calycinum. The buds are produced all around the margin, at the extremities of the primary veins.

the leaves of Bryophyllum calycinum, when placed on the surface of damp soil, exhibit little shoots all around their edge (Fig. 1296). The leaves of Dionæa muscipula (Fig. 237, p. 107), can also be made to produce buds, and so can those of species of Gesnera, Gloxinia, and Achimenes. Occasionally leaves take root and form plants, as was observed by Knight in Mentha Piperita.* Buds are formed accidentally on the leaves of Drosera, Portulaca, Cardamine pratensis, and Nepeta Glechoma. They are also formed on fleshy detached leaves, as on those of different species of Crassula and Aloe, on the bulb-scales of Eucomis regia, Lilium candidum, Hyacinth, and Squill, and on the leaves of Ornithogalum thyrsoides. The leathery leaves of Ficus elastica, Hoya carnosa, and of species of Citrus, Aucuba, and Theophrasta, are occasionally bud-bearing.†

976. In some instances plants, in place of producing seeds, bear peculiar bud-like bodies on their floral axis. This occurs in what are called viviparous or proliferous plants, such as Festuca ovina *var.* vivipara, Aira alpina, A. cæspitosa *var.* vivipara, Poa alpina, Cynosurus cristatus, Polygonum viviparum, and in some species of Allium. In these viviparous plants (which are often alpine) alterations take place in different parts of the flower by which young plants are produced. In Poa alpina, Dickie‡ noticed that the paleæ are the parts which chiefly deviate from the usual condition; they acquire an increase of development, perform all the functions of leaves, and possess the property of striking root when brought into contact with the soil. In Polygonum viviparum the perfect flowers are chiefly at the apex of the rachis, and the bud-like bodies are below, and consist of a central cellular amylaceous mass covered by scales. In Saxifraga cernua the gemmæ are somewhat similar. When detached from the parent they send out cellular roots, and the central part gives origin to the new plant. Saxifraga foliolosa, an arctic plant, has no perfect flowers, but is reproduced by leafy buds.

977. Besides this natural mode of propagation by gemmæ, new plants are also produced by divisions of the stem and branches. Many of the lower class of plants increase by a constant division of their axis or filaments. In the higher plants similar modes of propagation occur. Thus the Potato is naturally reproduced by means of tubers which are shortened under-ground branches, and sections of tubers containing buds (eyes) produce separate plants. When some under-ground stems are cut to pieces every fragment is capable of giving origin to buds and new plants. This may be seen in many Carices growing in sand, in creeping grasses, and in the Horse-radish. Hence the difficulty of eradicating these plants. When the stem of a tree is cut off we frequently perceive an abundant production of leaf-buds on the trunk which remains in the soil. Pollard-trees become very bushy by the production of numerous branches. Pollarding

* Knight, Physiol. Papers, p. 270.

† Munter, Bot. Zeit. for 1845, p. 537.

‡ Dickie, Notes on Viviparous plants, in Ann. of Nat. Hist. 1st ser. v. 297.

may be practised with most dicotyledonous trees, but it does not succeed in Coniferæ.

978. By means of slips or cuttings of the stem, gardeners propagate plants, more especially important varieties. These slips may be at once put into the soil, as in the case of Willows and Cactuses, and be made to put forth roots, or to strike, as it is called. By cuttings gardeners propagate Gooseberries, Currants, Figs, Vines, and some other plants. In deciduous trees the operation is best performed in winter. Sometimes gardeners employ layering, by bending down a branch into the earth, keeping it there with pegs, allowing it to form roots, and then cutting it off from the parent stem. In order to cause layers to form roots, they sometimes make a slit or notch on the shoot, or put a ligature round it, or ring the bark. In striking cuttings of plants, it is of great importance to attend to heat, light, and moisture, and to supply them in proper proportion. In causing cuttings to strike, we require a somewhat higher temperature than that of the climate in which they naturally grow. A Willow-cutting stuck in the open ground will strike root, but it does so much faster and more vigorously if placed in a hot-bed. A White-thorn cutting in the open ground will not root at all; in a warm propagating house it will do so readily. It is not the temperature of the atmosphere, but the temperature of the soil that requires to be raised. We must first obtain roots and then leaves will follow. The cellular tissue of roots is first produced by a local process, and the production of this tissue is kept up by the heat of the soil. Hence the necessity for bottom heat, in order to secure good roots in the first instance; and without them there will be no vigorous leaf-buds. Cuttings of different plants may, by being covered with wax, or by being placed in damp clay or moss, be transported to a distance. In this way slips of various fruit-trees, as well as of herbaceous plants, as Begonias, have been sent to a great distance.*

979. Another mode of propagating plants is by grafting, or by taking a part of one plant and making it grow upon another plant. This process sometimes takes place naturally. The branches of trees, when they come into contact, especially when there is an abrasion of the bark, unite. A curious instance of this is seen at the old burying-place of the M'Nabs at Killin. Old stems of the Ivy frequently show this natural grafting.† The roots of the Spruce Fir on the Alps

* In noticing the modes of sending slips to India, Falconar gives the following directions:—Cut the slips early in winter (November), selecting oldish, firm twigs, with the greatest number of buds; roll them up separately in cotton, after covering the wounds at the ends with cobbler's wax, or some similar composition. Make them up into bundles of from six to ten each, and wrap these bundles separately in cotton, coiled round them with moderate firmness; twenty to forty slips are enough for one packet. Put a wrapper or two of paper around the whole, and finish with an envelope of stout silk or even cloth, freely spread over on the inside with India rubber in the liquid or adhesive state, so that the side and end folds may stick in close apposition, making the whole air and water tight. In this way slips have been sent to Saharunpoor by Bombay (a distance of 7000 miles from Falmouth), in a state fit for planting when transmitted in less than two months.

† Specimens of this natural grafting may be seen in the Edinburgh Museum of Economic Botany.

sometimes unite by natural grafting, and thus, after the trees have been cut down, the old stumps continue to live. The following instance of remarkable root-grafting is recorded by Lindley. Two Carrots, red Surrey and white Belgian, grew so close that each twisted half round the other, and they became united. The red Carrot, with its small overgrown part above the junction, took the colour and large dimensions of the white, which in like manner, with its larger head above the joining, took the colour and small dimensions of the red one at and below the union. The roots were joined by a narrow neck, their upper and lower portions remaining separate. Each gave to its companion its own qualities, and received from the other its qualities. The white-headed Belgian Carrot gave a white extremity to its red companion, while the red-headed Surrey Carrot gave a red extremity to its pale-coloured companion.

980. The subject of grafting has received particular attention from Thouin and D'Albret.* The discovery of the art of grafting is said to be of the highest antiquity, but its inventor is not known. The Phœnicians transmitted it to the Carthagenians and Greeks, and the Romans received it from the latter. The authors who have treated of the art in some detail are—Theophrastus, Aristotle, and Xenophon among the Greeks; Inago among the Carthagenians; Varro, Pliny the naturalist, Virgil, Agricola, in Italy; Sickler in Germany; Bradley, Miller, and Forsyth, in England; Olivier de Serres, La Quintinie, Duhamel, Rosier, Cabanis, Thouin and D'Albret, in France. By grafting we propagate many woody, resinous, soft, or herbaceous plants, which either supply seeds rarely, or are difficult to strike from cuttings or layers. We propagate certain varieties, valued either for their fruit, the structure and form of flower, their colour, perfume, the nature of their wood, their general aspect, or the shades and variation of their foliage.

981. There are certain important requisites which must be attended to in grafting. In the case of Dicotyledonous trees, care must be taken to bring the growing parts into contact—the two alburnums and the two libers. We cannot expect that the old wood of trees, in which the active processes of plant life have ceased, will unite. In the case of Monocotyledonous trees, grafting does not succeed well. The plants on which grafting is practised must be botanically allied, or at all events there must be a similarity in the composition of their sap. Union may take place between plants which, in their natural state, require the same chemical ingredients in the same proportions. This is generally the case with varieties of the same species, more rarely with plants of different species, and least frequently with such as belong to different genera. The Lemon may be grafted on the Orange, because, as Lindley says, the sap of the latter contains all the

* Thouin, Mémoires sur les Greffes, in Annales du Museum, xvi. 209 and 350, xvii. 34; also article Greffe, in Dict. d'Agriculture, 1822. D'Albret, Cours Theorique et Pratique de la Taille des Arbres Fruitiers, 1851.

earthy and saline substances which the former requires, and can supply them in sufficient quantity to the engrafted twig. But the Fig or the Grape would not flourish and ripen fruit on the same stock, because these fruits require other substances than the root of the Orange extracts from the soil, or in greater quantity than the sap of the Orange can supply them. The sap of the stock, in order that grafting may be successful, must contain all that the engrafted bud or shoot requires in every stage of its growth. If the potash or lime required by the Grape be not taken up, and in sufficient quantity, by the root of the Orange, it will be in vain to graft the former upon the latter, with the hope of its coming to maturity or yielding perfect fruit.

982. Grafting of varieties on the stem of the species whence they are derived is very common, and is constantly practised with Roses, Camellias, Apples, &c. Species of the same genus are also frequently united. The Peach (Amygdalus persica) may be grafted on the Almond (Amygdalus communis), the Apricot (Prunus Armeniaca) on the Plum (Prunus domestica), the Plum on the Cherry (Prunus Cerasus), and the Pavia (Æsculus Pavia) on the Horse-chestnut (Æsculus Hippocastanum). But the operation will not succeed between the Horse-chestnut and the Almond. Genera of the same natural order also may sometimes be united. Thus the Pear (Pyrus communis) may be grafted on the Quince (Cydonia vulgaris), or on the Thorn (Cratægus Oxyacantha), or on the Amelanchier (A. vulgaris), all of these belonging to the natural order Rosaceæ. The Lilac (Syringa vulgaris) is said to adhere to the Ash (Fraxinus excelsior), and to Phillyrea latifolia ; the Olive (Olea europea) to the Ash ; the Chionanthus to the Ash and Lilac ; all belonging to the natural order Oleaceæ. The Chestnut (Castanea vesca) may be grafted on the Oak (Quercus Robur), in the family of Amentiferæ ; and Bignonia radicans on Catalpa, in Bignoniaceæ.

983. There are marked instances of plants which seem to be allied, and yet which cannot be grafted on each other. Thus Chestnuts will not graft on Beeches, nor Apples on Pears. As regards the persistence of leaves, it is in general necessary that the plants should correspond. But to this there are exceptions. Some Evergreens can be grafted on deciduous plants. Prunus Laurocerasus and P. lusitanica, both Evergreens, live for some time grafted on the Bird Cherry (Prunus Padus), and are less sensible to cold than those growing on their own roots. Eriobotrya japonica and E. glabra, also Evergreens, live for a very long time grafted on the Hawthorn (Cratægus Oxyacantha). The Cedar of Lebanon, grafted on the Common Larch, lives upwards of ten years, but it remains stunted and dwarf.

984. Although the general law is, that grafting can only take place between plants, especially trees, of the same family, there are certain exceptions. Loranthaceous parasites can form a union with genera in different orders. Thus the Mistleto has been found on the

Apple, Pear, Service-tree, Almond, belonging to Rosaceæ; Robinia, belonging to Leguminosæ; Ash, Oak, Poplar, Willow, belonging to Amentiferæ; Walnut, in Juglandaceæ; Spruce and Larch, in Coniferæ; Ash, in Oleaceæ. In these parasites, however, the process by which they adhere is not ordinary grafting. The seeds, and not the buds or slips, are applied to the stems on which they grow, and certain root-like processes are sent inwards. The habits of the plants are, moreover, such that they can accommodate themselves in a remarkable way to different kinds of nutriment. In ordinary circumstances, we cannot indiscriminately graft one plant upon another. The statements, however, made by Virgil* and Pliny† on this subject show that the ancients were of a different opinion. Pliny talks of seeing one plant bearing numerous kinds of different fruits. This can only be accounted for by the practice called Greffe des charlatans, which consists in cutting down a tree, hollowing out its trunk, and inserting numerous different plants in the centre, with their roots in the soil. In the course of years the young plants fill up the trunk, and appear as if they came from one stem; and the deception is rendered more complete when the trunk has not lost its vitality, and is able to push out buds with leaves.

985. The mode in which grafting is accomplished varies. Thouin has described about a hundred different ways, and D'Albret has written a volume on the subject. The mode of grafting may be divided into three—1. grafting by approach; 2. by slips or scions; and, 3. by buds. Grafting by approach or inarching is performed between two plants growing near each other. Wounds exactly similar are made on the parts which are to be grafted, and the boughs are brought into contact at the wounds thus produced, and are tied together so as to be kept in union. In this kind of grafting both the plants to be united live on their own roots, and mutually co-operate to form a union. The two plants so grafted may be allowed to live together during their united existence, or one of the plants may be cut off (headed down) after the grafting has been effected. In the last case the object is to transfer valuable species to stocks of a hardier and more vigorous nature. By inarching, many fine trees and shrubs are propagated; some large trees in parks and forests are made to assume an agreeable and picturesque aspect; and we are sometimes enabled to produce curved or angular timber, useful for the navy and in the arts. Inarching is performed when the sap is in full flow in spring.

986. In grafting by slips or scions the parts are cut in various ways. The slip cut from the one tree is called the graft or scion,

* "Et steriles platani malos gessêre valentes,
Castaneæ fagos, ornusque incanuit albo
Flore pyri, glandemque sues fregere sub ulmis."—*Virgil*, Georg. ii. 70.

† "Tot modis insitam arborem vidimus juxta Tiburtes Tullias omni genere pomorum onustam: alio ramo nucibus, alio baccis, aliunde vite, ficis, piris, punicis, malorumque generibus, sed huic brevis fuit vita."—*Plin.* lib. xvii. c. 16, sect. 26.

while the other tree to which it is united is called the stock. The stocks employed for ordinary fruits have been divided into two kinds—tree-stocks and dwarfing-stocks. The former consist of plants which naturally attain the same size as those from which the grafts or scions are taken; the second are plants of diminutive size. The usual dwarfing-stock for Apples is the Paradise or Doucin, for Pears the Quince, for Plums the Bullace, and for Cherries Prunus Mahaleb. The most common kind of grafting is called whip-grafting or tongue-grafting (Fig. 1297). The top of the stock and the base of the scion or graft are cut off obliquely at corresponding angles; a horizontal cut is then made near the top of the stock, *a*, and a slit made downwards in the centre of its sloping face; a similar slit in an upward direction is made in the scion, *b*. The tongue or cleft process of the stock is then inserted between the lips of the cut in the scion, and they are closely adjusted and united by clay or other means. Side-grafting resembles whip-grafting, but is performed on the side of the stock without heading it down.

987. Cleft-grafting consists in cutting the trunk, branches, shoots, and even roots of plants, and making in the section a cleft, which usually divides it into two equal parts, for the introduction of kindred grafts, in order that these may be nourished by the stock (Fig. 1298). Sometimes a wedge-shaped slit is made on one side of the stock for the insertion of a slip (Fig. 1299). We must join as exactly as possible all the parts of the graft operated upon with those of the cleft made in the stock; the libers especially should coincide. Grafts having leaves should be kept for a certain number of days in a moist temperature of 60° or 75° in a still atmosphere, and not exposed to bright light. This grafting is usually practised at 4-6 inches above the ground, and rarely higher than 32 feet. The thickness of the stocks varies from $\frac{1}{5}$ of an inch to $1\frac{1}{2}$ inch. Crown-grafting is performed by heading down the stock by a horizontal section, and inserting numerous grafts between its bark and wood, so as to form a sort of crown round it. An old method of grafting was called wimble or peg-grafting, in which a slip was inserted in a perforation or hole made in the stock. Flute or tubular grafting is rarely practised. It is performed by heading down the stock, so as to leave a few inches of clear bark next the cut. The bark is then split into longitudinal slips, which are turned down. A scion is taken of the same length as the part of the stock laid bare; the bark is detached by rubbing, the wood is pulled out, so as to leave the bark hollowed, which is then applied like a flute over the bare stem of the stock, and is properly fitted to it. If the bark is too large, a bit is cut out, and if it is too small, a slit is made, and one of the slips of the bark of the stock is made to supply the space.

988. Another mode of propagation is by means of buds taken from one plant and applied to the cut surface of another plant (Fig. 1300). This process is called budding, or grafting by buds. It consists in the removal of a portion of the bark bearing a bud from one

plant, and inserting it in a slit of the bark of another tree. The stock on which the bud is placed has a portion of bark removed in the way represented in Figure 1300, *a*, flaps at the side being left so as to

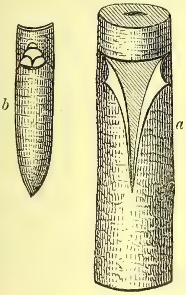

Fig. 1300.

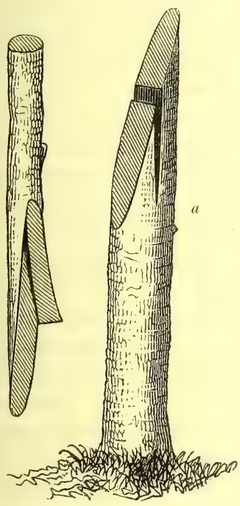

Fig. 1297.

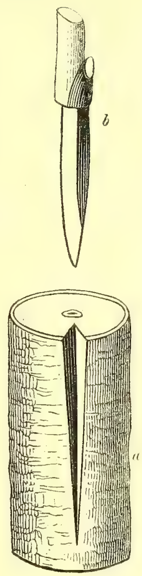

Fig. 1299.

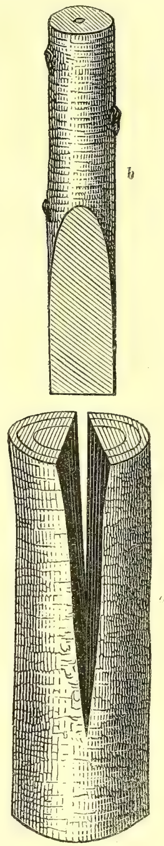

Fig. 1298.

cover a portion of the inserted bark, which is represented at *b*, with the bud or eye on it. The bud is tied down by bast. This kind of grafting is practised in spring and autumn, and is constantly employed for the multiplication of fruit trees. Budding is a kind of transplant-

Fig. 1297. Whip or tongue-grafting. The stock, *a*, is cut in such a way as to have a tongue-like process into which the slip or scion, *b*, similarly cut, is inserted.

Fig. 1298. Cleft-grafting, in which the stock, *a*, is split across so as to allow the insertion of the slip or scion, *b*, which is cut in such a way as to fit the wound in the stock.

Fig. 1299. A kind of cleft-grafting, in which the cleft is made at one side of the stock, *a*, and the scion, *b*, is prepared so as to fit it.

Fig. 1300. Propagation by budding. *a*, The stock, the bark of which is cut so as to receive the bud, *b*. The cut edges of the bark of the stock are folded over the portion of bark bearing the bud, after its insertion in the triangular wound.

ing. In ordinary transplanting, a tree is dug out of the ground at one place and removed to another. In budding, a piece is cut out of the stem of one tree, and is removed to another. The earth is the source of food to the former; elements already extracted from the earth are the nutriment of the latter. If from any cause a transplanted tree loses its fluid contents faster than it can get more from the earth, it dies; if a bud loses its fluid contents faster than it can get more from the living tissue to which it has been transferred, it also perishes. The leaf-bud of a tree consists of a central vital point, over which a skin of bark is drawn. If the growing point is destroyed, the bud perishes. It forms what is named the eye of the bud, and being brittle and tender, easily snaps off when the wood of the bud is jerked out. Great care is necessary in keeping the bud entire. The bark of the stock should run freely, so that the wood may completely separate. This takes place most readily in half-ripe young wood. Grafting succeeds best in plants with woody stems, but occasionally it is practised in herbaceous plants with success. The latter kind of grafting was adopted by Tschudy.* The graft is inserted in the axil of the leaf of the stock. In ordinary grafting, clay, or a mixture of bees-wax and tallow, are used for covering the grafted parts. Bits of India-rubber $\frac{1}{2}$ to $\frac{3}{4}$ of an inch broad are used for fastening grafts on slender stocks or branches.

989. Several advantages are derived from the multiplication of vegetables by grafts. We are enabled to perpetuate remarkable varieties which could not be produced by seed; we procure quickly many valuable trees, which are with difficulty multiplied by other means; we hasten the period of fruit-bearing; and we improve and propagate varieties of fruit trees. In the case of cultivated Apples and Pears, the seeds of our best fruits, such as the Ribston Pippin, the Nonpareil, and the Jargonelle, if sown, will not produce plants bearing these varieties of fruit, but they will have a tendency to reproduce the original species, viz., the Crab-apple or Pear. In the Peach orchards of America the kernels of the finest sorts are seldom found to produce trees bearing fruit fit for the table. It is said that one hundred seeds of the Golden Pippin, when sown in good soil, will produce large-leaved Apple trees, bearing fruit of a considerable size; but the tastes and colours of each will be different, and none will be the same in kind with the Pippin; some will be sweet, some bitter, some sour, some mawkish, some aromatic, some yellow, others green, red, or streaked. Such is the usual case with the seeds of cultivated Apples. Many seeds of the Ribston Pippin and of the Nonpareil have been raised, and none of the progeny have inherited the peculiar flavour and excellence of the parents. Seedlings from the same tree differ, and even pips from the same apple produce different kinds of fruit. There is a strong tendency in the plants raised from seeds of cultivated fruits to return to the state of wildings. By means of grafting we are enabled to continue esteemed varieties, and at the same

* Tschudy, Essai sur la Greffe de l'Herbe, des Plantes, et des Arbres, 1819.

time to impart vigour to young slips by putting them on good and well-grown stocks.

990. The seeds of certain plants have a tendency to *sport*, as it is called, especially when highly cultivated and supplied with abundance of good nutriment. This is the case with the seed of the Crab-fruit when sown in good soil. By the art of the gardener an improvement is produced in fruit naturally sour and inedible. The seeds of such fruits, especially after a long period of cultivation, have a tendency to produce plants which bear fruit of a better quality than the Crab. Plants showing such a tendency are carefully preserved, and slips are taken from them and grafted on well grown stocks, and thus additional vigour is imparted. Grafting has the effect of supplying to the scion a store of nutriment ready prepared and at once fitted for use. Moreover, the nature of the stock imparts often certain qualities to the fruit borne by the graft. The flavour of the Greengage Plum is said to differ according to the tree on which it grows, and this is said also to be the case with some varieties of Cherry. The process of ennobling fruit trees is by grafting slips on excellent stocks. Grafting sometimes changes the habit of the plant. Thus the Prunus canadensis, which in its natural state is a shrub, becomes an erect tree when grafted on the Plum. Such is also the case with Cytisus sessilifolius when grafted on the Laburnum, and with Cerasus Chamæcerasus on the Cherry. The Lilac grafted on the Ash becomes a tree. While some plants become more hardy by grafting, others become more delicate.

991. Mr. Knight entertained the idea that the only true mode of continuing plants was by seed, and that a young shoot taken from an old tree could not be made to live longer than the natural term of life of the tree from which it was taken. On this principle he accounted for the disappearance, or at least the scarcity, of many well-known fruits, such as the Red Streak, the Golden Pippin, and the Golden Harvey. According to Mr. Knight's theory, the vegetable individual is a plant which has originated from the development of a single seed; this individual may consist of many detached portions, each of which may exist apart from the others. A cutting of a tree is a part of the individual from which it was taken, and although it may have become a tree, still, according to Knight's view, it is no more than a developed state of a portion of the original plant. All parts of a tree are viewed as having a common end of their life, and different trees raised from one and the same tree by grafts are considered as decaying about the same time as the parent plant.

992. These views have not been confirmed by the observations of physiologists. Experiments show that young shoots of old trees, when used as grafts or slips, furnish as vigorous plants as the shoots of young trees. Even the terminal bud of some Palms, as the Date, has been removed at a time when vegetation was beginning to decrease in an old tree, and has been planted and produced a vigorous plant. A whole series of cultivated plants, such as the Vine, the Hop, the Italian

Poplar, and the Weeping Willow, are constantly propagated by division without any decreased power of vegetation being observed. Dr. Graham cut a twig of a Willow which, according to Mr. Knight, was dying of old age, and he transferred it to the Edinburgh Botanic Garden, where it is now a large and vigorous tree, although the individual from which it was taken died long ago.

993. Dr. Fleming, in the Quarterly Journal of Agriculture, refutes Knight's views, by showing that there are numerous plants which are propagated naturally by buds of various kinds, and that many such extensions are known to outlive the plants from which they are taken. Lindley remarks, there is no truth in the statement that propagation by seed is the only natural method of reproduction in plants. Many are propagated naturally by stems, bulbs, and tubers. The Sugar-cane propagates by the stem which, when blown down by a storm, emits roots at every joint, the Tiger-lily propagates by bulbils, the Jerusalem Artichoke and the Potato by tubers, and the species of Achimenes by scaly bodies like tubers. Such modes of propagation do not cause debility. The wild Strawberry has been more propagated by runners than by seeds, and yet there are no signs of decay. The Jerusalem Artichoke was introduced in 1617, and has been propagated by tubers, and yet there is no debility. The Couch-grass is propagated by its creeping stems, and yet, unfortunately for the farmer, it is as vigorous as ever.

994. There is no evidence of plants multiplied by division wearing out. The White Beurré Pears of France have been propagated thus from time immemorial. Cultivated Vines have been transmitted by perpetual division from the time of the Romans. The Vitis præcox of Columella is admitted by Dr. Henderson, on the best authority, to have been the Maurillon or Early Black July Grape of the present day; the Nomentana to have been the German Trammer; the Græcula, the modern Corinth or Currant; and the Dactyle, our Cornichons or Finger Grapes. The Golden Pippin and the Golden Harvey are still in the market. The former is among the most vigorous Apples of Madeira, and grows well in the London Horticultural Society's Garden. The Old Nonpareil was known in the time of Queen Elizabeth. Any scarcity in the production of these Apples must be attributed not to old age, but to negligence or want of care in cultivation. There is however no doubt that cultivated plants become feeble by the influence of various causes, such as exhaustion of the soil, improper food, mutilation, the effects of cold, &c. It is also true that seeds or slips taken from diseased and weak plants will partake often to a certain degree of the constitution of the plants from which they have been taken.

995. While numerous experiments have proved that the young shoots of old trees, when used as grafts, furnish as vigorous plants as the shoots of young trees, and that Knight's views in regard to there being one common period of death for all parts of a tree, are erroneous, there is still wanting definite information as to the age which trees

attain. The duration of their life has not been accurately determined. It exceeds so much the limit of man's life that it is not easy to collect data on the subject. Some exogenous trees attain a very great age. Trees which, in individual cases, attain great ages, belong to the most different natural families. Among them may be mentioned the Baobab, the Dragon-tree, species of Eucalyptus, Taxodium distichum, Pinus Lambertiana, Hymenæa Courbaril, species of Cæsalpinia and Bombax, the Mahogany tree, the Banyan, the Tulip-tree, the Oriental Plane, Limes, Oaks, and Yews.*

996. Mr. Knight, from adopting his peculiar theory of propagation, was led to set about producing new varieties of fruits from seeds. He procured seeds from the most esteemed varieties, cultivated them highly, selected those which gave the best promise of good fruit, grafted them on vigorous stocks, and thus he was enabled to produce the Acton Scott Peach, the Ingestrie and Downton Apples, and many others. He also effected valuable improvements in fruit by hybridizing. He found that a Crab fertilized by pollen from good fruiting plants, produced better kinds from seeds than could be had from seeds of improved fruits. Van Mons has also adopted means of producing improved varieties of fruit from seed. The following is the method he pursues:†—Seeds of cultivated varieties, or of wildings which have sprung from cultivated varieties, are sown. The plants from this sowing are reared and made to fruit as quickly as possible. Another generation is raised from these seeds. Thus he goes on always sowing the seeds of the last raised generation. Good new sorts are thus sometimes obtained amongst those of the second or third generation. But each successive generation is characterised by a more general amelioration than that of its predecessor, till at last a high degree of excellence is obtained. Of some fruits, good varieties are obtained from the third sowing. In others, after the fourth or fifth. In Pears, after the sixth or seventh. The varieties are afterwards propagated by grafting.

997. Some maintain that the stock and scion are incapable of producing any influence upon each other respectively, and that each retains to the last its own peculiar quality. This seems to be true, so far as their visible organisation is concerned; for when grafted trees are cut down, the timber of the stock and scion remains just what it is in cases where no grafting has taken place, and the shoots that pro-

* De Candolle gives the following list of some remarkable trees, the ages of which had been ascertained:—

	Years.		Years.
Elm (Ulmus campestris), about	335	Olive (Olea europæa)	700
Cypress (Cupressus sempervirens)	350	Oriental Plane (Platanus orientalis)	720
Cheirostemon platanoides	400	Cedar (Cedrus Libani)	800
Ivy (Hedera Helix)	450	Lime (Tilia europæa)	1076, 1147
Larch (Larix europæa)	576	Oak (Quercus Robur)	810, 1080, 1500
Chestnut (Castanea vesca)	600	Yew (Taxus baccata)	1214, 1458, 2588, 2880
Orange (Citrus Aurantium)	630	Taxodium distichum	3000 or 4000
Some Palms (Ceroxylon and Cocos)	600-700	Baobab (Adansonia digitata) about	5000

† Poiteau, Annal. Soc. d'Hort. de Paris, 1849.

ceed from them generally manifest in like manner exactly their original nature. In grafting an early Hawthorn on a late, and *vice versa*, it was found by the Archbishop of Dublin that the scions kept their times (about a fortnight difference), as if on their own stocks.* If we bud a Peach upon a Plum, each retains its own peculiar foliage. There can be no doubt, however, that the nature of the stock has a decided effect on the slip or scion, both as regards its nutritive and its reproductive organs. Thus it is stated that Pears grafted on the Mountain Ash are rendered more hardy, and bear fruit earlier; and when grafted on Quinces they become higher coloured. Apples grafted on the Siberian Bitter-sweet Apple are more highly coloured than when grafted on the Crab. Peaches on Plum stocks are coarser than on Peach stocks. The Beurré-Diel grafted on the Thorn produces hard fruit. This shows that the stock has an influence on the graft, and points out the importance of selecting stocks of good quality. The plan of ennobling fruit trees proceeds on the principle of grafting on superior stocks. Treffz made some experiments, from which it appeared that this ennobling process had a marked effect on the fruit of Apples, Currants, Gooseberries, Apricots, and Quinces.

998. In some instances it appears that the slip or scion has a decided effect on the stock. Thus, according to Hales, if we bud the variegated Jasmine on a non-variegated one, it sometimes happens that the buds sent out from the latter bear variegated leaves. It is reported that at Chelsea the variegated White Jasmine was budded upon a branch of a fine plant of Revolute Jasmine with green leaves, and in the succeeding year a slight appearance of variegation came out on the leaves of the Revolute Jasmine. The next year the branch which had been budded was cut out, so that the Revolute Jasmine was thus apparently deprived of all influence from the variegated bud. Nevertheless, the variegation in the remainder of the plant continued to increase, and the leaves and branches ultimately became all variegated, even more than the White Jasmine, whose bud was originally inserted. A variegated Ash graft has also caused variegation in the leaves of a common Ash stock. At Morningside, near Edinburgh, Mr. Evans states there is an instance of Pyrus Aria grafted on Pyrus Aucuparia, in which the stock, about two feet below the point of junction, has produced leaves resembling those of the graft along with those peculiar to itself.

999. Recapitulation of the chief facts relative to the propagation of plants by slips and buds:—

1. The lower classes of plants frequently multiply by division and separation of cells.
2. The higher classes of plants are often propagated by the separation of buds and offsets.
3. In viviparous plants buds occupy the place of seeds.
4. Gardeners propagate particular varieties of plants by cuttings or layering.

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* Annals of Nat. Hist. 1842.

5. Cuttings may either be inserted at once in the soil, or may be placed upon other plants by the process of grafting. In the latter case the slip or cutting is called the graft or scion, while the plant in which it is inserted is called the stock.
6. Grafting succeeds best with woody plants, but occasionally the parts of herbaceous plants may be united.
7. By grafting, varieties are continued which could not be propagated by seed, especially many which are valued for their flowers or fruit; at the same time the period of fruit-bearing is hastened.
8. Grafting can only be successfully performed between allied plants, more particularly individuals of the same species, and species of the same genus; occasionally allied genera can be united.
9. The various modes of grafting may be included under inarching, grafting by slips, and budding.
10. In grafting it is of importance to place the active growing parts of the plants in contact, and to keep them in apposition.
11. Good varieties of fruit are produced by sowing the seed in good soil, and by grafting on good stocks.
12. The seeds of the finest varieties of Apples, when sown, have a tendency to produce plants like the Crab-apple—the original species—and it is only by high cultivation and grafting that they can be perpetuated.
13. The stock has an effect on the graft or scion; hence the propriety of grafting on good stocks, which is denominated ennobling.
14. Mr. Knight supposed that all parts of a tree have one common period of death, and that young grafts taken from old trees would die at the same period as the plants whence they were taken.
15. He attributed the scarcity of many of the fine Apples of the 17th century to the fact that the original plants having died from old age, all the slips taken from them had also reached the limit of their existence.
16. He thought that reproduction by seed was the only true way of continuing the plant.
17. These views have not been confirmed by physiologists, who have shown that many plants are propagated naturally by buds and shoots and yet do not decrease in vigour; and that the failure of certain fruits is due to defect in management, and not to old age.
18. The age which trees attain has not been fully determined; some live for many centuries.
19. While the stock has a decided influence on the graft, it is also found in some instances that the latter has an effect on the former.
20. A plant with variegated leaves grafted on one with green leaves has sometimes caused variegation in the leaves of the stock.

CHAPTER XII.

DEVELOPMENT OF HEAT, LIGHT, AND ELECTRICITY BY PLANTS.

1000. *Temperature of Plants.*—We have already seen that, during the periods of flowering and germination, a considerable amount of heat is evolved (p. 519, 633). This seems to depend on the combination between the oxygen of the air and the carbon of the plant, and is accompanied with the formation of grape sugar and the evolution of carbonic acid. The heat at these stages of growth is often very evident, more especially in cases where numerous germinating seeds are placed together, and numerous flowers are enclosed in a common covering. The phenomenon requires to be noticed in circumstances in which the heat cannot be carried off rapidly by the air or the soil.* It is a matter of interest to determine whether or not heat is produced during the ordinary vital actions going on in the cells and vessels of plants. The investigation of this point has called forth the labours of several physiologists. Hunter instituted a series of experiments respecting the temperature of trees. He bored holes to the depth of ten or twelve inches in the trunks of trees, and inserted thermometers. He found that in spring, autumn, and winter the temperature of the internal part of a tree was usually about two degrees above that of the air. The results, however, were variable, and no satisfactory conclusions were deduced.† Schoepf, Bierkander, Maurice, and Pictet made similar experiments, and they agree in giving to trees with thick trunks a temperature lower than that of the air during great heat, and higher than that of the air during extreme cold.

1001. An extensive series of observations were made by Schubler at Tubingen by putting thermometers into holes which penetrated to the centre of the trunks of Pines and other trees. He found that the

* Fourcroy et Vauquelin, Mém. sur la Germination et la Fermentation des Graines, in Annales du Museum, vii. 1.

† Hunter, Experiments on Animals and Vegetables, with respect to the power of producing heat, in Philos. Trans. vol. 65, for 1775, p. 446.

temperature in the centre of a tree at sunrise, when the weather was clear, was higher than that of the surrounding atmosphere; and that at mid-day, or rather during the hottest part of the day, the contrary was the case. Schubler said that the tree was $1\frac{1}{2}^{\circ}$ to $2\frac{3}{4}^{\circ}$ colder than the air in summer, and $1\frac{1}{2}^{\circ}$ to 3° warmer in spring.* While in Schubler's experiments the temperature of trees with tolerably thick stems never attained the extreme of the temperature of the atmosphere, Reaumur saw slender trees heated 18° to 29° above the temperature of the air in the sun.† In all these experiments the results seem to depend on the effects of the sun's rays, on evaporation, on the temperature of the soil as influencing the ascending sap, and on the bad conducting power of the wood.

1002. The temperature of a plant, that is, of its juices, Dr. Hooker finds to depend materially on that of the soil at its spongioles. A good large unripe Shaddock on the tree will maintain the same temperature on the plains of India with the thermometer in the air at mid-day at 110°, and at midnight at 68°, the black bulb in the sun at 150°, and the radiating thermometer at night at 58°, with the plant and fruit fully exposed to all these vicissitudes. He mentions that, when the surface sand in the valley of Soane was heated to 110°, the fresh juice of Calotropis was only 72°. This latter temperature he found at fifteen inches depth in the soil where the plant grew. The power which the plant has in maintaining a low temperature of 72°, though the main portion which is subterranean is surrounded by a soil heated between 90° and 100°, is remarkable, and is no doubt proximately due to the rapidity of evaporation from the foliage, and consequent activity in the circulation. Its exposed leaves maintained a temperature of 80°, nearly 25° lower than the similarly exposed sand and alluvium. On the same night the leaves were cooled down to 54°, when the sand had cooled to 51°. Before daylight the following morning the sand had cooled to 43°, and the leaves to 45.5°.‡ It appears that the internal temperature of the trunks of trees depends in a great measure on that of the soil at the depth to which the roots penetrate. The liquid taken up by the roots rising vertically in the trunk, and being at the degree of heat which the soil possesses at the depth of the roots, tends to warm the tree in the cold season, and to cool it in comparison with the air in the warm season.

1003. While the nutritive processes are going on in the plant there is a certain amount of heat produced. This, however, is speedily

* Schubler, ueber die Temperatur der Vegetabilien, in Poggendorf, Annalen x. 589. and Thomson's Chemistry of Vegetables, 956. Halder, Beobachtungen ueber die Temperatur der Vegetabilien, Tubingen, 1826. Goeppert sur le Développement de la chaleur dans les Plantes, Breslau, 1850, and Vienna, 1832.

† Mohl, on the Vegetable Cell, by Henfrey, p. 102.

‡ The sap of the Ice-plant (*Mesembryanthemum crystallinum*) is said to be colder than the surrounding air. John states that on 13th September, when engaged in examining it at Berlin, the thermometer in the shade stood at $54\frac{1}{2}^{\circ}$, but when plunged into the sap of this plant it sunk to 41°. Evaporation probably had a powerful effect.

carried away by evaporation and other causes, and is not easily rendered evident. Dutrochet, by means of Becquerel's thermo-electric needle, showed an evolution of heat in plants. In doing this he required to prevent evaporation by putting the plant in a moist atmosphere. In these circumstances the temperature of the active vegetating parts, the roots, the leaves, and the young shoots, indicated a temperature above the air of $\frac{1}{2}$ to $\frac{3}{4}$ of a degree Fahrenheit. Van Beek and Bergsma, in their experiments on Hyacinthus orientalis and Entelea arborescens, found the proper heat of the active parts of plants about 1.8° F. above that of the air.* The vital or proper heat of plants, according to Dutrochet, is found chiefly in the green parts, and it undergoes a quotidian paroxysm, reaching the maximum during the day, and the minimum during the night. When stems become hard and ligneous, they lose this vital heat. Large green cotyledons gave indications of a proper heat. The hour of quotidian maximum varied from 10 A.M. to 3 P.M. in different plants.†

1004. The following are some of the observations made by Dutrochet in regard to the diurnal paroxysms of heat in the stem of Euphorbia Lathyris (Fig. 1111, p. 423):—

HOUR OF DAY.	Deviation of Thermo-electric Needle.	Proper Heat of Plant above the Atmosphere.	Temperature of the Atmosphere.
5th June.			
6 A.M.	$1\frac{1}{2}$	0.160° F.	62.24° F.
7 ,,	$1\frac{3}{4}$	0.198	62.24
8 ,,	2	0.324	62.24
9 ,,	3	0.324	62.42
10 ,,	4	0.450	62.60
11 ,,	4	0.500	62.96
12 ,,	$5\frac{1}{2}$	0.558	63.14
1 P.M.	$5\frac{1}{2}$	0.610	63.50
2 ,,	$4\frac{1}{2}$	0.500	63.86
4 ,,	3	0.216	63.68
6 ,,	1	0.108	63.50
8 ,,	$\frac{1}{2}$	0.054	62.96
9 ,,	$\frac{1}{4}$	0.027	62.60

The observations were continued on the 6th June with similar results, but the proper heat did not attain such a high maximum.

* Van Beek et Bergsma, sur la Température des Végétaux, in Ann. des Sc. Nat. 2d ser. Bot. xii. 90.

† Dutrochet, Recherches sur la Température propre des Végétaux, in Ann. des Sc Nat. 2d ser. Bot. xii. 77, 84. See also Edin. New Phil. Journal, xxviii. 103. Dutrochet, sur la chaleur propre des êtres vivans à basse Température, in Ann. des Sc. Nat. 2d ser. xiii. 5. 65.

1005. The following are some of the results which Dutrochet obtained, with different species of plants :—

NAMES OF PLANTS.	Hour of Maximum of Vital Heat.	Deviation of the Needle.	Maximum of Vital Heat.	Temperature of the Atmosphere.
Rosa canina	10 A.M.	$3\frac{1}{2}$	0.380° F.	71.60° F.
Allium Porrum	11 ,,	2	0.216	74.84
Borago officinalis	12 NOON.	$1\frac{1}{2}$	0.160	66.20
Euphorbia Lathyris . . .	1 P.M.	$5\frac{1}{2}$	0.610	63.50
Papaver somniferum . . .	1 ,,	$3\frac{1}{2}$	0.380	68.72
Cactus flagelliformis . . .	1 ,,	2	0.216	67.10
Helianthus annuus	1 ,,	$3\frac{2}{3}$	0.396	56.84
Impatiens Balsamina . . .	1 ,,	$1\frac{3}{4}$	0.198	60.80
Ailanthus glandulosa . . .	1 ,,	$2\frac{2}{3}$	0.290	71.60
Campanula Medium . . .	2 ,,	5	0.558	61.16
Sambucus nigra	2 ,,	$3\frac{1}{2}$	0.380	66.74
Lilium candidum	2 ,,	$4\frac{1}{2}$	0.504	63.10
Asparagus officinalis . . .	3 ,,	4	0.450	53.6
Lactuca sativa	3 ,,	$1\frac{1}{2}$	0.160	71.24

The hour of maximum varied from 10 A.M. to 3 P.M., and the temperature varied from about one-tenth to rather more than half a degree Fahrenheit. In the case of Fungi the following results were obtained :—

NAMES OF PLANTS.	Deviation of the Needle.	Heat of Fungus above the Air.	Temperature of the Atmosphere.
Agaricus eburneus	$3\frac{1}{4}$	0.36° F.	68.90° F.
Agaricus colubrinus . . .	$1\frac{2}{3}$	0.18	68.36
Agaricus annularius . . .	$1\frac{2}{3}$	0.18	63.50
Boletus æreus	$7\frac{1}{3}$	0.81	66.74
Lycoperdon hirtum . . .	$4\frac{1}{4}$	0.47	70.06

1006. Rameaux* repeated the experiments relative to the temperature of the trunks of trees, and likewise those relating to the heat of the active vegetating parts of plants, and he came to the conclusion that the temperature of plants depends on two distinct sources— 1. Organic actions going on in the young, soft, and herbaceous parts of plants, and which give rise to a temperature so slight that it requires delicate instruments to show it. 2. Meteorological influences, either immediate, as exercised on parts of plants exposed to the air, or mediate,

* Rameaux, des Températures Végétales, in Ann. des Sc. Nat. 2d ser. Bot. xix. 5.

as exercised on the soil and on the sap which is drawn up from it; the former being the most energetic. He remarks that in a tree at any one instant there are as many different temperatures as there are points unequally accessible to external sources of heat; that the sum of all these temperatures, or the entire heat of the tree, augments and diminishes with the surrounding temperature; that the variations of temperature are more rapid and more intense in the superficial than in the deep layers, and that parts having a small diameter are cooled and heated with more rapidity and energy than those whose diameter is great; that during day the temperature of the different concentric layers of a tree diminishes in going from the surface to the centre, and that this diurnal distribution is established more or less quickly and completely according to the nature of the surrounding temperature and the diameter of tree; that during the night, on the contrary, the temperature of the different layers increases from the surface to the centre, the nocturnal distribution varying in the same way according to the surrounding temperature and the diameter; that the action of solar rays is the most powerful cause of the temperature of plants; and that the ascending sap increases or diminishes the temperature of the parts it traverses according as these parts have a temperature lower or higher than its own.

1007. Gardner* made experiments on the influence of the dew-point in vegetables, considered especially with reference to their temperature. He concludes that certain vegetables are without specific heat; that the variations, plus and minus the atmospheric air, observed in plants, are owing chiefly to the state of the dew-point, its elevation causing an increase of heat by checking evaporation, and its depression by favouring evaporation producing coldness; that the sensible heat of plants is directly as the atmospheric temperature and the chemical action going on in their cells, and inversely as the radiation, evaporation, and conduction of the soil and air.

1008. *Luminosity of Plants.*—Considerable differences of opinion exist as to the luminosity exhibited by plants. Light is undoubtedly given out by Fungi in certain circumstances, but the occurrence of luminous phenomena in the higher plants is still a matter of dispute. Luminosity has been noticed in many species of Agaricus growing on dead or decaying wood, such as Agaricus olearius, indigenous in the south of Europe; Agaricus Gardneri, in Goyaz, Brazil; Agaricus igneus, in the island of Amboyna; and Agaricus noctilucens, in Manilla. The first two are of an orange colour, the third of an ash colour, and the fourth white. The light of the Agaric of the Olive-grounds (Agaricus olearius) may be compared to that of phosphorus; it is a continued white light without scintillations, very bright when the plant is young and recently gathered. Agaricus igneus has a bluish light. The whole plant of Agaricus Gardneri

* Gardner, on the Influences of the dew-point on the Temperature of Vegetables, in Annals of Philosophy for 1842.

gives out at night a bright phosphorescent light, somewhat similar to that emitted by the larger fire-flies, having a pale greenish hue. From this circumstance, and from growing on a Palm, it is called by the inhabitants of Villa de Natividade, Flor de Coco.*

1009. Drummond describes two species of Agaricus near the Swan River, which emit a most curious light.† They grow parasitically on trunks of trees such as Banksias. When placed on paper, the Agarics emitted by night a phosphorescent light sufficient to allow a person to read by it, and they continued to do so for several nights with gradually decreasing intensity as the plant dried up. Another phosphorescent Agaric was noticed by Mr. Drummond in Australia on the trunk of a dead Eucalyptus occidentalis. The upper surface of the pileus was nearly black, while the central portion and the gills were milk-white, the stipe being attached to one side of the pileus.

1010. Some species of Rhizomorpha are remarkable for the phosphorescence which they display. These plants vegetate in dark caverns, and in the coal mines of Germany. They are seen hanging from the roof in great numbers. Their luminous qualities are most developed in the furthest recesses of the mines.‡ Prestoc has noticed that the spawn of the Truffle (Fig. 1022, p. 345) is luminous, and that it may thus be collected at night in the Truffle-grounds. These are instances of luminosity in living Fungi, which disappears with life. Luminosity has also been observed in plants in a state of putrescence, as in rotten wood and in half-decayed potatoes.

1011. Tulasne has made observations on the light given out by Rhizomorpha subterranea. By preserving it in a proper state of humidity the phosphorescence was kept up for several evenings. When the Fungus began to dry it lost its luminosity.§ Tulasne considers the light as similar to the phosphorescence in decaying plants, and he concludes that the same agents, namely oxygen, water, and heat, furnish the combination necessary for producing phosphorescence, both in organized living beings and in those which have ceased to live. In both cases the luminous phenomenon accompanies a chemical reaction, which consists chiefly in the combination between organized matter and the oxygen of air, that is to say, a slow combustion, giving rise to carbonic acid. The light from Rhizomorpha and Agaricus olearius, as well as that from decaying wood, is stated by Meyen to be increased on plunging the plant or wood into oxygen gas ; he attributes the phenomenon to chemical action going on both in living and in decayed tissues.

1012. The light given out by some Mosses, as Schistostega osmundacea and Mnium punctatum, depends on optical appearances, and

* Gardner, on a New Phosphorescent Species of Agaricus, in Hook. Journ. of Botany, ii. 426.

† Drummond, on a curious luminous species of Fungus, from the Swan River, in Lond. Journ. of Bot. i. 215.

‡ Humboldt, ueber unterirdische Gasarten—Nova Acta, xi. Part 2, 605. Nees Von Esenbeck, die unterirdischen Rhizomorphen, in Nova Acta, xi. Part 2, 603.

§ Tulasne, sur la Phosphorescence Spontanée de l'Agaricus olearius, du Rhizomorpha subterranea, et des Feuilles Mortes du Chêne—Ann. des Sc. Nat. 3d. ser. Bot. ix. 338.

has nothing to do with the development of light from the substance of the plants. In the former the cellules of the germinating plant swollen into little globules, and in the latter the small drops of water on the leaves, produce a glimmering by a peculiar refraction and reflection of the daylight. The light of Schistostega is of a delicate emerald green. Similar appearances were observed by Milde on the young frond or prothallus of Ferns.

1013. The younger Linnæus states that the flowers of Nasturtium, the African Marigold, the orange Lily and other orange flowers, give out, at the end of a hot summer day, intermittent phosphorescence resembling little flashes of light. Dowden also mentions a luminous appearance of a similar nature in the common Marigold (Calendula vulgaris). He noticed it on the 4th of August 1842 at 8 P.M. after a week of very dry warm weather. A gold-coloured lambent light seemed to play from floret to floret, and to make a course round the disk of the flower.* James states that at Moseley in Worcestershire, after a hot dry day, the flashes of light from Papaver pilosum or hairy red Poppy, were observed by himself and others. The light given out by flowers has been remarked by various other observers. The plants in the flowers of which it has been observed are Tropæolum majus, Helianthus annuus, Calendula officinalis, Tagetes erecta and patula, Lilium chalcedonicum and bulbiferum, Polyanthes tuberosa, Papaver orientale and pilosum, Chrysanthemum inodorum, Œnothera macrocarpa, and Gorteria rigens. These luminous phenomena in flowers are considered by Professor Allman as being merely optical illusions. He says they are only seen in orange and gaudy flowers, and at twilight, not in darkness, and that they must be traced to an intermittent effect on the retina. Kutzing agrees in thinking that the luminous appearances in flowering plants are illusory, and he quotes the following passage from Goethe in proof of this:—"On the 19th June 1799, late in the evening, when the twilight was passing into a clear night, as I was walking up and down with a friend in the garden, we remarked very plainly about the flowers of the Oriental Poppy, which were distinguishable above every thing else by their brilliant red, something like flame. We placed ourselves before the plant and looked steadfastly at it, but could not see the flash again, till we chanced in passing and repassing, to look at it obliquely, and we could then repeat the phenomenon at pleasure. It appeared to be an optical illusion, and that the apparent flash of light was merely the spectral representation of the blossoms of a blue-green."

1014. The sap of plants is said to be luminous in certain instances. Mornay† describes a tree in South America called Cipó de Cunanam,

* Dowden, on a Luminous Appearance of the Common Marigold, in Brit. Assoc. Transactions for 1843, p. 79. The experiment was made with the Double Marigold, which does not exhibit the phenomenon of folding its florets in the evening.

† Mornay, in Philos. Trans. for 1816, p. 279.

with a milky juice, which gave out in the dark a bright light when wounded. The phosphorescent light appeared at every cut in the stem, and each drop of the milky juice was luminous. Martius also observed the same kind of light in the sap of Euphorbia phosphorea, a Brazilian plant, when wounded. When this was observed, the temperature was 97.25° F., but it ceased when the heat sank to 68° F.; he did not find that it affected the galvanometer in the least.* Senebier states that on one occasion, when confining an Arum in oxygen gas, it gave out light as well as heat. A fragment of a plant sent from the Madras Presidency, under the name of Cardiospermum, is said to be luminous. It was discovered in the jungle, and is said to cast a blaze of phosphoric light over all the grass in the vicinity. It has been celebrated by Indian writers. Lindley states that the dried fragment when moistened regained its phosphorescent appearance, shining in the dark like a dead fish or similar putrefying substance. The fragment became lustreless when dry, and acquired luminosity again when a moistened cloth was applied to its surface for an hour or two. Lindley thinks that it is the rhizome of some endogen with equitant leaves, and that it may perhaps be part of a Cymbidium or Eulophia, or a Marica. The rhizome of a grass called Anthesteria anathera is occasionally luminous by night in India during the rainy season. Other Grasses, as Andropogon contortus and Iwaruncusa, are reported to possess the same property.†

1015. *Electricity of Plants.*—Some observations have been made relative to the electricity of plants, which may be referred to at this place. Pouillet stated that electricity was developed during the ordinary process of growth in vegetables. Several pots filled with earth, and containing different seeds, were placed on an insulated stand in a chamber, the air of which was kept dry by quicklime. The stand was placed in connection with a condensing electrometer. At first no electric disturbance was manifested; but the seeds had scarcely sprouted when signs of it were evident; and when the young plants were in a complete state of growth they separated the gold leaves of the electrometer half an inch from each other. The exhalation from leaves may be considered as a cause of the development of electricity, as well as the changes effected by leaves on the oxygen and carbonic acid of the atmosphere. Plants are considered as generally in a nega-

* Martius, Reise nach Brazilien, i. 726. Meyen, ueber das Leuchtes des Meeres, in Nova Acta, xvi. Part 2, 138.

† Madden, in the Journ. of Agricult. and Hort. Soc. of India for 1850.

For further remarks on the luminosity of plants, consult Gesner, de Raris et Admirandis Plantis quæ sive quod noctu luceant sive alias ob causas Lunariæ dicuntur, Tiguri, 1555. Meyen, Neues Syst. der Pflanzen Physiol. ii. 192. Schleiden, Principles of Botany—translated by Lankester, pp. 542, 543, where numerous bibliographical references are given.

In the case of Dictamnus Fraxinella, it is reported that in a still warm evening the resinous vapour given off by the plant is in such abundance as to take fire when a flame is applied to it. The writer of the work entitled Garden Flowers says, that on a fine summer evening in June, before the twilight had commenced, he held a light about half an inch from the flower, when the vapour which it emitted took fire, and a beautiful blue flame ran over every part of the plant, which was about three feet high. It occupied half a minute in progress, and the plant was not injured.

tively electrical state. Dr. Graves thinks that in this way in tropical climates, where the superincumbent atmosphere is rendered positively electrical by evaporation from the sea, the negative state of plants leads to thunder storms. It is said that the pith and bark, as well as the two extremities of fruits, are in opposite states of electricity.

1016. Wartmann has made an extensive series of observations on the influence of atmospheric electricity, and that of the battery, in the development of plants; on the influence of electricity on the circulation of the sap; and on the electric currents existing in the soil and in plants. He states that there are electric currents in almost all parts of plants; that in the roots, stems, and branches, there exists a central descending current and a peripherical ascending one; that there are also lateral currents between the pith and the cambium; that the electric state of the soil, and probably also the exhalation which takes place by the organs furnished with stomata, influences the electricity of the atmosphere around.* Becquerel says that in the act of vegetation the earth acquires continually an excess of positive electricity, the bark and part of the wood an excess of negative electricity; that the leaves act like the green part of the parenchyma of the bark—that is to say, the sap which circulates in their tissues is negative with relation to the wood, to the pith, and to the earth, and positive with regard to the cambium; that the electric effects observed in vegetables are due to chemico-vital actions; and that the opposite electric states of vegetables and the earth give reason to think that, from the enormous vegetation in certain parts of the globe, they must exert some influence on the electric phenomena of the atmosphere.†

1017. Recapitulation of the chief facts connected with the temperature and luminosity of plants:—

1. During the periods of germination and flowering there is an evolution of heat which, in the case of numerous germinating seeds placed together, and of numerous flowers enclosed within a large bract, is often very marked.
2. The heat in these instances depends on a chemical action going on in the cells, and is accompanied with the evolution of carbonic acid.
3. The temperature of the central parts of the trunks of trees depends on that of the sap which is taken up by the roots, and which, owing to the bad conducting powers of the wood, parts with its heat very slowly.
4. In cold weather the internal temperature of the trunks of trees is often higher than that of the air, and in warm weather it is often lower.
5. Evaporation has a decided influence on the temperature of plants, as by means of it there is often a rapid abstraction of caloric.
6. The active growing parts of plants exhibit a moderate elevation of temperature, seldom exceeding 1° F. above that of the air; this is called by Dutrochet the vital or proper heat of plants.

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* Wartmann, Notes sur les Courants Electriques qui existent dans les Végétaux, in Bibliothèque Universelle de Genève, lxxv. Suppl. p. 301. Zantedeschi, sur l'Influence Mutuelle du Magnetisme et des actions Chimiques, in Bibliothèque Univ. de Genève, xliii. 22.

† Becquerel, sur les Causes du Dégagement de l'Electricité dans les Végétaux— Comptes Rendus, xxxi. 633. Electro-Physiologie, in Comptes Rendus, xxxii. 657. See also Bertholon, sur l'Electricité des Végétaux.

7. It attains a quotidian maximum, the period varying between the hours of 10 A.M. and 3 P.M.
8. Meteorological influences and organic actions affect the temperature of plants.
9. Some plants have a luminous appearance in certain circumstances.
10. This luminosity is very evident in the case of some Fungi, in which the light is of a bluish tint.
11. The phosphorescence of Fungi has been referred to chemical changes connected with the absorption of oxygen and its combination with carbon.
12. Certain luminous appearances have been traced to optical effects on the retina; this is especially the case with some Mosses.
13. Intermittent light is reported to have been emitted by some orange-coloured flowers in calm warm evenings.
14. There are great doubts as to the nature of this light, and many authors consider it as an optical illusion.
15. The milky sap of some plants has exhibited luminosity at a high temperature.
16. The rhizomes of some endogens of warm countries have also been found luminous.
17. The electrical phenomena exhibited by plants are very obscure, and the statements in regard to them are vague and unsatisfactory.
18. A disturbance of electrical equilibrium is said to take place during the growth of plants.
19. Plants are considered generally as in a negatively electric state, but opposite states are said to occur in different parts of the same plant.
20. Electric currents of an ascending and descending nature are mentioned by some as occurring in plants.

CHAPTER XIII.

VEGETABLE NOSOLOGY, OR THE DISEASES AND INJURIES OF PLANTS.

1018. It would be difficult to name any department of vegetable physiology concerning which so little is positively known, even to those most conversant with such matters, as the nature of the diseases to which plants are liable. The number of writings on the subject is inconsiderable, and the information afforded by them still more so. The subject, nevertheless, is one of great importance. It is intimately connected with the prosperity of our forests and the productiveness of agriculture. Plants, like all other organized bodies, are subject to a great many accidents and diseases. The most common causes of disease are improper soils, ungenial climates, frosts, long continued rains, great drought, violent storms, parasitic plants, insects, and wounds of various kinds.

1019. According to Schleiden, plants in a state of high cultivation are all more or less in a condition predisposed to disease. There is an unnatural and excessive development of particular structures or particular substances, and thus, the equilibrium being destroyed, the plants are liable to suffer from injurious external influences. The general morbid condition produced by cultivation is heightened into specific predisposition to disease when the conditions of cultivation are opposed too strongly or too suddenly to those of nature; as when natives of light or sandy soils, such as the Oat or Potato, are planted in heavy land; or when Wheat, Rye, or Barley are sown in land the first year after it has been manured; or when the climate is very unlike the original one of the plant, as in the case of Maize in most parts of Europe. The outward forms of diseases are sufficiently known, but the internal appearances are less understood, and for their proper apprehension they require a knowledge of vegetable anatomy. The characters are essentially similar in all living vegetable cells. There is a wall or membrane, composed of cellulose, lined by a viscid layer (the primordial utricle), composed of an albuminous matter abounding in nitrogen; the cavity of the cell is filled with watery juice, containing little nitrogenous matter, but having all the other compounds, such as gum, sugar, vegetable acids, inorganic salts, &c. dissolved in it. The chemical force of the plant appears to reside in the nitrogenous layer; all growth depends upon it, and it does not disappear until the cell-wall has become properly developed. When diseased plants are examined in the early stage, the first morbid appearance occurs in the nitrogenous layer, which becomes discoloured, coagulated, and granular, and the disease then extends to the cellular wall.

1020. The diseases of plants may be divided in the following way:—1. Diseases which are caused by an excess or deficiency of those agents which are necessary for the vigorous growth of plants; such as soil, light, heat, air, and moisture. 2. Those which are either originally caused, or, at all events, aggravated and modified by the attacks of parasites, more particularly belonging to the natural order Fungi. 3. Those due to the action of poisons, either taken up from the soil or from the atmosphere. 4. Those caused by mechanical injuries of different kinds, as by the attacks of animals, more particularly insects. Diseases caused by changes in the atmosphere are often epidemic, and spread over extensive districts of country. Those which are due to parasitic Fungi are propagated by contagion—the minute spores being carried by the winds. Exciting causes operate with great intensity in cases where plants are previously predisposed to disease. Thus, if a plant is in an enfeebled or weak condition, it is very liable to suffer both from epidemic and contagious diseases.

1021. The cryptogamic diseases of plants must be considered contagious, since they are produced by the contact of one portion of organic matter with another. The contact of diseased cells produces disease in healthy cells. Thus, if a healthy plant of Cactus be inoculated with some of the fluid from a plant affected with moist gangrene, diseased action will immediately commence and extend more or less rapidly. The action is analagous to what takes place with ferment when introduced into a saccharine liquid. The liability of the plant to the development of epidemic disease is produced by the state of the atmosphere as regards moisture, the prevalence of hot or cold weather, the amount of light, and probably the electrical condition of the air and earth. The natural decay of plants also renders them liable to attacks of Fungi, &c. Thus leaves before they fall are often affected. The trunk and branches of a tree become most frequently gangrenous when they have attained maturity. Soft fruits, as Apples, Pears, Oranges, Melons, and Grapes, are more exposed to the attacks of disease the riper they get. Ripe fruit is already entering into a state of decay, and this process is hastened by the introduction of the seeds of Fungi, or of the cells of diseased tissue. Most epidemic diseases may be averted by keeping plants properly exposed to light, air, and moisture.

1022. Many of the causes we have noticed may operate together in producing disease. If, from defect of nourishment in the soil, a plant is stunted or weak, it becomes predisposed to disease, and is very liable to the attacks of parasites. A sudden frost coming on in spring, after the sap has begun to flow, causes severe injury, and either kills the plant or renders it liable to disease. This occurrence is common in Britain, and is the cause why many half-hardy exotics require to be covered or kept in a dormant state until the season has advanced beyond the risk of frost. Many such plants grown on a wall with a southern exposure are stimulated by the heat of a fine day in early spring, and are thus unable to resist later frosts. Warm sun during the day, and frost at night, have proved fatal to many exotics introduced into Britain. Plants are fitted by their constitution for different climates. Some will bear a great range of temperature without injury; others can only bear a limited one. Some require a hot summer and a cold winter; others require a medium summer and a moderate winter.

1023. It has often been stated that tender exotics may by long cultivation be made to bear the climate of Britain. It has been thought that they may become accustomed to it by degrees, and thus be acclimatized. Some have even hinted that by sowing the seeds of such plants, in the first instance, in a warm temperate region, then collecting the seeds produced by the plants, and sowing them in colder districts, the species may be rendered hardy. We are constantly told that plants which, when first introduced into Britain, were put into stoves and greenhouses, are now growing in the open border freely, and that they can stand a climate which they could not do at first. Such statements do not rest on a sound basis; each species of plant bears a certain range of temperature, and we cannot extend its natural limits. The plants said to be acclimatized were not tried in the open air when first introduced, otherwise they would have been found to be hardy, without any previous process of cultivation in greenhouses. The well known shrub Aucuba japonica was treated in a stove when first introduced, and was afterwards planted out, and found to stand our climate. This was not an instance of acclimatizing, but indicated an error regarding the constitution of the plant which was brought from the colder parts of Japan, and was capable of enduring the cold of this climate naturally. Man did nothing in the way of changing its constitution and powers of endurance. A plant called Aponogeton distachyum flowers freely in the open pond of the Edinburgh Botanic Garden. This plant was introduced from Southern Africa, and was at first grown in stoves. A specimen was accidentally thrown into the garden pond many years ago, and there it has continued to thrive ever since, flowering during almost the whole year. The roots of the plant are deep in the water, and the pond is supplied by springs.* Had it been

* In the growth of aquatics attention must be paid not merely to the temperature of the surrounding air, but also to that of the water in the ponds. In the case of Richardia æthiopica and Aponogeton distachyum, plants of warm countries which grow in our ponds, facts are wanting as to

put into the pond when first introduced, the same result would have followed. We are too apt to suppose that plants coming from countries called hot, must necessarily be stove plants; not reflecting that they may have grown in very elevated and cold regions in these countries. Such is the case with many species introduced from Chili, Nepal, and Japan. There is no evidence that plants long cultivated in this country are able to withstand our winter cold better than formerly. The Dahlia, the Heliotrope, and the Potato, are affected in the same way by frost as when they were first introduced. Long cultivation has done nothing to increase their hardiness. When we consider that the great risk in this country is the accession of frost after a few genial days or weeks of spring, we may do something for the preservation of half-hardy plants by planting them in such localities and soils as to prevent them from being stimulated too easily, and from being attacked by frost when full of sap. We can put tender plants on elevated situations, not exposed to the direct rays of the sun, and on well drained soils, and thus prevent much injury. Hardiness, as we have already seen, may also be imparted by hybridizing and grafting. Tender trees or shrubs grown in warm and moist valleys, exposed to the sun's rays, are often injured by spring frosts. It is of great importance to define accurately when a plant may be said to suit a particular climate. It is not enough that it lives and sends out leaves, it must also be able to produce flowers and seeds, and to elaborate the peculiar secretions and products on which its qualities depend. The seeds of the Indian Hemp have been transmitted to this country, and the plants have grown well, even to the height of ten feet with thick stems, vigorous leaves, and abundance of flowers; but they did not produce the churrus or resinous matter which renders the plant valuable in India as a medicinal agent. The summer heat was wanting to enable the plant to perform all its functions. Such is also the case with Rhubarb, which, as regards the size and vigour of the plant, thrives well in this climate, but the root does

their habits in their native clime; and it would appear probable that in those instances in which they have been successfully cultivated in Britain, their roots and the lower part of their stems have been exposed to the influence of springs of a higher temperature than that which usually occurs in the ponds of this country. This view is confirmed by the circumstances connected with the growth of Aponogeton distachyum in the Edinburgh Botanic Garden. Mr. M'Nab has supplied us with the following particulars:—

"The Aponogeton distachyum was long cultivated in the Edinburgh Botanic Garden as a stove aquatic, in which situation it grew freely and flowered profusely. It was also long treated in the green-house aquarium, where it attained the same state of perfection as it did in the stove-house.

"About the year 1828, the large water-trough containing the Aponogeton was sunk into the west end of the open pond to a depth of three feet, where the plant has continued to thrive vigorously every year since, considerable patches (some eight feet in diameter) being seen in various parts of the pond.

"The depth of the pond varies from two to four feet, the bottom being wholly coated with mud, composed chiefly of decayed vegetable matter. It was originally paved with stones, each eight inches deep, and from four to five inches broad, sand only being placed in the interstices, so as to allow the springs, which are very numerous, to rise freely between them.

"The Aponogeton generally flowers during eight or nine months in the year. In autumn it produces viviparous buds, which drop from the plant, and grow freely in the mud. During severe winters, the leaves of the Aponogeton are destroyed by the frost, but the roots have never been killed, although the pond is frequently frozen over."

not produce a medicinal agent of the same quality as that grown in Chinese Tartary.

1024. Cold and bad soils are fruitful sources of disease. When plants are grown without the influence of light, they assume a white or yellowish aspect, thus becoming blanched or etiolated. In certain instances plants, even when exposed to light, present a pale and sickly hue, which is often referrible to the nature of the soil, or to constitutional weakness. In many crops we observe plants having a pallid aspect owing to ungenial weather and damp soil in the first instance. The diseased state thus induced is called by Berkeley chlorosis ; some have recommended for its removal the application of a weak solution of sulphate of iron along with draining.* Plants, whose natural habitat is shady, become diseased when excess of light is supplied. Frosts, as well as excess of heat, render the stamens and pistils abortive. Spotting of the leaves, and canker of the stem, are often due to similar causes. When moisture is supplied in too great quantity, the plants become dropsical ; and when the transpiration exceeds the absorption, the leaves often fall off. The dry and hot atmosphere of rooms often causes defoliation and disease in plants. Excessive development of hairs is sometimes a consequence of growing plants in very dry air. Diseases caused by changes in the atmosphere are often epidemic, and attack large districts of country.

1025. The influence of the sea breeze, carrying with it saline matter, is prejudicial to most plants. Plantations are frequently injured from this cause. A good illustration is seen at Gosford, near Edinburgh, where the trees, on reaching the top of a wall, are stopped in their growth by the sea breeze, and their tops form an inclined plane proceeding inwards from the wall as a base. Some plants withstand this influence better than others. The following trees, shrubs, and herbs, have been recommended as withstanding the sea air :—

Acer Pseudo-Platanus.
Pinus Strobus.
—— Pinea.
—— Cembra.
—— Pinaster.
Quercus Ilex.
Pyrus Aria.
Hippophae rhamnoides.
———— conferta.
Tamarix gallica.
——— germanica.
Pyrus japonica.
Leycesteria formosa.
Spiræa salicifolia.
Colutea cruenta.
Sambucus racemosa.
Coronilla Emerus.
——— varia.
Statice latifolia.
——— tartarica.
Armeria, various species.
Lathyrus grandiflorus.
Saxifraga cordata.
———— crassifolia.
Iberis sempervirens.

1026. Trees are sometimes destroyed or injured by external causes, such as by strong winds, severe storms, and electricity. The effects

* Berkeley, on Chlorosis in Plants, in Morton's Cyclopædia.

of lightning on trees is occasionally remarkable. The largest trunks are split into pieces. This was well seen in the case of a fine Oak at Edmonstone, near Edinburgh, which was struck by lightning in the summer of 1849. The trunk was shivered to pieces, and large portions were thrown to a considerable distance. Martius thinks that the splitting of trees into shreds in these instances depends on the effect of intense heat on the sap. The splitting takes place in various ways in different trees. In Oaks the cleavage is very perfect. The tree is divided into laths which are often thin and flexible, the direction of the cleavage corresponding to the medullary rays. In Beech trees the cleavage is coarser than in Oaks. In Poplars the cleavage is perpendicular to the medullary rays. Resinous trees, as Pines, Firs, and Larches, are not so liable to be cleft, probably from the nature of their non-conducting resinous matter, and from the small amount of sap. The Oak, Elm, Poplar, Beech, Holly, Horse-Chestnut, and Ash have been observed to be struck by lightning.

1027. The attacks of parasitic Fungi cause extensive injury and disease in plants. Some think that the spores of Fungi coming into contact with the plant act both as the predisposing and exciting cause of disease; others, perhaps more correctly, think that some change is first produced in the cells of the plant, which enables the spores to find a nidus, and then the disease goes on rapidly, assuming a peculiar type on account of the presence of the Fungus. In the same way as vegetable organisms found in diseases of the skin are not to be looked upon as the origin of the disease, but as being developed in textures previously morbid, and as giving often a peculiar character to the disease.* Many of the diseases of cultivated crops are attributed to Fungi.† The spores of Fungi are very minute, and are constantly floating in the air. They can easily be applied to the surfaces of plants. When they find an appropriate soil they send out extensive filiform ramifications which spread under the epidermis of plants, raise blisters, and finally burst forth in the form of orange, brown, and black spots constituting the fructification. They attack the stem, leaves, flowers, and fruit. Different species are restricted to different plants, and even to different parts of the same plant. The forms

* This subject has been already noticed under germination (p. 635). For further particulars as to the effects of Fungi and other cellular plants on diseases, and the nature of Entophytes growing on living organisms, the student may consult Deslongschamps on Cryptogamics on the internal surface of the air-cells in the eider-duck, in Comptes Rendus, 1841, p. 1110. Annals of Nat. Hist. viii. 229. Muller, on Fungi in the Lungs of Birds, Archiv. 1842, p. 198. Philosophical Magazine for 1853, ii. 74. Annals of Nat. Hist. ix. 131. Hannover, on Entophytes of Mucous Membranes, in Muller Archiv. for 1842, p. 281. Gruby, on Porrigophytes, in Muller Archiv. for 1842, p. 22, and in Comptes Rendus for 1843, xi. 301. Stilling, on a Contagious Confervoid Growth on Living Frogs, in Muller Archiv. for 1841, p. 279. Goodsir, on Achyla prolifera on Gold-fish, in Ann. Nat. Hist. ix. 333. Remarks on Entophytes, in Ray Soc. Reports for 1845, p. 417-432. See also reference in note at page 636.

† See Henslow, Report on the Diseases of Wheat, in Journ. Agricult. Soc. of England, ii. 1. Sidney, on the Parasitic Fungi of the British Farm, in Ibid. x. 382. Philippar, Traité Organographique et Physiologico-Agricole sur la Carie, le Charbon, l'Ergot, la Rouille, et autres maladies du même genre qui ravagent les Céréales, Versailles, 1837. Graham, on the Injuries sustained by Plants from the attacks of Parasitic Fungi, in Journ. Eng. Agric. Soc. xi. 443.

which the same Fungus assumes seem to vary sometimes, according to the plant on which it grows.

1028. The disease called Bunt, Smutballs, or Pepper-brand, is occasioned by the plant called Uredo Caries by De Candolle, and Uredo fœtida by Bauer. It attacks the grains of Wheat, and may be detected in them in their earliest state. It is represented in Figure 1301. It consists of extremely minute globules of a dark colour, at first attached to a thread-like matter or mycelium. Bauer estimates the diameter of each of the globules at 1-1600th of an inch, and consequently a grain of Wheat (reckoned at less than 1-1000th of a cubic inch) would contain four millions such spores.* The spores or powdery matter has a disgusting odour; hence the specific name given to it. The disease is propagated by contact. Steeping the grain is recommended by some as a means of prevention, and alkaline solutions have been suggested as a remedy. Uredo linearis, which is met with also in this disease, is considered as being a young state of the Mildew plant.

1029. Another disease, called Smut or Dust-brand, is caused by a Fungus called Uredo segetum. It resembles the Bunt Fungus in colour and shape, but its spores are not half so large, and it does not possess a fetid odour.† This Fungus destroys the ear of Corn by first causing the innermost parts of the flower to become abortive, while the pedicels on which these are seated swell and become very fleshy. The Fungus then consumes the whole of this fleshy mass, and at length appears between the chaff scales in the form of a black soot-like powder. It is said also to attack the stem and leaves. When ripe, the spores burst through the epidermis, and are dispersed in the form of a black powder like charcoal. The spore is 1-2800th of an inch in diameter. Smut is rare in Wheat, it is common in Barley, and more so in Oats. It is also seen in many grains, such as Arrhenatherum avenaceum.

1030. The disease denominated Rust, Red-rag, Red-robin, and Red-gum, is caused by a Fungus called Uredo Rubigo (Fig. 1302). It forms yellow and brown oval spots and blotches upon the stem, leaf, and chaff. The spores burst through the epidermis, and are dispersed as very minute grains. The disease is common in Corn and in Grasses. Mildew is a disease caused by a Fungus denominated Puccinia graminis (Fig. 1303). The ripe spore-cases of this plant are small dark brown club-shaped bodies, their thicker end being divided into two chambers, each filled with minute spores, and their lower end tapering into a fine stalk. The sori or clusters of spore-cases burst through the epidermis sometimes in vast numbers.‡ The minute

* See Figure by Bauer, in Penny Magazine for 1833, p. 126.

† See Figure by Bauer, in Penny Magazine for 1833, p. 180. See also Brongniart, sur le Développement du Charbon (*Uredo segetum*), dans les Graminées, in Ann. des Sc. Nat. 1st ser. xx. 171.

‡ Banks, on Blight, Mildew, and Rust of Corn, with Figures by Bauer, in Annals of Botany, ii. 51; also Nicholson's Journal, x. 225. Henslow, on the Specific Identity of Fungi producing Rust and Mildew, in Journ. Eng. Agric. Soc. ii. 22. Lambert, on Blight of Wheat, in Linn. Trans. iv. 193. Kirby, on certain Fungi which are parasites of the Wheat, in Linn. Trans. v. 112.

spores seem to enter the plant by the stomata. Some think that they, as well as other minute spores, are absorbed by the roots. The disease attacks Wheat. Spring Wheat is less liable to this disease than winter Wheat, and heavy soils are less subject to it than light ones. Many have supposed that the Barberry is in some way connected with the production of Mildew. This idea has been proved to be erroneous by the experiments of Staudinger, near Hamburg, and of Hornemann, at Copenhagen. Unger entertains the idea that Blight, Mildew, and Smut are to be considered as Exanthematous diseases of plants, caused by the spores of Fungi entering the stomata.*

1031. Henslow has shown by experiment, that if the diseased seeds of Wheat be steeped in a solution of sulphate of copper, they will not produce diseased grain, and that the sulphate of copper does no injury to their germination. The solution used is one ounce of sulphate of copper to a gallon of water for every bushel of Wheat. Grain also steeped in hot water did not reproduce these fungoid diseases. In East-Lothian, with the view of preventing Smut, seed Wheat is often

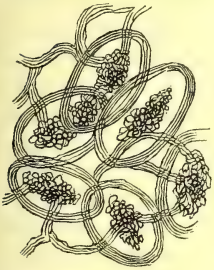

Fig. 1301.

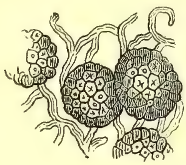

Fig. 1302.

Fig. 1303.

steeped in stale urine, and afterwards some newly slaked lime sifted on it. Sometimes a solution of salt is used as a pickle. Fourcroy and Vauquelin ascertained by analysis that blighted Wheat contained an acrid oil, putrid gluten, charcoal, phosphoric acid, phosphate of ammonia and magnesia, phosphate of lime, and no traces of starch.† As regards Bunt or Pepper-brand, Henslow remarks, that upon simply immersing the grain in water, the infected seeds float, and on the water being poured off nothing but the sound ones remain in the vessel. This simple process of separation is not, however, perfectly effective, because in thrashing the Wheat, many of the infected grains are crushed,

Fig. 1301. The Fungus (*Uredo Caries* or *Uredo fœtida*) which causes the disease called Bunt, Smutballs, or Pepper-brand. It consists of dark globules attached to a thread-like mycelium.

Fig. 1302. Fungus (*Uredo Rubigo*) which is met with in the disease called Rust or Red-gum. It forms yellow or brown oval spots upon different parts of plants.

Fig. 1303. Fungus (*Puccinia graminis*) which is found in the disease called Mildew. It consists of dark-brown club-shaped bodies, the thicker end of which is divided into two cavities filled with spores.

* Unger, Die Exantheme der Pflanzen und einige mit diesen verwandte Krankheiten der Gewächse, Vienne, 1833; also Ann. des Sc. Nat. 2d ser. Bot. ii. 193.

† Fourcroy et Vauquelin, de la Nature Chimique du Blé Carié, in Annales du Museum, vi. 332.

and the spores are dispersed in the form of fine powder, which adheres obstinately to the sound grains by means of an oily or greasy matter found in the Fungi. In order to detach them thoroughly, it has been considered useful to add some alkaline ley to the water in which they are washed. The alkali unites with the oil, and forms a soapy matter. Lime has been used for this purpose; common potash, substances containing ammonia, and the liquid from stable-dung, have also been employed. Other matters, as sulphate of copper, act by destroying the vegetating powers of the Fungi.

1032. Mr. Ellis of Barming, Kent, says, that the invariable prevention of Smut in Wheat is accomplished by scalding the blackest Wheat in boiling water, and afterwards drying it with lime. The Wheat placed in a colander or in a basket, is immersed in boiling water for a few seconds, just long enough to wet it completely; it is then immediately dipped in cold water, afterwards dried with lime, mixed with the other Wheat, and sown. By this means the Wheat was always found to be cured of Smut, while the vegetating principle was uninjured; great care being taken that the water was boiling, and the Wheat taken out of the water as soon as completely wetted. Mr. Ellis tried an experiment on a bushel of the blackest Wheat he could procure, which he divided in 16 equal parts, sowing them all the same day, but with different treatment. The result at harvest was, that the Wheat sown without preparation produced 33 black ears out of every 100, while that dipped in the boiling water and limed, had not a black ear in several thousands which were examined.

1033. Many other species of Uredo, as well as Ustilago, give rise to diseases. They receive their names from the plants on which they are parasitic, and it seems probable that the same species presents various forms according to the situation in which it grows.* Ustilago Maydis, or Maize Smut, is a Fungus which gives rise to protuberances on different parts of the Maize. The stem, upper leaves, and especially the bracts, become immensely swollen when attacked by this disease, and the ovaries, ovules, and male blossoms are not exempt. The parts affected are at first white, tinged with red, smooth and juicy. The cellular tissue increases in volume, and is permeated by radiating lines consisting of mycelium and spores. The spores are twice as large in linear measure as those of the Oat-Smut. At first the small balls contain a dark strong-smelling fluid, but ultimately the masses become dry, and present a quantity of dark dust mixed with irregular threads. Ustilago vittata causes disease in grasses in India. The spores of Ustilago hypodytes (Fig. 1304), also cause disease in grasses. The spores are black and round, and the disease

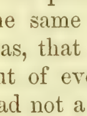

Fig. 1304.

Fig. 1304. Spores of a Fungus (*Ustilago hypodytes*) which causes disease in grasses. The spores are black and round, and are sometimes produced in great abundance in hay fields in France.

* Tulasne, sur les Ustilaginées et les Urédinées, in Ann. des Sc. Nat. 3d ser. Bot. vii. 12.

they occasion is denominated Grass-Smut. The plant is described by Tulasne. According to Leveillé, the immense quantity of black dust resulting from it in the hay fields of France produces injurious effects on haymakers.

1034. A species of Depazea or Septoria sometimes produces disease in the knots of the Wheat. Various species of Erysiphe, such as E. guttata, penicellata, graminis, adunca, and bicornis, give rise to kinds of mildew. Erysiphes are often met with in common Pea crops. Some say that Oidiums are merely particular states of Erysiphes. The plant producing mildew in the Vine, is Oidium Tuckeri of Berkeley. Other species of Oidium probably cause mildew in the Peach, Rose, Hop, Pea, and Onion. For destroying the mildew in Vines, sulphur is recommended to be dusted on them. Some also use a solution of hydro-sulphate of lime made by boiling sulphur and lime in water. A Fungus called Rhizoctonia Mali, is said to grow on the roots of Apples, Pears, and Quinces, and to cause destruction to the trees.

1035. Ergot is a monstrous state of the grain, in which the enlarged and diseased ovary protrudes in a curved form resembling a cock's spur; hence the name from the French *ergot*, meaning a spur. The ovary is black externally, spongy internally, and contains much oily matter. Some consider it as produced by the attack of a Fungus, which induces a diseased condition in the ovarian cells. The disease is usually met with in Rye, and the name of Spurred Rye is applied to it. It sometimes occurs in Wheat and in Barley, and it has also been noticed in Lolium perenne and L. arvense, Festuca pratensis, Phleum pratense, Dactylis glomerata, Anthoxanthum odoratum, Phalaris arundinacea, and Alopecurus agrestis. Ergot consists of a very dense tissue formed by polygonal cells united intimately with one another, and filled with an oily fluid. It is developed in the unimpregnated ovule of Rye; for although extremely dilated by the entophyte, and rendered difficult of recognition, the integuments of the ovule increase without completely losing the form which they would have assumed if they had grown into a true grain, imitating in this respect the ovaries of Wheat, in which Tilletia Caries (Bunt) has replaced the seed. The solid mass which has been called Sclerotium Clavus by De Candolle, and the filamentous portion called Sphacelia, by Leveillé and Fee, and Ergotætia by Quekett, are only, properly speaking, organs of vegetation. The Fungus destined to grow from this apparatus is an elegant Sphæria, probably that called by Fries Cordyliceps purpurea. This plant has been seen by Schumacher in diseased cereal grains, and it has been detected by Roussel in Sclerotium Clavus growing on Bromus sylvaticus, and Arundo Calamagrostis, and by Dumeril in Ergot of Rye. Tulasne has shown, that this Cordyliceps is produced from the Ergot when it is allowed to vegetate. Ergot of Grasses and Ergot of Cyperaceæ, according to Tulasne, do not belong to the same vegetable species.* Rye affected with this disease, when used as bread, is very prejudicial. The Abbé Tessier showed that Ergot caused gangrene in animals fed on it, and many instances are recorded of gangrene of the extremities occurring in persons who had lived on diseased Rye. Ergot is said to prevail in Rye grown on wet and stiff land.†

1036. The disease which has recently attacked the Potato in various parts of the world, is by many attributed to the attack of Fungi. This view has been strongly advocated by Berkeley,‡ who describes the Fungus as Botrytis infestans (Fig. 1305). The spores are supposed to enter the stomata, and to cause disease in the leaves in the first instance, which afterwards extends to the tubers.§ The effects produced on the leaves resembled much those caused by poisonous gases, such as hydrochloric, sulphurous, and nitric acids (p. 478).

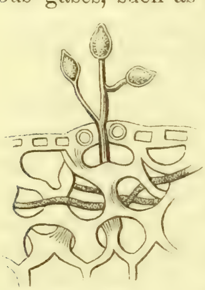

Fig. 1305.

Berkeley attributes the Potato disease entirely to Fungi. He states that the disease commenced in the leaves. They were attacked by the Mould, which ran its course in a few hours, and from the rapidity of the action the period for examination of the leaves was often passed over. The Fungus generated does not live on decayed or decaying matter, but is one which produces decay, and renders the plants unhealthy. The Fungus acts by feeding on the juices of plants, preventing the elaboration of the sap in the leaves, obstructing the admission of air and the emission of transpired fluids. The stem is thus overcharged with moisture, and ultimately rots, while every source of nutriment is cut off from the half-ripe tubers. The atmospheric conditions during the late disease made the Fungus spread rapidly.

1037. While there is no doubt that the Botrytis is developed in the progress of the Potato disease, the question arises whether or not it is the originating cause. The view which seems to be most consonant with the phenomena is, that changes are induced in the cells of the

Fig. 1305. Fungus (*Botrytis infestans*), which occurs on diseased leaves of Potatoes, and which is supposed by Berkeley, Morren, and Townley, to be the original cause of the late Potato disease. The Fungus is represented spreading through the substance of the leaf by means of its mycelium, which sends up, through the leaf, fructification bearing numerous spores.

* Tulasne on the Ergot of Rye, Sclerotium Clavus, in Comptes Rendus for Dec. 8, 1851; and in Ann. Nat. Hist. 2d ser. ix. 494.

† For remarks on Ergot, see Fontana, sur l'Ergot, in Journ. de Physique, vii. 42. Tessier sur les Maladies des Graines. Smith on Ergot, in Linn. Trans. xviii. 3.

‡ Berkeley on the Potato disease, in Journ. of Hort. Soc. of London, 1846.

§ Morren and Townley also adopt the Fungus-view of the Potato disease. The following is the description of the Botrytis infestans of Montagne:—Mycelium or sterile flocci lax, erect, white, more or less branched at apex; branches everywhere knotted, erecto-patent, spores lateral and terminal, solitary, ovoid-elliptical, comparatively large, same colour as tissue, sub-apiculate, with a granular nucleus. Botrytis infestans has also been noticed in the Tomato, while Botrytis parasitica has been observed in Turnips. Beet-root and Carrots are liable to similar attacks from species of Botrytis.

Potato by cultivation, which render the leaves liable to disease. Atmospheric influences are thus enabled to act upon them, so as to cause alterations in their cells; and the attack of a Fungus such as the Botrytis accelerates the morbid action, and causes it to assume a peculiar form. In this way high cultivation, atmospheric influences, and Fungi, all contribute to cause the disease. In the Potato disease of 1845, Harting says that brown granular matter was deposited in the cells, first in those near the epidermis, then the cellular walls lost their transparency, and the cellules could no longer be isolated by boiling water, next the cell-wall was destroyed, and small cavities were formed in the midst of the tissue, in which were agglomerated grains of starch, and finally parasitic organisms appeared in the cavities. The vegetable parasites developed were Polyactis alba, Fusisporium Solani, F. didymum, F. candidum, and Oidium violaceum. When the disease had advanced, insects were also present.

1038. Crum attributed the disease of the tubers of the Potato to rupture of the starch cells and mixture of their contents with nitrogenous matter, thus causing fermentation as in the Apple and Grape.* Solly objects to the Fungus theory of Potato disease. He says that decaying organic matter is necessary for the growth of Fungi. He thinks that the disease is caused by the presence of putrifying azotized matter in the stem, just below the surface of the soil; that this is carried to all parts of the plant, causes a struggle between vital and chemical forces, and induces decomposition by a process of fermentation. The azotized matter, in a condition to act as ferment, is produced by the state of the season, by deficiency of light, and by other meteorological causes. Analyses show that the constituents of the diseased Potato undergo a rapid and important change. Dr. Lyon Playfair and Mr. Phillips found that the amount of albumen and gluten decreased from 2.34 in the sound Potato to .32 in the diseased, and when the disease advanced they finally disappeared.

1039. Mitscherlich† says that the change which cellulose undergoes by the action of a peculiar ferment is characteristic of the substance. This fermenting agent is obtained when half-putrid Potatoes cut up into pieces are placed in water, with portions of fresh Potatoes, and allowed to stand until the cells of the fresh portions begin to be easily separable. It is also formed, though more slowly, when fresh Potatoes, cut up, are set aside, covered with water; the liquid is filtered, and fresh Potatoes, cut in slices, added to it; when these are decomposed, a portion of the liquid may be treated with water, and more slices of Potato added, which soon become decomposed, and in

* Hassall thinks, that the rapid decay of many fruits, more especially those of the Apple tribe, is owing to the formation of Fungi in their interior. These Fungi appear in the form of ramified filaments passing in all directions between and around the cells of the parenchyma of the fruit. They insinuate themselves between the cells of the pulp of the fruit, detach them from their connection with each other, destroy their vitality, and ultimately produce decomposition.

† Ann. der Chem. und Pharm. lxxv. p. 305; Reports of the Berlin Acad. March 1850, p. 102; Chemical Gazette.

this manner increase the activity of the liquid. Hence, just as in the fermentation of an infusion of malt, the yeast, the fermentative Fungus, becomes augmented, so does the ferment increase. It only acts upon the cellulose, which forms the walls of the starch-cells of the Potato; first, the cells separate from each other, so that it furnishes us with a convenient means of obtaining the cells with their contents in an isolated state, and facilitating their examination; the walls of the cells are subsequently also dissolved, and the starch particles fall out; in this manner, in twenty-four hours, a slice of Potato is rendered so soft, to a depth of two lines, that this portion can be removed by a pair of forceps, the hard mass of the Potato lying beneath the softened layer; so that this process takes place successively from the outside towards the interior; not by the whole of the Potato being simultaneously permeated by the ferment to the innermost portion. Exactly the same process as that which we can produce spontaneously, he says, occurs in the Potato disease, which, during late years, has done so much mischief. In this also, the cellulose, and not the starch, is decomposed; and the liquid, which the author had kept for a long time in contact with one of the diseased Potatoes, immediately produced the decomposition of a sound one. This decomposition is, therefore, he says, not the disease itself, but merely the result of it. Its cause undoubtedly depends upon the dying, or the previous death, of the entire plant; and just as it is well known in the case of other plants, that they die when the apices of their roots are too strongly cooled, so may a sudden cold rain, following a long warm winter, produce a similar condition of the Potato plant. It is only after decay has commenced that Fungi and insects attack the plant.

1040. Liebig attributed the Potato disease to diminished or suppressed transpiration depending on the hygrometric state of the atmosphere.* He refers to Hales' accurate researches in regard to the Hop-blight, in which the disease is traced to the want of correspondence between absorption and transpiration, and a consequent stagnation and decomposition of the juices. The same thing, he thinks, takes place in the Potato in consequence of cold and an atmosphere loaded with moisture, and he shows that in 1845 and 1846, when the disease overran Europe, damp, cold, and rainy weather followed heat and drought, just at the period of the most luxuriant growth of the Potato. The vessels and cells became charged with fluids, owing to the checked transpiration; there was stagnation of the sap and death. Fungi and putrefaction are, according to him, the consequences of the death of the plant. Klotzsch proposes to check the Potato disease by pinching off the extreme points of the branches and twigs to the extent of half an inch downwards, when the plants have attained the height of six or nine inches above the soil, and to repeat this on every branch and twig on the tenth or eleventh week. This check to the

* Liebig on the Potato Blight, in his Researches on the Motion of the Juices in the Animal Body, p. 87.

stem and branches, he thinks, will direct the nutrient matters in the direction of the increase and multiplication of subterranean as well as aerial branches. This leads to increased development of tubers, and strengthens the leaves and stalks.* Tombelle Lomba of Namur says that he has saved Potatoes from disease by cutting off the stems, after flowering, with a very sharp sickle, and then covering the ground with earth to the depth of not less than one and a half inch. The top-dressing thus applied was not disturbed until the Potatoes were ripe. The haulm was removed after being cut. It is said that the tubers acquired a good size, and were of excellent quality. If these facts are true, it would appear that, while leaves are necessary to the development of tubers, the latter, on acquiring a certain size, can continue their growth by their own proper and unassisted vitality.

1041. The general conclusions to be drawn from all that has been said relative to the Potato disease are, that changes are induced in the cells and vessels of the Potato by certain obscure meteorological and epidemic causes, that an alteration takes place in the cellulose and in the contents of the cells, which speedily leads to decay; that parasitic Fungi find a nidus in the decaying organic matter, so as to accelerate and give a character to the disease, and that as yet no remedy has been devised.†

1042. Dry rot is a disease to which the wood of trees is liable. It may be traced in the first instance to some alteration in the woody tissue produced by moisture or other causes, and the subsequent development of a Fungus which spreads its mycelium through the texture, and produces rapid disorganization. Trees growing in wet and ill-drained soil are subject to rot. The more abundant the alburnum or sap-wood, the more liable are trees to decay. The disease which has recently attacked the Larch is attributed by some to the roots reaching ungenial soil, and to the production of dry rot. This rot in the Larch begins in the heart-wood, near the root, and it spreads outwards; layer after layer crumbling like saw-dust. Among the crumbling mass is to be found in abundance the mycelium of some Fungus. When the rot has reached the alburnum a thick leathery white formation appears between the bark and wood, which formation is identical with the appearances connected with dry rot. In dry rot the decay takes place in the first instance in the contents of the woody tubes, and thus a suitable soil is supplied for the spores of Fungi, such as Merulius lacrymans or vastator, and Polyporus destructor. When these plants begin to grow, they spread their mycelium with great rapidity. If air is allowed to circulate freely around wood, dry rot does not attack it. But if it is placed in a damp situation without a circulation of air, then decay takes place. The spawn of the dry-rot Fungus deprives

* Klotzsch in Appendix to Liebig's Researches on the Juices of Animals, p. 102.

† For further remarks on the Potato Disease, see Report on this subject in the Transactions of the Highland Society for October 1846, p. 436; also Fromberg on the Potato Disease, in Journal of Agriculture for July 1846, p. 338. Martius on the Potato Epidemic (in German), Munich 1842.

the woody tubes of their contents, for the purpose of getting the nourishment it requires, and the wood loses its consistency and toughness, the walls of the tubes becoming brittle, and ruptured.*

1043. The great cause of decay in wood is moisture. Wood in a dry state may be preserved for a long time, as may be seen in the case of wood in some old buildings as Westminster Hall. Saw-dust is wood in small pieces ; when wet it soon rots, but when dried thoroughly it may be kept for an indefinite period. To have timber in the driest state, it ought to be felled between the fall of the leaf and the spring, the nearer the former time the better. The timber of some trees is much more subject to decay than that of others. The wood of the Cypress is very durable.† A great error in building is painting wood early, and thus enclosing within it the elements of decay by not allowing the escape of moisture. In olden times the wood was left bare, and exposed to currents of air which kept it dry. Hence its durability. Such is the case with the roof of Westminster Hall, which dates from the time of Richard the Second, and still is sound. So also the wooden roof of York Minster, constructed in the thirteenth and fourteenth centuries ; also the timber of the Hospitium, constructed about the same period in the garden of the Yorkshire Philosophical Society. Old doors and ancient pews in village churches owe their durability to the same causes, namely, thorough drying by exposure to air without being covered with paint or plaster.

1044. Various means have been proposed for preventing timber from being attacked by dry rot. We have already alluded (p. 449) to Boucherie's method of causing growing trees to absorb fluids of different kinds, which he considered as acting on the contents of the woody tubes in such a way as to render them less liable to disease. The solutions he employed were acetate of lead, pyrolignite of iron, and corrosive sublimate. He also found that trees, immediately after being cut down, when their extremities were immersed in these solutions, absorbed them with rapidity. A tree having been sawn near the root, is placed in a horizontal position, and a cap of leather or waterproof cloth is tied firmly over the lower end, leaving a sufficient space for the solution. This is introduced by a flexible tube luted to the leathern cap, and communicating with a barrel placed at some height above the timber, so as to give the pressure of a column of six or eight feet. The liquid is put into the barrel. In this way twenty or forty gallons of the solution of acetate of lead may be made to filter through the pores of the wood. Mr. Hyett has adopted Boucherie's method, and has given colours to timber by making the wood absorb in succession fluids,

* Schwabe on Dry Rot, in Linnæa for 1840, p. 194. Dr. R. Dickson's Lecture on Dry Rot. Ray Society's Reports for 1845, Botany, p. 84. See also Quekett on the Presence of a Fungus in the interior of a living Oak Tree, in Quart. Journ. of Microscopical Science, i. 72. Naegeli on Fungi in the interior of Plants, in Linnæa, xvi. 288.

† Chests containing Egyptian Mummies were made of Cypress. The gates of St. Peter's at Rome, which had lasted from the time of Constantine to that of Pope Eugene the Fourth, *i.e.* 1100 years, were of Cypress, and had during that time suffered no decay.

which, by their combination, produced a coloured compound, such as ferrocyanuret of potassium and sulphate of iron.

1045. Timber, after being cut, has been subjected to various processes for the purposes of rendering it durable. Kyanizing is performed by subjecting the wood to the action of corrosive sublimate, by means of which it is probable that the albuminous matter is coagulated, fermentation is prevented, and hence the wood is rendered less liable to decay and to the atttacks of Fungi. Kyan's solution is made to pass rapidly through wood in vacuo. Sir William Burnett found that the application of chloride of zinc to vegetable matters, such as wood and canvas, had the property of effectually guarding them against all the ordinary causes of destruction, without communicating any bad property to the substance prepared from it. Canvas so acted on was kept long in damp cellars, and exposed to various vicissitudes, without being injured, while ordinary canvas in similar circumstances became rotten. The process has received the name of Burnettizing. Burnett's antiseptic solution, of one pound of chloride of zinc to five gallons of water, has been tried in Woolwich Dockyard with success.

1046. Mr. Bethell uses creasote for the preservation of wood. The creasote acts by coagulating the albumen, and preventing putrefactive decomposition. Along with the creasote there are other products of the distillation of coal tar, especially bituminous oils, which enter into the cells, and by surrounding the woody fibres, prevent the action of water and air. There are two methods pursued—1. By placing the wood in a strong iron cylinder, exhausting the air from it by an air-pump, until a vacuum is produced equal to about 12 lbs. on the square inch; then the creasote is allowed to flow into the cylinder, and afterwards pressure is put on the creasote by a force-pump equal to about 150 lbs. on a square inch. The timber is then taken out fit for use. 2. By placing the timber in a drying-house, and passing the products of the combustion of coal-tar through it. Thus the timber is dried rapidly, and impregnated to a certain extent with oily matter, and with the creasote given off from the fuel used to heat the house. The timber is then taken out, and immersed in hot creasote in an open tank. A load of fir timber will absorb 40 gallons; close-grained woods less. A cubic foot of Beech usually weighs 8 lbs. heavier after being so prepared. Creasote is said to prevent the decay of wood, and to stop the attacks of Teredo navalis.

1047. Gangrene is a disease of plants similar to what occurs in animal tissues. It is met with in leaves, fruits, and stems. Succulent parts are most liable to be attacked. It is divided into moist and dry gangrene; the moist occurring in the succulent parts of plants, and the dry attacking the woody parts, as the stem of shrubs and trees. All forms of gangrene are sometimes called Canker; but this term is more especially confined to a peculiar disease of the bark and stem of Apple and Pear-trees. Moist gangrene occurs often in Cactaceæ and Mesembryaceæ; it is also met with in the Cucumber, Melon, and other fruits, as well as in the Balsam and in succulent plants. It begins by dark green spots of various sizes, which soon increase and change colour. A swelling first takes place, and then a contraction; the epidermis bursts, and a dark fluid oozes out, having a fetid odour. The disease goes on increasing, until complete disorganisation takes place. The diseased cells are found to contain dark granules. Sometimes also a vibrio has been detected. The disease is produced by cold and moisture. Its cure is attempted by cutting away diseased parts, giving a proper amount of temperature, a drier atmosphere, and a drier soil.

1048. A peculiar disease attacks some kinds of Stone-fruit. It consists in a peculiar enlargement of the shell of the young fruit, which then grows up into a distended leathery bag. The cause of it is unknown. In a Bird Cherry found on the Himalayas, this is so common as to have given rise to the supposition that the plant in this condition is a distinct species, which has been called Cerasus cornuta. On the banks of the Dee, near Aberdeen, Mr. Wyville Thomson observed the fruit of the Prunus communis, var. insititia, presenting the appearance of green legumes in place of drupes—the fruit being abortive.

Fig. 1306.

1049. Phanerogamous parasites are also injurious to plants. Among them may be noticed especially species of Cuscuta or Dodder (Fig. 1306), which prove destructive to crops of Flax and Clover. Their seeds are sown with these crops, and germinate like other plants. Ere long they become attached to the stems of the plants in their vicinity by means of suckers, and then they act as true parasites, living on the sap of the plants, and finally destroying them. It is of great importance for the farmer to see that the seeds of Flax and Clover are free from those of Dodder. Other parasites, as Broom Rapes (Fig. 126, p. 54), Mistleto (Fig. 125, p. 53), &c., in a certain degree injure the plants on which they grow, but they are by no means so injurious as the Dodders.*

1050. Many substances act as poisons to plants as well as animals. We have already given full details in regard to the effects of poisonous

Fig. 1306. A parasitic plant called Dodder (*Cuscuta*), which grows from seed in the usual way, with its roots in the soil, but afterwards twines round other plants, such as Trefoil and Flax, and attaches itself to them by means of suckers, *a*. It loses all connection with the soil, and lives on the plant, which it finally destroys.

* Babington on the Flax Dodder, in Journ. Eng. Agric. Soc. ii. 63.

gases on vegetation (p. 478). The experiments of Turner and Christison distinctly show that irritant gases, such as sulphurous, hydrochloric, and nitric acid, act by destroying first the parts to which they are applied, more especially those where there is abundance of moisture; while narcotic gases, like hydrosulphuric acid, have a general effect on the irritability of the plant. Marcet and Macaire* experimented on the influence of fluid poisons on plants. They concluded that metallic poisons acted on vegetables in the same way as on animals. They were absorbed, and destroyed the organs to which they were applied; while narcotic vegetable poisons destroyed the whole vitality of the plants, without any local irritation. In their experiments they employed arsenious acid, corrosive sublimate, salts of mercury, tin, copper, and lead, Cocculus indicus, Belladonna, Opium, Nux vomica, Digitalis, oxalic acid, and prussic acid.

1051. Injurious effects are produced on plants by insects of various kinds. Some of them feed on the plants; others form habitations for themselves in the leaves and flowers; others puncture different organs with the view of depositing their ova. Earcockle, Purple, or Peppercorn, is a disease caused by a minute animal called Vibrio Tritici, or the Eel of the Wheat. The disease was noticed by Needham more than a century ago. The infected grains turn dark green at first, and ultimately nearly black. They become rounded, resembling a small Peppercorn, but with one or more deep furrows on their surface. The husk of the chaff spreads open, and the awns are twisted. The blighted grains are full of a moist, white, cottony substance, and contain no flour. When the cottony matter is placed in a drop of water under the microscope, a multitude of minute eel-shaped animalcules are seen in active motion.† Early in March the animalcules find their way into the grain from the earth, and thence into the young plant. They ascend within the stem, and reach the ovary. They then grow rapidly, and die after depositing numerous ova. The young are hatched in eight or ten days afterwards, and speedily attain 1-33d of an inch in length, and 1-1200th of an inch in diameter. When full-grown, the vibrio is $\frac{1}{4}$th of an inch long, and 1-30th of an inch in diameter. Not less than 50,000 of the young might be packed in a moderately-sized grain of wheat. They retain their vitality long. The mass may be allowed to dry, so that the slightest touch would reduce it to powder, and yet, when moistened with water, the animalcules will revive and become active. They may be dried and revived many times before they are killed. According to Bauer and Henslow, these revivals may extend over six or seven years. The infected grains

* Marcet, de l'action des Poisons sur le Règne Végétal, in Ann. de Chimie et de Physique, xxix 200; Macaire-Prinsep, ibid. xxxix. 85.

† Roffredi, sur l'origine des petits Vers ou Anguilles du Bled rachitique—Journ. de Physique, v 1, 197, vii. 369; also Needham's remarks on the same subject—Journ. de Physique, v. 226. Bauer on Vibrio Tritici, with Drawings, in Phil. Trans. for 1823, p. 1; Curtis on Vibrio Tritici, in Journ. Agric. Soc. England, vi. 513. Spikelets of Poa are sometimes seen of a purple colour, containing numerous Vibrios.

float in water for a short time, but on being saturated with moisture they sink. Scalding water kills the vibrio.

1052. Entomological writers give accounts of numerous insects which are prejudicial to white and green crops.* Some, like locusts, destroy the whole vegetation rapidly; others are more slow in their ravages. Curtis enumerates sixty insects which prey upon the Potato crop.† The Wheat midge (Cecidomyia Tritici) is a minute two-winged fly, myriads of which are seen, in the early part of June, from seven to nine in the evening. They deposit their eggs, by means of a long retractile ovipositor, in the blossoms of Wheat. From these eggs are produced small yellow maggots, which are the larvæ of the fly, and which occasion much mischief.‡ A short time before the proper period of ripening, several ears in a field of Wheat may be seen to present a yellow and prematurely ripened appearance. On examining these ears, there will be found a multitude of these little yellow larvæ lying between the husk and the young grain. They eat up the pollen, and thus prevent the grain from coming to maturity. The destruction thus caused sometimes amounts to one-third of the crop. The caterpillars of the Wheat midge are about 1-12th of an inch in length, and the chrysalis is reddish orange. It is not easy to suggest a remedy against the Wheat midge. All that can be done is to endeavour to separate the pupæ from the corn in barns by means of a wire-gauze sieve placed below the winnowing machine. The Hessian fly (Cecidomyia destructor) is injurious to Wheat in North America. It deposits its eggs near the base of the straw, and destroys the stem above the root. These species of Cecidomyia are fortunately often destroyed in great numbers by the Ichneumons, which deposit their ova in their bodies.

1053. Aphides attack almost every plant. Many of them infest the cultivated crops. Aphis Fabæ is an insect of a sooty black colour which attacks the Bean crops, appearing first on the tender upper shoots. The aphides multiply to an enormous extent. A single insect, according to Allman, may be in one year the progenitor of 100,000,000,000,000,000 of young ones. A similar insect attacks the Pea. Aphis Rapæ is a green-coloured insect which infests Turnips. The infected leaves are curled up and distorted, and the insects are found in multitudes within the folds, towards the end of summer and in autumn. The insect attacks the Potato, and is identical with Aphis vastator. The only remedy for Aphides is to remove the infected leaves as soon as they are discovered.§ The larva of the beautiful

* Duncan, on Insects most injurious to Vegetables, and on the means best calculated to counteract their ravages, in Trans. of Highland Soc. for 1844. Hardy, on Insects injurious to the Turnip Crop. Westwood, numerous Entomological Papers, during 1850–53, in the Gardener's Chronicle. See also M'Intosh's Book of the Garden, vol. ii.

† Curtis, on Insects affecting the Potato Crop, in Journ. Agric. Soc. England, x. 70.

‡ Kirby, History of Tipula Tritici and of Ichneumon Tipulæ, with observations on other insects that attack the Wheat, in Linn. Trans. iv. 230, and v. 96.

§ Leaves occasionally present an aspect as if injured by insects, when in reality the appearance is caused by parts of the tissue decaying in a peculiar way. See Gardener's Chronicle, Sept. 22, 1849.

little beetle called Coccinella, or Lady-bird, commits great devastation among the destructive Aphides, on which it feeds. The larva of another insect, called the Lace-wing or Chrysopus, also destroys Aphides.

1054. The Apple-tree mussel or dry scale, Aspidiotus conchiformis, attacks the bark of Apples, Pears, Plums, Apricots, and Peaches. Species of Coccus are often destructive to plants. One of them destroyed, in 1843, the whole Orange-trees in the island of Fayal, one of the Azores. The usual exportation of fruit from Fayal was 12,000 chests annually, but in 1843 there was not one. The insect extended its devastation also to St. Michel's. The support of the numerous families, the fortunes of the merchants engaged in this commerce, the revenue of the country, and the wealth and even the very existence

Fig. 1307.

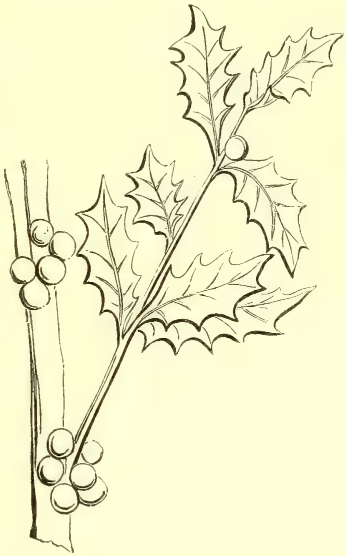

Fig. 1308.

of the population, were thus directly affected by the operations of a diminutive insect. A species of Coccus infests Coffee plantations in Ceylon, and often causes great destruction to the crop. After the attack of the Coccus, a dark-coloured Fungus attacks the plants. The

Fig. 1307. Species of Cactus, on which the Cochineal insect (*Coccus Cacti*) feeds. The plant is called *Opuntia cochinellifera*. The female insect supplies the dye. The Nopaleries of the West Indies are plantations of this Cactus, which is called the Nopal plant. The male winged insect is represented at *a* in the Figure.

Fig. 1308. The Kermes Oak (*Quercus coccifera*), on which the Coccus ilicis feeds. This Coccus, represented on the branch in the Figure, yields a scarlet dye, which appears to be the scarlet alluded to in many passages of Scripture (Gen. xxxviii. 28; Exod. xxviii. 6, 8, 15; Num. iv. 8; Lev. xiv. 4; 2 Sam. i. 24; Lam. iv. 5; Nahum, ii. 4). Mr. Hamel, however, endeavours to prove that the red colour so often spoken of in the Bible and by ancient writers was produced by the Armenian Cochineal, which is found on the roots of Æluropus lævis, a common plant in the Steppes of Eriwan.

cochineal insect feeds on a species of Cactus (Opuntia cochinellifera), and produces injury to the plant (Fig. 1307). The female insect supplies the dye.

1055. The Kermes insects (Coccus ilicis) are found on a species of Oak (Quercus Ilex) common in the Levant, Spain, and South of France (Fig. 1308). The Crimson Kermes dye was used in early times. It was known to the Phœnicians by the name of Tola or Thola, and to the Greeks under that of Coccus, whence the Romans derived their name Coccineus, the Spaniards their Coccinella, and the English their Cochineal. It was known to the Arabs and Persians by the names of Kermez and Alkermez, whence the French derived the name of the colour, Cramoisie, and we our Crimson. From the Latin epithets vermiculum and vermiculatum, given to it in the middle ages, when it was thought to originate from a worm, have been derived the French vermeil and the English vermilion, although now applied to cinnabar. On the roots of Scleranthus perennis, the Coccus polonicus, or Coccus radicum, is found. It furnishes the Polish or German cochineal. It was formerly collected for dyeing red in the Ukraine and Lithuania.*

1056. Species of Lozotænia roll up the leaves of different trees and shrubs. The pea-green moth (Tortricida viridana) curls up the leaves of the Oak in a peculiar manner. A moth called Tinea Clerckella attacks the leaves of Pears and Apples, and especially the Chaumontelle and Glout-morceau Pears, causes blisters on the leaves, and destroys the parenchyma. Blister-moths also attack the leaves of Oak, Elm, and Celery. Many insects, called Miners (from the caterpillars feeding only on the pulp of leaves and leaving the cuticle entire), attack the Turnip, Vine, Primrose, Rose, Cineraria, and Bramble. They form tortuous galleries in the leaf, and change its colour into a red-brown or ochreous tint. This mode of life is not restricted to one order of insects. Certain species of beetles, moths, and flies have the same propensity. Species of Phytomyza and Chromatomyia cause markings on leaves by undermining them. Chromatomyia nigra (Phytomyza nigra) causes white marks on the leaves of the Primrose. These are winding canals on the upper side of the leaves. Ch. obscurella and flaviceps act in the same way on the leaves of Honeysuckle. Ch. Syngenesiæ is one of the miners which attack the leaves of Senecio vulgaris and Jacobæa, Carduus arvensis, Sonchus oleraceus, &c. Phytomyza flava is a mining insect which attacks the leaves of Ranunculus repens. Ph. albiceps attacks the leaves of Heracleum Sphondylium and Carduus arvensis. Ph. Aquilegiæ attacks Columbine leaves. Cossus ligniperda and Scolytus destructor cause diseases in the bark of

* Lac is a dye procured from a Coccus (Coccus Ficus, or Coccus Lacca). The lac insects in the East Indies are nourished on many different trees. Lac in its natural state is called *stick-lac*. *Seed-lac* is a collection of granules got from stick-lac, after the colouring matter has been extracted by water. *Lump-lac* is seed-lac after it has been purified by fire and formed into cakes; while *shell-lac* is the purified lac, or the substance liquefied, strained, and formed into transparent laminæ.

Elms, &c. The only way to cure the disease is by cutting out all the old infected bark, destroying the channels in which the ova and larva are, and then washing with lime water mixed with some soot.

1057. Many trees, especially the Oak and Willow, are liable to the disease called Galls, which is due to attacks of insects (species of Cynips, &c). The insects wound the bark and leaves while depositing their ova, and the irritation causes a formation of a deposit around them. The galls of commerce are produced on Quercus infectoria. In blue galls the insect is still in the interior, while in white galls the insect has escaped by a perforation. There are various kinds of galls formed on different parts of the Oak. The Oak-apple is the largest gall of the Oak, and it is developed on the extremity of a twig. It is divided into numerous cavities, each containing a grub, pupa, or perfect fly, according to the season. Another gall is produced by a Cynips. It is in size and form like a Currant, and is developed on the male catkins of the Oak, which, when the gall is on them, continue to live even when other catkins have fallen off. Another gall like the last is found attached to the leaves of the Oak. Some of them are as large as a marble. The Artichoke gall is an irregular development of the bud, and consists of a number of leafy scales overlapping each other. At first sight it might be taken for a young cone; but on dissection it is found like other galls to contain insects in various stages of growth according to the season. The Oak spangle is an appendage of the leaf attached by a central point to its under surface; the inner side is smooth, the outer red, hairy, and fringed. Each contains a single insect, which retains its habitation till March, long after the leaves have fallen to the ground. These spangles resemble parasitic Fungi in their appearance, and have often been mistaken for them.*

1058. The species of Spruce (Abies) are liable to a peculiar disease produced by the attacks of an insect called Adelges Abietis. This disease consists of an alteration in the colour and form of the leaves, which are aggregated together in the shape of cone-like excrescences. Mr. Hardy, in describing the insect and its mode of attack, says:—The original matriarch lives outside the gall, remaining all winter in a dwarf state at the root of a bud. As soon as the bud swells, she revives likewise, and speedily becoming enlarged with the juice imbibed, she lays some hundreds of eggs. The bud meanwhile, instead of growing in length, becomes fleshy, and this fleshiness is communicated to the leaves. The consequence is an arrested bud, into the recesses of which the young, issuing from the cluster of ova on the

* The apples of Sodom are by some supposed to be galls found on an Oak. The galls, when on the tree, are said to be of a rich purple colour, and to be varnished over with a soft substance of the consistence of honey. They shine with a brilliant lustre in the sun, and appear like a tempting fruit, but when chewed they have an intensely bitter taste (Lambert, on Galls found on a species of Oak on the shore of the Dead Sea, in Linn. Trans. xvii. 445). Some, however, consider the so-called apples of Sodom (*Mala insana*) to be the fruit of Solanum sodomeum and of Calotropis gigantea.

outside of it beneath, betake themselves, and become soon closed in by the increased irritation occasioned by their presence in its interior.*

1059. The wire-worm is very destructive to plants. It is a cylindrical worm of a yellowish colour, marked by very distinct rings, and covered with a hard, horny skin. It is not a perfect insect, but the larva of a beetle called Elater. It lives for five years in the state of larva, becoming more destructive all that time, and then changes to an inactive pupa, from which the perfect beetle finally emerges. The beetle itself does not destroy plants. Allman mentions numerous remedies as having been proposed against the wire-worm. The use of the roller is by some strongly recommended; also, the folding of oxen and sheep in the infected fields. Several chemical applications have also been used, such as lime, soot, and common salt. A curious discovery has been recently made on the subject, namely, that certain plants have the power of expelling the wire-worm. These plants are Woad and White Mustard; and it is found that if a crop of either of these plants be grown on a field infested with the wire-worm, this pest will be completely expelled, and the field may be sown with the ordinary crops the following year. Hand-picking is an obvious and most useful mode, and the farmer should be warned to protect rooks, which, though they do a little harm in eating up some of his corn, or rooting out a Potato or two, do infinitely more good in destroying wire-worms and other injurious insects.

1060. The remedies proposed for the attacks of insects are numerous. Quick-lime, Sulphur, Turpentine, Tobacco, have all been recommended. In the case of Aphides the vapour of Tobacco is useful. It is not easy to get rid of the species of Coccus with their cottony covering. The only remedy seems to be the cleaning of the leaves and other parts of the plant by the hand. The vapour of sulphur will kill many insects, but then it acts injuriously on plants. A solution of Tobacco, the crushed leaves of the Cherry Laurel, which give out a hydrocyanated vapour, ammoniacal liquor, coal tar, and many other substances, have been employed in different instances. The insect (Anobia) which feeds on plants in Herbaria may be destroyed by a solution of corrosive sublimate and Camphor in Alcohol. In order to prevent the attacks of these insects, it is advisable to touch all the specimens in a herbarium with such a solution.†

1061. As regards a remedy for the Potato disease, M. Bollman, one

* For an account of insects attacking wood, see Kirby on insects that prey on timber, in Linn. Trans. v. 246.

† Curtis recommends the following mixture:—

Corrosive sublimate, two drachms.
Sulphuric ether, three drachms.
Dissolve and add alcohol, three ounces.
Spirit of turpentine, two ounces.

The mixture commonly used in Edinburgh consists of—

Corrosive sublimate, one drachm.
Camphorated spirit, three ounces.

of the Professors in the Russian Agricultural Institution at Gorigoretsky, has recently stated that thoroughly dried Potatoes always produce a crop free from disease. The drying must be conducted at a high temperature, perhaps from 80° to 100° F. or more, and must be continued for a long time—a month at least. Bollman has succeeded in having excellent crops of Potatoes since 1850 by adopting this method, while other fields around his were suffering from the disease. Other parties in Russia have found the plan successful. Professor Bollman remarks that it is usual in some parts of Russia to smoke-dry Flax, Wheat, Rye, and Onion seeds. Potatoes smoke-dried have been found by M. Wasileffsky to be little liable to disease. The Potato will bear a very high temperature during the process of drying. In one instance the thermometer stood at 136°, and it was ascertained that the vitality of the Potato was not destroyed even when its rind was charred.*

1062. Recapitulation of the chief facts connected with the diseases and injuries of plants :—

1. The common causes of diseases in plants are improper soils, ungenial climates, frosts, rains, drought, storms, parasitic plants, insects, and wounds of various kinds.
2. Diseases frequently originate in the nitrogenous lining of the cell-walls, and thence are propagated to the contents of the cells and to contiguous tissues.
3. Diseases have been divided into—those arising from excess or deficiency of light, heat, air, moisture, or the ingredients of the soil; those caused by parasitic Fungi; those attributable to the action of poisons; and those produced by mechanical injuries, and by attacks of insects.
4. Some of these diseases are propagated by contagion, more especially those occasioned by Fungi; others spread epidemically, and seem to depend on atmospheric changes and meteorological causes.
5. Some plants are more predisposed than others to disease, and it is found that those plants are most liable to be attacked by parasitic Fungi which are enfeebled in their growth.
6. Plants grown in an ungenial climate and soil, are very liable to disease; tender exotics in Britain are often injured by spring frosts.
7. Plants are suited to particular climates, and it is impossible to increase by cultivation their power of enduring heat or cold; there is no evidence of plants being acclimatized by a process of cultivation.
8. The sea-breeze, carrying with it saline particles, is often very injurious to trees. Some trees resist the effects of the sea breeze better than others.
9. The attacks of parasitic Fungi are a very frequent source of disease. These Fungi may either originate the disease, or aggravate and modify it after it is produced.
10. Many diseases in cultivated grains, such as Bunt, Smut, Rust, and Mildew, are referred to attacks of species of Uredo, Puccinia, and Ustilago.
11. Various remedies have been suggested, such as steeping grain in boiling water, in a solution of sulphate of copper and in alkaline solutions.
12. Other Fungi, more especially species of Erysiphe and Oidium, gives rise to Mildew in plants. The Vine Mildew caused by Oidium Tuckeri, is said to be prevented by the application of sulphur.
13. Ergot is a diseased condition of the ovary of Grasses, which assumes a spurred appearance, well seen in diseased Rye. It seems to be caused by an attack of a Fungus called Cordyliceps purpurea.

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* Bollman, Experiences et Conclusions sur les Moyens de prévenir la Maladie des Pommes de Terre, St. Petersburg, 1853; also Gardener's Chronicle, June 4, 1853.

14. The late Potato disease has been attributed by Berkeley and others, to a Fungus attacking the leaves, and afterwards causing injury to the tubers. The disease seems to appear first in the leaves, which, when affected, present the same aspect as those injured by irritant gases.
15. By others the disease is attributed to changes in the cells caused by cultivation, which render the plant liable to various epidemic influences; a nidus is formed for the spores of Fungi, which accelerate decay, and give a peculiar character to the disease.
16. Bollman says that drying, if conducted at a sufficiently high temperature, and continued long enough, is a complete antidote to the disease.
17. Dry rot is a disease to which the wood of trees is liable; alterations take place in the cells and vessels, and a Fungus called Merulius lacrymans or vastator, is developed, which causes a very rapid disintegration of the wood.
18. Dry-rot occurs also in wood after being cut, when it is exposed to damp, and when at the same time there is not a free circulation of air. Some woods are more liable to dry-rot than others.
19. The modes of preventing dry-rot are keeping the wood dry and well ventilated; steeping it in a solution of corrosive sublimate (Kyanizing), or in a solution of chloride of Zinc (Burnettizing); or causing it to absorb, after Boucherie's method, solutions of acetate of lead, or of pyrolignite of iron, or of creasote.
20. Some succulent plants are liable to gangrene, by which the parts become sphacelated, and decay.
21. Plants are also liable to be destroyed by the attack of phanerogamous parasites, such as the Dodder.
22. Metallic and vegetable poisons destroy plants; the former act as irritants, the latter as narcotics.
23. Acid and narcotic gases in the atmosphere are injurious to plants, causing disease and death.
24. Many insects act injuriously on plants, either destroying them at once, or inflicting wounds which end in a diseased condition of the parts.
25. The disease called Earcockle or Purple, is caused by the Vibrio Tritici or Wheat-eel.
26. Species of Cecidomyia, Aphis, and Coccus, are destructive to cultivated plants.
27. Galls are produced by the attacks of insects (species of Cynips), which deposit their ova in the bark and leaves of plants. Oaks and Willows are frequently affected with galls.
28. A species of Adelges causes a peculiar cone-like formation on the branches of Spruce.
29. The wire-worm, which is the larva of a beetle, is very destructive to plants.
30. Various remedies have been suggested to prevent the attacks of insects, such as quicklime, sulphur, turpentine, Tobacco, and the liquor of gas-works.

PART III.

TAXOLOGICAL BOTANY, OR THE CLASSIFICATION OF PLANTS.

CHAPTER I.

GENERAL REMARKS ON CLASSIFICATION.

1063. In examining the Vegetable Kingdom, we observe that the individuals composing it are formed by the Almighty in accordance with a principle of order, as well as a principle of special adaptation. We have already remarked the order pursued in the arrangements of the various parts of the root, stems, leaves, and flowers of plants, and we have traced, in some degree, the modes in which they are fitted to perform their different functions. We now proceed to apply the facts of Vegetable Anatomy and Physiology to the classification of plants, and to consider the plan according to which they are grouped together in classes and families.

1064. We see around us various kinds or sorts of plants which more or less resemble each other—or, in other words, are more or less related to each other. In Taxological or Systematic Botany we endeavour to mark these resemblances and to determine their relations. It is impossible to give a scientific arrangement of the plants of the globe without a thorough knowledge of structure and morphology, and without an extensive knowledge of the vegetation of all parts of the world. We cannot expect to determine the system on which plants have been grouped until we have an accurate acquaintance with all the forms which they present. Hence, in the present state of our knowledge, there must be imperfection in our attempts at systematizing. The Floras of many regions in Africa, India, China, Australia, and America, are still unknown, and we may therefore conclude that in all systems there will be gaps to be filled up as our knowledge increases. Sufficient, however, is known to enable us to group plants according to certain evident alliances.

1065. The necessity for arrangement is evident, when we reflect that there are more than 120,000 known species of plants on the earth. In order to make these available for scientific purposes, it is absolutely essential that they should be named and classified. In associating plants in certain groups we naturally proceed on an idea of resemblance or likeness. While in ordinary language this idea is vague, and is often founded on imperfect data, it is clear that in science it must be strict and rigorous. It is not enough to say that one plant resembles another in its general aspect, we must ascertain the particulars of agreement, and the points in which they differ; we must weigh well the importance of the characters, and must compare organs which are equivalent in value; and thus we shall often find, that plants which to common observers appear alike, are in reality totally different. The study of organography gives us a strict and accurate technical language which must be rigidly adhered to in classification. The labour bestowed in the acquisition of botanical terminology is by no means lost. It is the foundation on which all classificatory arrangements proceed. We must not be misled by the mere derivation of terms, we must study their true import. Thus the term papilionaceous means, like a butterfly; but we must not on that account suppose that every flower having a fancied resemblance to a butterfly is papilionaceous. We know that in scientific language such a flower is composed of certain definite parts, the vexillum, alæ, and carina, arranged in a certain order, and to them we must look as constituting the character.

1066. Plants as they occur in nature are viewed as individuals resembling or differing from each other. Some individuals are so decidedly alike that we at once give them the same names. Thus a field of wheat is composed of numerous similar individuals which can be separated from each other, but cannot be distinguished by any permanent or marked difference. Although there may be some difference in size and other minor points, still we at once say they are stalks of Wheat. Every grain of Wheat when sown, produces a stalk of Wheat; these stalks yield grains which produce individuals like their parents. The shoots or buds given off from the base of Wheat by tillering, also produce stalks of Wheat. On such universal and inevitable conceptions as these, our idea of *Species* is founded.

1067. A Species, Forbes remarks, is the type or original of each sort of plant, represented in time by a succession of similar individuals; and may be defined as an assemblage of individuals presenting certain constant characters in common, and derived from one original protoplast or stock. The individuals are thus considered as having arisen from one parent stock. They may differ slightly in size, or in colour, and other unimportant respects, but they resemble each other more closely than they resemble any other plants, and their seeds produce similar individuals. Martin says, species are distinct forms of plants originally created, and producing, by certain laws of generation, others like themselves. Species, then, comprehend all the individuals which have issued from a single being or one pair of beings, according as the sexes are conjoined or separated.

1068. Observation and common daily experience demonstrate, in the actual circumstances in which we exist, the permanence of the types which constitute the species of living bodies. There is no evidence whatever of a transmutation of species. The erroneous statements regarding the conversion of Oats into Rye have proceeded on imperfect observations.* The individuals, however, of a species may present certain differences in regard to size, colour, &c., these differences depending on soil, and on different conditions of heat, light, and moisture. Such differences are not incompatible with the idea of a common origin, and moreover, there is always a tendency to return to the original type. Hence Ball defines a species, that group of vegetable forms of which we are led, by observation and analogy, to believe that the differences between the individuals composing it may be made to disappear by the continued agency of external circumstances, either upon the individuals themselves or upon their descendants. What are called *Varieties*, therefore, are variations in species which are not in general of a permanent character, and cannot be kept up in ordinary circumstances by seed. By cultivation, however, such varieties are sometimes perpetuated. This is usually accomplished by means of cuttings or grafts, and in certain instances even by seed. Thus the varieties of the cereal grains and of culinary vegetables have been propagated so as to constitute permanent races.

1069. Plants which are cultivated are liable to *sport*, as it is called, and the peculiarities and variations thus produced are sometimes kept up. Thus, Lindley remarks, there are races of double Larkspurs, and of striped flowers, called uniques. So also there are permanent varieties of Camellias and Chrysanthemums, Pelargoniums, Orchids, Amaryllides, Fuchsias, and many other garden flowers. The Carrot, when cultivated, in place of flowering, lays up a large store of nourishment in its root, and does not flower till the second year. The Moss-rose is a sport produced by glandular projections of the calyx and peduncle. This is called mossiness. The first Moss-rose was a sport, and the rest are kept up by careful selection and cultivation. The

* A curious case has been narrated, in which a spikelet of Oat came out from a head of Wheat. On examination, it appeared that the stalk of the Oat had twisted itself round the ear of Wheat when both were very young, and they had grown up together in close apposition—the chaff of the Wheat completely hiding the stalk of the Oat, which was at last, by some accident or violence, snapped from its parent and left clinging to its supporter, all trace of its origin being hidden.—*Gardener's Chronicle*, October 6, 1849.

Celosia has a thickened, flattened (fasciated) stalk, and crowded flowers—a sport forming the Cockscomb. The tendency to grow in a fasciated Cockscomb manner is kept up by saving seeds of these sporting specimens, and rejecting all which do not show the monstrosity. The Canterbury Bell often shows a sport in the form of a fasciated flowering stem, and of flowers running together into a fine crescent-shaped head.

1070. In culinary vegetables the tendency to sport is very evident. In this way all the varieties of Cabbage, Cauliflower, Brocoli, Savoys, and Curled Greens are derived from one stock, Brassica oleracea. This plant grows wild on the sea-shore, and when cultivated it assumes peculiar forms. Thus it forms a heart, as in ordinary Cabbage; its flower-stalks become thickened and shortened, as in Cauliflower and Brocoli; or its parenchyma is largely developed between the vessels, so as to give rise to the crisp and curled appearance of Greens. This tendency in the plant to produce monstrosities was early noticed by cultivators, and care was taken to propagate those individuals which showed abnormal appearances. The seeds of such were saved, put into good soil, and no plants were allowed to remain except such as presented the required form. In this manner certain races of culinary vegetables have been established. If, however, these cultivated plants are allowed to grow wild and scatter their seed in ordinary soil, they will in the progress of time revert to the original type or species. Instances such as these show the remarkable effects of cultivation in perpetuating varieties by seed.

1071. Remarkable varieties in fruit are produced by cultivation and grafting, as already explained (p. 664). All these varieties are kept up by the art of the gardener. The seeds of the best Apples, when sown, have a tendency to produce plants which bear fruit resembling the Crab, and if they are sown in ordinary soil, and allowed to grow in a wild state, they will return at length to the type or true species (Pyrus Malus), which they will perpetuate.

1072. In regard to the cereal grains, Wheat, Barley, Oats, &c., they have been so long cultivated that we are at a loss to know the original types or species. We have been forced, in the mean time, to call them species, although they are probably mere cultivated varieties of unknown species, perpetuated as races. That Wheat is an abnormal state of some plant, it has been remarked, might be conjectured from the fact that it does not become wild; if left to itself it disappears. Not that (as in the case of many abnormal states of plants) it does not produce fertile seeds, nor does it (as is the case with others) return to its original state; but when deprived of that cultivation which has brought it to the abnormal state, it dies off, it becomes choked or destroyed by external agents which it is too weak to resist, or it does not multiply in a ratio sufficient to counterbalance the numerous causes of destruction to which wild plants are liable. Fabre has stated recently that the Wheat is a cultivated variety of the grass called Ægilops ovata. This plant first undergoes a change by which it becomes what has been called Ægilops triticoides, and then in successive years is converted into true Wheat. The wild grass called Ægilops ovata, according to him, is subject to a sport (Ægilops triticoides), and the seeds of this variety have a tendency to sport still more; until, in the course of about twelve years, by careful cultivation it can produce the form known as cultivated Wheat.* This discovery, as Lindley says, does not invalidate the characters by which the genera Ægilops and Triticum (as taken from wild species, such as Triticum maritimum, &c.) are separated, any more than the existence of a Peloria in Linaria invalidates the characters derived from the distinction between regular and irregular flowers.

1073. It is of great importance to distinguish between mere varieties and true species, and to determine the limits of variation in different species.† By not attending to this, many varieties have been described as species, and by their change or disappearance have given rise to great confusion and incorrectness both in descriptions and in arrangements. We must not exalt into species individuals showing differences which are not of a permanent nature in the ordinary wild state of the plant. The multiplication of the species of Salix, Rosa, Rubus, Hieracium, Saxifraga, and Solanum, and of many other genera, is to be attributed in no small degree to inattention to the limits within which certain species vary. Another source of fallacy arises from hybrids being occasionally reckoned as true species, as in the case of Bryanthus erectus, already noticed (p. 594). Hybrids or cross breeds, as already stated, are rare among wild plants, but they are common in gardens. These hybrids, however, are rarely fertile, or at least do not continue so for many generations. They have always a tendency to revert to one of the parents.‡

1074. Certain species not identical in origin, have common features of resemblance, and are associated together under what is called a *Genus*. A genus, then, is an assemblage of nearly related species, agreeing with one another, in general structure and appearance, more closely than they accord with other species. Thus the Scotch Rose, the Dog Rose, the China Rose, and the Sweet-briar, are all different species included in one genus, Rosa. So also Brambles and the Raspberry are comprehended in the genus Rubus. It may happen that a single species may be reckoned as forming a genus, when the peculiarities are as marked as those constituting other genera. Thus, if there was only one species of Oak, it would be sufficient to constitute a genus, as much so as at present, when it includes 200 species. It is

* See Fabre's views, as given in the Gardener's Chronicle for July 17, 24, and 31, 1852. See also Courte Introduction au Travail de M. Esprit Fabre d'Agde, sur la Metamorphose de deux Ægilops en Triticum, par M. Felix Dunal. Des Ægilops du Midi de la France, et de leur transformation, par M. Esprit Fabre d'Agde.

† Henslow, on the requisites necessary for the advance of Botany, with remarks on the limits of Species, in Mag. Zool. and Bot. i. 113.

‡ See full notice of Hybrids at p. 594, *et seq.*

distinguished by its acorn from other allied genera, such as the Beech, the Hazel, and the Chestnut. The species in a genus present one general plan, and may be said to be formed after the same pattern. Some species of a genus, having special points of resemblance, may be grouped together in a Sub-genus.

1075. Forbes,* in treating of the relations of individuals, species, or genera, to geological time and geographical space, remarks :—" The *individual*, whether we restrict the word to the single organism, however produced,—or extend it to the series of organisms, combined or independent, all being products of a single seed or ovum—has but a limited and unique existence in time, which, short as it must be, can be shortened by the influence of unfavourable conditions, but which no combination of favouring circumstances can prolong beyond the term of life allotted to it according to its kind. The *species*, whether we restrict the term to assemblages of individuals resembling each other in certain constant characters, or hold, in addition, the hypothesis (warranted, as might be shown from experience and experiment), that between all the members of such an assemblage there is the relationship of family, the relationship of descent, and consequently that they are all the descendants of one first stock or protoplast, is like the individual in so much as its relation to time are unique: once destroyed, it never reappears. But, unlike the individual, it is continued indefinitely so long as conditions favourable to its diffusion and prosperity—that is to say, so long as conditions favourable to the production and sustenance of the individual representatives or elements, are continued coincidently with its existence. The *genus*, in whatever degree of extension we use the term, so long as we apply it to an assemblage of species intimately related to each other in common and important features of organization, appears distinctly to exhibit the phenomenon of centralization in both time and space, though with a difference, since it would seem that each genus has a unique centre or area of development in time, but in geographical space may present more centres than one. An individual is a positive reality; a species is a relative reality; a genus is an abstraction, an idea—but an idea impressed on nature and not arbitrarily dependent on man's conceptions. An individual is one; a species consists of many resulting from one; a genus consists of more or fewer of these manies resulting from one linked together not by a relationship of descent but by an affinity dependent on a Divine idea. Lastly, An individual cannot manifest itself in two places at once; it has no extension in space; its relations are entirely with time, but the possible duration of its existence is regulated by the law of its inherent vitality: A species has correspondent and exactly analogous relations with time and space—the duration of its existence as well as its geographical extension, is entirely regulated by physical conditions: A

* Prof. E. Forbes on the supposed Analogy between the Life of an Individual and the Duration of a Species.

genus has dissimilar or only partially comparable relations with time and space, and occupies areas in both, having only partial relations to physical conditions." *

1076. On looking at genera, it will be seen that some of them, such as Oaks, Hazels, Beeches, and Chestnuts, have a strong resemblance or family likeness, and that they differ remarkably from such genera as Firs and Pines, Maples and Ashes. Certain genera may in this way be grouped so as to form Orders or Families. While genera are groups of allied species, Orders are groups of allied genera, or, according to Forbes, more comprehensive genera. Thus, Firs, Pines, and Larches, belong to different genera, but all agree in being cone-bearing, and are grouped under Coniferæ. The Rose, the Raspberry, the Bramble, the Strawberry, the Cinquefoil, the Cherry, and the Plum, all agree in their general organography, and are united under Rosaceæ. Certain genera have more points in common than others, and are grouped together under sub-divisions of orders called Sub-orders. Thus, the Plum and the Cherry have a drupe as their fruit, and are more nearly allied to each other than they are to the Apple; again, the Strawberry, Raspberry, and Bramble, are more allied to each other than to the Cherry or Apple. We have thus Sub-orders of Rosaceæ, namely, Amygdaleæ, including the Plum, Peach, Cherry, and Almond; Pomeæ, including the Apple, Pear, Medlar, and Quince; Potentilleæ, including the Strawberry, Cinquefoil, and Raspberry; and Roseæ, comprehending the Roses. The order Leguminosæ contains plants having legumes, and it is divided into Sub-orders, according to the nature of the flowers, namely, Papilionaceæ, with papilionaceous flowers, æstivation imbricate, upper petal exterior; Cæsalpinieæ, flowers not papilionaceous, but irregular, æstivation imbricate, upper petal interior; and Mimoseæ, flowers not papilionaceous, regular, æstivation valvate. Cruciferous plants agree in their tetrapetalous flowers with the petals arranged like a cross, and in their tetradynamous stamens, and they are divided into Sub-orders founded on their fruit, namely, Siliquosæ, with

* In writing upon this subject Professor Forbes says:—"What we call class, order, family, genus are all only so many names for genera of various degrees of extent. It is in this sense I use the term genus. Technically a genus is a group to which a name (as Ribes) is applied; but essentially Exogen, Ranunculaceæ, and Ranunculus, are genera of different degrees. Now, one of the chief arguments in favour of the *naturalness* of genera or groups, is that derived from the fact, that many genera can be shown to be centralized in definite geographical areas, Erica for example; that is, we find the species gathered all or mostly within an area, which has some one point where the maximum number of species is developed. But in geographical space we not unfrequently find that the same genus may have two or more areas within each of which this phenomenon of a point of maximum number of species is seen, with fewer and fewer species radiating as it were from it. This is what I mean by more centres than one in geographical space. Thus Viola has an American, as well as an Old World point of maximum development, around which we may group the species, gradually diminishing in number. In time, however, or in other words, in geological distribution, so far as we know, each generic type has had, so to speak, a unique and continuous range. Thus we find that all the species of a genus are grouped together within a succession of formations which commence at a certain point and cease at another; but when once a generic type has ceased, it never reappears. Therefore I speak of a genus having a unique centre in time. I say that a genus is an abstraction, a Divine idea. I think the very fact of the centralization of groups of allied species, in other words, of genera, in space and time, is sufficient proof of this. Doubtless we make many so-called genera that are artificial, but a true genus is natural, and as such is not dependent on man's will."

a siliqua, and Siliculosæ with a silicula. Orders may be divided still more minutely so as to group certain nearly allied genera into Tribes and Sub-tribes.

1077. Certain orders agreeing in evident and important general characters are united together so as to form Classes; and subdivisions of classes are made in the same way as in the case of orders. There are thus Sub-classes associating certain orders included in one Class. The usual divisions are Classes, Orders, Genera, and Species. These occur in all systems of classification.

1078. A more minute subdivision may be made as follows:—

I. Classes.
  a. Sub-classes.
II. Orders or Families.
  a. Sub-orders.
  b. Tribes.
  c. Sub-tribes.
III. Genera.
  a. Sub-genera or Sections.
IV. Species.
  a. Varieties.

1079. An enumeration of the marks by which one Class, Order, Genus, or Species is distinguished from another is called its Character. In giving the characters of any division, we notice merely those which are necessary to distinguish it from others. This is called its Essential Character. A plant may also be described completely, beginning at the root, and proceeding to the stem, branches, leaves, flowers, fruit, seed, and embryo. This is not essential, however, for the purposes of classification, and would be quite superfluous in that point of view. In the character of the Classes the important points of structure on which they are constituted are given. In the character of Orders (the ordinal character) we give the general structure of the included plants, especially of their flowers and fruit. In the Generic character, we notice the modification of the ordinal character in a given genus—the character being taken from the parts of the flower and fruit, as in the order. In the Specific character are included certain less important modifications of form, whether in the stem, leaves, or flowers, which serve to distinguish allied species.

1080. The essential character of a genus, when given in Latin, is put in the nominative case, that of a species in the ablative. The names of the Classes are variously derived, according to the views of the authors in regard to classification. They express some points of structure or development which are of marked importance or permanence. The Orders are named from some characteristic genus included in them, except in artificial methods, where some organ is taken as the means of distinction. Genera are derived either from the Latin name of one of the species, from the structure or qualities of the included species, or from the name of some botanist, &c. Thus Prunus is a genus including the Plum, the Sloe, &c.; Rosa, the Rose; Papaver, the Poppy; Hookeria is a genus named after Hooker; Lithospernum, from two Greek words signifying a stone and seed, is given to a genus, the species of which have hard stony nuts or achenes.

1081. In giving the name of a plant we mention its genus and species. Thus the common Dog-rose is called Rosa canina, the first being the generic name, the second the specific. Specific names may indicate the country in which a plant is found, the locality in which it grows, the form of its roots, stem, or leaves, the colour of its flowers, &c. A species named in honour of its discoverer or describer has the specific name usually in the genitive, as Veronica Jacquini, named after Jacquin. When the name is given in compliment to a botanist, without reference to the discovery, then the specific name is in the adjective form, as Veronica Lindleyana. Sometimes a generic name is used specifically, and then it is put as a noun after the genus, with a capital letter, and the two names may not agree in gender; thus we have such names as Cratægus Oxyacantha, Æthusa Cynapium, Viburnum Opulus, Veronica Chamædrys. To the genus and species are added certain letters, indicating the botanist who founded them. Thus Valeriana L. is the genus Valerian, as constituted by Linnæus, and Valeriana officinalis L. is the officinal Valerian, as described by Linnæus; Oxytropis, DC., is the genus so called by De Candolle. Sometimes authors happen to describe the same plant by different names. It is of importance, therefore, to give the Synonymes of other botanists, with their names. Thus Salvadora persica of Garcin is S. Wightii of Arnott, and S. indica of Wight's Illustrations.

1082. After the description of a plant we usually mention its Habitat, that is, the country or province in which it grows, with the nature of the locality, whether alpine or lowland, dry or moist, &c. When the plant is an annual, this is indicated by the marks A. or ⊙, biennial by B. or ♂, perennial by P. or ♃, a shrub by Sh. or ♄, and a tree by T. If an authentic specimen has been seen from the author of the species, then a point of admiration is put before his name thus, ! DC. De Candolle uses the letters v. v. s. (vidi vivam spontaneam), to indicate that he has seen a living native specimen of the plant, v. v. c. (vidi vivam cultam) to mark that he has seen a living cultivated specimen, v. s. s. (vidi siccam spontaneam) a dried native specimen, v. s. c. (vidi siccam cultam) a dried cultivated specimen. Other abbreviations have been noticed under Organography, and a tabular view of them will be given with the Glossary.

CHAPTER II.

SYSTEMS OF CLASSIFICATION.

1083. There are two systems pursued in the arrangement of plants; one is called the Artificial method, and the other the Natural method. In both of them the genera and species, or the minor divisions, are the same, but the higher divisions of classes and orders are totally unlike, and are founded on entirely different principles. The genera and species are very differently arranged in the two systems. In artificial methods one or two organs are selected in an arbitrary manner, and they are taken as the means of forming classes and orders; while in the natural method plants are grouped according to their alliance in all their important characters. Plants belonging to the same class and order in the former system may have nothing in common except the number of the stamens and pistils, or the form of their flowers, or some other arbitrarily selected character; while in the latter, plants in the same class and order are related by true affinity, and correspond in all the essential points of their structure and organography. When a student knows the artificial class and order to which a plant is to be referred, he does not thereby become acquainted with its structure and properties; plants diametrically opposed in these respects may be associated together. When he determines, on the other hand, the place of a plant in the natural system, he necessarily acquires a knowledge of its structural relations and affinities. Hence a knowledge of the latter system is that which must be the aim of every botanical student.

I. ARTIFICIAL SYSTEMS OF CLASSIFICATION.

1084. One of the earliest attempts at a methodical arrangement of plants was made by Andreas Cæsalpinus,* a native of Arezzo in Florence, some time Professor of Botany at Padua, and afterwards Physician to Pope Clement VIII. He is called by Linnæus, primus verus systematicus. In his work De Plantis, published at Florence in 1583, he distributed the 1520 plants then known into fifteen classes,

* Cæsalpinus (Andreas), de Plantes libri, xvi. 1583.

the distinguishing characters being taken from the fruit. About the year 1670, Dr. Robert Morison* of Aberdeen published a systematic arrangement of plants. He divided them into eighteen classes, distinguishing plants according as they were woody or herbaceous, and taking into account the nature of the flowers and fruit. In 1690 Rivinus† promulgated a classification founded chiefly on the forms of the flowers. Tournefort‡ about the same time took up the subject of vegetable Taxonomy. He was a cotemporary of Ray, and was Professor of Botany at Paris in 1683. He was long at the head of the French School of Botany, and published a systematic arrangement in 1694-1700. He described about 8000 species of plants, and distributed them into twenty-two classes, chiefly according to the form of the corolla, distinguishing herbs and under-shrubs on the one hand from trees and shrubs on the other. The system of Tournefort was for a long time adopted on the Continent, but was ultimately displaced by that of Linnæus.

1085. Carl von Linné, or, as he is commonly called, Linnæus,§ was born on the 23d of May 1707, at the village of Rooshoolt (Råshult), in Smaland, a province of Sweden, where his father, Nicholas Linnæus, was clergyman. He entered as a pupil at the University of Lund, and about the years 1727-28, was received into the house of Stobæus, a physician in that city, where he had abundant opportunities of prosecuting Natural History. He afterwards proceeded to Upsal, and had to struggle with great difficulties during his studies there. He aided Celsius in his Hierobotanicon or account of the plants of Scripture, and he became assistant to Rudbeck, professor of botany. He afterwards travelled in Lapland, took his degree in Holland, visited England, and commenced practice in Stockholm, where he lectured on botany and mineralogy. He finally became professor of botany at Upsal, and was one of the most popular lecturers of the day. He died on the 8th of January 1778, in the 71st year of his age. His Herbarium is now in the possession of the Linnæan Society.

1086. One of his biographers, in summing up his merits, says,—"Educated in the severe school of adversity, accustomed from his earliest youth to put a high value on verbal accuracy and logical precision; endowed with a powerful understanding, and capable of undergoing immense fatigue, both of body and mind, Linnæus produced a most important revolution in botanical science. He improved the distinctions of genera and species, introduced a better nomenclature on the binomial method, and invented a new and comprehensive system founded on the stamens and pistils. His verbal accuracy and the remarkable terseness of his technical language, reduced the crude matter that

* Morison, Præludia Botanica, 1672. Plantarum Historia Universalis, 1680.

† Rivinus (Augustus Quirinus) paterno nomine Bachmann, Introductio Generalis in Rem Herbariam, Lipsiæ, 1690.

‡ Tournefort, Elémens de Botanique, 1694. Institutiones Rei Herbariæ, 1700.

§ Linnæus, Systema Naturæ, 1735; Genera Plantarum, 1737; Philosophia Botanica, 1751; Species Plantarum, 1753.

was stored up in the folios of his predecessors into a form which was accessible to all men. He separated with singular skill the important from the unimportant in their descriptions. He arranged their endless synonymes with a patience and a lucid order that were quite inimitable. By requiring all species to be capable of a rigorous definition, not exceeding twelve words, he purified Botany from the endless varieties of the gardeners and herbalists; and by applying the same strict principles to genera, and reducing every character to its differential terms, he got rid of the cumbrous descriptions of the old writers." It is said of Linnæus, that although no man of science ever exercised a greater sway, or had more enthusiastic admirers, yet his merit was not so much that of a discoverer as of a judicious and strenuous reformer. The knowledge which he displayed, and the value and simplicity of the improvements which he proposed, secured the universal adoption of his suggestions, and crowned him with a success altogether unparalleled in the annals of science.

1087. The system of Linnæus is founded on the sexes of plants, and hence it is often denominated the sexual system. It is called an artificial method because it takes into account only a few marked characters in plants, and does not propose to unite them by natural affinities. It is an index to a department of the book of nature, and as such is useful to the student. It does not aspire to any higher character, and although it cannot be looked upon as a scientific and natural arrangement, still it has a certain facility of application which commends it to the tyro. In using it, however, let it ever be remembered, that it will not of itself give the student any view of the true relations of plants as regards structure and properties, and that by leading to the discovery of the name of a plant, it is only a stepping-stone to the natural system. Linnæus himself claimed nothing higher for it. He says—Methodi Naturalis fragmenta studiose inquirenda sunt. Primum et ultimum hoc in Botanicis desideratum est. Natura non facit saltus. Plantæ omnes utrinque affinitatem monstrant uti territorium in mappa geographica.* Accordingly, besides his artificial index, he also promulgated fragments of a natural method of arrangement.

1088. In the artificial system of Linnæus, plants are divided into Flowering and Flowerless—the latter being included in the twenty-fourth class, under the name of Cryptogamia, and the former, or Phanerogamia, being divided into twenty-three classes, the characters of which are founded on the number, the insertion or position, the relative length, and the connection of the stamens. Among flowerless plants the orders are similar to those of the natural system, while in flowering plants they are determined by the number of the styles, the character of the fruit, the number and connection of the stamens in those classes where these characters are not already taken into consideration, and on the hermaphrodite or unisexual nature of the flowers.

1089. The first eleven classes are determined by the number of

* Linn. Philos. Botanica, Stockholm. 1751, p. 27.

the stamens, the term *andria* being employed to express male or stamen, and the Greek numerals being prefixed. In these classes there are stamens and pistils in every flower, the stamens are distinct from each other, and although they may differ in length, yet these differences are not in the ratio of two long and two short, or of four long and two short.

Class I. MONANDRIA—plants having flowers with one stamen, as Hippuris, Centranthus (Fig. 556, p. 210).

— II. DIANDRIA—flowers with two stamens, as Veronica (Fig. 559, p. 211), Ash (Fig. 638, p. 231), Lilac, Salvia. There is one British grass in this class.

— III. TRIANDRIA—flowers with three stamens, as Wheat (Fig. 637, p. 231), Oat (Fig. 565, p. 212), and many Grasses, Scirpus (Fig. 635, p. 230), Valerian (Fig. 496, p. 198), Iris. Many of the plants are Monocotyledonous.

— IV. TETRANDRIA—flowers with four stamens, as Alchemilla (Fig. 585, p. 219), Galium, Plantago. The stamens in this class do not differ in length in the proportion of two long and two short.

— V. PENTANDRIA—flowers with five stamens, as Vitis (Fig. 571, p. 215), Chenopodium (Fig. 412, p. 174), Campanula, Primula, Solanum, Umbelliferous plants. This class embraces a large number of Dicotyledons.

— VI. HEXANDRIA—flowers with six stamens, as Narcissus (Fig. 569, p. 214), Lily (Figs. 411, 413, p. 174), Tulip (Fig. 593, p. 220), Hyacinth, Luzula (Fig. 572, p. 215). This class contains many Monocotyledons. The six stamens do not differ in length in the proportion of four long and two short.

— VII. HEPTANDRIA—flowers with seven stamens, as Æsculus (Fig. 335, p. 143). This class contains only one British plant, Trientalis europæa (Fig. 1309).

Fig. 1309.

— VIII. OCTANDRIA—flowers with eight stamens, as Erica, Vaccinium, Paris.

— IX. ENNEANDRIA—flowers with nine stamens, as Rhubarb (Fig. 577, p. 216). There is only one British plant in this class, Butomus umbellatus.

— X. DECANDRIA—flowers with ten stamens, as Sedum (Fig. 525, p. 204), Saxifraga, Dianthus.

— XI. DODECANDRIA—flowers with twelve to nineteen stamens, as Reseda, Asarum.

The two succeeding classes contain plants with hermaphrodite flowers, having twenty or more unconnected stamens :—

Fig. 1309. European Chickweed Winter-green (*Trientalis europæa*), the only British plant in the class Heptandria of Linnæus.

Class XII. Icosandria—flowers with twenty or more stamens inserted on the calyx—or in other words, perigynous—as in Rosaceous plants, Pear (Fig. 395, p. 165), Opuntia (Fig. 589, p. 219), Cherry (Fig. 612, p. 227).

— XIII. Polyandria—flowers with twenty or more stamens inserted on the receptacle—in other words, hypogynous—as in Ranunculus, Papaver (Fig. 611, p. 226), Anemone.

The characters of the two next classes are founded on the relative length of the stamens, the flowers being at the same time perfect, the stamens usually unconnected, but sometimes united by their anthers :—

Class XIV. Didynamia (meaning superiority of two)—flowers having four stamens, two of which are long and two short, the latter being next each other, as in Antirrhinum (Fig. 625, p. 229), Lamium, Scrophularia, Gloxinia.

— XV. Tetradynamia (meaning superiority of four)—flowers having six stamens, of which four are long and two short; the long stamens are in pairs opposite to each other, and the short stamens are inserted on either side between the pairs, as in Wallflower (Figs. 409 and 410, p. 173), and in Cruciferous plants generally.

The four following classes are determined by the connection or union of the stamens—this union taking place by their filaments or by their anthers :—

Class XVI. Monadelphia (meaning a single brotherhood)—stamens united by their filaments, so as to form a single tube or column round the pistil, as in Malva (Fig. 604, p. 222, and Fig. 618, p. 228), Geranium.

— XVII. Diadelphia (meaning two brotherhoods) — stamens united into two sets or bundles by their filaments, as in Lathyrus (Fig. 620, p. 228), and in many Papilionaceous flowers; Polygala, Fumaria. In many instances the sets are unequal—nine stamens forming one, and a single stamen forming the other.

— XVIII. Polyadelphia (meaning many brotherhoods)—stamens united into more than two sets or bundles by their filaments, as in Hypericum (Fig. 621, p. 228). The only British genus in this class is Hypericum (St. John's-wort); it contains many species.

— XIX. Syngenesia (meaning growing together)—stamens united together by their anthers, as in Senecio (Fig. 105, p. 45), and other Composite flowers.

In the next class the character is founded on the union between the stamens and pistil :—

Class XX. Gynandria (meaning pistil and stamen)—stamens and styles united together in one column, as in Orchis (Fig. 616, p. 228), Aristolochia (Fig. 617, p. 228), Asclepias (Fig. 657, p. 235).

In the three succeeding classes the flowers are unisexual, some containing stamens only, others, pistils only:—

Class XXI. Monœcia (meaning one household)—flowers with stamens only and others with pistils only on the same plant, as in the Hazel (Fig. 582, p. 217), Euphorbia (Fig. 506, p. 200), Carex, Arum, Pinus.

— XXII. Diœcia (meaning two households)—flowers with stamens only and others with pistils only on separate plants, as in the Willow (Fig. 390, p. 162, Figs. 578, 579, p. 216), Hemp (Fig. 574, p. 216), Hop, Poplar.

— XXIII. Polygamia (meaning many marriages)—stamens and pistils separate in some flowers and united in others, either on the same or on different individuals, as in some Palms, Atriplex. The British genera in this class are Atriplex, Obione, and perhaps Parietaria.

The last class includes Flowerless plants.

Class XXIV. Cryptogamia—plants in which, as implied in the name, the organs of reproduction are concealed, as in Ferns (Fig. 969, p. 324), Mosses (Fig. 1003, p. 335), Lichens (Fig. 1013, p. 342), Fungi (Fig. 1031, p. 347), and Sea-weeds (Fig. 1046, p. 352).

1090. The Orders in the first thirteen classes of the Linnæan system are determined by the number of the styles, or of the stigmas when there are no styles. The term *gynia* is applied to them (meaning female or pistil), with the prefix of a Greek numeral.

Order 1. Monogynia, includes plants in the first thirteen classes, with one style to each flower, as in Primula (Fig. 699, p. 246), Tobacco (Fig. 415, p. 175).

— 2. Digynia, includes those with two styles, as in Dianthus (Fig. 691, p. 243).

— 3. Trigynia, those with three styles, as in Silene.

— 4. Tetragynia, those with four styles, as in Paris.

— 5. Pentagynia, those with five styles, as in Columbine (Fig. 416, p. 175), Sedum (Fig. 680, p. 241), Flax, (Fig. 692, p. 245).

— 6. Hexagynia, those with six styles, as in Butomus.

— 7. Heptagynia, those with seven styles.

— 8. Octogynia, those with eight styles.

— 9. Enneagynia, those with nine styles.

— 10. Decagynia, those with ten styles, as in Phytolacca.

Order 11. Dodecagynia, those with eleven or twelve styles, as in Sempervivum.

— 12. Polygynia, those with more than twelve styles, as in Ranunculus (Fig. 694, p. 245), Strawberry, (Fig. 695, p. 245).

The orders in Class XIV. Didynamia, are distinguished by their seed-vessels :—

1. Gymnospermia (meaning naked seeds) the fruit consisting of single-seeded Achenes, which Linnæus mistook for naked seeds, as in Dead-nettle (Fig. 339, p. 145), and other Labiatæ.
2. Angiospermia (meaning seeds in a seed-vessel), numerous seeds enclosed in an evident pericarp or seed-vessel, which is often bilocular, as in Scrophularia (Fig. 789, p. 269).

The orders in Class XV. Tetradynamia, are also distinguished by the fruit :—

1. Siliculosa, fruit, a Silicle or short pod, as in Capsella (Fig. 805, p. 273), and Draba (Fig. 804, p. 273).
2. Siliquosa, fruit, a Siliqua or long pod, as in Wallflower (Fig. 803, p. 273).

The orders of Classes XVI. XVII. XVIII. are distinguished by the number of the stamens, that character not being taken into account in forming these classes. The orders are named in the same way as the classes, thus :—

1. Triandria, with three stamens, as in Tamarind ; 2. Pentandria, with five, as in Passiflora, Erodium ; 3. Hexandria, with six, as in Fumaria ; 4. Heptandria, with seven, as in Pelargonium ; 5. Octandria, with eight, as in Polygala ; 6. Decandria, with ten, as in Geranium, Genista, Lathyrus, and many Papilionaceous flowers ; 7. Dodecandria, with twelve ; 8. Polyandria, with twenty or more, as in Hibiscus, Malva, Hypericum.

In Class XIX. the orders are determined by the state of the flowers, whether hermaphrodite or unisexual, or having separate involucres. At first Linnæus included all synantherous plants, and put such genera as Viola, Lobelia, and Siphocampylus, in a separate order, denominated Monogamia. Afterwards, however, he made the class a natural one, by including only compound flowers (Compositæ). The following are the orders :—

1. Polygamia Æqualis (Fig. 1310, *a*), (meaning flowers all equal). The flowers in the Capitula are all perfect—that is, each of them has stamens and pistil, as in Dandelion (Fig. 361, p. 153).
2. Polygamia Superflua (Fig. 1310, *b*), (meaning some flowers superfluous). The flowers of the disk, or centre of the Capitula, are

hermaphrodite (Fig. 105, p. 45), while those of the ray or of the margin are pistillate (Figs. 352, 353, p. 209), and are fertilized by the pollen of the central flowers, as in the Daisy.

3. Polygamia Frustranea (Fig. 1310, *d*), (meaning some flowers neuter). The flowers of the disk or centre are perfect (hermaphrodite), those of the ray are neutral (having either abortive pistils or none), as in Centaurea (Fig. 392, p. 163), which is the only British genus in the order. The marginal flowers, in such instances, often become very large and showy.
4. Polygamia Necessaria (Fig. 1310, *c*), (meaning central and marginal flowers necessary for perfect seed). The flowers of the disk are staminate, those of the ray are pistillate, as in Calendula (Fig. 371, p. 156). No British plants are found in this order.
5. Polygamia Segregata (Fig. 1310, *e*), (meaning flowers separated), each flower of the Capitulum separated from the others by a distinct involucre, as in Echinops (Globe-thistle). No British .plants are found in this order.

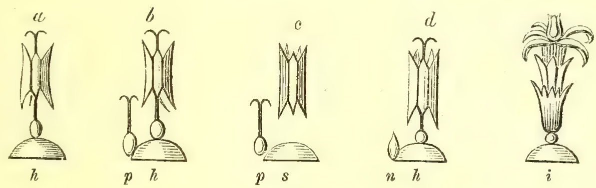

Fig. 1310.

6. Monogamia (meaning that the flowers are single and not compound), solitary flowers—that is, not collected in a Capitulum, but with united anthers, as in Viola, Lobelia. This order was afterwards abolished, and the plants contained in it were referred to the class indicated by the number of the stamens (Pentandria).

In Classes XX. XXI. and XXII. the number of the stamens which is not taken into account in determining the classes is used to distinguish the orders :—

1. Monandria, one stamen, as Orchis, Euphorbia, (Fig. 506, p. 200, and Fig. 610, p. 226). 2. Diandria, two stamens, as Stylidium, Cypripedium, Lemna (Fig. 603, p. 221), Salix (Figs. 578, 579, p. 216.) 3. Triandria, three stamens, as Carex (Fig. 634, p. 230), Phœnix. 4. Tetrandria, four stamens, as Urtica (Fig. 628, p. 229), Myrica. 5. Pentandria, five stamens, as Humulus, Cannabis (Fig. 574, p. 216). 6. Hexandria, six stamens, as Aristolochia (Fig. 617, p. 228), Cocos,

Fig. 1310. These Figures illustrate the orders of the class Syngenesia of Linnæus, and the subdivisions of the natural order Compositæ. *Polygamia æqualis*, *a*, with the flowers all hermaphrodite, *h*; the ovary, style, and stigma are represented as situated on the receptacle with the united anthers surrounding the style. *Polygamia superflua*, *b*, in which the tubular or floscular flowers of the disk, *h*, are hermaphrodite, and the ligulate flowers of the ray, *p*, are pistillate and fertile. *Polygamia necessaria*, *c*, in which the flowers of the disk or centre, *s*, are staminate, while those of the ray or margin, *p*, are pistillate and fertile. *Polygamia frustranea*, *d*, in which the flowers of the disk, *h*, are hermaphrodite, those of the ray, *n*, are neutral or abortive. *Polygamia segregata*, *e*, in which the flowers, *i*, are involucrate.

Tamus. 7. Octandria, eight stamens, as Populus, Corylus (Fig. 388, p. 161). 8. Enneandria, nine stamens, as Mercurialis. 9. Decandria, ten stamens. 10. Dodecandria, twelve stamens, as Stratiotes. 11. Polyandria, stamens ∞, as Poterium. 12. Monadelphia, filaments united in one tube, as Pinus, Anacharis, Taxus (Fig. 619, p. 228). 13. Polyadelphia, filaments united in many clusters, as Ricinus (Fig. 622, p. 229).

In Class XXIII. the orders are founded on the position of the hermaphrodite, staminate, and pistillate flowers :—

1. Monœcia, hermaphrodite, staminate, and pistillate flowers on the same plant, as Parietaria, Acacia, Atriplex.
2. Diœcia, hermaphrodite flowers on one plant, staminate and pistillate flowers on another plant, occasionally in Chamærops (Figs. 580, 581. p. 216) and Hippophae.
3. Triœcia, hermaphrodite flowers on one plant, staminate on a second, and pistillate on a third.

In Class XXIV. the orders are the same as in the natural system, and therefore not definable by a single character :—

1. Filices, Ferns (Fig. 969, p. 324). 2. Musci, Mosses (Fig. 1003, p. 335). 3. Hepaticæ, Liverworts (Fig. 1007, p. 337). 4. Lichenes, Lichens (Fig. 1013, p. 342). 5. Algæ, Seaweeds (Fig. 1046, p. 352). 6. Fungi, Mushrooms (Fig. 1031, p. 347).

1091. The system of Linnæus, even when regarded simply as an index to the vegetable kingdom, is by no means complete. The parts of flowers often vary in number, and cannot be confined within the strict rules required by this method of arrangement; moreover, unless the stamens and pistils are perfect and complete, and the plant is in full flower, it is impossible to determine its class and order. When the system is rigidly adhered to, we find that species belonging to the same genus are separated. Thus the genus Lychnis has most of its species hermaphrodite, with ten stamens and five styles, but there is at least one British species diœcious. In order, therefore, to keep the genus entire, and not separate the species, Linnæus adopted the plan of putting Lychnis in the class Decandria and order Pentagynia, and under the class Diœcia order Decandria, placing the name of the diœcious species, and referring the student to the 10th class for a description. In this way the genera—which are founded on natural affinities, and are not constructed by a mere arbitrary method—are preserved in their integrity. All the species of one genus are placed together, whether they accord or not with the characters of the class and order; the place of the genus being determined by the characters of the majority of the species. The names of the anomalous species are given in italics, in the classes and orders to which they belong according to the Linnæan method, and reference is made to the description of them as given under the genus.

1092. Key to the Classes and Orders of the Linnæan artificial system :—

A. Flowering Plants, Phanerogamia.

I. Stamens and Pistils in every flower.

1. Stamens unconnected.

a. Stamens either of equal length, or at all events neither didynamous nor tetradynamous;

1 in number	Class I. Monandria	Order 1. Monogynia	1 free Style.
2	II. Diandria	— 2. Digynia	2 free Styles.
3	III. Triandria	— 3. Trigynia	3 —
4	IV. Tetrandria	— 4. Tetragynia	4 —
5	V. Pentandria	— 5. Pentagynia	5 —
6	VI. Hexandria	— 6. Hexagynia	6 —
7	VII. Heptandria	— 7. Heptagynia	7 —
8	VIII. Octandria	— 8. Octogynia	8 —
9	IX. Enneandria	— 9. Enneagynia	9 —
10	X. Decandria	— 10. Decagynia	10 —
12 to 19,	XI. Dodecandria	— 11. Dodecagynia	12 to 19
20 or more, perigynous	XII. Icosandria	— 12. Polygynia	20 or more.
20 or more, hypogynous	XIII. Polyandria		

b. Stamens differing in length in certain proportions :

Two long and two short	XIV. Didynamia	Order 1. Gymnospermia	Fruit, Achenes.
		— 2. Angiospermia	Fruit, Capsular.
Four long and two short	XV. Tetradynamia	Order 1. Siliculosa	Fruit, a Silicula.
		— 2. Siliquosa	Fruit, a Siliqua.

2. Stamens connected—

By their Filaments in one parcel or tube	XVI. Monadelphia	Order Triandria ... 3 Stamens. — Pentandria ... 5 — — Decandria ... 10 — — Polyandria ... Numerous Stamens. and so on as in the first 13 Classes.
By their Filaments in two parcels	XVII. Diadelphia	
By their Filaments in three or more parcels	XVIII. Polyadelphia	
By their Anthers (Composite flowers)	XIX. Syngenesia.	Order 1. Polygamia æqualis, florets all ☿. — 2. Polygamia superflua, florets of the disk ☿, those of the ray ♀, but fertile. — 3. Polygamia frustranea, florets of the disk ☿, those of the ray abortive. — 4. Polygamia necessaria, florets of the disk, ♂, those of the ray ♀, and fertile. — 5. Polygamia segregata, each flower with a separate involucre.
With the Pistil on a column	XX. Gynandria	Order Monandria ... 1 Stamen. — Diandria ... 2 Stamens. and so on as in the first 13 Classes.

II. Stamens and Pistils in separate flowers.

On the same Plant	XXI. Monœcia	Order Monandria ... 1 Stamen. — Diandria ... 2 Stamens. — Hexandria ... 6 — — Polyandria ... Numerous Stamens. and so on as in the first 13 Classes. Order Monadelphia ... Stamens monadelphous.
On separate Plants	XXII. Diœcia	

III. Stamens and Pistils in the same and in separate flowers on the same or on separate Plants	XXIII. Polygamia	Order 1. Monœcia, ☿, ♂, and ♀ on the same plant. — 2. Diœcia, ☿, ♂, ♀, on two plants. — 3. Triœcia, ☿, ♂, ♀, on three plants.

B. Flowerless Plants.

Organs of reproduction inconspicuous	XXIV. Cryptogamia	Order 1. Filices, Ferns. — 2. Musci, Mosses. — 3. Hepaticæ, Liverworts. — 4. Lichenes, Lichens. — 5. Algæ, Sea-weeds. — 6. Fungi, Mushrooms.

1093. The Linnæan method is sometimes used as an index to the natural system, as seen in the British Floras of Hooker and Arnott, and of Babington. When we keep the system in its proper place, there is no fear of the student being misled by false ideas of its value. It has been well remarked by Professor Edward Forbes:— "Those who slightingly think of the Linnæan system forget in the present to look back fully and fairly on the past. They should remind themselves of the state in which Botany was when Linnæus undertook to make its treasures consultable. The understanding of things depends greatly on the perception of their order and relations. When that order and those relations require deep study ere we can comprehend them clearly, the man who gives us a clue, however insignificant it may be in its own nature, is not only conferring on us an invaluable benefit, but endowing the despised instrument with golden value. Such a clue did Linnæus give when he put forth his system. The scientific systematist, surrounded by the stores of his herbarium, should not forget that those treasures were often amassed in the first instance by adventurous and earnest men, rendering good service by their hands and energy, as good in its humble way as that which he gives by his head and philosophy. It was not to be expected of such men that in the field they should occupy themselves with thoughts of arrangement and affinity; their part was to observe and select, and the guide to their observation and selection was in most cases no other than the Linnæan system. An easy means of acquiring and arranging information is a great help to the workmen of science, and no department has gained more thereby than Botany, which, through the facilities afforded by the artificial method devised by Linnæus, has had its facts amassed in enormous quantity for the use of its more philosophic votaries, and owes its present advanced state in a great measure to such humble means. The clue to the labyrinth then having served such noble purposes becomes a consecrated object, and should rather be hung up in the temple than thrown aside with ignominy."*

1094. Artificial aids are required in all systems of classification. Hence we find that many authors have adopted a method of analysis in order to detect the place of a plant in the system, and to ascertain its name. This process of analysis is one which we naturally adopt in discriminating objects. It was suggested by Lamarck, and has been used by Lindley and other advocates of a natural method. It is also applied to the Linnæan system, and it may be illustrated by a quotation from Ralf's work entitled Analysis of the British Flora. It will be seen that there are two characters given, one of which must belong to the plant under examination, and by a process of analysis the student proceeds from one to another until he determines the genus or species. Thus in the following analytical table, a plant belonging to Didynamia Angiospermia is under consideration. If it has a superior perianth, and is a British plant, it must be Linnæa; if the perianth is

* Forbes, Introductory Lecture delivered in King's College, London.

inferior, we proceed to No. 2, and then we determine whether it is leafless and scaly, or possesses leaves. In the former case we are referred to No. 3, and find that the plant is either Lathræa or Orobanche; in the latter we proceed to No. 4, and so on.

1095. Analytical method of ascertaining the name of a plant:—

Class DIDYNAMIA, Order ANGIOSPERMIA.

1.	Perianth superior	Linnæa.
	Perianth inferior	2
2.	Plant leafless, scaly	3
	Plant with leaves	4
3.	Corolla with upper lip galeate entire	Lathræa.
	Corolla ringent 4-5 cleft	Orobanche.
4.	Seeds 2-4, pericarp evanescent	Verbena.
	Seeds numerous, pericarp not evanescent	5
5.	Calyx inflated	6
	Calyx not inflated	7
6.	Calyx 4-toothed	Rhinanthus.
	Calyx 5-toothed	Pedicularis.
7.	Calyx 4-toothed	8
	Calyx 5-parted	10
8.	Capsule 2-seeded	Melampyrum.
	Capsule many-seeded	9
9.	Upper lip of Corolla notched	Euphrasia.
	Upper lip of Corolla entire	Bartsia.
10.	Corolla gibbous or spurred at the base	11
	Corolla not gibbous nor spurred	12
11.	Corolla spurred	Linaria.
	Corolla gibbous	Antirrhinum.
12.	Corolla nearly regular	13
	Corolla irregular	14
13.	Corolla rotate	Sibthorpia.
	Corolla campanulate	Limosella.
14.	Corolla subglobose	Scrophularia.
	Corolla campanulate	Digitalis.

The same method may be pursued in regard to the species of a genus, as well as in regard to the orders of the natural system.*

II. NATURAL SYSTEM OF CLASSIFICATION.

1096. In arranging plants according to the Natural System, the object is to bring together those which are allied in all essential points of structure. It is called natural, because it proposes to follow the system of Nature, and thus takes into account the true affinities of plants on a comparison of all their organs. One of the first natural

* See Lindley's Elements of Botany, and Ralf's Work already referred to in the text.

methods of classification was that proposed by Ray about 1682.* He separated flowering from flowerless plants, and divided the former into Dicotyledons and Monocotyledons. His orders were founded on correct views of the affinities of plants, and he far outstripped his cotemporaries in his enlightened views of arrangement. He may be said to have laid the foundation of that system which has been elucidated by the labours of Jussieu, De Candolle, Brown, Lindley, Endlicher, and others.

1097. Antoine Laurent de Jussieu, the great leader in the natural method of classification, was born at Lyons in 1748, and was educated at Paris under the care of his uncle, Bernard de Jussieu. At an early age he became Botanical Demonstrator in the Jardin des Plantes, and was thus led to devote his time to the science of Botany. Being called upon to arrange the plants in the garden, he necessarily had to consider the best method of doing so, and adopted a system founded in a certain degree on that of Ray, in which he embraced all the discoveries in organography, adopted the simplicity of the Linnæan definitions, and displayed the natural affinities of plants. Jussieu subsequently became Professor of Rural Botany, and he died in 1836 at the age of 88.

1098. The system of Jussieu made its way slowly in this country, and it was not until Robert Brown brought it under notice that it was adopted.† It is now the basis of all natural classifications. One of the early supporters of this natural method was Auguste Pyrame De Candolle, who was born in 1778, and who, after attending the lectures of Vaucher at Geneva, devoted himself to botanical pursuits. He subsequently prosecuted his studies at Paris, and lectured on Botany at the College of France. He commenced his publications in 1802, and in 1804 he promulgated his Elementary Principles of Botany. In 1807 he became Professor of Botany at Montpellier, and in 1816 he was appointed to the Chair of Natural History at Geneva, with the charge of the Botanic Garden. In that city he carried on his future botanical labours, and began his Prodromus Systematis Universalis Regni Vegetabilis, which was intended to embrace an arrangement and description of all known plants. He was enabled to complete eight volumes of the work before his death, and it has since been carried on by his son Alphonse De Candolle, with the aid of other eminent botanists. The system followed by De Candolle is a modification of that of Jussieu, and it is generally adopted at the present day. De Candolle's own herbarium was extremely rich. He had visited and carefully examined many of the most extensive collections, especially those of Paris; and many entire collections, as well as separate families, in which he was specially engaged, were from time to time submitted to his examination by their possessors. He had thus opportunities of comparison greatly beyond what in ordinary circumstances fall to the lot of an

* Ray, Methodus Plantarum, 1682; and Methodus Plantarum emendata et aucta, 1703.

† Brown, Prodromus Floræ Novæ Hollandiæ, 1810.

individual. His library, too, was stored with almost every important publication that could be required for his undertaking. With such ample materials, aided by his untiring zeal and the persevering energy of his character, he steadily pursued his allotted task, and only ceased to labour at it when he ceased to live. For some years his health declined, and it is to be feared that the severe and incessant attention which he paid to the elaboration of the great family of Compositæ had made a deep inroad upon it. As a relaxation from his labours he undertook in the last years of his life a long journey, and attended the scientific meeting held at Turin; but he did not derive from this the anticipated improvement in his health, which gradually failed until his death, on the 9th September 1841.*

1099. In arranging plants according to a natural method, we require to have a thorough knowledge of structural and morphological botany, and hence we find that the advances made in the latter departments have materially aided the efforts of systematic botanists. We may regard plants in various points of view, either with reference to their elementary tissues, their nutritive, or their reproductive organs. The first two are the most important, as being essential for the life of individuals, while the latter are concerned in the propagation of the species. These sets of organs bear a certain relation to each other, and we find that plants may be associated by a correspondence in all of them. In comparing the characters of plants, we must take care that we contrast organs belonging to the same class of functions, and the value of the characters must depend upon the importance of the functions performed by the organs.

1100. Henslow gives the following rules for fixing the subordination and relative values of characters:—1. When two organs, belonging to different classes of functions, have the same relative value in their respective series, that organ will possess the greatest value which belongs to the most important function. 2. Those organs of the same series are of the greatest value which are of the most general occurrence. 3. The adhesion which often subsists between an inferior and a superior organ, serves to point out the relative value of any two of the former; since it will be the same as that which was previously established for those of the latter, to which they respectively adhere. 4. The greater degree to which an organ is liable to vary, indicates an inferiority of value. Thus, the shape of the leaves is of little importance beyond determining the specific distinctions of plants. 5. The relative periods at which organs are formed and developed may also be taken as some test of their relative importance; those which are earliest formed being considered more important than others, with which they are immediately connected, of the same class.†

* Daubeny, Sketch of the Writings and Philosophical Character of Augustin Pyramus De Candolle, in Edin. New Philos. Journal for April 1843. Dunal, Eloge Historique de A. P. De Candolle, Montpellier, 1842.

† Henslow, Principles of Descriptive and Physiological Botany, p. 140.

1101. The following table illustrates the relative values of organs belonging to the elementary tissues, and to the nutritive and the reproductive functions :—

Relative Values.	Elementary Tissues.	Nutritive Organs.	Reproductive Organs.
1.	Cellular Tissue.	—	—
2.	Vascular Tissue. Spiral vessels. Porous vessels. Scalariform vessels. Stomata.	Embryo. Cotyledon. Radicle. Plumule. Spore. Prothallus.	—
3.	—	Descending Axis. Ascending Axis. Leaf. Frond. Thallus.	Stamens and Pistils. Antheridia and Archegonia. Fruit. Pericarp. Theca.
4.	—	—	Perianth. Calyx. Corolla.
5.	—	—	Inflorescence. Thalamus. Bracts and Involucre.

1102. Cellular tissue is reckoned of the highest value, as being of universal occurrence, and as carrying on, in many instances, all the functions of plants. In considering the elementary tissues alone, we divide all plants into Cellular and Vascular—the former including the lower tribes, such as Lichens, Seaweeds, and Mushrooms, the latter including the higher flowerless plants with scalariform vessels, and all the flowering plants with spiral vessels. Stomata are found in vascular and not in cellular plants. In the nutritive and reproductive organs there is nothing which can be considered of the same value as cellular tissue. In the nutritive organs the embryo occupies the highest place, and by examining it we divide plants into Acotyledonous, having no cotyledons, but occasionally producing a prothallus, Monocotyledonous, with one cotyledon, and Dicotyledonous, with two cotyledons. Proceeding to the secondary organs in the nutritive class, we find that the root gives rise to the divisions of Heterorhizal, Endorhizal, and Exorhizal of Richard. Next the stem is Cellular or Thallogenous, Acrogenous, Endogenous, and Exogenous. The thallus is veinless, the frond of Acrogens has often a forked venation, the leaves of Endogens are parallel-veined, and those of Exogens reticulated. In the reproductive system the stamens and pistils occupy the highest place, as being the essential organs of flowering plants (Phanerogamia), while antheridia and archegonia have the same value in flowerless plants (Cryptogamia). Succeeding these organs in value comes the fruit, which is either a theca with spores, or a pericarp with seed. The floral envelopes are the next in the series; they are absent in Cryptogamous plants, and present in Phanerogamous; their arrangement is ternary in Monocotyledons, quinary and quaternary in Dicotyledons. The inflorescence and bracts, as found in flowering plants, occupy the lowest place in the subordination.

1103. We thus find, that by comparing these different organs in plants, we arrive at certain great natural divisions, including plants which are associated by affinity of structure and function, as exhibited in the following table :—

Cellular Plants without Vessels or Stomata.	Vascular Plants with Scalariform Vessels, and Stomata.	Vascular Plants with Spiral Vessels, and Stomata.	
Acotyledonous.	Acotyledonous, with Prothallus.	Monocotyledonous.	Dicotyledonous.
Heterorhizal.	Heterorhizal.	Endorhizal.	Exorhizal.
Thallogenous.	Acrogenous.	Endogenous.	Exogenous.
No Venation.	Forked Venation.	Parallel Venation.	Reticulated Venation
Cryptogamous.	Cryptogamous.	Phanerogamous.	
Thecæ with Spores, or naked Spores.	Thecæ with Spores.	Angiospermous or Gymnospermous.	
Flowerless.	Flowerless.	Floral Envelopes Ternary.	Flor. Env. Quaternary or Quinary.
No Inflorescence, nor Bracts.	No Inflorescence, nor Bracts.	Having Inflorescence and Bracts.	

1104. It is impossible to represent the affinities of plants in a linear series. 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 allowance must be made for constant anomalies, in as far as man's definitions are concerned. Maout considers the vegetable kingdom as divided into three great *continents*, which are the Classes, Dicotyledons, Monocotyledons, and Acotyledons; each of them is divided into *regions*, which are Subclasses; these in their turn are divided into *cities*, which are the Orders; the cities into *quarters*, which are Genera; and these into *houses*, which are Species. Continents are separated by seas of different extent, and there are projecting promontories which make them approach at some points; Regions are separated by straits or united by isthmuses; Cities communicate by lines and roads, representing a sort of

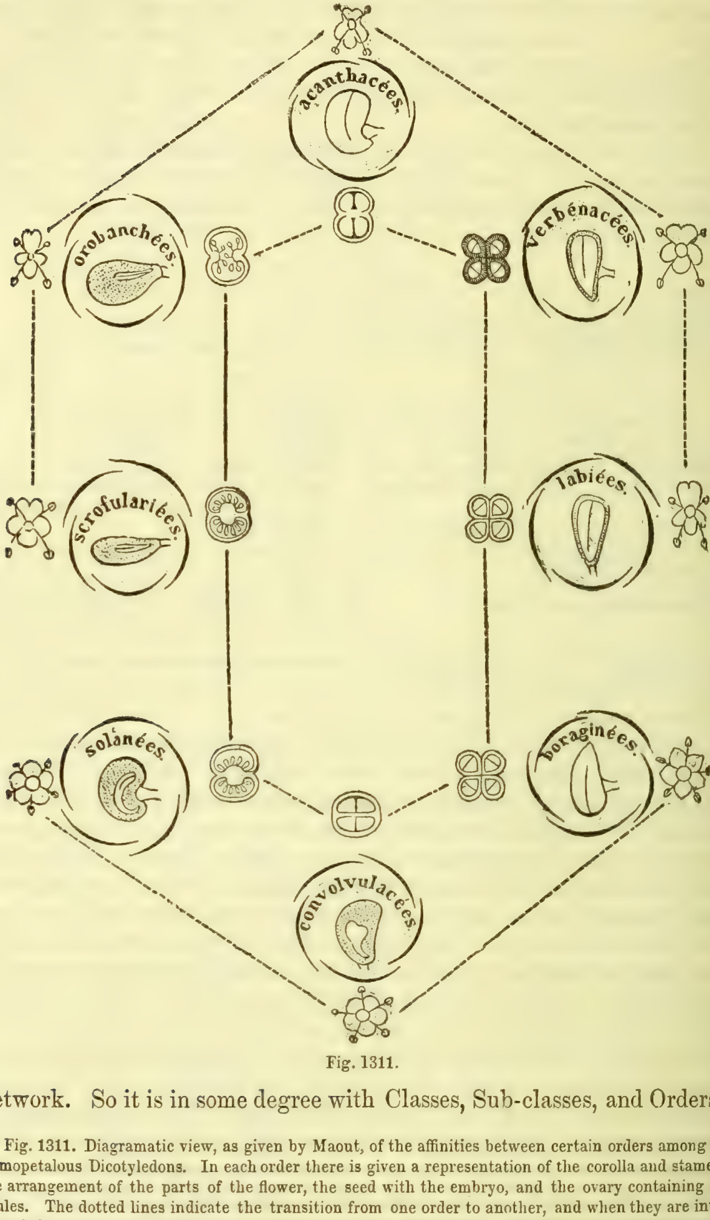

Fig. 1311.

network. So it is in some degree with Classes, Sub-classes, and Orders.*

Fig. 1311. Diagramatic view, as given by Maout, of the affinities between certain orders among the Gamopetalous Dicotyledons. In each order there is given a representation of the corolla and stamens, the arrangement of the parts of the flower, the seed with the embryo, and the ovary containing the ovules. The dotted lines indicate the transition from one order to another, and when they are interrupted they point out a want of immediate connection in that quarter. The orders with regular corollas below are thus shown to be separated from those with irregular corollas above.

* Maout, Eléments de Botanique, p. 867.

1105. In the great class of Dicotyledonous plants there is a sub-class called Corollifloræ, and under it are included numerous Alliances and Orders. Taking one of these Alliances, Maout endeavours to show the affinities of the Orders by the accompanying diagram (Fig. 1311). Let us commence with Solanaceæ. In proceeding from that Order to the others we may take two roads, the one represented by the pistils, which may be called the Gynœcial road, the other by the corolla and stamens, which may be denominated the Andrœcial road. In going from Solanaceæ to Scrophulariaceæ, we find it impossible to pass by the Andrœcial road, as there is no connection between a regular corolla with five stamens, and an irregular one with four unequal stamens, as shown in the figure. But if we take the Gynœcial road we are conducted at once to the Scrophulariaceæ, the structure of which is the same, since it consists of a double carpel forming a two-celled ovary, with many ovules. In passing to Orobanchaceæ we go at once by the Andrœcial road, as the form of the corolla and the nature of the stamens correspond; but while in both the seeds are albuminous, the ovaries differ, for by a partial obliteration of the septum, the ovary in the Orobanchaceæ becomes unilocular in place of bilocular.

1106. From Solanaceæ the transition to Boraginaceæ is through Convolvulaceæ, and we may pass both by the Gynœcial and Andrœcial road. There is in each of the three orders a regular corolla with five divisions, and bearing five alternate stamens. From the bilocular multi-ovular ovary of Solanaceæ, we pass through the bilocular quadri-ovular ovary of Convolvulaceæ to the four-lobed and quadri-ovular ovary of Boraginaceæ. The latter have a marked affinity to Labiatæ as regards the quadri-locular ovary, but differ in having a regular corolla, with five equal stamens, in place of an irregular one with four didynamous ones. The transition from Labiatæ to Verbenaceæ is easy both as regards the Gynœcial and Andrœcial road; the irregular corolla with didynamous stamens being found in both, and the ovary having four divisions which form separate achænia in Labiatæ, and united ones in Verbenaceæ. We next proceed to Acanthaceæ, with their irregular flowers and didynamous stamens, and their two-celled ovary with four ovules. In this way also there is direct passage to Scrophulariaceæ, with irregular flowers, didynamous stamens, and a two-celled ovary with numerous ovules.

1107. Thus the circuit is completed, and the affinities of the orders, as regards their corolla, stamens, and pistils, are seen. Solanaceæ, Convolvulaceæ, and Boraginaceæ have regular corollas with five stamens, while the other orders have irregular corollas with didynamous stamens. The lines indicate the alliance of the first three orders in this respect, while the interruption of the lines at the margins shows the want of correspondence between them and the other orders in their corolline characters. In the Gynœcial System we find orders with unilocular, bilocular, and quadrilocular ovaries; the two former being either multiovular or quadriovular, and the latter being quadriovular. From the bilocular and multiovular ovary of Solanaceæ we come to the bilocular quadriovular one of Convolvulaceæ, then to the four-divided ovaries of Boraginaceæ and Labiatæ, the quadrilocular ovary of Verbenaceæ, the bilocular quadriovular ovary of Acanthaceæ, and then to the unilocular bicarpellary ovary of Orobanchaceæ, which leads to the bicarpellary bilocular ovaries of Scrophulariaceæ and Solanaceæ. The lines connecting them show that there is a transition from the one to the other. The orders from Convolvulaceæ to Orobanchaceæ are represented with perisperm surrounding the embryo, while those on the other side are usually aperispermic. The direction of the parts of the embryo is also shown with the arrangement of the parts of the corolla. This must be looked upon as giving a view of the usual characters of these orders, and by no means as pointing out all their peculiarities. In many of them the stamens, in place of being didynamous, are reduced to two by abortion, and other variations of a similar kind occur.

1108. Having examined the general principles upon which the natural system is founded, we shall now give a sketch of some of the more important Taxological plans which have been propounded. Jussieu* divided plants into three primary groups—Acotyledones, Monocotyledones, and Dicotyledones, and included under them fifteen classes. One of the classes is Acotyledonous, three Monocotyledonous, and eleven Dicotyledonous. The three Monocotyledonous classes are distinguished by the position of the stamens, whether inserted on the thalamus (hypogynous), attached to the calyx (perigynous), or to the ovary (epigynous). Dicotyledonous plants are divided into Apetalous (monochlamydeous), plants having a calyx only; Monopetalous (gamopetalous), plants having united petals; Polypetalous, plants having separate petals; and Diclinous, plants which are unisexual and incomplete: the last constitutes the fifteenth class, while the other ten classes of Dicotyledons included in the other three divisions are determined chiefly by the position of the stamens and the corolla in relation to the ovary.

1109. Under these classes he included 100 orders. Class 1, is represented by such orders as Fungi, Algæ, Musci, Filices. Class 2, by Araceæ, Cyperaceæ, and Gramineæ. Class 3, by Palmæ, Liliaceæ, Amaryllidaceæ, and Iridaceæ. Class 4, by Musaceæ and Orchidaceæ. Class 5, by Aristolochiaceæ. Class 6, by Proteaceæ, Lauraceæ, Polygonaceæ. Class 7, by Amaranthaceæ, Plantaginaceæ. Class 8, by Acanthaceæ, Labiatæ, Scrophulariaceæ, Solanaceæ, Boraginaceæ, and Gentianaceæ. Class 9, by Ericaceæ, Campanulaceæ. Class 10, by Compositæ. Class 11, by Dipsacaceæ and Rubiaceæ. Class 12, by Araliaceæ and Umbelliferæ. Class 13, by Ranunculaceæ, Papaveraceæ, Cruciferæ, Aceraceæ, Hypericaceæ, Guttiferæ, Geraniaceæ, Malvaceæ, and Caryophyllaceæ. Class 14, by Saxifragaceæ, Cactaceæ, Onagraceæ, Rosaceæ, and Leguminosæ. Class 15, by Angiospermous orders, such as Euphorbiaceæ, Cucurbitaceæ, and Amentiferæ; and by Gymnospermous orders, such as Coniferæ.

* Jussieu (Antoine Laurent de), Genera Plantarum, secundum ordines naturales disposita, 1774.

1110. Tabular View of Jussieu's Natural System.

Acotyledones,			Class I.	Acotyledones.
Monocotyledones,		Stamens Hypogynous,	II.	Mono-hypogynæ.
		Stamens Perigynous,	III.	Mono-perigynæ.
		Stamens Epigynous,	IV.	Mono-epigynæ.
Dicotyledones.	Apetalæ, (No petals).	Stamens Epigynous,	V.	Epistamineæ.
		Stamens Perigynous,	VI.	Peristamineæ.
		Stamens Hypogynous,	VII.	Hypostamineæ.
	Monopetalæ, (Petals united).	Corolla Hypogynous,	VIII.	Hypocorollæ.
		Corolla Perigynous,	IX.	Pericorollæ.
		Corolla Epigynous,	X.	Epicorollæ, Synantheræ. (Anthers united).
			XI.	Epicorollæ, Corisantheræ. (Anthers separate.)
	Polypetalæ, (Petals separate).	Petals Epigynous,	XII.	Epipetalæ.
		Petals Hypogynous,	XIII.	Hypopetalæ.
		Petals Perigynous,	XIV.	Peripetalæ.
	Flowers unisexual, or without a Perianth,		XV.	Diclines.

1111. De Candolle's system* is in many respects similar to that of Jussieu. He has the same primary divisions. Under Dicotyledons there are four groups, under Monocotyledons two groups, and under Acotyledons two groups. Among Dicotyledons the sub-classes are founded on the number of the floral envelopes, the union or separation of the petals, and the insertion of the stamens. Among Monocotyledons he included some Cryptogamous plants, and he formed two divisions, according as the floral envelopes were present or absent. The Acotyledons or Cellular plants were divided into those having leaves and those without leaves.

1112. Tabular View of De Candolle's Natural System.

A. Vasculares or Cotyledoneæ.

Class I. Dicotyledones or Exogenæ.

Sub-class	1. Thalamifloræ.	Petals distinct, stamens hypogynous.
—	2. Calycifloræ.	Petals distinct or united, stamens perigynous or epigynous.
—	3. Corollifloræ.	Petals united, hypogynous, usually bearing the stamens.
—	4. Monochlamydeæ.	Having a calyx only, or no floral envelope.

Class II. Monocotyledones or Endogenæ.

—	5. Mono-Phanerogamæ.	Having floral envelopes.
—	6. Mono-Cryptogamæ.	Without floral envelopes.

B. Acotyledoneæ or Cellulares.

—	7. Foliosæ.	Having leaves.
—	8. Aphyllæ.	Leafless.

* De Candolle (Augustin Pyramus), Théorie Elémentaire de la Botanique, ou Exposition des Principes de la Classification Naturelle, 1813.

As examples of Sub-class 1, may be mentioned Ranunculaceæ, Papaveraceæ, Caryophyllaceæ, Hypericaceæ; as examples of Sub-class 2, Leguminosæ, Rosaceæ, Umbelliferæ, and Compositæ; of Sub-class 3, Gentianaceæ, Labiatæ, Solanaceæ, Primulaceæ; of Sub-class 4, Polygonaceæ, Euphorbiaceæ; of Sub-class 5, Liliaceæ, Palmæ, Gramineæ; of Sub-class 6, Equisetaceæ and Filices; of Sub-class 7, Musci and Hepaticæ; and of Sub-class 8, Fungi and Algæ.

1113. As one of the most complete works on the Genera of Plants has been published by Endlicher,* it seems proper to give a sketch of his system. He divides the whole Vegetable Kingdom into two Regions:—

Regio I. THALLOPHYTA. Stemless plants, with no vessels nor evident organs of reproduction, producing germinating spores. This Region is divided into two Sections:—

Sectio I. PROTOPHYTA. Plants developed without soil; deriving nourishment from the elements in which they grow; their fructification being indefinite. This embraces the classes Algæ and Lichenes.

Sectio II. HYSTEROPHYTA. Plants produced on decaying organisms; nourished externally from a matrix; all the organs appearing at once, and perishing in a definite manner, as in the class of Fungi.

Regio II. CORMOPHYTA. Plants with stem and root growing in opposite directions. Spiral vessels and organs of reproduction distinct in the more perfect. This Region includes three Sections.

Sectio III. ACROBRYA. Stem increasing by the apex, the lower part being unchanged, and only conveying fluids. Under this section are three Cohorts, as he denominates them.

Cohors 1. *Anophyta.* Having no spiral vessels; both sexes perfect; spores free within sporangia; as illustrated by the classes Hepaticæ and Musci.

Cohors 2. *Protophyta.* Having vascular bundles more or less perfect, and spores free within unicellular or pluricellular sporangia; including five classes, illustrated by the orders Equisetaceæ, Filices, and Lycopodiaceæ.

Cohors 3. *Hysterophyta.* Organs of reproduction perfect; seeds acotyledonous; polysporous; plants parasitic; as shewn in the class Rhizantheæ.

Sectio IV. AMPHIBRYA. Plants with stems increasing in diameter at the circumference, the vegetation being peripherical; containing eleven classes, illustrated by the orders Glumaceæ, Juncaceæ, Liliaceæ, Araceæ, Palmæ.

* Endlicher, (Stephanus) Genera Plantarum secundum Ordines Naturales disposita, 1836-1840.

Sectio V. Acramphibrya. Plants having a stem which increases both in length and diameter, the vegetation being peripherico-terminal. Under this he includes four Cohorts.

Cohors 1. *Gymnospermæ.* Plants with naked ovules, impregnated by the application of the pollen to the micropyle; including the class Coniferæ.

Cohors 2. *Apetalæ.* Plants without a perigone, or with a rudimentary or simple one, which is green or coloured, and is either free or united to the ovary; including six classes, illustrated by the orders Piperaceæ, Amentiferæ, Urticaceæ, Polygonaceæ, Lauraceæ, and Proteaceæ.

Cohors 3. *Gamopetalæ.* Plants with calyx and corolla, the latter being gamopetalous, rarely abortive. It includes ten classes, illustrated by the orders Plumbaginaceæ, Compositæ, Campanulaceæ, Cinchonaceæ, Asclepiadaceæ, Labiatæ, Scrophulariaceæ, Primulaceæ, Ericaceæ.

Cohors 4. *Dialypetalæ.* Calyx and corolla present; the former being polysepalous or gamosepalous, free or adherent to the ovary; the latter being usually polypetalous, rarely cohering by means of the base of the stamens, its insertion being hypogynous, perigynous, or epigynous, rarely abortive. This contains twenty-two classes, illustrated by the orders Umbelliferæ, Saxifragaceæ, Ranunculaceæ, Cruciferæ, Papaveraceæ, Caryophyllaceæ, Malvaceæ, Geraniaceæ, Rosaceæ, Leguminosæ.

1114. The following is the arrangement adopted by Lindley* in his recent work on the Vegetable Kingdom :—

Class I. Thallogens—Asexual or Flowerless plants without proper stems or leaves. Under this he includes three Alliances—Algales, Fungales, and Lichenales.

— II. Acrogens—Asexual or Flowerless plants with stems and leaves, including three Alliances—Muscales, Lycopodales, and Filicales.

— III. Rhizogens—Sexual or Flowering plants, with Acotyledonous embryos and fructification springing from a thallus, as in Rafflesiaceæ.

— IV. Endogens—Monocotyledonous flowering plants with Endogenous stems, parallel venation, and ternary symmetry. This class is subdivided into 4 sections—

1. Plants with glumaceous flowers formed by imbricated bracts.
2. Petaloid unisexual flowers.

* Lindley (John), The Vegetable Kingdom, or the Structure, Classification, and Uses of Plants, illustrated upon the Natural System, 1846. This work gives a full view of all the systems of Natural Classification, and may be consulted by the student for complete details.

3. Petaloid hermaphrodite flowers adherent to the ovary.
4. Petaloid hermaphrodite flowers free from the ovary.

Under these sections are included 11 Alliances, such as Glumales, Arales, Palmales, Narcissales, Orchidales, Juncales, and Liliales.

Class V. Dictyogens—Monocotyledonous plants with reticulated venation, including such orders as Dioscoreaceæ, Smilaceæ, and Trilliaceæ.

— VI. Gymnogens—Polycotyledonous Exogens with naked seeds, as Coniferæ and Cycadaceæ.

— VII. Exogens—Dicotyledonous plants with seeds in a seed-vessel. Under this class he puts the following sub-classes :—

Sub-class 1. *Diclinous Exogens*, or Dicotyledons with unisexual flowers, and no tendency to form hermaphrodite flowers; including 8 Alliances, such as Amentales, Urticales, Euphorbiales, Menispermales, Cucurbitales.

Sub-class 2. *Hypogynous Exogens*, or Dicotyledons with hermaphrodite or polygamous flowers, and stamens entirely free from the calyx and corolla; including 14 Alliances, such as Violales, Cistales, Malvales, Nymphæales, Ranales, Berberales, Ericales, Rutales, Geraniales, Silenales, Chenopodales, and Piperales.

Sub-class 3. *Perigynous Exogens*, or Dicotyledons with hermaphrodite or polygamous flowers, the stamens growing to the side of either the calyx or the corolla, ovary superior, or nearly so. This includes 10 Alliances, such as Daphnales, Rosales, Saxifragales, Gentianales, Solanales, Echiales, and Bignoniales.

Sub-class 4. *Epigynous Exogens*, or Dicotyledons with hermaphrodite or polygamous flowers, the stamens growing to the side of either the calyx or corolla, ovary inferior, or nearly so. This includes 7 Alliances, such as Campanales, Myrtales, Cactales, Grossales, Cinchonales, Umbellales, and Asarales.

1115. These are some of the most important methods of arrangement as adopted in the standard works of the day, and a comparative view of them is given by Henslow* in the following Table :—

* Henslow, Syllabus of a Course of Lectures on Botany, Cambridge, 1848.

Henslow's Approximate Comparison of the Systematic Views of Jussieu, De Candolle, Endlicher, and Lindley.

JUSSIEU, 1789.	DE CANDOLLE, 1819.	ENDLICHER, 1836.	LINDLEY, 1846.
	* Cellulares *v.* Acotyledoneæ.	* Thallophyta.	† Flowerless. (alliances).
algæ, 2. lichenes. fungi, 1.	aphyllæ	I. PROTOPHYTA.	I. THALLOGENS ... 1. algales. 3. lichenales. 2. fungales.
	ACOTYLEDONES .... IV.	II. HYSTEROPHYTA.	
		* * Cormophyta.	4. muscales.
I. ACOTYLEDONES 1 .... musci, 4. hepaticæ, 3.	foliosæ	1. Anophyta.	II. ACROGENS
	* * Vasculares *v.* Cotyledoneæ.		
	† Monocotyledones *v.* Endogenæ.		5. lycopodales. 6. filicales.
filices, 5.]	MONO-CRYPTOGAMÆ ...... III.	III. ACROBRYA. 2. Protophyta.	
			* * Flowering.
		3. Hysterophyta.	III. RHIZOGENS. (1 alliance.)
II. MONOCOTYLEDONES. 2, 4, 3 — mono- -hypogynæ. -epigynæ. -perigynæ.	MONO-PHANEROGAMÆ ... II.	IV. AMPHIBRYA.	IV. ENDOGENS (11 alliances.) and V. DICTYOGENS. (1 alliance.)
	† † Dicotyledones *v.* Exogenæ.		
III. DICOTYLEDONES. 4. Diclines irregulares 15 — gymnospermæ. angiospermæ.	4. Monochlamydeæ	1. Gymnospermæ.	VI. GYMNOGENS.
1. Apetalæ 5, 6, 7 — epi- peri- hypo- -stamineæ.		2. Apetalæ.	1. Diclinous (8 alliances.)
8, 9 — hypo- peri- -corollæ.	3. Corolliflorae		2. Hypogynous (14 alliances.)
2. Monopetalæ 10 corisantheræ, 11 synantheræ — epi-	DICOTYLEDONES I.	V. ACRAMPHIBRYA. 3. Gamopetalæ.	VII. EXOGENS.
	2. Calycifloræ		3. Perigynous (10 alliances.)
3. Polypetalæ... 12, 14, 13 — epi- peri- hypo- -petalæ.	1. Thalamifloræ	4. Dialypetalæ.	4. Epigynous (7 alliances.)

1116. The following is the arrangement which we propose to follow in the Class-Book :—

Plants are arranged in two great Divisions—PHANEROGAMOUS, COTYLEDONOUS, or FLOWERING Plants; and CRYPTOGAMOUS, ACOTYLEDONOUS, or FLOWERLESS Plants. Of Phanerogamous Plants there are two classes :—

CLASS I. DICOTYLEDONES, EXOGENÆ, or ACRAMPHIBRYA, in which spiral vessels are present (Fig. 1312); the stem is exogenous

Fig. 1312.

Fig. 1313.

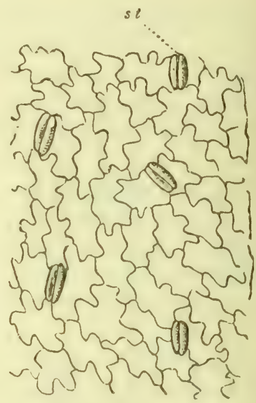

Fig. 1314.

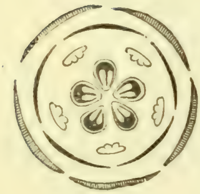

Fig. 1316.

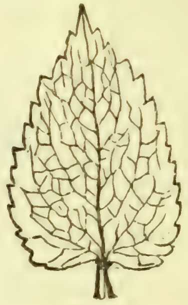

Fig. 1315.

Fig. 1317.

(Fig. 1313); stomata are present (Fig. 1314); the venation of the leaves is reticulated (Fig. 1315); the flowers have stamens and pistils,

Fig. 1312. Spiral vessels as occurring in a Dicotyledon or Exogen.
Fig. 1313. Exogenous stem of an Oak, showing concentric circles of wood and a separable bark.
Fig. 1314. Stomata in the epidermis of a Dicotyledon.
Fig. 1315. Reticulated venation in the leaf of a Dicotyledon.
Fig. 1316. Quinary symmetry in a perfect or hermaphrodite flower of a Dicotyledon.
Fig. 1317. Quaternary symmetry in a perfect flower of a Dicotyledon.

and the symmetry is quinary or quaternary (Figs. 1316 and 1317); the ovules are either in an ovary (Fig. 1318), or naked (Fig. 1319); and the embryo is dicotyledonous (Fig. 1320). In this class there are included four Sub-classes.

Sub-class I. THALAMIFLORÆ — Flowers usually dichlamydeous, petals separate, inserted on the thalamus, and stamens hypogynous (Figs. 1321 and 1322). It may be illustrated by the following natural orders :—

Ranunculaceæ.	Violaceæ.	Hypericaceæ.
Magnoliaceæ.	Caryophyllaceæ.	Guttiferæ.
Papaveraceæ.	Malvaceæ.	Geraniaceæ.
Cruciferæ.	Aurantiaceæ.	Rutaceæ.

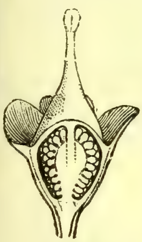

Fig. 1318.

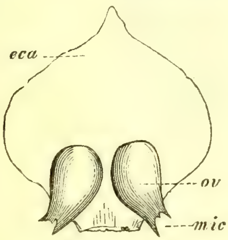

Fig. 1319.

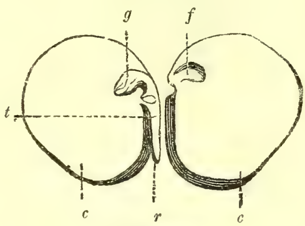

Fig. 1320.

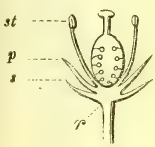

Fig. 1321.

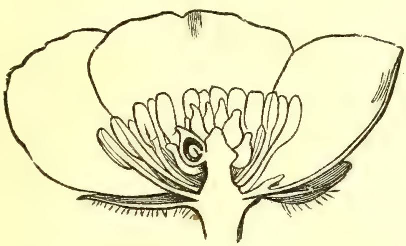

Fig. 1322.

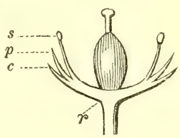

Fig. 1323.

Sub-class II. CALYCIFLORÆ — Flowers usually dichlamydeous, petals either separate or united, stamens either perigynous (Fig. 1323) or epigynous (1324). This sub-class has two sub-divisions—

1. *Polypetalæ* or *Dialypetalæ*—in which the petals are separate (Fig. 1325), illustrated by the following natural orders :—

Fig. 1318. Ovary of a Dicotyledon, containing ovules (Angiospermæ).

Fig. 1319. Naked ovules of a Dicotyledon, with the exposed micropyle, *mic*, and a scale or bract, *eca* (Gymnospermæ).

Fig. 1320. Dicotyledonous embryo of an Exogen. Cotyledons, *c c*, radicle, *r*, tigellus, *t*, plumule or gemmule, *g*, and depression for it, *f*.

Fig. 1321. Diagram to illustrate Thalamifloral Dicotyledons. Sepals, *s*, petals, *p*, and stamens, *st*, all free, and inserted into the receptacle, *r*, below the ovary.

Fig. 1322. Flower of a Ranunculus, illustrating Thalamifloral Exogens. The petals are separately inserted on the thalamus, and the stamens are hypogynous.

Fig. 1323. Diagram to illustrate Calycifloral Dicotyledons with perigynous stamens. Petals, *p*, and stamens, *s*, inserted on the calyx, *c*, surrounding the ovary.

Celastraceæ.
Anacardiaceæ.
Leguminosæ.
Rosaceæ.
Melastomaceæ.
Myrtaceæ.
Onagraceæ.
Passifloraceæ.
Crassulaceæ.
Cactaceæ.
Saxifragaceæ.
Umbelliferæ.

2. *Monopetalæ* or *Gamopetalæ*—in which the petals are united (Fig. 1326), as illustrated in the orders—

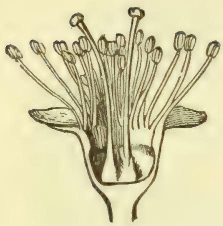
Fig. 1325.

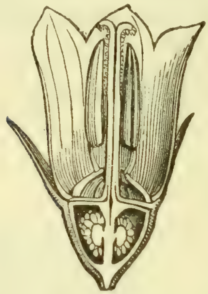
Fig. 1326.

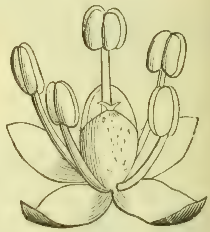
Fig. 1329.

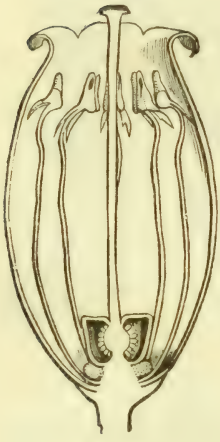
Fig. 1327.

Fig. 1324.

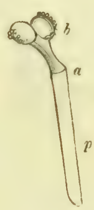

Fig. 1330.

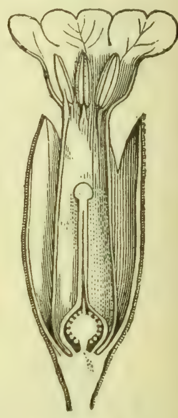
Fig. 1328.

Caprifoliaceæ.
Galiaceæ.
Cinchonaceæ.
Dipsacaceæ.
Valerianaceæ.
Compositæ.
Campanulaceæ.
Lobeliaceæ.
Vacciniaceæ.

Fig. 1324. Diagram to illustrate Calycifloral Dicotyledons with Epigynous stamens. Petals, *p*, and stamens, *s*, united to the calyx, *c*, and all adherent to the ovary, *o*, so as to be above it; *r*, receptacle.

Fig. 1325. Flower of Cherry, one of the Rosaceæ, showing a Calycifloral Exogen, with a polypetalous corolla.

Fig. 1326. Flower of Campanula, showing a Calycifloral Exogen, with a gamopetalous corolla.

Fig. 1327. Flower of a Heath, showing a Corollifloral Exogen, with the stamens hypogynous, and free from the corolla.

Fig. 1328. Flower of Primula, showing a Corollifloral Exogen, with the stamens united to the corolla, which is hypogynous.

Fig. 1329. Flower of Chenopodium, showing a Monochlamydeous Exogen. In this plant the embryo is truly Dicotyledonous.

Fig. 1330. Achlamydeous male flower of Euphorbia, one of the Dicotyledons. Peduncle, *p*; *b*, the solitary stamen or male flower attached to the peduncle by a joint, *a*.

Sub-class III. COROLLIFLORÆ — Flowers dichlamydeous, petals united, corolla hypogynous. In this sub-class there are two subdivisions :—

1. *Hypostamineæ*—in which the stamens are inserted into the receptacle and not united to the corolla (Fig. 1327), as illustrated in the orders—

Ericaceæ.	Epacridaceæ.

2. *Epicorollæ* or *Epipetalæ*—in which the stamens are inserted on the corolla (Fig. 1328), as illustrated by the orders—

Gentianaceæ.	Solanaceæ.	Acanthaceæ.
Polemoniaceæ.	Scrophulariaceæ.	Primulaceæ.
Convolvulaceæ.	Labiatæ.	Plumbaginaceæ.
Boraginaceæ.	Verbenaceæ.	Plantaginaceæ.

Sub-class IV. MONOCHLAMYDEÆ, or APETALÆ—flowers either with a calyx only (Fig. 1329), or achlamydeous (Fig. 1330). In this sub-class there are two subdivisions :—

1. *Angiospermæ*—in which the ovules are contained in a pericarp, and are fertilized by the action of the pollen on the stigma (Fig. 1329), as in the following natural orders, many of which contain unisexual flowers—

Chenopodiaceæ.	Proteaceæ.	Euphorbiaceæ.
Polygonaceæ.	Thymelæaceæ.	Urticaceæ.
Begoniaceæ.	Aristolochiaceæ.	Piperaceæ.
Lauraceæ.	Nepenthaceæ.	Amentiferæ.

These orders are all truly Dicotyledonous, while another order Rafflesiaceæ (Fig. 127, p. 54), is Acotyledonous.

2. *Gymnospermæ*—in which the ovules are not contained in a true pericarp, and are fertilized by the direct action of the pollen without the intervention of a stigma (Fig. 1331), and the embryo is polycotyledonous (Fig. 1332), as illustrated in the natural orders—

Coniferæ.	Cycadaceæ.

CLASS II. MONOCOTYLEDONES, ENDOGENÆ, or AMPHIBRYA, in which spiral vessels are present; the stem is endogenous (Fig. 1333); stomata occur; the venation is usually parallel (Fig. 1334); sometimes slightly reticulated (Fig. 1335); the flowers have stamens and pistils, and the symmetry is ternary (Figs. 1336, 1337); the ovules are contained in an ovary; the embryo is monocotyledonous (Fig. 1338).

Under this Class are included three Sub-classes :—

Sub-class I. DICTYOGENÆ—plants with reticulated venation in their leaves (Fig. 1335), as illustrated in the orders Dioscoreaceæ, Trilliaceæ, and Smilaceæ.

Sub-class II. PETALOIDEÆ, or FLORIDÆ—in which the leaves are parallel-veined; the flowers usually consist either of a coloured perianth (Fig. 1339), or of whorled scales (Fig. 1336). This sub-class is divided into—

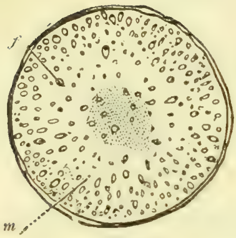

Fig. 1333.

Fig. 1331.

Fig. 1334.

Fig. 1332.

Fig. 1335.

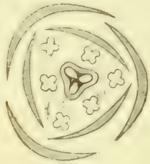

Fig. 1336.

Fig. 1337.

1. *Epigynæ*—in which the Perianth is adherent, the ovary is

Fig. 1331. Cone of a Pine belonging to Coniferæ, in which the ovules are covered by bracts, but are not contained in a true ovary with a stigma.

Fig. 1332. Polycotyledonous embryo of a Pine, one of the Gymnospermous Dicotyledons. The radicle, *r*, the tigellus, *t*, and the cotyledons, c.

Fig. 1333. Endogenous stem of a Monocotyledonous plant; *m*, the loose central cellular portion; *f*, the outer or cortical portion.

Fig. 1334. Parallel-veined leaf of a Monocotyledon or Endogen.

Fig. 1335. Slightly reticulated leaf of a Monocotyledonous plant (a species of Smilax). The plant is referred to the sub-class Dictyogens.

Fig. 1336. Trimerous flower of a Monocotyledon (*Luzula*), with ternary symmetry. The floral envelopes are glumaceous but verticillate in this plant.

Fig. 1337. Ternary symmetry in a perfect or hermaphrodite flower of a Monocotyledon (*Lilium album*).

inferior, and the flowers are usually hermaphrodite (Fig. 1340), as in the following natural orders :—

Hydrocharidaceæ.	Marantaceæ.	Hæmodoraceæ.
Orchidaceæ.	Musaceæ.	Amaryllidaceæ.
Zingiberaceæ.	Iridaceæ.	Bromeliaceæ.

2. *Hypogynæ*—in which the Perianth is free, the ovary is superior, and the flowers are usually hermaphrodite (Fig. 1337), as illustrated by the following orders :—

Liliaceæ.	Pontederiaceæ.	Commelynaceæ.
Melanthaceæ.	Juncaceæ.	Alismaceæ.
Gilliesiaceæ.	Palmæ.	Butomaceæ.

Fig. 1339.

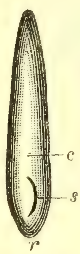

Fig. 1338.

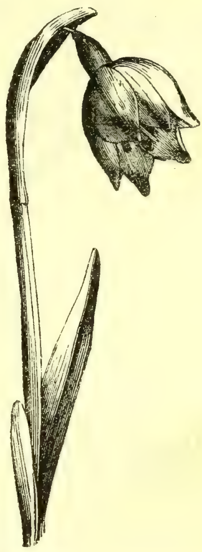

Fig. 1340.

3. *Incompletæ*—flowers incomplete, often unisexual, with no proper perianth, or with a few verticillate scales (Fig. 1341), as illustrated in the following natural orders :—

Pandanaceæ.	Naiadaceæ.
Araceæ.	Restiaceæ.

Sub-class III. GLUMIFERÆ—flowers glumaceous, consisting of imbricated bracts (Fig. 1342), venation parallel, as illustrated by the natural orders —

Cyperaceæ.	Gramineæ.

Fig. 1338. Monocotyledonous embryo of an Endogen (*Triglochin*), showing the cotyledon, *c*, the radicle, *r*, and the slit, *s*, where the plumule appears during germination.

Fig. 1339. A Monocotyledon (*Crocus sativus*), with parallel venation, and a coloured perianth, the parts of which exhibit trigonal symmetry.

Fig. 1340. Monocotyledon (*Leucojum*), with the ovary inferior, and the floral envelopes and stamens epigynous.

Class III. ACOTYLEDONES, or ACROGENÆ and THALLOGENÆ,

Fig. 1342.

Fig. 1341.

Fig. 1343.

Fig. 1344.

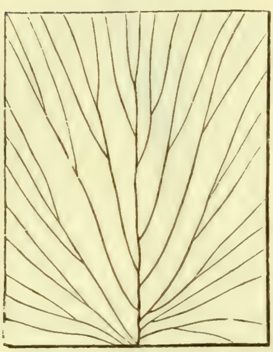

Fig. 1345.

Fig. 1347.

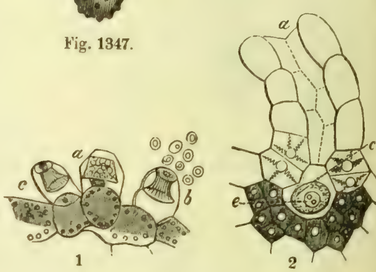

Fig. 1346.

or THALLOPHYTA and ACROBRYA, in which the plants are either

Fig. 1341. One of the incomplete unisexual Monocotyledons. A species of Arum, in which the male and female flowers are separate, and are each surrounded by minute scales; *a*, female flower; *b*, male flowers; *c*, abortive flowers; *d*, extremity of the spadix.

Fig. 1342. Glumiferous Monocotyledon (*Triticum*), consisting of numerous flowers formed by imbricated bracts.

Fig. 1343. Scalariform vessels, which are met with in the higher division of Acotyledonous plants, particularly in Ferns.

Fig. 1344. Acrogenous woody stem of a Fern.

Fig. 1345. Forked venation of the frond of a Fern.

Fig. 1346. Antheridia, 1, and Archegonium, 2, of a Fern, being the supposed organs of reproduction. For explanation, see Figures 1229 and 1231, p. 574.

Fig. 1347. Spore or cellular germinating body of an Acotyledonous plant.

entirely cellular, or consist partly of scalariform vessels (Fig. 1343) · the stem when woody is Acrogenous (Fig. 1344); stomata occur in the higher orders; the leaves are either veinless or have a forked venation (Fig. 1345); no flowers are present; the reproductive organs consist of Antheridia and Archegonia (Fig. 1346); spores or cellular embryos are produced which have no cotyledons (Fig. 1347).

Under this class there are two divisions :—

Sub-class I. ACROGENÆ, ACROBRYA, or CORMOGENÆ—with a distinct stem (Fig. 1344), bearing leaves and branches (Fig. 1348), as illustrated in the natural orders—

Equisetaceæ.	Lycopodiaceæ.	Musci.
Filices.	Rhizocarpeæ.	Jungermanniaceæ.

Sub-class II. THALLOGENÆ, THALLOPHYTA, or CELLULARES—having no distinct stem nor leaves, but forming a cellular expansion of various kinds which bears the organs of reproduction (Fig. 1349). It is illustrated by the orders—

Lichenes.	Fungi.	Algæ.

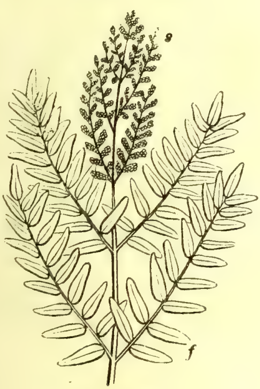

Fig. 1348.

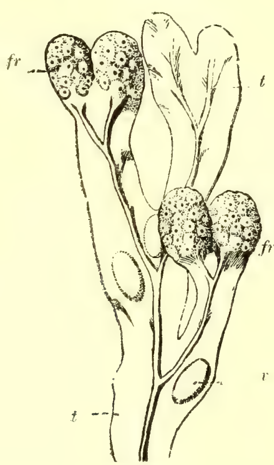

Fig. 1349

1117. The system of De Candolle is the basis of this proposed arrangement, and some of the Divisions are derived from Jussieu and

Fig. 1348. An Acrogen (*Osmunda regalis*), with an axis and leaves. The upper part of the frond, *f*, bears the fructification, *s*, in the form of sporangia and spores.

Fig. 1349. A Sea-weed (*Fucus vesiculosus*), illustrating one of the cellular Cryptogamic plants. It produces a cellular thallus, *t t*, which bears the fructification, *fr*, *fr*. Vesicles of air, *v*, exist in the frond. The venation is false, consisting only of condensed cellular tissue, without any woody tubes or vessels.

Lindley. An index to this arrangement is given in the following tabular view :—

A. Phanerogameæ, Cotyledoneæ, or Flowering Plants.

Class I. Dicotyledones, Exogenæ, Acramphibrya.

* Dichlamydeæ, having Calyx and Corolla.

Sub-class I. Thalamifloræ (Polypetalæ or Dialypetalæ Hypogynæ)	*Ranunculaceæ.*
Sub-class II. Calycifloræ ...... Perigynæ and Epigynæ — 1. Polypetalæ or Dialypetalæ	*Rosaceæ.*
Sub-class II. Calycifloræ ...... Perigynæ and Epigynæ — 2. Monopetalæ or Gamopetalæ	*Compositæ.*
Sub-class III. Corollifloræ (Monopetalæ or Gamopetalæ, Hypocorollæ).	
1. Hypostamineæ (Stamens free from Corolla, hypogynous) ...	*Ericaceæ.*
2. Epicorollæ (Stamens on hypogynous Corolla)	*Boraginaceæ.*

** Monochlamydeæ and Achlamydeæ, having a Calyx only, or no Envelope.

Sub-class IV. Monochlamydeæ or Apetalæ ... 1. Angiospermæ — *a.* Embryo Dicotyledonous (spermogens)	*Polygonaceæ.*
Sub-class IV. Monochlamydeæ or Apetalæ ... 1. Angiospermæ — *b.* Embryo Acotyledonous (sporogens)	*Rafflesiaceæ.*
Sub-class IV. Monochlamydeæ or Apetalæ ... 2. Gymnospermæ or Gymnogenæ, embryo usually Polycotyledonous	*Coniferæ.*

Class II. Monocotyledones, Endogenæ, Amphibrya.

Sub-class I. Dictyogenæ, leaves netted	*Trilliaceæ.*
Sub-class II. Petaloideæ or Floridæ, with a verticillate perianth ...... 1. Epigynæ	*Orchidaceæ.*
Sub-class II. Petaloideæ or Floridæ, with a verticillate perianth ...... 2. Hypogynæ	*Liliaceæ.*
Sub-class II. Petaloideæ or Floridæ, with a verticillate perianth ...... 3. Incompletæ	*Araceæ.*
Sub-class III. Glumiferæ, with imbricated bracts	*Gramineæ.*

B. Cryptogameæ, Acotyledoneæ, or Flowerless Plants.

Class III. Acotyledones Acro-Thallogenæ.

Sub-class I. Acrogenæ, Acrobrya, Cormogenæ	*Filices.*
Sub-class II. Thallogenæ, Thallophyta, Cellulares	*Algæ.*

CHAPTER III.

ARRANGEMENT AND CHARACTERS OF THE NATURAL ORDERS.

1118. Having now considered the primary divisions of the natural system, we proceed to give the characters of the natural orders, which are associated under the different classes and sub-classes. We have already stated, that in a linear series it is impossible to group the orders according to their affinities. Each order is allied, not merely to those which immediately precede and follow it in such a series, but to various other orders which are necessarily removed from it. On the confines of classes and sub-classes, orders occur which have characters common to two or more of the groups, and we constantly meet with aberrant genera which form a connecting link between two orders. In Botany, as in all departments of natural science, there are no rigid lines of demarcation, but one division seems to pass into another by an insensible gradation. Our definitions express the most marked and important characters of the groups, without attempting to embrace all the anomalies; and as our knowledge of the vegetation of the globe advances, we are enabled to improve the definitions of the groups, and to form intermediate divisions.

1119. In the following pages the natural orders are briefly defined, their general geographical distribution is given, some of the illustrative genera in each order are enumerated, the properties of the plants included in the orders are mentioned in so far as they have been determined, and a short notice is added of the more important medicinal and economical plants. At the end of each of the sub-classes an analysis is given of the natural orders included in it, so as to enable the student to detect the place of a genus or species in the natural system. In this the plan adopted by Lindley has been followed, with some modifications. The student is referred to Lindley's standard work, entitled "The Vegetable Kingdom," for a full account of the characters, alliances and affinities, distribution and properties, of the orders.

I.—PHANEROGAMEÆ, COTYLEDONEÆ, OR FLOWERING PLANTS.

CLASS I.—DICOTYLEDONES, EXOGENÆ, OR ACRAMPHIBRYA.

SUB-CLASS 1.—THALAMIFLORÆ.

1120. Natural Order 1.—Ranunculaceæ, the Buttercup order (Figs. 1350 to 1356).—Herbs, rarely shrubs, with an acrid watery

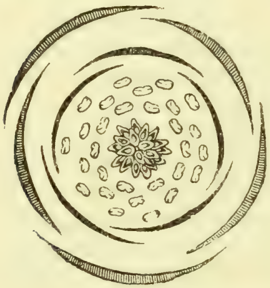

Fig. 1350.

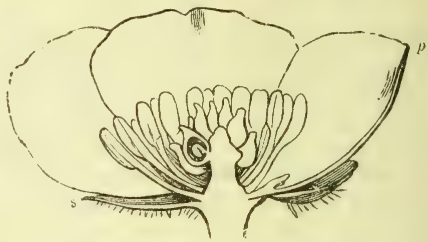

Fig. 1352.

Fig. 1351.

Fig. 1353.

Fig. 1354.

Fig. 1355.

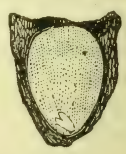

Fig. 1356.

juice, and generally with much-divided, exstipulate leaves (Fig. 263, p. 117), the petioles of which are dilated and sheathing. Sepals 3-6,

Figures 1350 to 1356 illustrate the natural order Ranunculaceæ.

Fig. 1350. Diagram of flower of Ranunculus, with five sepals, five petals, numerous stamens and carpels. Fig. 1351. Spurred petal of Columbine. Fig. 1352. Section of flower of Ranunculus, shewing sepals, *s*, petals, *p*, numerous stamens, with adnate anthers, placed below the carpels. Fig. 1353. Numerous single-seeded carpels of Ranunculus. Fig. 1354. Ripe achene of Ranunculus. Fig. 1355. Ripe follicle of Columbine. Fig. 1356. Anatropal seed of Aconite, cut vertically, showing abundant homogeneous albumen, and a small embryo.

Further illustrations of the Crowfoot order:—Flower of Ranunculus, Fig. 337, p. 144. Flower of Columbine, Fig. 393, p. 164; Fig. 524, p. 204; Fig. 670, p. 237; Fig. 462, p. 190. Scale-bearing petal of Ranunculus, Fig. 511, p. 202. Petal of Trollius, Fig. 512, p. 202. Petal of Hellebore, Fig. 518, usually deciduous, sometimes deformed (Fig. 482, p. 195). Petals 3-15, sometimes anomalous (Fig. 1351), at other times suppressed. Stamens usually ∞, with adnate anthers (Fig. 1352). Carpels numerous, one-celled (Fig. 1353, Fig. 693, p. 245), or united into a single, many-celled pistil (Fig. 698, p. 246). Fruit, achenes (Fig. 1354), follicles (Fig. 1355), or baccate. Seeds anatropal, with horny albumen, and a minute embryo (Fig. 1356).

1121. The Buttercup or Crowfoot family characterise a cold, damp climate, and when met with in the tropics, they occur on the sides and summits of mountains. There are about 1000 known species, of which 1-5th is found in Europe, and 1-7th in North America. *Illustrative Genera.*—Clematis, Thalictrum, Anemone, Hepatica, Adonis, Myosurus, Ranunculus, Caltha, Trollius, Eranthis, Helleborus, Aquilegia, Delphinium, Aconitum, Pæonia, Actæa, Podophyllum.

1122. The plants of the order have narcotico-acrid properties, and are usually more or less poisonous. The acridity varies at different seasons, and in different parts of the plant; it is frequently volatilised by heat, and destroyed by drying. Some plants of the order are bitter and tonic.

Aconitum ferox. The root furnishes the Indian poison called Bikh, Bish, or Nabee. Aconitum Napellus, Monkshood (Fig. 482, p. 195). The leaves are used to allay pain in neuralgia, and contain a narcotic alkaloid, Aconita, or Aconitina.

Clematis erecta and Flammula. The leaves have been employed as blisters.

Coptis trifolia, Gold thread. The roots are used in North America as a stomachic bitter.

Delphinium Staphisagria, Stavesacre. The seeds contain an alkaloid called Delphinia, and have been used for destroying vermin. The species of Delphinium are commonly known as Larkspurs.

Helleborus officinalis (the Black Hellebore of the ancients), H. niger, and other species, are famed as drastic purgatives.

Moutan officinalis (Pæonia Moutan) is the Tree-Pæony of China, remarkable for its showy flowers and large disk (Fig. 672, p. 238). Fortune mentions a plant near Shanghae which produced from 300 to 400 blossoms annually.

Nigella sativa (Fig. 266, p. 118). The seeds were formerly used instead of pepper, and they are supposed to be the fitches or black cummin (Ketzach) mentioned in Isaiah xxviii. 25, 27.

Podophyllum peltatum, May-apple, is used in North America as a cathartic. Its fruit is acid, and is called Wild Lemon.

Ranunculus, Crowfoot or Buttercup, whence the order is named. The species are generally acrid in a fresh state. The pericarps lose their acridity as they become ripe. The seeds are bland. Ranunculus sceleratus and Flammula are very acrid. The fasciculated roots of R. Ficaria have been used as an article of food, on account of the starch which they contain.

1123. Nat. Ord. 2.—Dilleniaceæ, the Dillenia order.—Trees, shrubs, or under-shrubs, with alternate, exstipulate leaves, five per-

p. 203. Petal of Larkspur, Fig. 521, p. 203. Petals of Aconite, Fig. 523, p. 203. Follicles of Columbine, Fig. 416, p. 175; Fig. 772, p. 265. Disk and Follicles of Pæony, Fig. 672, p. 238, and Fig. 788, p. 269. Achene of Clematis, Fig. 743, p. 255. Forms of leaves, Fig. 262, p. 117; Fig. 265, p. 118; Fig. 267, p. 119, and Fig. 305, p. 130.

sistent sepals in two rows, five deciduous imbricated petals, indefinite stamens often turned to one side, a 2-5-carpellary apocarpous or syncarpous fruit, arillate anatropal seeds, and homogeneous albumen. There are about 200 known species which occur chiefly in Australasia, India, and Equinoctial America. They have astringent qualities, and some of them are large trees, which afford excellent timber. *Ill. Gen.* —Dillenia, Hibbertia, Candollea, Curatella, Delima, Tetracera.

1124. Nat. Ord. 3.—MAGNOLIACEÆ, the Magnolia order (Figs. 1357, 1358).— Trees or shrubs, with alternate coriaceous leaves, and convolute stipules, which cover the buds, and are deciduous. They are remarkable for the beauty of their foliage, and the fragrance of their flowers. Sepals usually 3-6, deciduous. Petals, three or more, imbricated (Fig. 1357). Stamens ∞, distinct, with adnate anthers.

Fig. 1357.

Fig. 1358.

Carpels, one-celled, numerous, on an elevated receptacle. Fruit, of numerous, dry or succulent, dehiscent or indehiscent, carpels. Seeds often arillate, and suspended from the fruit by a long funiculus; albumen fleshy and homogeneous; embryo minute. The Magnoliads abound in North America, and characterise one of Schouw's phytogeographic regions. There are two sub-orders: — 1. Magnolieæ, with the carpels arranged in a cone-like manner, and leaves not dotted; 2. Wintereæ, with the carpels verticillate in a single row, and dotted leaves. The known species amount to nearly 70. *Ill. Gen.*—Talauma, Magnolia, Liriodendron, Tasmannia, Drimys, Illicium.

1125. The plants of this order have bitter, tonic, and aromatic qualities.

Drimys Winteri (Fig. 1358) yields Winter's bark, so called on account of its being discovered by Captain Winter.* It has stimulant aromatic properties. Its woody tissue presents a punctated appearance. Drimys granatensis supplies the aromatic bark called Casca d'Anta in Brazil.

Fig. 1357. The White-wood or Tulip-tree (*Liriodendron tulipifera*).

Fig. 1358. Winter's bark (*Drimys Winteri or aromatica*), brought from the Straits of Magellan, in 1579, by Captain Winter.

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* At a meeting of the Linnæan Society, held June 18, 1850, the President (Dr. Robert Brown) exhibited portions of Winter's bark trees, from the Straits of Magellan, cut down in 1826 by Captain

Illicium anisatum, on account of its flavour and the stellate arrangement of its fruit, receives the name of Star-Anise. It is used by the Chinese as a spice, and for flavouring liqueurs.

Liriodendron tulipifera (Fig. 1357) is called Tulip-tree, from the appearance of its flowers. Its leaves are abrupt or truncated. It is sometimes called White-wood. The bark is bitter and tonic.

Magnolia glauca, Swamp Sassafras or Beaver-tree, yields a bark which is used as a substitute for Cinchona.

Tasmannia aromatica is a New Holland tree, the fruit of which is sometimes used as a substitute for pepper.

1126. Nat. Ord. 4.—Anonaceæ, the Custard-apple order.—Trees or shrubs with alternate, entire, exstipulate leaves, three persistent sepals, six petals in two rows, usually valvate, sometimes combined, numerous stamens covering a large hypogynous receptacle, numerous carpels containing one or more ovules, a succulent or dry fruit, consisting of a number of one or many-seeded carpels, distinct or combined, seeds with a brittle spermoderm, ruminate albumen, and a minute embryo. There are about 300 known species of Anonads. They occur in tropical regions, and many of them furnish valuable fruits. *Ill. Gen.*—Bocagea, Xylopia, Uvaria, Guatteria, Duguetia, Anona, Rollinia.

1127. The plants of this order are generally aromatic and fragrant.

Anona squamosa yields the sweetsop, A. muricata the soursop, and A. reticulata the netted Custard-apple. A. Cherimolia produces the Peruvian Cherimoyer, said to be one of the finest known fruits. A. palustris furnishes West Indian Cork-wood.

Duguetia quitarensis is said to supply the elastic wood called Lance-wood, used by coachmakers.

Monodora Myristica, the Calabash-Nutmeg. Its seeds contain an aromatic oil resembling that of the East Indian nutmeg.

Uvaria febrifuga produces a febrifuge fruit.

Xylopia aromatica yields a dry aromatic fruit, used as pepper in Africa, and commonly called Piper æthiopicum. X. glabra is the Bitter-wood of the West Indies.

1128. Nat. Ord. 5.—Schizandraceæ, the Schizandra order.—Trailing shrubs, with alternate exstipulate leaves, allied to Anonaceæ, but differing in their habit, their unisexual flowers, their imbricate æstivation, and their homogeneous albumen. The stamens are often monadelphous, and the fruit consists of numerous baccate carpels. There are 12 known species which occur in India, Japan, and the hotter parts of North America. They abound in an insipid mucus, and the fruit of some is edible. *Ill. Gen.*—Kadsura, Schizandra.

1129. Nat. Ord. 6.—Menispermaceæ, the Moon-seed order.—

P. P. King, R.N., presenting inscriptions made through the bark by a midshipman who accompanied the Spanish expedition under Captain Cordoba in 1786, and by one of the companions of Captain Bougainville in 1767; the annual rings in the former case distinctly corresponded with the interval between 1786 and 1826.

Trailing shrubs with alternate, simple, usually entire leaves, and unisexual (often diœcious) flowers. Symmetry generally ternary. Stamens distinct or monadelphous, and attached to an androphore. Carpels supported on a gynophore, one-celled, containing a single curved ovule. Fruit drupaceous, one-celled, curved around a placental process. Seed solitary and curved; embryo with the cotyledons coiled up in a peripherical form. The woody matter is often closely compacted in wedges, separated by large medullary plates, giving the stem a peculiar aspect on a cross section.* Menispermads are common in the tropical woods of Asia and America, and they climb among the trees to a great height. There are about 300 known species. *Ill. Gen.* — Anamirta, Jateorrhiza, Menispermum, Cissampelos, Cocculus.

1130. The plants of this order have narcotic and bitter properties; some of them are very poisonous.

Anamirta paniculata yields the fruit known in commerce as Cocculus indicus, and which has been sometimes illegally used to impart bitterness to malt liquor. The seed contains a crystalline narcotic principle called Picrotoxine, while the pericarp yields another poisonous alkaloid, called Menispermine.

Coscinium (Menispermum) fenestratum supplies a false Calumba root which contains much Berberine.

Jateorrhiza palmata (Cocculus palmatus) supplies the bitter tonic root known as Calumba (Figs. 131-133, p. 55). It contains a bitter principle called Calumbine.†

Cissampelos Pareira, Wild Vine or Velvet-leaf, furnishes the tonic and diuretic root, known by the name of Pareira brava.

1131. Nat. Ord. 7.—LARDIZABALACEÆ, the Lardizabala order.—Twining shrubs, with alternate exstipulate leaves, ternary symmetry and unisexual flowers, resembling Menispermads, but differing in their compound leaves, ovules sunk on the inner surface of the ovary, and minute embryo in abundant solid albumen. They are found in the cooler parts of South America and China. They seem to have no active properties. Some yield edible fruits. There are 15 known species. *Ill. Gen.*—Akebia, Holböllia, Lardizabala.

1132. Nat. Ord. 8.—BERBERIDACEÆ, the Barberry order (Figs. 1359-1362).—Shrubs, or herbaceous perennial plants, with alternate compound leaves, which are often spiny from non-development of the parenchyma (Fig. 238, p. 107). Sepals, three, four, or six, deciduous, in a double row. Petals equal to the sepals in number, and opposite to them, or twice as many. Stamens equal in number to the petals, and opposite to them (Fig. 1359). Anthers with two cells, each opening by a recurved valve from below upwards (Fig. 1360, and Fig. 646, p. 233). Carpel solitary, one-celled; stigma orbicular (Fig. 1361). Fruit baccate or capsular. Seeds anatropal; albumen fleshy and horny (Fig. 1362, and Fig. 913, p. 303). They

* For remarks on this heteromorphous family, see Paper by Miers, in Annals and Mag. of Nat. Hist. 2d Ser. vii. 33.

† See remarks on true and false Calumba plants in the Botanical Magazine for July 1852, tab. 4658.

are found in temperate parts of the northern and southern hemispheres. There are 100 known species.

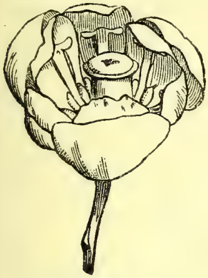
Fig. 1359.


Fig. 1360.

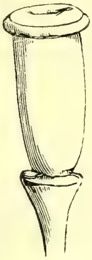
Fig. 1361.

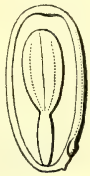
Fig. 1362.

1133. In their properties they are acid, bitter, and astringent.

Berberis vulgaris, the common Barberry. Its fruit contains oxalic acid, and is used as a preserve; while its bark and stem are astringent, and yield the bitter yellow crystalline matter Berberine. Its stamens display peculiar irritability (p. 557). The root of several species of Berberis is said to have furnished the astringent matter called Lycium by Dioscorides, and still used in India under the name of Ruswut.—See Dr. Simpson in Monthly Journal of Med. Science, Jan. 1853.

Leontice (Caulophyllum) thalictroides, blue Cohosh, has an evanescent pericarp, the drupe-like seeds becoming naked.

Mahonias are shrubs commonly cultivated in gardens. They are Barberries with pinnate leaves.

1134. Nat. Ord. 9. — Cabombaceæ, the Water-Shield order.—Aquatic plants with floating peltate leaves. Sepals and petals three or four, alternating. Stamens 6-36. Carpels distinct, two to eighteen. Seeds definite; embryo in a vitellus, outside abundant fleshy albumen. They are allied to Nymphæaceæ and Nelumbiaceæ, and differ in their distinct carpels, definite ovules, abundant albumen, and nearly complete absence of a torus. They occur in America and New Holland. There are 3 known species. *Ill. Gen.*—Cabomba, Hydropeltis.

1135. Nat. Ord. 10.—Nymphæaceæ, the Water-Lily order (Figs. 1363 to 1366).—Aquatic herbs with large showy flowers, and cordate or peltate leaves (Fig. 1363), arising from a prostrate rhizome, which is sunk in the mud. Sepals usually 4, persistent. Petals numerous, deciduous, inserted on a fleshy torus, and passing by a gradual transition out of the sepals into the stamens, which are numerous, have petaloid filaments, and are inserted into the torus (Fig. 1364). Ovary surrounded by the torus, many-celled, many-seeded, with radiating stigmas (Figs. 1364, 1365). Fruit indehiscent, pulpy when ripe. Seeds anatropous, attached to spongy dissepiments (Fig. 1365); embryo small, in a vitellus, outside farinaceous albumen (Fig. 1366,

Figures 1359 to 1362 illustrate the natural order Berberidaceæ.

Fig. 1359. The flower of the Barberry, showing its sepals, petals, and irritable stamens having appendages at their base. Fig. 1360. The two-celled anther opening by two valves, which become recurved as seen in Fig. 646, p. 233. Fig. 1361. Solitary one-celled carpel, with the orbicular nearly sessile stigma. Fig. 1362. Anatropal seed, with orthotropal embryo in the axis of solid albumen.

Fig. 900, p. 299). There are considerable differences of opinion as to the position of Water-lilies. The structure of the rhizome resembles that of Endogens, in which class many botanists are disposed to place them (see Lindley's Vegetable Kingdom, p. 410). The Water-lilies chiefly inhabit quiet waters in the northern hemisphere; they are

Fig. 1363.

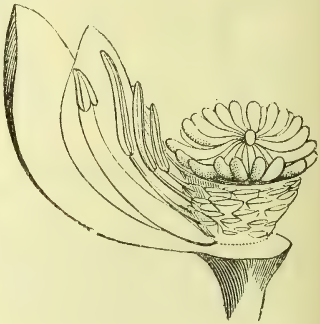

Fig. 1364.

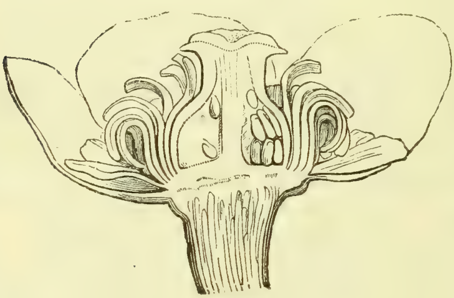

Fig. 1365.

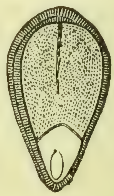

Fig. 1366.

rare in the southern hemisphere. There are 50 described species. *Ill. Gen.*—Euryale, Victoria, Nymphæa, Nuphar.

1136. The order possesses bitter, astringent, and some say narcotic properties. The plants contain much starch in their rhizomes, which are used for food in the same way as potatoes. Their petioles

Figures 1363 to 1366 illustrate the natural order Nymphæaceæ.

Fig. 1363 Nymphæa Lotus, showing large, cordate, reticulated leaves with involute vernation, and showy flowers.—(See note, p. 237). Fig. 1364. Section of flower of Nymphæa alba, showing peduncle, torus or disk, petals, stamens with petaloid filaments, and radiating stigmas. Fig. 1365. Section of flower of Nuphar luteum, showing sepals, petals, stamens, and ovary with ovules. Fig. 1366. Seed of Nymphæa alba, cut vertically, to show the embryo in the vitellus or embryo-sac, with perispermic albumen.—(See also Fig. 900, p. 299).

have large air-tubes, as well as spiral fibres, which can be separated and used for wicks.

Nuphar luteum, yellow Pond-lily, has styptic leaves. Its flowers have a peculiar smell, said to resemble brandy.

Nymphæa alba, white Water-lily. Its rhizomes have been used for dyeing and tanning. Nymphæa Lotus, Lotus Water-lily, is supposed to be the Shushan and Shushannah of the Old Testament (Note, p. 237).

Victoria regia (Fig. 235, p. 107), Victoria Water-lily, is found in the still waters of the whole of the warm parts of Eastern South America.* Its flowers, when expanded, are a foot and more in diameter. Its leaves vary from four to six or eight feet in diameter. Their under surface is of a red colour, and exhibits large prominent ribs. The edges of the leaves are finally turned upwards. The seeds are used for food. They are roasted with Indian corn, and hence the plant is called Water-maize—(See also p. 644).

1137. Nat. Ord. 11.—NELUMBIACEÆ, the Water-Bean order (Fig. 1194†, p. 561).—Aquatic herbs resembling Water-lilies, but differing in their large exalbuminous embryo, and their remarkably enlarged tabular torus, in the hollow of which the nuts are half buried, and finally become loose (Fig. 1367). Found in quiet waters of temperate and tropical regions in the southern hemisphere; very frequent in the East Indies. There are at least 3 known species. *Ill. Gen.*—Nelumbium.

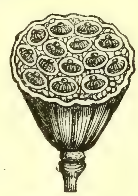

Fig. 1367.

1138. The plants of the order are remarkable for their large, showy flowers and leaves. Their nuts are eatable.

Nelumbium luteum, yellow Water-bean, has starchy rhizomes, with tubers, like those of the sweet potato, which are used for food. N. speciosum, sacred Water-bean, is the Egyptian Lotus represented on Egyptian and Indian monuments. Its fruit, which is edible, is supposed to have constituted the Pythagorean Bean. Its rhizome is used for food in China. The threads from the spiral vessels of its leaf and flower-stalks are used for wicks.

1139. Nat. Ord. 12.—SARRACENIACEÆ, the Water-Pitcher order. —Perennial herbs growing in bogs, with hollow pitcher-shaped or

Fig. 1367. The enlarged honeycombed torus of Nelumbium with the nuts immersed in it.

* In Hooker's illustrations of the Royal Water-lily, it is stated, that it was first noticed by Haenke fifty years ago, in the Rio Mamore, a tributary of the Amazon, then by Bonpland in 1820 near Corrientes, who called it a Nymphæa; then by D'Orbigny in 1828; by Pöppig in 1832 on the Amazon, who called it Euryale Amazonica; by Schomburgk on 1st January 1837, in the Berbice river, and in 1842 in the Essequibo; in 1845 by Mr. Bridges in Bolivia; and by Weddell in the river Barbado; next by Dr. W. H. Campbell in the Essequibo; and finally, in 1849, by Mr. Spruce near Santarem, and at other places. The Victoria has various native names, such as Mururá, Irupé or Yrupé, Moringua, and Dachocho. It is plentifully distributed throughout the whole Amazon district. Some leaves are mentioned by Spruce as being twelve feet in diameter. The deeper the water in which the Victoria grows, the larger the leaves. Spruce says that the leaves, when turned up at the margins, look, when floating, like large tea-trays, with here and there a bouquet protruding between them. The native name of Yrupé has reference to this; it means water-platter,—from *y* water, and *rupé* a dish.—See description of Victoria in Kew Journal, June 1810, p. 176. See also Lawson on Water-lilies.

† In this figure the flowers ought to have been represented as supported on long stalks above the water. The large tabular torus is seen in the centre.

trumpet-shaped leaves (Fig. 332, p. 141). Calyx usually consists of five persistent sepals. Petals five or 0. Stamens ∞. Style often expanding at its summit into a large peltate plate, with a stigma beneath each of its five angles. Fruit, a 2-5-celled capsule with axile placentas, bearing numerous albuminous seeds. The pitchers formed by the petioles of the leaves contain a peculiar secretion, the use of which is unknown. Sarracenia receives the name of Side-saddle flower, in allusion to its tubular leaves. The plants are found abundantly in North America. Heliamphora nutans occurs in Guiana. There are 7 known species. *Ill. Gen.*—Sarracenia, Heliamphora.

1140. Nat. Ord. 13.—Papaveraceæ, the Poppy order (Figs. 1368

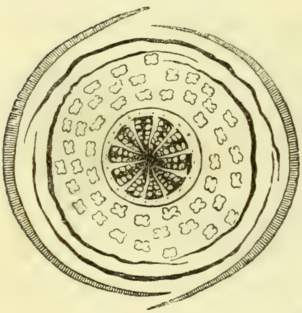
Fig. 1368.

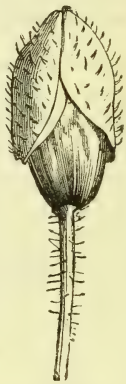
Fig. 1369.


Fig. 1370.


Fig. 1371.

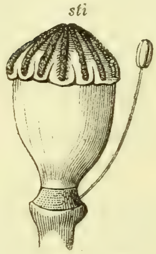

Fig. 1372.


Fig. 1373.

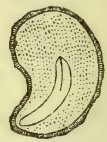
Fig. 1374.

to 1374).—Herbs with milky or coloured juice, and alternate exsti-

Figures 1368 to 1374 illustrate the natural order Papaveraceæ.

Fig. 1368. Diagram showing two sepals, four crumpled petals, numerous stamens, pistil with parietal placentas. Fig. 1369. Disepalous caducous calyx. Fig. 1370. Tetrapetalous corolla, and numerous stamens inserted below a pod-like pistil. Fig. 1371. Siliquæform fruit of Celandine. Fig. 1372. Pistil of Poppy with sessile stigma, *sti*. Fig. 1373. Capsular fruit of Poppy opening by pores below the stigma. Fig. 1374. Seed with embryo, and albumen.

pulate leaves. Sepals two, rarely three, caducous (Fig. 1369). Petals four (Fig. 1370), rarely six, usually crumpled in æstivation. Stamens 8-24 or more (Fig. 1370). Fruit unilocular, siliquæform (pod-like), with 2-5 parietal placentas (Fig. 1371), or capsular with numerous placentas (Figs. 1372 and 1373). Seeds numerous, with embryo in the midst of fleshy and oily albumen (Fig. 1374). The order is chiefly confined to Europe. There are 130 known species. *Ill. Gen.*—Bocconia, Sanguinaria, Chelidonium, Argemone, Meconopsis, Papaver, Glaucium, Eschscholtzia, Platystemon.

1141. Narcotic properties characterise the order. Some of the plants yield an acrid juice.

Argemone Mexicana, Mexican or Gamboge Thistle, has narcotico-acrid seeds. An aperient oil is procured from them.

Bocconia frutescens, Parrot-weed or Tree-celandine, yields an acrid yellow juice.

Chelidonium majus, Celandine (Fig. 809, p. 274), has an orange juice which exhibits the movements of Cyclosis (page 423).

Eschscholtzia has a peculiar enlargement of the upper part of the peduncle, from which the calyx separates like the extinguisher of a candle.

Papaver somniferum, Opium Poppy. The unripe capsules yield a milky juice, which, when concrete, constitutes opium.* The active principle of opium is the alkaloid called Morphia, which is combined with meconic acid. Turkey opium is that chiefly used in Britain. The seeds of the opium poppy yield a bland oil, which is extensively used on the Continent. Poppy oil-cake has also been used for cattle.

Sanguinaria canadensis, Blood-root or Puccoon, yields a red juice. The plant is emetic and purgative. It contains a basic matter Sanguinarine.

Fig. 1375.

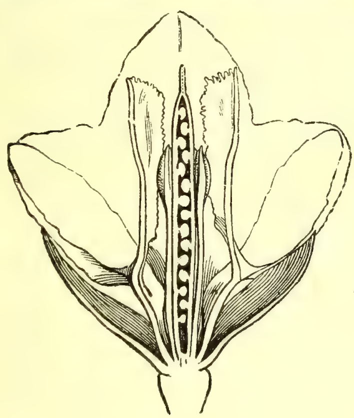

Fig. 1378.

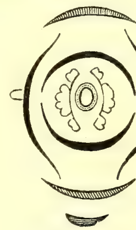

Fig. 1376.

Fig. 1377.

1142. Nat. Ord. 14.—Fumariaceæ, the Fumitory order (Figs. 1375 to 1378).—Herbs with brittle stems, a watery juice, alternate,

Figures 1375 to 1378 illustrate the natural order Fumariaceæ.

Fig. 1375. Raceme of Fumaria officinalis, with irregular petals, one of which is gibbous at the

* See account of preparation of opium at Patna, in Hook. Journal of Botany for August 1849, p. 231.

cut, exstipulate leaves, and irregular unsymmetrical flowers (Fig. 1375). Sepals two, deciduous. Petals four, cruciate, irregular, one or two of them often saccate or spurred, and the two inner frequently cohering at the apex, so as to include the anthers and stigma. Stamens either four and free, or six and diadelphous, each bundle being opposite the outer petals, and the central anther being two-celled, while the two outer are one-celled (Fig. 1376). Fruit, a round and indehiscent nut (Fig. 1377), or a one-celled and two-valved pod (Fig. 1378). Seeds crested, with a minute embryo and fleshy albumen. Fumeworts occur chiefly in temperate regions of the northern hemisphere. Some of them, as Diclytra spectabilis, are very showy. They possess slight bitterness and acridity. There are 110 known species. *Ill. Gen.*—Hypecoum, Diclytra, Corydalis, Fumaria, Platycapnos.

1143. Nat. Ord. 15.—Cruciferæ or Brassicaceæ, the Cruciferous or Cabbage order (Figs. 1379 to 1388).—Herbaceous plants with

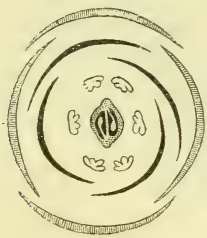

Fig. 1379.

Fig. 1380.

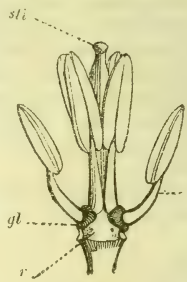

Fig. 1381.

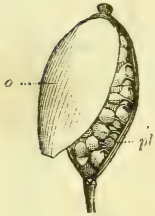

Fig. 1383.

Fig. 1384.

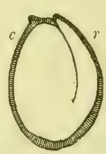

Fig. 1385.

Fig. 1382.

alternate, exstipulate leaves, racemose or corymbose flowers (Fig. 374, p. 157), usually yellow or white, and an ebracteated inflorescence.

base. Fig. 1376. Diagram of flower of Fumitory, showing single bract below, two sepals, two outer and two inner petals, six stamens in two bundles, two of the stamens perfect and four imperfect, one-celled pistil with a single seed.—(See note, p. 190). Fig. 1377. Fruit of Fumitory, an achene. Fig. 1378. Section of Hypecoum, showing a pod-like fruit with numerous seeds. —(See p. 261).

Figures 1379 to 1388 illustrate the natural order Cruciferæ.

Fig. 1379. Diagram of a Cruciferous flower, with four imbricate sepals, four petals, six stamens, tetradynamous, the two short ones solitary, and opposite the lateral sepals, the four

Sepals four, deciduous (Fig. 1380). Petals four, cruciate (Fig. 1380). Stamens tetradynamous (Fig. 1381). Fruit, a siliqua (Fig. 1382),

Fig. 1388.

Fig. 1386.

Fig. 1387.

or silicula (Figs. 1383, 1384). Seeds exalbuminous (Fig. 1385); embryo with the radicle folded on the cotyledons (Figs. 1386-88). The want of symmetry in the flower is explained at page 190. The plants are generally distributed, but abound in cold and temperate regions, especially in Europe. There are about 1700 known species. *Ill. Gen.*—Matthiola, Cheiranthus, Nasturtium, Barbarea, Arabis, Cardamine, Dentaria, Lunaria, Alyssum, Draba, Cochlearia, Thlaspi, Teesdalia, Iberis, Cakile, Hesperis, Sisymbrium, Erysimum, Camelina, Capsella, Lepidium, Isatis, Brassica, Sinapis, Crambe, Raphanus, Bunias, Senebiera, Subularia, Schizopetalon.

1144. The order has been divided into Sub-orders and Tribes, according to the nature of the fruit and of the embryo. The following are the Sub-orders founded on the nature of the fruit:—1. Siliquosæ,—a siliqua, opening by valves (Fig. 1382, Fig. 707, p. 248, and Fig. 825, p. 278). 2. Siliculosæ, Latiseptæ,—a silicula, opening with two flat or convex valves, replum in the broadest diameter (Fig. 1383, Fig. 827, p. 278). 3. Siliculosæ, Angustiseptæ,—a silicula with folded or keeled dehiscent valves, replum in narrow diameter (Fig. 1384, Fig. 828, p. 278). 4. Nucumentaceæ,—an indehiscent silicula, often one-celled, having no replum. 5. Septulatæ,—valves with transverse phragmata on their inside. 6. Lomentaceæ,—a pod dividing transversely into single-seeded portions, the beak sometimes containing one or two seeds, while the true pod is abortive (Fig. 829, p. 278). Divisions of these sub-orders are formed according to the nature of the embryo:—1. Pleurorhizeæ (Fig. 1386),—cotyledons accumbent o =. 2. Notorhizeæ (Fig. 1387),—

long in pairs opposite the anterior and posterior sepals, siliquose fruit, with two divisions to the right and left of the axis, separated by a replum, seeds attached by a funiculus to each side of the placentas. The floral symmetry is quaternary, but the stamens become six by collateral chorisis of two of them, and the fruit bicarpellary by abortion of two of the carpels. Fig. 1380. Cruciferous flower of Brassica Eruca. Fig. 1381. Tetradynamous stamens of Wallflower, *e*, receptacle, *r*, gland at base of stamens, *gl*, stigmas, *sti*. Fig. 1382. Siliqua of Wallflower, opening by two valves from below upwards, seeds in a single row, attached to either side of the siliqua. Fig. 1383. Silicula of Draba, (Latiseptæ) opening by two flat valves. Fig. 1384. Silicula of Capsella (Angustiseptæ) opening by two folded boat-shaped valves. Fig. 1385. Exalbuminous seed of Wallflower. Fig. 1386. Accumbent cotyledons, and lateral radicle of Wallflower (Pleurorhizeæ). Fig. 1387. Incumbent cotyledons and dorsal radicle of Hesperis (Notorhizeæ). Fig. 1388. Twice folded or coiled up cotyledons and dorsal radicle of Bunias (Spirolobeæ).

Additional figures illustrating the Cruciferous order. Figs. 98 and 99, p. 43; Fig. 409, p 173; Fig. 480, p. 194; Fig. 513, p. 202; Fig. 594, p. 220; Fig. 708, p. 248; Fig. 890, p. 297.

cotyledons incumbent o || . 3. Orthoploceæ,—cotyledons conduplicate o>>. 4. Spirolobeæ (Fig. 1388),—cotyledons twice folded o || || . 5. Diplecolobeæ,—cotyledons thrice folded o || || || .—(See fuller explanation of some of these terms, p. 304.)

1145. Crucifers are antiscorbutic and pungent, and occasionally acrid in their properties. None of them are poisonous. The order contains many of the culinary vegetables in constant use. The plants have much nitrogen and sulphur in their composition. Many garden flowers, as Wallflower, Stock, Rocket, and Honesty, belong to this order.

Anastatica hierochuntina, the Rose of Jericho, is found in the deserts of Syria and Egypt. Its annual stems, when withered and dried, coil up like a ball, but expand on the application of moisture.

Brassica campestris is the origin of the Swedish Turnip. The seeds of B. chinensis furnish oil at Shanghae. B. Napus, Rape or Coleseed, yields a bland fixed oil; oil-cake is prepared from its seeds. B. oleracea, is the type whence the varieties of Cabbage, Brocoli, Cauliflower, and Greens are derived by cultivation. B. Rapa, the common Turnip.

Cochlearia officinalis, common Scurvy-Grass, found both on the sea shore and high on the mountains. C. Armoracia (Armoracia rusticana) the Horse-radish.

Crambe maritima, the Sea-kale. Its seeds yield a kind of oil-cake called Crambolina.

Isatis tinctoria, Woad, yields a blue dye. Isatis indigotica, is used as Indigo in China.

Lepidium sativum, common garden Cress, has pungent qualities.

Nasturtium officinale, common water Cress, supplies an excellent salad.

Raphanus sativus, the Radish (Fig. 594, p. 220).

Sinapis alba, white Mustard. The seeds are whitish, and contain a fixed oil, with a principle called Sinapin, which gives rise to the formation of an acrid matter. Sinapis nigra (Brassica nigra), black Mustard. The seeds are dark coloured, and supply the proper table mustard. They contain a fixed oil, besides Myronic acid and Myrosine. The two latter, on the addition of water, combine and form a pungent volatile oil, on which the physiological action of mustard depends.

1146. Nat. Ord. 16.—Capparidaceæ, the Caper order (Figs. 419, 420, p. 176).—Herbs, shrubs, or trees with alternate leaves and tetramerous flowers; allied to Crucifers, but distinguished by the stamens being often indefinite, and if six, scarcely ever tetradynamous, by the want of a replum in the one-celled ovary, which is often supported on a gynophore, and by their reniform seeds. Capparids are chiefly tropical plants. There are about 350 species. There are two suborders:—1. Cleomeæ, fruit capsular. 2. Cappareæ, fruit berried. *Ill. Gen.*—Gynandropsis, Cleome, Physostemon, Polanisia, Cadaba, Capparis, Cratæva.

1147. In their properties, Capparids resemble Crucifers. They have pungent, stimulant, and antiscorbutic qualities.

Capparis spinosa (Fig. 419, p. 176) in the southern parts of Europe, C. rupestris in Greece, C. Fontanesii in Barbary, and C. ægyptiaca in Egypt, supply Capers, which are the flower-buds of the plants. The last named species is supposed to be the Hyssop (Esobh and Hyssopus) of Scripture.

Cleome and Polanisia furnish very pungent species, which are sometimes used like mustard.

Cratæva gynandra, Garlick Pear, has a vesicant root.
Polanisia icosandra has been used as a vermifuge.

1148. Nat. Ord. 17.—RESEDACEÆ, the Mignonette order (Figs. 1389 to 1392).—Herbaceous plants, rarely shrubs, with alternate leaves having minute glands at their base, and racemose or spiked inflorescence (Fig. 370, p. 155). Sepals 4-7, sometimes united. Petals 2-7, lacerated and unequal, with broad or thickened claws (Figs. 1389, 1390). Stamens definite, inserted on a fleshy disk. Fruit

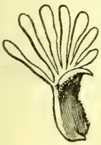

Fig. 1389.

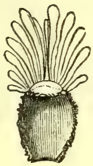

Fig. 1390.

Fig. 1391.

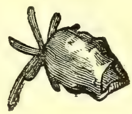

Fig. 1392.

usually one-celled, opening early at the apex, with 3-6 parietal placentas (Figs. 1391, 1392); sometimes it appears as carpellary leaves surrounding a central placenta. Seeds several, reniform, or curved and exalbuminous; embryo arcuate. The plants of the order chiefly inhabit Europe and the adjoining parts of Asia and Africa. There are 41 known species. *Ill. Gen.*—Reseda, Astrocarpus.

1149. The properties of the order are little known. Some of the species display slight acridity.

Reseda Luteola, Weld, yields a yellow dye. Reseda odorata, Mignonette, is prized for the fragrance of its flowers. It is rendered shrubby by pinching off the flower-buds.

1150. Nat. Ord. 18.—FLACOURTIACEÆ or BIXACEÆ, the Arnotto order.—Shrubs or small trees, with alternate exstipulate leaves, often marked with round transparent dots. Sepals and petals 4-7, the latter sometimes 0. Stamens, same number as petals or a multiple of them. Ovules attached to parietal placentas. Fruit one-celled, either fleshy and indehiscent, or a 4-5-valved capsule containing pulp, in which numerous albuminous seeds are enveloped. The plants are almost entirely natives of the hottest parts of the East and West Indies and of Africa. There are 90 known species. *Ill. Gen.*—Bixa, Oncoba, Ludia, Laetia, Prockia, Azara, Flacourtia, Erythrospermum.

1151. Some of the plants of the order are bitter and astringent, others yield edible fruits.

Bixa Orellana has angular seeds covered with an orange-red pulp, which constitutes Arnotto, and is used for a red dye, and for staining cheese, as well as in the manufacture of Chocolate.
Flacourtia sapida and sepiaria furnish sub-acid fruits.

Figures 1389 to 1392 illustrate the natural order Resedaceæ.

Figs. 1389 and 1390. Lacerated petals of Reseda, with their scale-like broad claws. Fig. 1391. Transverse section of the ovary of Reseda, showing three parietal placentas with several ovules. Fig. 1392. Fruit of Reseda, open at the apex, so that the seeds become seminude or exposed.

1152. Nat. Ord. 19.—Cistaceæ, the Rock-rose order (Figs. 1393 and 1394).—Shrubs or herbs, often viscid, with simple, entire leaves, and showy flowers. Sepals 3-5, persistent, unequal, the three inner with twisted æstivation. Petals five, very rarely three, caducous, often crumpled, twisted in an opposite direction from the sepals. Stamens definite or ∞, distinct. Fruit a one-celled capsule with parietal placentas, or imperfectly 3-5-celled, by dissepiments arising from the

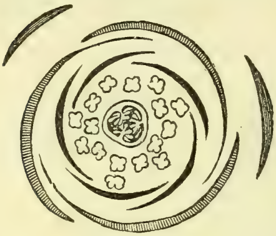

Fig. 1393.

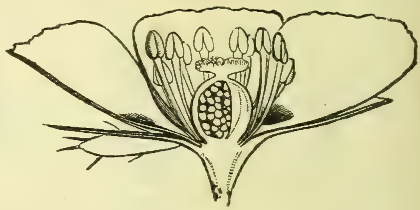

Fig. 1394.

middle of the valves, and bearing placentas at or near the axis (dehiscence being loculicidal). Seeds usually orthotropal, with mealy albumen; embryo curved or spiral. The plants are found chiefly in the south of Europe and north of Africa. There are about 190 known species. *Ill. Gen.*—Fumana, Cistus, Helianthemum, Lechea, Hudsonia.

1153. The Rock-roses are generally resinous and balsamic.

Cistus creticus (Fig. 529, p. 205), and other species (C. ladaniferus, C. Ledon), furnish the resinous substance called Ladanum, which is used as a stimulant and emmenagogue. Some suppose that this is the myrrh mentioned in Genesis under the Hebrew name of Lot.

Cochlospermum Gossypium yields the gum Kuteera, which resembles tragacanth in its properties.

Helianthemum vulgare, and its varieties, show a remarkable irritability in the stamens when touched (page 557).

1154. Nat. Ord. 20.—Violaceæ, the Violet order (Figs. 1395 to 1399).—Herbs or shrubby plants, with usually alternate, stipulate leaves (Fig. 321, p. 137), having an involute vernation, and flowers often irregular (Fig. 320, p. 137, and Fig. 398, p. 168). Sepals five, persistent, attached above their base. Petals five, often unequal, one being spurred (Fig. 1396). Stamens five, with short and broad filaments, which are often elongated beyond the introrse anther lobes; in the irregular flowers two of the stamens have appendages; anthers sometimes united (Fig. 1397, Fig. 650, p. 234). Style declinate, with an oblique hooded stigma (Fig. 1397, Fig. 750, p. 256). Fruit

Figures 1393 and 1394 illustrate the natural order Cistaceæ.

Fig. 1393. Diagram of the flower of Helianthemum, showing two outer sepals, three inner contorted, five petals twisted in an opposite direction to the sepals, numerous stamens, a one-celled pistil with three parietal placentas. Fig. 1394. Section of flower of Helianthemum, showing sepals, petals, indefinite stamens, ovary with numerous ovules, short style and peltate stigma.

a three-valved capsule (Fig. 1398), with parietal placentas in the middle of the valves (loculicidal). Seeds definite or ∞, albuminous,

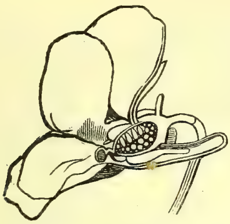

Fig. 1396.

Fig. 1397.

Fig. 1395.

Fig. 1398.

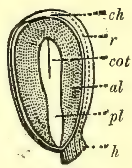

Fig. 1399.

anatropal, with a straight embryo (Fig. 1399). There are two suborders:—1. Violeæ, with irregular flowers, occurring chiefly in Europe, Siberia, and America; 2. Alsodeæ, with regular flowers, principally found in South America and Africa.* There are upwards of 300 known species. *Ill. Gen.*—Viola, Ionidium, Amphirrhox, Alsodeia.

1155. The Violet-worts are generally emetic, and some have purgative properties. In the roots of many of them a principle called Violin, similar to Emetin, has been found.

Ionidium parviflorum, and other species, are called Cuchunchully, and are used in Peru and in other parts of America as cathartics and emetics. Ionidium Itubu, called Poaya, yields a root which is employed like Ipecacuan.

Viola canina, Dog Violet, has been prescribed in skin diseases. Viola odorata, March Violet, is famed for its fragrance. It is the Ion of the Greeks. Its petals yield a blue colour, used as a test for acids and alkalies, and they possess laxative qualities. The root of the plant is emetic and purgative. Viola tricolor is the origin of all the varieties of Pansy or Heartsease.

1156. Nat. Ord. 21.—Droseraceæ, the Sun-dew order (Figs. 1400, 1401).—Herbaceous marsh-plants, often covered with glandular hairs

Figures 1395 to 1399 illustrate the natural order Violaceæ.

Fig. 1395. Diagram of the flower of the Pansy, having five sepals, five petals, five stamens with appendages, a three-valved fruit with parietal placentas. Fig. 1396. Section of the flower of a Violet, showing the spurred petal, with a staminal appendage within it, and the ovary with numerous ovules. Fig. 1397. Five stamens of a Violet united by their anthers, two of them with long filiform appendages; obliquely hooded stigma in the centre. Fig. 1398. Fruit of the Pansy opening in a loculicidal manner by three valves. Seeds numerous in the middle of the valves. Fig. 1399. Anatropal seed of the Pansy cut vertically, showing the straight embryo, *pl*, with the cotyledons, *cot*, in the midst of albumen, *al*. The hilum is marked *h*, the chalaza, *ch*, and the raphe, *r*.

* Some add Sauvagesieæ, which have regular flowers, with no apicilar staminal appendages, five hypogynous scales, and septicidal fruit.

(Fig. 1400); they have alternate leaves, with fringes at their base, and a circinate vernation. Sepals five, persistent. Petals five, im-

Fig. 1400.

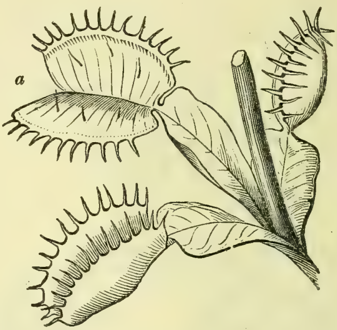

Fig. 1401.

bricate. Stamens as many as petals, or two or three times as many, distinct, withering. Styles 3-5, sometimes united. Fruit a one-celled, 3-5-valved capsule, with loculicidal dehiscence. Seeds numerous; embryo small, in the base of fleshy albumen. The plants are found in marshy grounds in various parts of the world. There are 90 known species. *Ill. Gen.*—Drosera, Aldrovanda, Drosophyllum, Dionæa.

1157. The Sundews have acid and slightly acrid properties.

Aldrovanda vesiculosa is so called on account of its vesicle-like leaves, which are whorled and cellular.

Dionæa muscipula, Venus's Fly-trap (Fig. 1401), found in the North American marshes, has hairs on its leaves, which, when touched, cause the closure of the two halves of the blade (p. 497).

Drosera, Sundew. The species are remarkable for their glandular hairs, which are covered with drops of fluid in sunshine (Fig. 1400). Hence the name of Ros Solis, and of the Italian liqueur Rossoli, in the preparation of which a species of Sundew is employed. The hairs in some of the Droseras (D. lunata) are said to close upon insects which light on them. Drosera communis is said to be poisonous to sheep.

1158. Nat. Ord. 22.—Polygalaceæ, the Milkwort order (Figs. 1402 and 1403).—Herbs or shrubs with simple exstipulate leaves (Fig. 1402). Pedicels have three bracts, and the flowers are irregular, unsymmetrical, and falsely papilionaceous. Sepals five, irregular, odd one posterior, two inner ones (wings) usually petaloid. Petals more or less united, usually three, of which one (the keel) is anterior, larger, and sometimes crested. Stamens 6-8, usually combined into a tube which is split on the upper side; anthers one-celled, opening by

Figures 1400 and 1401 illustrate the natural order Droseraceæ.

Fig. 1400. Leaf of Drosera rotundifolia, or round-leaved Sundew, covered with glandular hairs.

Fig. 1401. Leaves of Dionæa muscipula, called Venus's Fly-trap, showing the expanded blade of the leaf, *a*, with three irritable hairs on each division of the lamina. These hairs, when touched cause the closure of the two halves of the lamina or blade of the leaf.

pores. Ovary usually two celled, with a single pendulous, anatropal ovule in each cell; style curved. Capsule flattened with albuminous, carunculate seeds, containing a straight embryo. The order is considered by St. Hilaire and others as allied to Sapindaceæ, and some authors place it near Leguminosæ, from which it differs in its hypogynous stamens, and in the odd sepal being superior and the odd petal inferior. The plants are scattered over various quarters of the globe. There are about 500 known species. *Ill. Gen.*—Salomonia, Polygala, Mundia, Securidaca.

Fig. 1403.

1159. The Milkworts are generally bitter and acrid, and their roots yield a milky juice.

Polygala Senega, Snake-root, is a North American species, the root of which is used as an emetic, cathartic, and sialagogue. It contains an acrid principle called Polygaline or Senegine. Many other species of Polygala have similar qualities, and are reputed to be antidotes to the bites of snakes.

1160. Nat. Ord. 23.—Krameriaceæ, the Rhatany order.—The genus Krameria is the only one in this order which differs from Polygalaceæ in the want of the falsely papilionaceous flowers, in its simple one-celled ovary, and in the absence of albumen.

Fig. 1402.

Krameria triandra, which yields the Rhatany-root, is a native o South America. The root is very astringent. It yields a blood-red-infusion, which has been used to adulterate port wine. It is prescribed medicinally as an astringent in hemorrhage and chronic mucous discharges. It is also mixed with charcoal in tooth-powder.

1161. Nat. Ord. 24.—Tremandraceæ, the Porewort order.—The plants of this order are slender, heath-like shrubs, with hairs usually glandular. They are allied to Polygalaceæ, and differ in their regular symmetrical flowers, valvate calyx, and hooked appendages at the apex of their seeds. They are found in New Holland. There are 16 known species. *Ill. Gen.*—Tetratheca, Tremandra, Platytheca.

1162. Nat. Ord. 25.—Tamaricaceæ, the Tamarisk order (Figs. 1404-5).—Shrubs or herbs usually growing by the sea-side, with entire, scale-like leaves, and spiked or racemose flowers (Fig. 1404). Calyx 4-5-parted, persistent. Petals 4-5, withering, imbricate. Stamens 4-5, or twice that number, free or united; anthers introrse, opening longitudinally. Styles three. Fruit, a three-valved, one-

Figures 1402 and 1403 illustrate the natural order Polygalaceæ.

Fig. 1402. Polygala vulgaris, common Milkwort, with its simple exstipulate leaves, irregular flowers, and crested keel. Fig. 1403. Diagram of the flower of Polygala, with three bracts, five unequal sepals, two interior large and petaloid, five (usually only three) unequal petals, eight stamens diadelphous, and a two-celled ovary. The pollen of Polygala is represented in Figs. 660, 661, p. 236.

celled capsule, with three basal or parietal placentas, bearing numerous anatropal, comose, exalbuminous seeds. Embryo straight. The species

Fig. 1404.

Fig. 1405.

abound in the basin of the Mediterranean, and are confined to the northern hemisphere of the Old World. The known species amount to 43. *Ill. Gen.*—Tamarix, Myricaria, Trichaurus.

1163. Tamarisks have an astringent, and slightly bitter and tonic bark. Those growing close to the sea abound in salts of soda.

Myricaria germanica is a common ornamental garden shrub.

Tamarix africana and T. gallica (Fig. 1404), when burned, yield much sulphate of soda. The latter is said to be one of the plants which yield manna. Tamarix mannifera produces a kind of manna (called Mount Sinai manna), which seems to be a secretion from a species of Coccus inhabiting the tree. Other species of Tamarix are attacked by gall-producing insects, and the galls are used as astringents. Tamarix orientalis (Fig. 1405) is said to be the Hebrew Eshel, which is translated in some parts of the Bible, grove, and tree.—(See Gen. xxi. 33; 1 Sam. xxii. 6, and xxxi. 13).

1164. Nat. Ord. 26.—Frankeniaceæ, the Frankenia order.—Herbs or undershrubs, with opposite exstipulate leaves, and flowers embosomed in leaves. They are allied to Caryophyllaceæ, and differ in their parietal placentation, and straight embryo. They have a tubular furrowed calyx, and long-clawed petals with appendicular scales. They occur chiefly in the north of Africa and south of Europe. Their properties are mucilaginous. There are 24 known species. *Ill. Gen.*—Frankenia, Beatsonia, Anisadenia.

1165. Nat. Ord. 27.—Elatinaceæ, the Water-pepper order.—

Figures 1404 and 1405 illustrate the natural order Tamaricaceæ.

Fig. 1404. Tamarix gallica, supposed by some to be one of the plants which supplied the manna mentioned in Scripture, Exod. xvi. 15, &c. Fig. 1405. Tamarix orientalis, the Tamarisk-tree of the East, supposed to be the Eshel of the Hebrews.

Small annuals growing in marshes, with opposite leaves, interpetiolary membranaceous stipules, and minute axillary flowers. Sepals and petals 3-5. Stamens as many, or twice as many as the petals, distinct. Fruit a 3-5-celled septicidal capsule. Seeds numerous, attached to a central placenta, exalbuminous; embryo straight. The order is perhaps allied to Rutaceæ, in which alliance it is placed by Lindley. The plants are found in all quarters of the globe. Their properties are said to be acrid; hence the English name of the order. There are 22 known species. *Ill. Gen.*—Elatine, Bergia, Anatropa.

1166. Nat. Ord. 28.—Caryophyllaceæ, the Clovewort order (Figs. 1406 to 1412).—Herbaceous plants with stems tumid at the

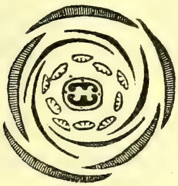

Fig. 1406.

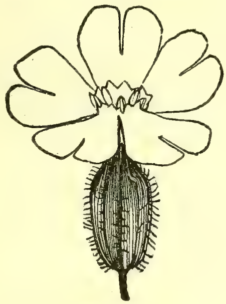

Fig. 1407.

Fig. 1408.

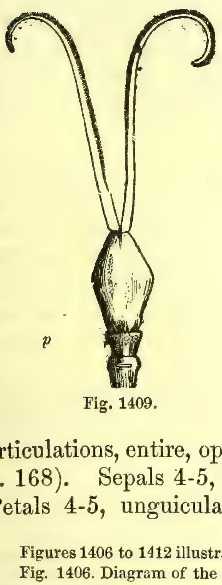

Fig. 1409.

Fig. 1411.

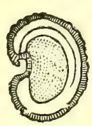

Fig. 1412.

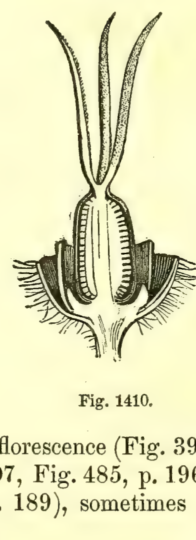

Fig. 1410.

articulations, entire, opposite leaves, and cymose inflorescence (Fig. 397, p. 168). Sepals 4-5, distinct or united (Fig. 1407, Fig. 485, p. 196). Petals 4-5, unguiculate (Fig. 1408, Fig. 459, p. 189), sometimes 0.

Figures 1406 to 1412 illustrate the natural order Caryophyllaceæ.

Fig. 1406. Diagram of the flower of Dianthus, belonging to the sub-order Sileneæ, showing five imbricated sepals which are united below, five imbricated and contorted petals, ten stamens in two rows, ovary at first with partitions but finally one-celled with a free central placenta. Fig. 1407. Flower of Lychnis with gamosepalous calyx, five unguiculate or bifid petals having scales at the

Stamens as many, or twice as many as the petals, sometimes fewer. Ovary often supported on a gynophore (Fig. 1409), usually one celled, with a free central placenta (Fig. 1410). Styles 2-5, papillose on their inner surface (Figs. 1409 and 1410). Fruit a capsule opening by 2-5 valves, or by teeth at the apex, which are twice as many as the stigmas (Fig. 1411). Seeds usually indefinite; embryo curved round mealy albumen (Fig. 1412). There are three Sub-orders:—1. Sileneæ, the Pink tribe, with united sepals opposite the stamens when the latter are of the same number. 2. Alsineæ, the Chickweed tribe, with distinct sepals, bearing the same relation to the stamens as in Sileneæ. 3. Mollugineæ, the Carpetweed tribe, in which the petals are awanting, and the stamens are alternate with the sepals when of the same number. The plants are found principally in temperate and cold regions. There are about 1100 known species. *Ill. Gen.*—Dianthus, Saponaria, Gypsophila, Silene, Lychnis, Cucubalus, Sagina, Buffonia, Alsine, Honckenya, Arenaria, Stellaria, Cerastium, Mollugo.

1167. Cloveworts have scarcely any marked properties. Some say that the principle called Saponine, which is found in some of the plants, has poisonous qualities. Some of the plants have showy flowers.

Dianthus Caryophyllus, the Clove-pink, is the origin of all the cultivated varieties of Carnation. In the variety called Picotee, the petals are slightly serrated with a number of small dots or lines either on a white or a yellow ground. In the Carnation the petals are entire or striped only; there are no dots nor small lines, and no break in the colour of the stripe. Bizarres are Carnations with two or more colours on a white ground. Flakes are Carnations with only one colour.

Saponaria contains Saponine, which imparts to it saponaceous qualities. The same principle is found in species of Silene, Lychnis, and Cucubalus.

1168. Nat. Ord. 29.—Vivianiaceæ, the Viviania order.—Herbaceous or suffruticose plants, with opposite or whorled exstipulate leaves and regular flowers in corymbose cymes. They are characterised by a ten-ribbed valvate calyx, a marcescent corolla, ten free stamens, a three-celled loculicidal capsule, and albuminous seeds, with a curved embryo. They are found in South America, and are not remarkable for any useful properties. There are 15 known species. *Ill. Gen.*—Cæsarea, Viviania, Linostigma.

1169. Nat. Ord. 30.—Malvaceæ, the Mallow order (Figs. 1413 to 1418).—Herbs, shrubs, or trees, with alternate, stipulate, palmately-divided leaves (Fig. 101, p. 44), often stellate hairs, and showy in-

throat. Fig. 1408. Unguiculate petal of Pink. Fig. 1409. Capsule of Pink composed of two carpels with two styles which are stigmatose along their inner surface; the ovary is stipitate or supported on a gynophore, *p*. Fig. 1410. Flower of Lychnis cut longitudinally, showing the capsule with its central placenta and numerous ovules. Three out of five styles are left. Fig. 1411. Fruit of Lychnis opening by ten teeth at its apex, and surrounded by the persistent calyx with its five segments. Fig. 1412. Seed of Lychnis, showing the embryo curved round mealy albumen.

For additional illustrations, see Fig. 404, p. 170; Fig. 723, p. 250; Figs. 892 and 894, p. 297.

volucrate flowers on axillary peduncles (Fig. 1414). Sepals five, rarely three or four, united at the base, valvate, often having an epicalyx. Petals of the same number as the sepals, twisted (Fig. 1413).

Fig. 1416.

Fig. 1414.

Fig. 1417.

Fig. 1413.

Fig. 1418.

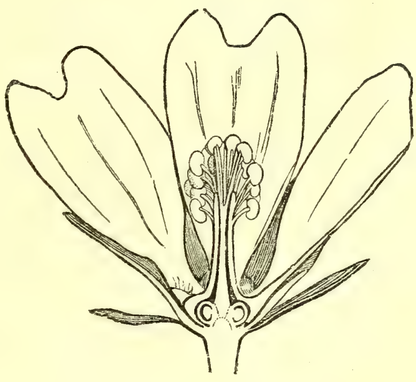

Fig. 1415.

Stamens ∞, monadelphous, united to the claws of the petals; anthers one-celled, reniform, introrse, opening transversely (Fig. 1416); pollen hispid (Fig. 1417). A many-celled ovary, with placentas in the

Figures 1413 to 1418 illustrate the natural order Malvaceæ.

Fig. 1413. Diagram of flower of Mallow, showing three parts of epicalyx or involucre, five parts of the valvate calyx, five contorted petals, numerous monadelphous columnar stamens, ovary composed of numerous carpels united round a central axis. Fig. 1414. Cymose axillary cluster of flowers of Malva sylvestris. Fig. 1415. Vertical section of the flower of Mallow, showing calyx, corolla monadelphous stamens and the carpels. Fig. 1416. Monadelphous stamens, forming a columna androecium; anthers one-celled, reniform, opening by a transverse slit. Fig. 1417. Pollen of Mallow, with rough points on the extine. Fig. 1418. Persistent calyx surrounding the fruit of the Mallow.

axis (Fig. 1418); or several ovaries, separate or separable when ripe; styles equal in number to the carpels, distinct or united. Fruit composed of several monospermal or polyspermal carpels, either combined or separate. Seeds with little albumen; embryo curved with folded cotyledons. The plants abound in tropical regions, and in the hotter parts of the temperate zone. There are 1000 known species. *Ill. Gen.*—Malope, Althæa, Lavatera, Malva, Sida, Abutilon, Urena, Pavonia, Thespesia, Abelmoschus, Hibiscus, Gossypium, Lagunea.

1170. The properties of the Mallowworts are mucilaginous and demulcent. They supply various kinds of fibres.

Abelmoschus esculentus furnishes a mucilaginous fruit used in soups, and called Ochro, Okra, or Gombo.

Abutilon esculentum. Its flowers are used in Brazil as a vegetable.

Althæa officinalis, Marsh Mallow, the Guimauve of the French, is used medicinally to supply mucilage. Althæa rosea, the Hollyhock, the Malache of Dioscorides, has similar properties. Its leaves furnish a blue dye like Indigo. In 1821, 280 acres of land in England were planted with it in order to furnish fibres.

Gossypium. Various species of this genus furnish cotton, which consists of the hairs attached to the seeds. These hairs are usually hollow cells, but occasionally they become flattened.* There are probably four distinct species of plants furnishing the Cotton of commerce:—1. Gossypium herbaceum (Fig. 101, p. 44), the common Cotton plant of India, a variety of which supplies the Chinese or Nankin Cotton. 2. G. arboreum, the Tree-Cotton of India, with red flowers, and a fine silky cotton. 3. G. barbadense, Barbadoes Cotton, called in India Bourbon Cotton; this supplies the highly esteemed Sea Island Cotton, also the Georgian and New Orleans Cotton. 4. G. peruvianum of Cavanilles, or G. acuminatum, which supplies the Pernambuco or Brazil Cotton; it has black seeds adhering together into a kidney-shaped mass. The quality of Cotton is influenced much by the dryness and moisture of the climate. It does not thrive in a very moist atmosphere. In Sea-Island Cotton it is not found that the salts of soda exist in great quantity. It chiefly contains salts of potash. The value of Cotton in manufacture depends on the length or tenacity of its tissue or staple.† The import of Cotton into Great Britain in 1850, amounted to 928,243,232 pounds. The growth of the cotton manufacture in this country will be shown by the following statement of the weight of the raw material used in different years of the present century, viz.—

	Lbs.		Lbs.
1800	56,010,732	1835	363,702,963
1805	59,682,406	1840	592,488,000
1810	132,488,935	1845	721,979,953
1815	99,306,343	1846	442,759,336
1820	151,672,655	1847	474,707,615
1825	228,005,291	1848	713,020,161
1830	263,961,452	1849	775,469,008

The average weekly consumption of cotton in Great Britain in 1852, was estimated at 35,804 bales (average weight of each 380 lbs.), consisting of 5750 Upland, 22,002 New Orleans and Alabama, and 450 Sea Island (in all 28,202 American), 2404 Brazil, 1877 Egyptian, 3162 East Indian, and 159 West Indian, &c. The seeds of Cotton supply oil fit for lamps, and when bruised they

* Crum, in speaking of dyeing, says that in the case of cotton there is usually an absorption of the fluid, and then in the process a deposit of the metallic or solid colouring matter inside the tubes. In some cases in which the cotton was not dyed, he found it a flattened solid fibre, without any tube. This may depend on an abortive state of the seed combined with pressure.

† Royle on the Culture and Commerce of Cotton in India and elsewhere.

are used for oil-cake. In Esther i. 6, the Hebrew word translated Green, is a Sanscrit word, Karpas, which is supposed to mean cotton. Cotton is noticed in Sanscrit writings 800 B.C. Cotton seems to be meant by the Latin word Carbasus. Royle suggests, that the curtain found by Layard at Nineveh, which fell to pieces when touched, was made of Cotton.

Hibiscus cannabinus. Its inner bark furnishes a kind of Sun-hemp in India. Hibiscus mutabilis has showy flowers which change colour, passing in the course of the day from a cream-coloured rose to a delicate pink or rich rose. Hibiscus Rosa-sinensis. Its petals are used by the Chinese to blacken their eye-brows.

Lavatera arborea, the Tree-Mallow, grows on rocks exposed to the influence of the sea, as on the Bass Rock and Ailsa Crag.

Malachra capitata. Its leaves are used in Panama as an anthelmintic.

Malva Alcea, has astringent petals which furnish a black dye. Malva sylvestris, the common Mallow, has been used as a demulcent.

Paritium tiliaceum is employed for the preparation of cordage.

Sida. Various species of this genus furnish fibres. Sida Phyllanthos and Sida Pichinchensis ascend on the mountain of Antisana and the volcano Rucu-Pichincha, to the elevation of 13,000 or 15,000 feet.

1171. Nat. Ord. 31.—STERCULIACEÆ, the Silk-cotton order.—Large trees or shrubs, with simple or compound leaves, and occasionally unisexual flowers, resembling the Malvaceæ in their general characters, particularly in their columnar stamens, but differing in their two-celled extrorse anthers. They are tropical plants. There are 130 known species. *Ill. Gen.*—Adansonia, Eriodendron, Bombax, Durio, Ochroma, Cheirostemon, Helicteres, Heritiera, Sterculia, Delabechea.

1172. The Sterculiads resemble the Malvaceæ in their properties.

Adansonia digitata (Fig. 176, p. 73), the Baobab tree, Monkey-bread or Ethiopian Sour-gourd, is one of the largest trees in the world, its trunk attaining a diameter of 30 feet. Its fruit yields an acid pulp which is mixed with water, and used as a drink. Its leaves, when dried, furnish the substance called Lalo, employed in Africa as an astringent. The tree yields useful fibres. The bark is febrifugal.

Bombax Ceiba, the Silk Cotton-tree, has a cottony matter surrounding its seeds, which is used for stuffing cushions and other domestic purposes. Such is also the case with Bombax pentandrum, the Cotton-tree of India. The hairs want the tenacity required for manufacture. Canoes are made from the trunk of Bombax in the West Indies.

Brachychiton is the Bottle-tree of New Holland.

Cheirostemon platanoides, Arbol de las Manitas, or the Hand-plant of Mexico (Macpalxochiquahuilt of the Mexicans), is so called from the peculiar appearance of its five curved anthers.

Chorisia speciosa, yields a Cotton called vegetable silk, used for stuffing cushions.

Durio zibethinus, the Durian, yields an edible fruit with a civet-like odour. At first the perfume is very disagreeable, but by degrees the fruit is highly relished.

Eriodendron Samauma summits all the trees in the Amazon forests, and is called by Spruce the monarch of the forest. It rarely puts forth a branch until it has overtopped all the trees around.

Helicteres, Screw-tree, so called on account of the screw-like appearance of its twisted follicles.

Ochroma Lagopus is a West Indian tree, having a light cork-like wood, a tonic bark, and a woolly lining of its fruit.

Sterculia guttata and villosa furnish fibres which are made into ropes and cloth.

1173. Nat. Ord. 32.—BYTTNERIACEÆ, the Chocolate order (Fig.

1419).—Trees, shrubs, and undershrubs, with simple leaves, resembling the Sterculiaceæ and Malvaceæ, but differing from the former in their introrse anthers, slightly monadelphous and often partially sterile stamens; and from the latter in their usually definite not columnar stamens, two-celled anthers, and smooth pollen. The fruit is a capsule composed of a few carpels. They are chiefly tropical or sub-tropical plants. Upwards of 400 species have been recorded. *Ill. Gen.*—Thomasia, Lasiopetalum, Abroma, Byttneria, Theobroma, Guazuma, Hermannia, Pentapetes, Dombeya, Astrapæa, Pterospermum, Eriolæna.

Fig. 1419.

1174. In their properties Byttneriads resemble Malvaceæ.

Abroma augustum has a fibrous bark, which is used for cordage.

Guazuma ulmifolia yields a sweetish mucilaginous fruit.

Theobroma Cacao, the Cacao-tree (Fig. 1418), is a small tree which abounds in the forests of Demerary. From the seeds called Cacao-beans, the substances called Cocoa and Chocolate are prepared. The former consists of the roasted seeds or their outer coverings, reduced to powder, while the latter is prepared from the beans, with a mixture of Sugar, Vanilla, Cinnamon, and Arnotto. In 1852 the British importation of Cocoa was 6,268,525 lbs., of which 3,382,944 were for home consumption. The seeds contain a tonic principle called Theobromine, allied to Theine, and a fatty oil is expressed from them called the Butter of Cacao. From the pulp of the fruit a kind of spirit is distilled.

1175. Nat. Ord. 33.—TILIACEÆ, the Linden order (Fig. 357, p. 151, Fig. 929, p. 307).—Trees or shrubs with alternate leaves having deciduous stipules (Fig. 282, p. 123), floral envelopes tetramerous or pentamerous, calyx valvate, stamens ∞, outer ones sometimes petaloid and abortive, anthers two-celled (Fig. 651, p. 234), a glandular disk, style one, fruit dry or pulpy with several cells, often by abortion one-celled, seeds anatropal and albuminous. They are chiefly tropical plants. In northern temperate regions some form timber-trees. There are upwards of 350 known species. *Ill. Gen.*—Sloanea, Luhea, Corchorus, Triumfetta, Tilia, Grewia, Aristotelia, Elæocarpus, Monocera, Friesia.

1176. The plants of the order possess mucilaginous qualities. Many of them yield timber, fibres, and edible fruits.

Aristotelia Maqui produces a succulent fruit, which is eaten, and is made into wine.

Corchorus capsularis yields the textile material called Jute, or Jute Hemp, used for manufacturing coarse canvas or Gunny, of which Rice-bags are made. C. olitorius, Jews' Mallow, is used as a pot-herb. The infusion of the leaves of C. mompoxensis is used as tea in Panama.

Grewia sepida. Its berries are acid, and are used for Sherbet in the East.

Tilia europæa, the Lime or Linden tree, has a fibrous endophlœum, which furnishes the Bass or Bast employed in the manufacture of Russian mats, and used by gardeners in tying up plants. The wood is used for wainscoating and carving,

Figure 1419 illustrates the natural order Byttneriaceæ. Theobroma Cacao, the small tree which yields Cacao beans, whence cocoa and chocolate are made. The large capsular fruit is shown which contains pulp and seeds.

and for the manufacture of gunpowder-charcoal. An infusion of the flowers has been used as an antispasmodic and sedative. T. americana is called Basswood.

1177. Nat. Ord. 34.—DIPTEROCARPACEÆ or DIPTERACEÆ, the Sumatra-Camphor order.—Large trees with resinous juice, alternate, involute leaves, convolute stipules; long, wing-like, imbricate, unequal, calyx lobes; contorted petals; indefinite, distinct, or polyadelphous stamens, subulate anthers; coriaceous, one-celled fruit, surrounded by the calyx, the enlarged divisions of which form winged appendages; single, exalbuminous seed. Tropical Indian trees. There are nearly 50 known species. *Ill. Gen.*—Dipterocarpus, Dryabalanops, Vateria, Shorea.

1178. The plants of this order yield a resinous balsamic juice which assumes various forms.

Dipterocarpus. Various species yield a balsam called Gurjun or Wood-oil, which is used like Copaiva Balsam, and is also employed in painting.

Dryabalanops Camphora or aromatica, supplies the hard Camphor of Sumatra, which exists in a solid state in the interior of the wood, sometimes in pieces weighing 10 or 12 lbs. It also yields on incision a resinous oily fluid called the liquid Camphor, or Camphor-oil of Borneo. The tree is from 100-130 feet high, and 7-10 feet in diameter at its base.

Shorea robusta. The wood is much used in India under the name of Sál. The plant also yields a balsamic resin called Dhoona or Dammer pitch, used for incense.

Vateria indica furnishes the Piney Resin or Piney Dammar of India, which is extensively used as a varnish, and for making candles.

1179. Nat. Ord. 35.—CHLÆNACEÆ, the Leptolæna order.—Trees or shrubs with alternate, feather-veined, entire leaves, convolute stipules, involucrate flowers, which have three imbricate sepals, five convolute petals, numerous stamens, often monadelphous, a three-celled ovary, a capsular fruit, and albuminous seeds. They are found in Madagascar. There are about 8 species, the properties of which are not known. *Ill. Gen.*—Sarcolæna, Leptolæna, Schizolæna, Rhodolæna.

1180. Nat. Ord. 36.—TERNSTRÖMIACEÆ, the Tea order (Figs.

Fig. 1420.

Fig. 1421.

1420, 1421).—Trees or shrubs with alternate coriaceous, usually exsti-

Figures 1420 and 1421 illustrate the natural order Ternströmiaceæ.

Fig. 1420. Thea Bohea, or Cantonensis, the plant which yields Black and Green Tea at Canton. Fig. 1421. Thea viridis, the plant of the best Tea districts of China, which supplies the Black and Green Tea generally used in Britain.

pulate, and entire leaves, showy and generally unsymmetrical flowers. Sepals 5-7, with imbricate æstivation. Petals 5, 6, or 9, often combined at the base. Stamens ∞, distinct or united. Fruit a 2-7-celled capsule, usually with a central column. Seeds large, very few, with or without albumen. They are ornamental plants, found chiefly in Tropical America and in Eastern Asia. Those cultivated in Britain are principally from North America and China. There are about 140 known species. *Ill. Gen.*—Ternströmia, Freziera, Laplacea, Kielmeyera, Stuartia, Gordonia, Camellia, Thea.

1181. The plants of the order have stimulating and slightly narcotic properties.

Camellia japonica. Numerous varieties of this plant are cultivated, which are highly esteemed by florists. The plants require moderate protection in Britain. From the seeds of C. oleifera an oil is expressed. C. Sasanqua, called Sasanqua Tea, has fragrant flowers, which are sometimes mixed with other kinds of Tea.

Freziera theoides, a shrub common on the volcano of Chiriqui, is used for Tea in Panama.

Thea is the genus which includes the various species and varieties of Tea. According to Fortune, there are two species of Tea, Thea Bohea (Fig. 1420), and Thea viridis (Fig. 1421), from each of which Black and Green Tea is manufactured. The latter species is that which supplies the Tea sent from China to Britain. The difference in the appearance and quality of Teas depends partly on the climate and species, but chiefly on the time of gathering, and the mode of manufacture. The young leaves, quickly dried and subjected to a particular kind of manipulation, supply the Green Tea, while the older leaves dried more slowly, and after undergoing a process of fermentation, constitute the Black Tea. In some instances Tea is dyed of a green colour by means of a mixture of Turmeric, Prussian Blue, and Gypsum.* The ordinary Black Teas of commerce are known by the names of Bohea, Congou, Souchong, and Pekoe; while the Green are Twankay, Hyson, Hyson Skin, Gunpowder, and Imperial. Teas are occasionally perfumed by the addition of the flowers of Olea fragrans, and Aglaia odorata. The East India Company, at Dr. Royle's suggestion, are now cultivating the Chinese Tea plant in their Himalayan possessions with great success. The plants were transported by Mr. Fortune from the best Tea district in China. In 1851 the Tea plantations in India covered 656 acres of public land, besides that in the occupation of the Zemindars. The Assam Tea is furnished by a distinct species called Thea Assamica, with larger leaves and a taller stem. Tea contains oily matter, tannin, and a bitter principle called Theine, which is identical with Caffeine. In 1852 there were imported into Britain 66,361,020 lbs. of Tea, of which 54,724,615 were for home consumption. Large quantities of a spurious article called *Lie-Tea*, has been of late imported into Britain for the purposes of adulteration. It consists of the sweepings of tea warehouses, granulated by addition of gruel formed from the husks of rice, and coloured by addition of Turmeric and Prussian Blue. The Brick Tea of Thibet occurs in blocks, shaped like bricks, and wrapped up in paper or other materials. It is one of the Lie-Teas, pressed into moulds and dried.

1182. Nat. Ord. 37.—Olacaceæ, the Olax order.—Trees or shrubs, often spiny, with alternate, exstipulate leaves, a cup-shaped calyx, be-

* Specimens of the dye, along with various kinds of Tea, have been presented by Mr. Fortune to the Edinburgh Museum of Economic Botany. For further details relative to Tea, see Fortune's Three Years' Wanderings in the Northern Provinces of China; Ball, on the Cultivation and Manufacture of Tea; Royle, Illustrations of the Botany of the Himalaya, and Productive Resources of India; Warrington on the Teas of Commerce, in the Quarterly Journal of the Chemical Society, iv. 156, and Phytologist for June 1852. Seemann, in the Kew Miscellany for January 1852.

ing enlarged with the fruit and often covering it, five valvate petals, 5-10 stamens, partly sterile, five fertile ones being opposite the petals, a disk, a succulent fruit with a hard endocarp, and an albuminous seed without integuments (exutive). An order of mostly tropical shrubs, containing few species. Some yield edible fruits. *Ill. Gen.*—Opilia, Olax, Heisteria, Ximenia, Diplocalyx, Iodina.

1183. Nat. Ord. 38.—Icacinaceæ, the Icacina order.—Evergreen trees and shrubs allied to Olacaceæ, but differing in the calyx not enlarging with the fruit, stamens being alternate with the petals, ovary plurilocular, with axile placentation, and seeds having the usual integuments (indutive). The order is chiefly tropical. There are 65 species, the properties of which are not known. *Ill. Gen.*—Icacina, Sarcostigma, Pogopetalum.

1184. Nat. Ord. 39.—Cyrillaceæ, the Cyrilla order.—Evergreen shrubs with exstipulate leaves, allied to Olacaceæ and differing chiefly in their imbricate not valvate petals, which are not hairy. They are found in North America. There are five species known. *Ill. Gen.*—Cyrilla, Elliottia.

1185. Nat. Ord. 40.—Aurantiaceæ, the Orange order (Figs. 1422 to 1424).—Trees or shrubs with alternate, compound, exstipulate, dotted leaves, and fragrant flowers (Fig. 315, p. 135). Calyx short, urceolate or campanulate, 3-5-toothed. Petals 3-5. Stamens equal

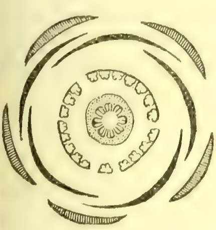
Fig. 1422.

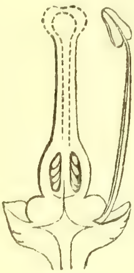
Fig. 1423.

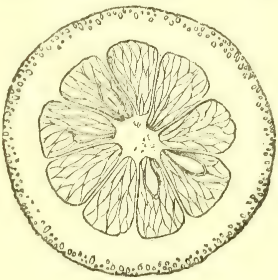
Fig. 1424.

in number to the petals, or a multiple of them, inserted along with the petals on a hypogynous disk (Fig. 1423); filaments sometimes united in one or more bundles. Ovary free; style cylindrical; stigma thickish (Fig. 1423). Fruit a hesperidium (Fig. 1424), sometimes, as in fingered Citrons and horned Oranges becoming monstrous by the separation of the carpels (Figs. 886, 887, p. 294) or by the multiplication of carpels, so that one fruit is included within another. Seeds exalbuminous (Figs. 898, 899, p. 299), often polyembryonous. Chiefly East Indian plants, the known species being about 100. *Ill. Gen.*—Limonia, Glycosmis, Rissoa, Bergera, Murraya, Cookia, Feronia, Ægle, Citrus.

Figures 1422 to 1424 illustrate the natural order Aurantiaceæ.

Fig. 1422. Diagram of the flower of the Orange, with five divisions of the calyx, five imbricate petals, irregularly polyadelphous stamens, and pulpy ovary. Fig. 1423. Pistil of Orange, with hypogynous disk and stamen inserted into the lower part of it. Fig. 1424. Hesperidium, or fruit of Orange (see p. 288), with separable rind, and separable pulpy cells formed by the endocarp. See also Orange leaf, Fig. 304, p. 130; young fruit and disk, Fig. 867, p. 288.

1186. The leaves and the rind of the fruit contain a volatile fragrant oil, and the pulp of the fruit is more or less acid.

Ægle Marmelos, the Indian Bael or Bela, yields a delicious fruit. Its root and bark are antispasmodic. The decoction and jelly of the fruit are used in diarrhœa.

Citrus Aurantium, the Sweet Orange, has been so generally distributed over different quarters of the globe, that its native country can scarcely be determined. It has been naturalised in Europe. Oranges are imported into Britain from the Azores, Lisbon, Malta, and Sicily. In 1851 the imports were 300,500 packages, weighing 35,000 tons. The chief kinds are the Common Orange, the Chinese or Mandarin, the Maltese and the St. Michaels. The last is characterised by its smooth rind and absence of pips (p. 602). There are other varieties of Orange, such as the Navel Orange of Pernambuco, so called from the peculiar appearance at the top of the fruit (p. 293), and the Tangerine Orange. The Orange-tree is very fruitful; a single tree will produce 20,000 Oranges fit for use. The rind yields an oil called Oil of Orange, while the flowers supply another kind of oil. The pulp of the fruit contains malic acid. C. vulgaris (C. Bigaradia of some authors), the Bitter or Seville Orange, is probably a variety. It differs from the Sweet Orange in the larger wing of its petiole, its more fragrant flowers, its darker fruit, and its more bitter rind and pulp. In the young state, the fruit is known as Orangettes or Curaçoa Oranges. The flowers yield an essential oil called Neroli oil. The distilled water of the flowers has hypnotic qualities. The rind of the Bitter Orange is used in conserves, as for making marmalade. C. Limonum, the Lemon, yields an acid antiscorbutic juice. It contains citric acid. Its rind is adherent and not separable like that of the Orange; such is also the case with the Lime and Citron. A good Lemon-tree will produce 8000 Lemons. The fruit is imported from Sicily, Spain, and Portugal. C. Limetta produces the Lime, and var. Bergamia, the Bergamot. C. Medica is the source of the Citron.* C. Decumana furnishes the Shaddock; C. paradisi the forbidden fruit; and C. Pompelmos the Pompelmoose. C. japonica, the Kumquat of China, is grown in pots for its flowers and fruit. The fruit is small, oval, and orange-coloured.

Cookia punctata furnishes the edible Wampee fruit of China and of the Indian Archipelago.

Feronia elephantum yields a gum resembling Gum Arabic.

1187. Nat. Ord. 41.—Hypericaceæ, the St. John's Wort order (Figs. 1425 to 1428).—Herbs, shrubs, or trees with a resinous juice, regular flowers, opposite, entire, exstipulate leaves, usually with transparent dots and blackish glands. Sepals 4-5, persistent, two outer often smaller. Petals 4-5, unequal-sided, twisted in æstivation, often bordered with black dots. Stamens generally ∞ and polyadelphous (Fig. 1426). Carpels 3-5 partially united. Fruit a

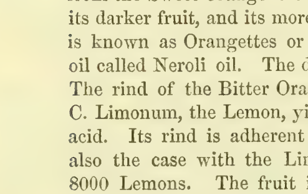

Fig. 1426.

Figures 1425 to 1428 illustrate the natural order Hypericaceæ.

Fig. 1425. Diagram of the flower of Hypericum, with five sepals, two of them exterior, five twisted petals, numerous polyadelphous stamens, three united carpels, with numerous seeds on a central placenta, which sends processes outwards. Fig. 1426. Section of a flower of Hypericum, showing sepals, petals, bundles of stamens, ovary with numerous ovules on a central placenta, and long styles. Fig. 1427. Flower of Parnassia palustris, showing the free stamens and the ovary. Fig. 1428. Petal of Parnassia, with a bundle of abortive stamens, usually called the nectary. Parnassia is removed from Droseraceæ on account of its exalbuminous seeds, and other characters.

* This seems to be the Hebrew Tappuach, translated Apple-tree and Apples in Prov. xxv. 11; Cant. ii. 3, 5, vii. 8, viii. 5; Joel i. 12.

capsule with septicidal dehiscence. Seeds numerous and exalbuminous. The order is generally distributed both in warm and temperate regions. There are 280 known species. The properties of the plants are

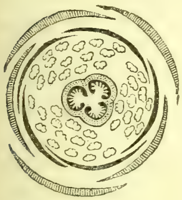
Fig. 1425.

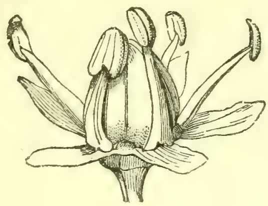
Fig. 1427.

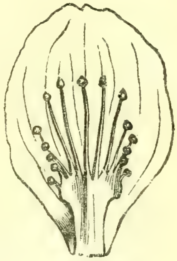
Fig. 1428.

usually purgative; some are tonic and astringent. Many Hypericums yield a yellow juice and an essential oil. Species of Vismia yield a gum resin like Gamboge. *Ill. Gen.*—Ascyrum, Hypericum, Parnassia, Elodea, Vismia, Reaumuria. *

1188. Nat. Ord. 42.—Guttiferæ or Clusiaceæ, the Gamboge order.—Trees or shrubs with a resinous juice, opposite coriaceous entire leaves, and occasionally unisexual flowers. Sepals and petals 2, 4, 5, 6, or 8, the former often unequal, the latter equilateral. Stamens numerous, often united. Disk fleshy. Ovary one or many-celled; stigma usually sessile and radiate. Fruit dry or succulent, one or many-celled. Seeds exalbuminous, often immersed in pulp. Natives of humid and hot places in tropical regions, chiefly South America. There are 150 known species. *Ill. Gen.*—Clusia, Moronobea, Mammea, Garcinia, Xanthochymus, Cambogia, Mesua, Calophyllum.

1189. The properties of the order are in general acrid and purgative. The plants yield a yellow gum resin.

Calophyllum Calaba furnishes the East Indian resin called Tacamahaca. Other species also yield resin and oils.

Cambogia Gutta (Hebradendron cambogioides of Graham) is the source of Ceylon species Gamboge.

Clusia. The species are handsome trees, which send out remarkable abnormal roots from their stems and branches. Clusia alba yields a resinous juice which is employed in place of pitch. Clusia flava is called Mountain or Wild Mango, and in Jamaica it receives the name of Balsam-tree.

Garcinia. Different species of this genus yield a substance like Gamboge. Garcinia cochinchinensis has been said to be the source of the Siam Gamboge, the best commercial specimens of which are in the form of pipe Gamboge, but this is very doubtful. Garcinia elliptica, found in Sylhet and Tavoy, also supplies a kind of Gamboge. Coorg or Wynaad Gamboge is also the produce of a Garcinia, perhaps G. pictoria. Gamboge is used as a pigment and as a drastic purgative. Garcinia Mangostana, a native of Malacca, produces the Mangosteen, one of the finest known fruits. It is filled with a delicious pulp. Its rind is used as an astringent.

Mammea americana produces an excellent fruit, the Mammee Apple or wild Apricot of South America.

* Some put Reaumuria in a separate order, Reaumuriaceæ, distinguished by its shaggy seeds and appendages at the base of the petals.

Mesua. The species have a hard and durable timber. Their bark and root are bitter and tonic.

Pentadesma butyracea, is called the Butter and Tallow Tree of Sierra Leone, in consequence of the fatty matter furnished by its fruit when cut.

1190. Nat. Ord. 43.—Marcgraviaceæ, the Marcgravia order.—Trees or shrubs allied to Guttiferæ, and differing chiefly in their alternate leaves, unsymmetrical flowers, and versatile anthers. Some of the plants have remarkable pitcher-like bracts. They are found in equinoctial America chiefly. Little is known of their properties. The species are 26. *Ill. Gen.*—Norantea, Marcgravia.

1191. Nat. Ord. 44.—Hippocrateaceæ, the Hippocratea order.—Shrubby plants with opposite simple leaves having deciduous stipules. Sepals and petals five, imbricate. Stamens three, monadelphous. Fruit either consisting of three winged carpels or baccate. Brown and Lindley put the order near Celastraceæ, notwithstanding its hypogynous stamens. They are principally South American plants; some occur in Africa and India. Little is known of their qualities. The nuts of Hippocratea comosa are oily and sweet. The fruit of Tontelea pyriformis is eaten in Sierra Leone. There are 86 species recorded. *Ill. Gen.*—Hippocratea, Tontelea, Salacia.

1192. Nat. Ord. 45.—Malpighiaceæ, the Malpighia order.—Trees or shrubs, often climbing, with opposite or alternate leaves, and short deciduous, sometimes intrapetiolar, stipules; occasionally showing peltate hairs. Sepals five, combined at the base, glandular. Petals five, unguiculate. Stamens ten, often monadelphous. Ovary generally of three carpels. Fruit a drupe, a woody nut, or a samara. Seed orthotropal, suspended by a cord, exalbuminous; embryo straight or curved. Malpighiads are nearly all tropical plants. There are 555 species described. *Ill. Gen.*—Malpighia, Byrsonima, Nitraria, Banisteria, Hiptage, Hiræa, Gaudichaudia.

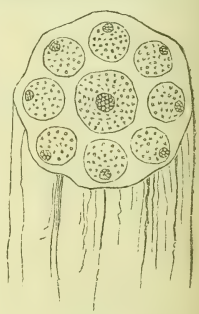

Fig. 1429.

1193. Their properties are generally astringent. Many are handsome trees or climbers with showy flowers. The wood is sometimes formed in an anomalous manner (Fig. 1429).

Byrsonima. The bark of some of the species is used for tanning, and as a tonic and astringent. Some produce acid astringent fruit used in dysentery.

Malpighia glabra and punicifolia furnish the Barbadoes Cherry, used in Jamaica as a dessert.

Nitraria tridentata, according to Munby, is the true Lotus-tree of the ancients. It is found in the desert of Soussa, near Tunis, and produces a succulent fruit having stimulating qualities. The genus is by some put in a separate order called Nitrariaceæ.

1194. Nat. Ord. 46.—Erythroxylaceæ, the Erythroxylon order.—Allied to Malpighiads, and distinguished by the flowers growing from among imbricated scales, the absence of calycine glands, the pre-

Fig. 1429. Anomalous fasciculated stem of a Malpighiad of South America. See page 85.

sence of plaited scales at the base of the petals, and by the ovules being anatropal and cordless. They are West Indian and South American plants. Some of them have stimulating qualities, others yield a tonic bark. Erythroxylon Coca, a Peruvian plant, called Ipadú by the Indians of the Rio Negro, is famed for exciting the nervous system.* The bark of E. suberosum supplies a reddish-brown dye. There are 75 known species. *Ill. Gen.*—Erythroxylon.

1195. Nat. Ord. 47.—ACERACEÆ, the Maple order (Fig. 1430).—Trees with opposite, simple, often palmate, exstipulate leaves (Fig. 1430), and corymbose or racemose unsymmetrical flowers. Calyx usually of five parts. Petals as many as the sepals, or none. Stamens generally eight, inserted on or around a hypogynous disk. Ovary of two carpels, more or less united; ovules in pairs. Fruit samaroid (Fig. 1430, Fig. 850, p. 284). Seed solitary, exalbuminous; embryo coiled. Found in the temperate parts of Europe, Asia, and America. There are 60 species. *Ill. Gen.*—Acer, Negundo.

Fig. 1430.

1196. Their properties are saccharine, the trees yield light and useful timber.

Acer Pseudo-platanus is the Common Sycamore or Greater Maple, which thrives well even when exposed to the sea. Its leaves resemble those of the True Plane, hence its specific name. In Scotland it is called Plane Tree. Its timber is used for machinery, for bowls and other turnery, and for charcoal. A. campestris, the Common Maple, has often beautifully-veined wood. A. saccharinum, the Sugar-Maple, supplies the maple sugar of America. The saccharine juice is procured by incisions in the stem. A. dasycarpum and other species yield sugar.

1197. Nat. Ord. 48.—SAPINDACEÆ, the Soapwort order (Fig. 1431).—Trees, shrubs, or climbers with tendrils, rarely herbs; having alternate or opposite, usually compound leaves, and unsymmetrical, generally irregular and polygamous flowers. Calyx with 4-5 sepals. Petals 4-5, occasionally 0, sometimes with an appendage inside. Disk fleshy. Stamens usually 8-10. Ovary 2-3-celled; style undivided, or 2-3-cleft. Fruit capsular (Fig. 791, p. 270) or fleshy, sometimes winged. Seeds exalbuminous, arillate; embryo usually curved. Found chiefly in the tropical parts of South America and India. The Hippocastaneæ or Horse-chestnuts, distinguished by opposite leaves, and two ovules in each cell, one erect, and the other suspended, occur in the north of India, Persia, and the United States. There are about 400 known species. *Ill. Gen.*—

Fig. 1430. Branch of Acer saccharinum, the Sugar Maple, showing palmate leaves and samaroid fruit.

* Spruce says, that an Indian with a chew of Ipadú in his cheek will go two or three days without food, and without feeling any desire to sleep. The leaves are the part used.

Serjania, Paullinia, Schmidelia, Sapindus, Cupania, Nephelium, Æsculus, Pavia, Dodonæa, Ophiocaryon, Meliosma.

1198. The properties are various. Many of the plants have saponaceous qualities, hence the name of the order. Some are astringent; others yield edible fruits and seeds, and not a few are poisonous.

Æsculus Hippocastanum, the Horse-chestnut (Fig. 1431). Its bark is febrifugal. Its seeds contain saponaceous matter. They are used as food for sheep, and they have been recommended as substitutes for Coffee. The leaves and fruit of Æsculus ohiotensis, Buck-eye or American Horse-chestnut, are said to be poisonous.

Cupania (Blighia) sapida, furnishes the Akee fruit, with its remarkable succulent edible arillus.

Nephelium (Euphoria) Litchi, furnishes the Li-chi fruit of China. N. Longan supplies another Chinese fruit called Longan. Another species of Nephelium yields the Rambutan fruit.

Ophiocaryon paradoxum is the Snake-nut-tree of Demerara, so called on account of its peculiar coiled embryo, resembling a snake.

Fig. 1431.

Paullinia sorbilis, the Guaraná plant. The seeds of this plant, after being dried and deprived of their white aril, are pounded and kneaded into a dough, which is afterwards made up into cakes or balls, so as to constitute the Guaraná of the Indians of the Rio Mauhé, and of other parts of Brazil. This substance supplies an important beverage to a very large population, and its tonic properties seem to be due to a bitter crystalline matter called Guaranine, identical with Theine. Some species of Paullinia have anomalous fasciculated stems.

Sapindus Saponaria, Soap-berry. The acrid fruit of this and other species forms a lather with water, and is used for soap. The pounded fruit is said to poison fish. S. esculentus produces an edible fruit.

1199. Nat. Ord. 49.—Rhizobolaceæ, the Suwarrow-nut order.—Trees with opposite, digitate, exstipulate leaves. Sepals 5-6, more or less combined. Petals 5-8, unequal. Stamens ∞ arising with the petals from a hypogynous disk. Fruit of several combined indehiscent, one-seeded nuts. Seed reniform, exalbuminous, with a cord dilated into a spongy excrescence; radicle very large. Found in South America. Known species 8. *Ill. Gen.*—Caryocar.

1200. The plants of the order are large timber trees, some of which yield edible fruit.

Fig. 1431. Flowering branch of Æsculus Hippocastanum, the Horse-chestnut, showing cymose irregular unsymmetrical flowers having five petals and seven stamens.

Caryocar butyrosum (Pekea tuberculosa) is a gigantic tree of Demerara, producing the Souari, Suwarrow, or Surahwa nuts, the kernels of which are esteemed the most agreeable of all the nut kind. They yield a bland, sweet oil. The timber of the tree is used for ship-building.

1201. Nat. Ord. 50.—Meliaceæ, the Melia order.—Trees or shrubs with alternate, exstipulate, simple or compound leaves. Sepals 3, 4, or 5, more or less united. Petals, the same number. Stamens twice as many as the petals. Disk, cuplike. Ovary, with cells varying from 3 to 12. Fruit succulent or capsular. Seeds not winged, with or without albumen; embryo with leafy cotyledons. They are chiefly tropical plants, and are found in Asia, America, and Africa. Known species 150. *Ill. Gen.*—Melia, Aglaia, Lansium, Trichilia, Guarea, Carapa.

1202. The properties of the order are bitter, astringent, and tonic. Some of the plants act as powerful purgatives and emetics.

Carapa. The species of this genus have frequently a febrifuge bark, and some yield an anthelmintic oil.

Guarea. The species have often purgative and emetic properties, and require caution in their use.

Lansium. From species of this genus the fruits of the Indian Archipelago, called Langsat or Lanséh and Ayer are procured.

Melia Azedarachta, the Neem-tree or Pride of India, has febrifugal qualities. The pericarp yields an oil used for lamps.

Under this order many Botanists have placed the genus Canella. Its place, however, seems to be uncertain. Martius puts it under a separate order, Canellaceæ, allied to Guttiferæ. Canella alba has an aromatic bark, and is called Wild Cinnamon in the West Indies. Canella Bark has some resemblance to Winter's Bark.

1203. Nat. Ord. 51.—Humiriaceæ, the Humirium order.—Balsamic trees or shrubs, with alternate, simple, exstipulate leaves. Calyx in five divisions. Petals five, imbricate. Stamens ∞, monadelphous; anthers two-celled, with a membranous connective beyond the lobes. Disk often present. Ovary five-celled. Fruit a drupe. Seed albuminous; embryo orthotropal. Natives of tropical America. The Balsam of Umiri is procured from Humirium floribundum, by making incisions into its trunk. Known species 18. *Ill. Gen.*—Humirium.

1204. Nat. Ord. 52.—Cedrelaceæ, the Mahogany order.—Trees with alternate, pinnate, exstipulate leaves, allied to Meliaceæ, and chiefly distinguished by their indefinite and winged seeds. The fruit is capsular, the valves separating from a thick axis. They are common in the tropical parts of America and India. Known species 25. *Ill. Gen.*—Swietenia, Soymida, Chloroxylon, Flindersia, Cedrela.

1205. The properties of the order are fragrant, aromatic, and tonic. Many yield timber.

Cedrela febrifuga, is so called from possessing a febrifugal bark. C. Toona, Toon, has similar properties; it is a timber-tree of India.

Chloroxylon Swietenia produces the Satin-wood of India, and yields a kind of Wood-oil.

Oxleya xanthoxyla is the Yellow-wood of New South Wales.

Soymida febrifuga, the Red-wood tree, is febrifugal and astringent.

Swietenia Mahagoni, the Mahogany, grows in dense forests, and forms one of the most lofty and gigantic tropical trees. The wood is chiefly imported from Honduras and Cuba. It is said that 31,668 tons of mahogany were imported into Britain in 1848.

1236. Nat. Ord. 53.—VITACEÆ or AMPELIDEÆ, the Vine order (Figs. 1432-1434).—Shrubby plants climbing by tendrils, with tumid

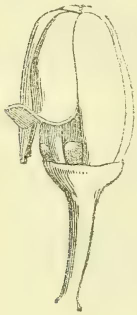

Fig. 1432.

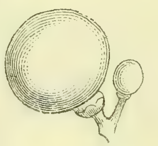

Fig. 1434.

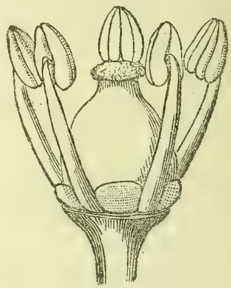

Fig. 1433.

joints, simple or compound leaves, opposite below, alternate above, and small green flowers arranged in a racemose or umbellate manner (Figs. 152 and 153, p. 64). Calyx small, nearly entire (Fig. 1432). Petals 4-5, induplicate, inserted outside a disk, sometimes cohering at their tips, and caducous (Fig. 1432). Stamens 4-5, opposite the petals, inserted on the disk (Fig. 1433). Ovary usually two-celled, with two erect ovules in each cell. Fruit a uva (Fig. 1434). Seeds with a bony spermoderm; embryo small in horny albumen. The tendrils in this order are abortive branches (p. 64). Vineworts inhabit the milder and hotter regions of the globe. They are common in the East Indies. The Grape Vine (Fig. 152, p. 64), is said to be a native of the shores of the Caspian, whence it has been widely distributed. Known species 260. *Ill. Gen.*—Cissus, Ampelopsis, Vitis, Leea.

1207. The plants of this order have acid leaves and a pulpy fruit more or less acid at first, but developing Grape-sugar as it ripens. They have frequently large dotted vessels abounding in sap, and they bleed copiously. Spiral vessels with air are common in the Vine.

Ampelopsis (Cissus) virginica is the Virginian Creeper, commonly cultivated as a climber.

Figures 1432 to 1434 illustrate the natural order Vitaceæ.

Fig. 1432. Flower of Vitis vinifera, common Grape Vine, showing the gamosepalous calyx and the petals united at the apex, and separating below. Fig. 1433. Andrœcium and gynœcium of the Vine, with the disk surrounding the base of the ovary. Fig. 1434. The Grape or fruit of the Vine, a uva, or berry not adherent to the calyx (p. 287). After the forbidden fruit, it is the first fruit mentioned in Scripture, the Hebrew word Gephen meaning Vine, occurring in Gen. ix. 20. It is the Ampelos of the Greeks, hence the name Ampelideæ given to the order.

Cissus. Some of the species yield acrid fruit, others are useful as dyes.

Vitis vinifera, the Grape Vine, has followed the footsteps of man. Its fruit has been greatly improved by cultivation, and has been used for the making of wine for more than 4000 years. Its leaves are astringent. The verjuice of the young fruit contains much tartaric, and some citric and malic acid. Bitartrate of Potass is found in the fruit. It is said that 300 tons of Grapes are imported into Britain every autumn from Sicily, Lisbon, and Hamburg. In a dried state Grapes are known as Raisins (uvæ passæ majores). The Sultana Raisin of Smyrna is seedless. The finest Raisins are the Muscatel. Archer says, that the average annual quantity of Raisins imported into Britain during the last five years, has been 12,000 tons. The dried Currants of commerce, a corruption of Corinths (uvæ passæ minores), are the produce of the small seedless Corinthian Grape, which is cultivated in many of the Greek islands. The quantity of Currants imported annually is said to be 21,000 tons. Vitis vulpina abounds in some parts of America. In Rhode Island it is called Wild Vine, and its fruit is known as Fox-Grapes.

1208. Nat. Ord. 54.—GERANIACEÆ, the Cranesbill order (Figs. 1435 and 1436).—Herbs or shrubs, with tumid joints, opposite or

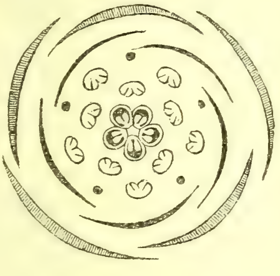

Fig. 1435.

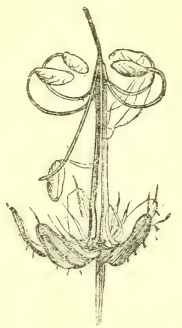

Fig. 1436.

alternate leaves, usually palmately-veined and lobed (Fig. 422, p. 177), often stipulate. Sepals 5, imbricate, one sometimes spurred. Petals 5, unguiculate, contorted in æstivation. Stamens usually 10, monadelphous, occasionally some sterile. Ovary of five bi-ovular carpels placed round an elongated axis to which the styles adhere. Fruit formed of five one-seeded carpels, which finally separate from the base of the central axis or beak, and curve upwards by means of the attached styles (Fig. 1436); the fruit is said to be gynobasic, and the long beak or carpophore gives origin to the name of the order. Seed exalbuminous; embryo curved and doubled up, with plaited cotyledons. Distributed over various parts of the world. The species of Pelargonium abound at the Cape of Good Hope. Known species about 500. *Ill. Gen.*—Erodium, Geranium, Monsonia, Pelargonium.

Figures 1435 and 1436 illustrate the natural order Geraniaceæ.

Fig. 1435. Diagram of the flower of a Geranium, with five imbricate sepals, five twisted petals, ten perfect stamens in two rows, and an outer row of abortive stamens, five bi-ovular carpels forming the ovary. Fig. 1436. Fruit of a Geranium, showing the five monospermal carpels separating from the base of the long beak-like process, and curving up by means of the styles, which remain adherent to the upper part of the beak.

1209. The order has astringent and aromatic properties. Many of the plants are fragrant. Some have a musky odour.

Geranium maculatum receives the name of Alum-root from the astringency of its root. G. parviflorum yields edible tubers called native carrots in Australia.

Pelargonium. In this genus the adherent calycine spur is well seen. The species are showy and fragrant, and are extensively cultivated under the common name of Geraniums. They have been improved by hybridization and by the art of horticulture. P. triste supplies tubers which are eaten at the Cape of Good Hope.

1210. Nat. Ord. 55.—LINACEÆ, the Flax order (Figs. 1437 to 1440).—Herbs with entire, sessile, alternate or opposite or verticillate

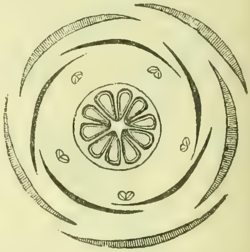

Fig. 1437.

Fig. 1438.

Fig. 1439.

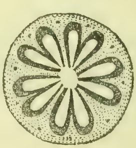

Fig. 1440.

leaves (Fig. 1438), which are exstipulate or have occasionally a pair of minute glands at their base. Flowers regular and symmetrical. Sepals 3-5, imbricate. Petals 3-5, contorted in æstivation. Stamens united at the base, 3-5, usually with intermediate abortive ones in the form of teeth opposite the petals. Ovary 3-5-celled; styles 3-5 (Fig. 1439). Fruit a plurilocular capsule, in which the cells are more or less completely divided into two by spurious divisions proceeding from the dorsal sutures (Fig. 1440). Seeds, one in each cell, anatropal, with little or no albumen; embryo straight, cotyledons flat. Distributed over various quarters of the globe, but most abundant in Europe and

Figures 1437 to 1440 illustrate the natural order Linaceæ.

Fig. 1437. Diagram of the Flax plant, showing five imbricate sepals, five contorted petals, five alternating stamens, and five divisions of the ovary, each of which is divided into two by a spurious septum from the dorsal suture. Fig. 1438. Linum usitatissimum, the Flax plant. It is the Hebrew Pishtah referred to in Exod. ix. 31; Josh. ii. 6, and in many other passages of the Old Testament; and it is the Linon of Matth. xii. 20. Fig. 1439. Syncarpous pentacarpellary ovary of the Flax plant, with five distinct styles. Fig. 1440. Syncarpous fruit of the Flax plant, showing the five cells or loculaments, divided each into two by a spurious dorsal septum.

the north of Africa. Known species 90. *Ill. Gen.*—Linum, Cliococca, Radiola.

1211. The order is distinguished by its mucilaginous properties, and by yielding valuable fibres. Some species are purgative and diuretic.

Linum catharticum, perhaps too much neglected, is called Purging-flax from its properties. L. usitatissimum, the cultivated Flax (Fig. 1438), yields tenacious fibres (Fig. 45, p. 23), used in the manufacture of linen. Its seeds are demulcent and oily. The oil is procured from them by expression. They supply oil-cake for cattle, and in the state of powder the cake is employed as poultices. An infusion of the seeds is used as a demulcent. Linseed-oil mixed with Lime-water, under the name of Carron-oil, is a favourite remedy for burns and scalds. The broken fibres detached during the process of heckling, are used as tow by surgeons. Of late years the fibres of Flax, by being steeped in a solution of Carbonate of Soda, and afterwards dipped in a weak acid solution, are broken up into minute divisions, so as to form what is called Flax-Cotton, which has been used in manufacture in the same way as Cotton. The quantity of foreign flax imported into Britain in 1849 was 1,806,786 cwts.

1212. Nat. Ord. 56.—Oxalidaceæ, the Wood-sorrel order (Fig. 1441).—Herbaceous or shrubby plants with alternate, rarely opposite, simple or compound leaves, and regular flowers. Sepals five, imbricate. Petals five, twisted. Stamens ten, more or less monadelphous, of different lengths. Fruit usually a five-celled capsule, sometimes drupaceous. Seeds with a fleshy outer coat, which bursts in an elastic manner when ripe, so as to expel the seeds; embryo straight and large in thin albumen. The plants are allied to Geraniaceæ, and differ chiefly in their gynœceum. The plants of the order are met with both in hot and in temperate regions. They are very common in America and at the Cape of Good Hope. The shrubby species are confined to warm climates. Known species about 330. *Ill. Gen.*—Oxalis, Biophytum, Averrhoa, Hugonia.

Fig. 1441.

1213. The Oxalids or Wood-sorrels have generally acid properties, from the presence of oxalic acid in the form of Binoxalate of Potass, which is called the salt of sorrel. Some of them have sensitive leaves (p. 493.)

Averrhoa Bilimbi, the Blimbing of the East Indies, has an acid fruit, which is used as a pickle. A. Carambola has a similar fruit.

Oxalis crenata bears tubers which are used as potatoes. It is one of the plants called Arracacha. Its leaves are acid. O. Deppei has fleshy roots, which are used as culinary vegetables. O. anthelmintica has acrid tubers, which are used as a vermifuge. O. bupleurifolia and other Indian species have phyllodia (p. 135.)

Fig. 1441. Oxalis Acetosella, the common Wood-sorrel, with ternate leaves, and obcordate leaflets. By some it is considered as the true Irish Shamrock.

1214. Nat. Ord. 57.—BALSAMINACEÆ, the Balsam order (Figs. 1442 and 1443).—Annual succulent herbs, with simple, exstipulate leaves, and irregular flowers. Sepals five, coloured, irregular, the odd one spurred. Petals five, irregular, distinct or cohering. Stamens five. Ovary of five united carpels; stigmas sessile (Fig. 1442). Fruit, a capsule opening septifragally by five elastic valves, which become coiled up (Fig. 1443). Seeds exalbuminous; embryo straight. The flowers are usually showy. The ripe capsules burst elastically when touched, so as to scatter the seeds; hence the name of Impatiens noli-me-tangere given to one of the species. The plants abound in India. There are 110 known species. *Ill. Gen.*—Impatiens, Balsamina, Hydrocera.

Fig. 1442.

Fig. 1443.

1215. Nat. Ord. 58.—TROPÆOLACEÆ, the Indian Cress, or Nasturtium order (Fig. 1444).—Trailing or twining herbs, with alternate, exstipulate, and peltate or palmate leaves. Calyx spurred (Fig. 1444), formed by five united sepals. Petals five, the two upper arising from the throat of the calyx, remote from the three lower unguiculate petals. Stamens usually eight, distinct. Ovary of three united, one-seeded, carpels. Fruit indehiscent, monospermal, carpidia separating from a common axis. Seeds exalbuminous, filling the cells; embryo large. They are chiefly South American plants. There are about 40 species. *Ill. Gen.*—Tropæolum.

Fig. 1444.

1216. The properties of the order are acridity and pungency, resembling in this respect some of the Cruciferæ.

Tropæolum majus is the common Indian Cress," or garden Nasturtium, the unripe fruit of which is pickled, and used as a substitute for Capers. The roots of T. tuberosum are eaten in Peru. The species have showy, yellow, orange, scarlet, and blue flowers; thus the Xanthic and Cyanic series are represented in the genus.

1217. Nat. Ord. 59.—LIMNANTHACEÆ, the Limnanthes order.—The plants of this order differ from Tropæolaceæ in their regular flowers, their erect ovules, and in the tendency to adhesion between the

Figures 1442 and 1443 illustrate the natural order Balsaminaceæ.

Fig. 1442. Fruit or capsule of Impatiens noli-me-tangere, Touch-me-not, consisting of five united carpels, with a sessile stigma. Fig. 1443. Capsule of Impatiens, with five recurved valves, which separate with elasticity from the central placenta so as to scatter the seeds (p. 413).

Fig. 1444. Irregular flower of Tropæolum majus, common Indian Cress or garden Nasturtium, with its coloured, spurred (calcarate) calyx, and five petals, three of which are stalked.

stamens and the calyx. Probably the order should be placed among Perigynous Exogens. It contains a few North American species, which have properties similar to Indian Cresses. *Ill. Gen.*—Limnanthes, Flörkea.

1218. Nat. Ord. 60.—PITTOSPORACEÆ, the Pittosporum order.—Trees or shrubs, with alternate, simple, exstipulate leaves. Sepals and petals, 4-5, distinct, or slightly cohering. Stamens five; anthers often porose. Ovary 2-5-celled; style one. Fruit, a capsule or berry. Seeds numerous, anatropal, often covered with a resinous pulp; embryo minute, in fleshy albumen. New Holland plants chiefly. They have more or less resinous qualities. The berries of some Billardieras are eatable. In Cheiranthera linearis the anthers are thrown to one side, and have a hand-like aspect. Known species 78. *Ill. Gen.*—Pittosporum, Cheiranthera, Sollya, Billardiera.

1219. Nat. Ord. 61.—BREXIACEÆ, the Brexia order.—Trees, with alternate, simple, stipulate leaves, and green flowers in axillary umbels. Calyx five-parted. Petals five, contorted. Stamens five, arising from a narrow cup, with teeth between them. Style one. Fruit drupaceous, five-cornered, five-celled, rough. Seeds numerous, albuminous. Madagascar plants, of which little is known. There are 6 species described. *Ill. Gen.*—Brexia.

1220. Nat. Ord. 62.—ZYGOPHYLLACEÆ, the Bean-caper and Guaiacum order (Figs. 1445 and 1446).—Herbs, shrubs, or trees, with

Fig. 1445.

Fig. 1446.

opposite, stipulate, usually pinnate, not dotted leaves. Calyx 4-5-

Figures 1445 and 1446 illustrate the natural order Zygophyllaceæ.

Fig. 1445. Guaiacum officinale, Guaiac or Lignum Vitæ. It has pari-pinnate shining leaves. Fig. 1446. Tribulus terrestris, showing its pinnate leaves and spiny carpels of a triangular form attached to an axis. The name of Caltrops is applied to the genus in consequence of the fruit resembling the machines formerly used to obstruct cavalry.

parted, convolute. Petals unguiculate, at first minute, afterwards large, imbricate. Stamens 8-10, often arising from the back of scales. Ovary 4-5-celled, surrounded by glands or a disk; style simple. Fruit usually a capsule, 4-5-angled, opening in a loculicidal manner by 4-5 valves. Seeds usually albuminous (Tribulus is exalbuminous); embryo green. Bean-capers are generally distributed. Some are peculiar to America; others are found in Europe, India, Africa, and New Holland. There are 100 known species. *Ill. Gen.* —Peganum, Fagonia, Roepera, Zygophyllum, Guaiacum, Melianthus, Tribulus.

1221. The plants have diaphoretic and anthelmintic properties. The wood of the arborescent plants of the order is very hard and durable.

Guaiacum officinale (Fig. 1445), a West Indian tree, supplies the resin called Guaiac, which exudes from it spontaneously and after incisions. The wood is hard, and when fully matured has a greenish black colour. It receives the name of Lignum vitæ, and is remarkable for the crossing of its fibres. The resin (Guaiacine of some) and the wood are stimulant and diaphoretic, and have been employed medicinally in cutaneous and syphilitic affections. G. sanctum has similar properties.

Larrea mexicana is called the Creazote plant.

Melianthus major secretes much saccharine matter in its flowers.

Tribulus terrestris (Fig. 1446) is supposed to be the Tribolos translated Thistles in Matt. vii. 16, and Heb. vi. 8. It grows in dry, barren places in the East. It is a prickly plant, which runs along the surface of the ground.

Zygophyllum Fabago, Bean-caper, is so called on account of its flower-buds being used as substitutes for Capers.

1222. Nat. Ord. 63.—Rutaceæ, the Rue order (Figs. 1447 to 1449). — Herbs, shrubs, and trees, with exstipulate dotted leaves

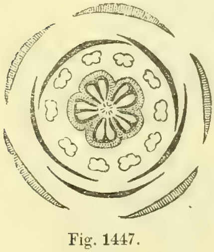

Fig. 1447.

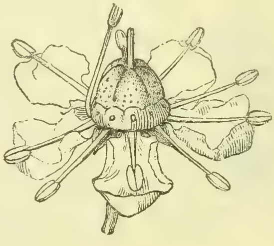

Fig. 1448.

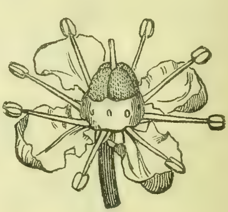

Fig. 1449.

and perfect flowers (Fig. 668, p. 237). Calyx in 4-5 divisions. Petals 4-5, occasionally 0. Stamens, as many, or twice, or thrice as many, as the petals, placed outside a hypogynous disk. Ovary, sessile

Figures 1447 to 1449 illustrate the natural order Rutaceæ.

Fig. 1447. Diagram of Ruta graveolens, common or garden Rue, showing five divisions of the calyx, five twisted petals, ten stamens in two rows, five divisions of the ovary with two ovules in each. Fig. 1448. Flower of Rue showing the hooded petals, the stamens, the hypogynous punctated disk, and the ovary with its carpels; the flower being pentamerous. Fig. 1449. The same organs shown in a tetramerous flower of Rue.

or stalked (Fig. 421, p. 176), 3-5-lobed; styles united, occasionally separated at the base. Fruit of several carpels, either combined, or more or less distinct, often separating when ripe, and dehiscing by one or both sutures. Seeds, one or two in each carpel; the true Ruteæ (European plants) have albuminous seeds, while the Diosmeæ (from the Cape and New Holland) have exalbuminous seeds. The plants are found in Europe, Cape of Good Hope, New Holland, and America. There are upwards of 400 known species. *Ill. Gen.*—Galipea, Cusparia, Bonplandia, Pilocarpus, Boronia, Correa, Adenandra, Diosma, Barosma, Dictamnus, Ruta, Cneorum.

1223. The order is characterised by its peculiar penetrating odour. The plants are employed medicinally as antispasmodics, tonics, and febrifuges.

Correa alba. Its leaves are used in Australia for tea.

Dictamnus Fraxinella, False Dittany (Fig. 421, p. 176), abounds in volatile oil, so that the atmosphere around it is said, in certain circumstances, to become inflammable.

Diosmas are the Bucku or Buchu plants found at the Cape of Good Hope, which are remarkable for their overpowering and penetrating odour, owing to the presence of a yellowish volatile oil. Diosma, or rather Barosma crenata, serratifolia, and other species, are used medicinally in Catarrhus Vesicæ. Their leaves are antispasmodic and diuretic.

Esenbeckia febrifuga is employed in Brazil as a substitute for Peruvian bark.

Galipea officinalis furnishes a tonic, febrifugal bark called Angostura. A similar bark is furnished by G. Cusparia (Bonplandia trifoliata). It is probable that the Melambo bark is the produce of another species.

Ruta graveolens, common Rue (Fig. 668, p. 237), has antispasmodic, anthelmintic, and emmenagogue properties. Its leaves and unripe fruit are used medicinally. The plant is the Peganon of Scripture mentioned in Luke xi. 42. R. montana is a very acrid Spanish plant, the juice of which is said to cause vesication.

1224. Nat. Ord. 64.—Xanthoxylaceæ, the Prickly-Ash order.—Trees or shrubs, with exstipulate, dotted leaves, resembling the Rutaceæ, and distinguished by their polygamous flowers. They are chiefly found in tropical America. Known species, 110. *Ill. Gen.*—Xanthoxylon, Ptelea, Cyminosma.

1225. They have pungent and aromatic qualities, and have been used medicinally as stimulants, sialagogues, and tonics. They yield a volatile oil, and a bitter principle called Xanthopicrine.

Ptelea has a bitter aromatic fruit, which is used for Hops, and as a pickle.

Xanthoxylons receive in America the name of Prickly Ash, and from their pungency they are often called Peppers. X. caribæum is used as a febrifuge. X. Budrunga has fragrant seeds having the odour of Lemons. The fruit and seeds of X. hastile have been used for intoxicating fish.

1226. Nat. Ord. 65.—Ochnaceæ, the Ochna order.—A small group of undershrubs or trees allied to Rutaceæ, and distinguished by their simple, dotless, stipulate leaves, and their enlarged fleshy gynobase or torus. They are found in the tropical parts of India, Africa, and America. Known species, 90. *Ill. Gen.*—Gomphia, Walkera, Ochna, Godoya, Coriaria?

1227. The order is characterised by bitter, tonic properties. The plants want the aromatic qualities of the Rueworts.

Coriaria. This genus is by some placed in this order; while by others it is made the type of a new order, Coriariaceæ. C. myrtifolia has poisonous properties. Its tricostate leaves (Fig. 275, p. 122) are sometimes mixed with Senna, and have produced narcotic effects. This species, as well as C. ruscifolia, are used for staining black. An infusion of the leaves strikes a dark blue with sulphate of iron. The fruit of some of the Coriarias is edible.

Gomphias are used as bitter tonics, and some of them yield oil.

Ochna hexasperma has an astringent bark.

a b

Fig. 1450.

1228. Nat. Ord. 66. — Simarubaceæ, the Quassia order (Fig. 1450).—Trees or shrubs, with alternate, exstipulate, dotless, usually compound leaves. Calyx in four or five divisions. Petals 4-5, imbricated. Stamens 8-10, arising from the back of hypogynous scales. Ovary 4-5-lobed, stipitate; style simple. Fruit, consisting of 4-5 drupes arranged around a common receptacle. Seeds, one in each drupe, pendulous, anatropal, exalbuminous. Natives chiefly of the tropical parts of India, America, and Africa. Known species about 40 or 50. *Ill. Gen.* — Quassia, Simaba, Simaruba, Castela, Ailanthus, Brucea Picrasma, Spathelia.

1229. Bitterness prevails in this order, the plants being used as tonics.

Brucea antidysenterica has a bitter and astringent bark and wood. Its bark was formerly supposed to be false Angostura, and to have poisonous properties; but this is now shown to be the produce of Strychnos Nux-vomica.

Castela Nicolsoni, Goatbush, is sometimes used as a substitute for Quassia.

Picrasma (Picræna) excelsa, Bitterwood, is a large tree, the wood of which is the common Quassia of the shops. It is bitter and tonic, and is sometimes used as a substitute for hops. An infusion of it poisons flies. It contains a bitter principle called Quassine.

Quassia amara, the true Quassia plant, called Guavito Amargo in Panama (Fig. 1450), is a tall shrub found in Surinam, having pinnate leaves with winged petioles. The wood is not imported into Britain.

Simaba Cedron is a tree of New Grenada, which has long been celebrated as an antidote to snake bites. The seeds, or rather the cotyledons, are used for this purpose.

Simaruba amara, or officinalis. The bark of the root is used as a substitute for Quassia. It is prescribed in cases of diarrhœa and dysentery. Its timber is said to resemble that of the White Pine.

Fig. 1450. Quassia amara, true Quassia plant of Surinam—*a*, showing its impari-pinnate leaves with winged petioles, and racemose flowers; *b*, its stipitate fruit, consisting of five drupes surrounding a common receptacle with a simple style.

1230. Analysis of the Natural Orders of Thalamifloral Exogens, with references to the numbers of the orders in the preceding pages.*

I. Flowers Polyandrous. Stamens more than 20.

1. *Leaves exstipulate* (*without stipules*).
a. Carpels more or less distinct (at least as to the styles), or solitary.
Stamens distinct (not united).
Carpels immersed in a tabular fleshy disk......... Nelumbiaceæ, 11.
Carpels not immersed in a disk.
Embryo in a vitellus..................................... Cabombaceæ, 9.
Embryo not in a vitellus, minute.
Seeds arillate.. Dilleniaceæ, 2.
Seeds exarillate.
Albumen ruminate .... Anonaceæ, 4.
Albumen homogeneous.
Flowers hermaphrodite .... Ranunculaceæ, 1.
Flowers unisexual .... Schizandraceæ, 6.
Stamens monadelphous or polyadelphous .... Hypericaceæ, 41.
b. Carpels wholly combined into a solid pistil, with more placentas than one.
Placentas parietal.
Seeds exalbuminous .... Capparidaceæ, 16.
Seeds albuminous.
Embryo in a vitellus .... Nymphæaceæ, 10.
Embryo not in a vitellus.
Seeds in pulp, sap watery .... Flacourtiaceæ, 18.
Seeds not in pulp, sap milky .... Papaveraceæ, 13.
Placentas in the axis.
Stigma umbrella-like, petaloid .... Sarraceniaceæ, 12.
Stigma simple.
Leaves compound.. Rhizobolaceæ, 49.
Leaves simple.
Petals equal in number to the sepals.
Seeds few.
Stigma nearly sessile, radiating or peltate Guttiferæ, 42.
Stigma on a distinct style, five-lobed Humiriaceæ, 51.
Seeds numerous.
Petals flat .... Marcgraviaceæ, 43.
Petals crumpled .... Cistaceæ, 19.
Petals not equal in number to the sepals Ternströmiaceæ,36.

2. *Leaves stipulate* (*with stipules*).
a. Carpels more or less distinct (at least as to the styles) or solitary.
Carpels indefinite .... Magnoliaceæ, 3.
b. Carpels wholly combined into a solid pistil, with more placentas than one.
Calyx imbricate or twisted in æstivation.
Flowers involucrate .... Chlænaceæ, 35.
Flowers not involucrate.................................. Cistaceæ, 19.

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* This artificial analysis of the Orders of Thalamifloral Exogens is intended to aid the student in finding the order to which a plant belongs. Lindley's analytical method is followed with certain modifications, so as to adapt it to De Candolle's system.—(See Lindley's Vegetable Kingdom, p. 801). Such analyses are necessarily more or less imperfect, on account of the shortness of the characters given.

Calyx valvate in æstivation.
Calyx irregular, enlarged in fruit.................... Dipterocarpaceæ, 34.
Calyx regular, not enlarged.
Stamens monadelphous.
Anthers, one-celled .... Malvaceæ, 30.
Anthers, two-celled.
Stamens columnar, all perfect .... Sterculiaceæ, 31.
Stamens columnar, some sterile......... Byttneriaceæ, 32.
Stamens distinct.. Tiliaceæ, 33.

II. Flowers Oligandrous. Stamens fewer than 20.

1. *Leaves exstipulate.*
a. Carpels more or less distinct, or solitary.
Anthers with recurved valves................................ Berberidaceæ, 8.
Anthers with longitudinal valves.
Albumen abundant, embryo minute.
Flowers unisexual or polygamous.
Seeds numerous .... Lardizabalaceæ, 7.
Seeds solitary or twin................................. Xanthoxylaceæ, 64.
Flowers hermaphrodite.
Embryo in a vitellus.................................... Cabombaceæ, 9.
Embryo not in a vitellus.
Herbs, with homogeneous albumen.
Sepals two.. Fumariaceæ, 14.
Sepals more than two............................ Ranunculaceæ, 1.
Shrubs, with ruminate albumen .... Anonaceæ, 4.
Albumen scanty or 0, embryo large .... Menispermaceæ, 5.
b. Carpels combined into a solid pistil or ovary.
Placentas parietal.
Stamens tetradynamous.. Cruciferæ, 15.
Stamens not tetradynamous.
Large hypogynous disk.
Flowers tetramerous, fruit closed at apex ...... Capparidaceæ, 16.
Flowers not tetramerous, fruit open at apex ... Resedaceæ, 17.
Small hypogynous disk or 0.
Albumen abundant.
Fruit fleshy or with central pulp.................. Flacourtiaceæ, 18.
Fruit without central pulp, juice milky.... .... Papaveraceæ, 13.
Albumen scanty or 0....................................... Frankeniaceæ, 26.
Placentas covering the dissepiments......................... Nymphæaceæ, 10.
Placentas in the axis.
Styles separate to the base.
Calyx valvate.. Vivianiaceæ, 29.
Calyx imbricate.
Petals twisted in æstivation, embryo straight... Linaceæ, 55.
Petals not twisted, embryo curved.................. Caryophyllaceæ, 28.
Styles more or less combined.
Fruit gynobasic.
Stamens arising from scales .... Simarubaceæ, 66.
Stamens not arising from scales.
Styles wholly combined.
Flowers hermaphrodite .... Rutaceæ, 63.
Flowers unisexual or polygamous............ Xanthoxylaceæ, 64.
Styles divided at the apex.
Flowers irregular.

Fruit with elastic recurved valves ...... Balsaminaceæ, 57.
Fruit without elastic valves .... Tropæolaceæ, 58.
Flowers regular................................. Limnanthaceæ, 59.
Fruit not gynobasic.
Calyx imbricate.
Calycine divisions forming a complete whorl.
Carpels four or more.
Seeds winged.. Cedrelaceæ, 52.
Seeds wingless.
Stamens united into a long tube......... Meliaceæ, 50.
Stamens free, or nearly so.
Leaves dotted .... Aurantiaceæ, 40.
Leaves without dots....................... Brexiaceæ, 61.
Carpels fewer than four.
Seeds comose .... Tamaricaceæ, 25.
Seeds not comose.
Ovules ascending or horizontal........... Pittosporaceæ, 60.
Ovules suspended............................ Cyrillaceæ, 39.
Calycine whorl irregular.
Flowers symmetrical.............................. Guttiferæ, 42.
Flowers unsymmetrical.
Petals with appendages at their base ... Sapindaceæ, 48.
Petals without appendages at their base.
Fruit a samara................................. Aceraceæ, 47.
Fruit not samaroid.
Flowers having a papilionaceous aspect.
Ovary two-celled................................. Polygalaceæ, 22.
Ovary one-celled................................. Krameriaceæ, 23.
Calyx valvate.
Anthers porose.. Tremandraceæ, 24.
Anthers opening by slits.
Calyx enlarging in fruit......................... Olacaceæ, 37.
Calyx continuing small .... Icacinaceæ, 38.

2 *Leaves stipulate.*
a. Carpels distinct or solitary.
Anthers with recurved valves..................................... Berberidaceæ, 8.
b. Carpels wholly combined, with more placentas than one.
Placentas parietal.
Leaves with circinate vernation and glandular hairs Droseraceæ, 21.
Leaves with straight vernation and no glandular hairs Violaceæ, 20.
Placentas in the axis.
Styles distinct to the base.
Calyx imbricated.
Marsh plants, petals small, sessile.................. Elatinaceæ, 27.
Trees or shrubs, petals conspicuous, stalked...... Malpighiaceæ, 45.
Calyx valvate.. Tiliaceæ, 33.
Styles more or less combined.
Fruit gynobasic.
Gynobase fleshy .... Ochnaceæ, 65.
Gynobase dry.
Leaves regularly opposite .... Zygophyllaceæ, 62.
Leaves more or less alternate.
Fruit beaked... .... Geraniaceæ, 54.
Fruit not beaked .... Oxalidaceæ, 56.
Fruit not gynobasic.
Calyx imbricate.

Flowers involucrate .... Chlænaceæ, 35.
Flowers not involucrate.
Stamens three .... Hippocrateaceæ,44.
Stamens more than three.
Calyx glandular.. Malpighiaceæ, 45.
Calyx not glandular.
Embryo curved................................ Sapindaceæ, 48.
Embryo straight.............................. Erythroxylaceæ,46.
Calyx valvate.
Stamens columnar... Sterculiaceæ, 31.
Stamens not columnar.
Stamens opposite to the petals if equal to them in number.................................... Vitaceæ, 53.
Stamens alternate with the petals if equal to them in number.................................. Tiliaceæ, 33.

Apetalous species occur in the following Thalamifloral orders:—Ranunculaceæ, Menispermaceæ, Papaveraceæ, Flacourtiaceæ, Caryophyllaceæ, Sterculiaceæ, Byttneriaceæ, Tiliaceæ, Malpighiaceæ, Geraniaceæ, Rutaceæ, Xanthoxylaceæ. Some species belonging to the orders Anonaceæ and Rutaceæ are Gamopetalous.

SUB-CLASS 2.—CALYCIFLORÆ.

1. POLYPETALÆ, OR DIALYPETALÆ.

1231. Nat. Ord. 67.—Stackhousiaceæ, the Stackhousia order.—Herbs, occasionally shrubs, with simple, alternate, stipulate leaves. Calyx five-cleft, tube inflated. Petals five, arising from the top of the calycine tube, claws united. Stamens five, distinct, perigynous. Styles 3-5. Fruit of 3-5 monospermal, indehiscent carpels, with a central column. Seed anatropal, albuminous. The order contains a few New Holland plants. Known species 10. *Ill. Gen.*—Stackhousia.

1232. Nat. Ord. 68.—Celastraceæ, the Spindle-tree order.—Shrubs or trees, with alternate, rarely opposite, simple, stipulate leaves. Sepals and petals 4-5, imbricate. Stamens 4-5, inserted on a large disk which surrounds the ovary. Fruit superior, 2-5-celled, capsular or drupaceous. Seeds usually arillate, albuminous, with a large straight embryo. Chiefly natives of the warm parts of Europe, North America, and Asia; also of the Cape of Good Hope. Known species about 270. *Ill. Gen.*—Euonymus, Catha, Celastrus, Elæodendron.

1233. The order is more or less acrid, and some of the plants yield oil.

Catha edulis is the Kat or Khât of the Arabs, the leaves of which are stimulant. Celastrus receives the name of False Bitter-sweet. C. scandens has a purgative and emetic bark. The plant is called Virginian Wax-work in America. C. venenatus is very spiny. C. paniculatus has stimulant seeds.

Elæodendron. The species of this genus have drupaceous fruit, which is sometimes edible.

Euonymus europæus, the common Spindle-tree, has a beautiful scarlet arillode (Fig. 901, p. 299). The charred wood is used in France for cannon gunpowder, and the charred young shoots are employed in drawing. E. tingens has a yellow inner bark, which is used as a dye. E. atro-purpureus and E. americanus (sometimes called Strawberry-tree) have crimson capsules, and bright scarlet arillodes. The name Burning-bush is given to Euonymus in America.

1234. Nat. Ord. 69.—Staphyleaceæ, the Bladder-nut order.—Shrubs allied to Spindle-trees, and distinguished by their compound leaves, with stipules and stipels, more or less separate carpels, and a bony spermoderm. Some consider them as having hypogynous stamens, and place them near Sapindaceæ. They are scattered over the globe. They receive the name of Bladder-nut from the membranous inflated fruit of some species, such as Staphylea pinnata. Their bark is often bitter, while their seeds are oily and acrid. Known species 14. *Ill. Gen.*—Staphylea.

1235. Nat. Ord. 70.—Rhamnaceæ, the Buckthorn order (Fig. 1451).—Shrubs or trees, often spinose, with simple, alternate leaves, and small flowers. Calyx 4-5-cleft, valvate. Petals 4-5, cucullate or convolute, inserted on the throat of the calyx, sometimes 0. Stamens 4-5, opposite the petals. Ovary sometimes adherent to the calycine tube, immersed in a fleshy disk; ovules solitary. Fruit a capsule, berry, or drupe. Seeds erect, albuminous, not arillate. Generally distributed. Known species 250. *Ill. Gen.*—Paliurus, Zizyphus, Hovenia, Rhamnus, Ceanothus, Phylica, Pomaderris, Gouania.

Fig. 1451.

1236. The properties of the order are generally acrid and purgative. Some are bitter, tonic, and astringent; others yield dyes. The fruit of some is edible.

Ceanothus americanus. An infusion of the twigs is prescribed as an astringent, and the leaves are used for tea under the name of New Jersey tea.

Hovenia dulcis is remarkable for the enlargement of its peduncles, which become succulent, and are used as a fruit in China.

Rhamnus, Buckthorn, is the type of the order. R. catharticus yields a cathartic

Fig. 1451. Paliurus aculeatus or Zizyphus Paliurus, a thorny Rhamnaceous plant, supposed to be the Hebrew Shamir, translated Briars in many passages in Isaiah.

fruit. The syrup of Buckthorn, and the dye called sap-green or bladder-green, are prepared from it. The fruit of R. infectorius, R. saxatilis, and R. amygdalinus, constitute the French berries of the shops, which, in their unripe state, are used for a yellow dye.

Sageretia theezans is used for tea by the poor in China.

Zizyphus (Fig. 150, p. 63). The species of this genus supply eatable fruit in general. Jujube paste is prepared from the fruit of Z. Jujuba and vulgaris. Z. Lotus is the Lote-bush, the fruit of which is used by the Arabs. It gave its name to the ancient Lotophagi. The Hebrew Naazuz or Naatzutz, translated Thorn (Is. vii. 19, and lv. 13), perhaps refers to a species of Zizyphus. Royle conjectures that it may mean an Acacia.

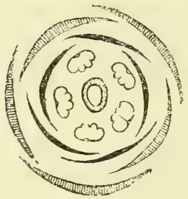

Fig. 1452.

Fig. 1454.

Fig. 1453.

1237. Nat. Ord. 71.—Anacardiaceæ, the Cashew order (Figs.

Figures 1452 to 1455 illustrate the natural order Anacardiaceæ.

Fig. 1452. Diagram of the flower of Rhus, showing five divisions of the calyx, five imbricate petals, five alternating stamens, a one-celled ovary, with a solitary ovule. Fig. 1453. Branch of Rhus Cotinus bearing cymose clusters of small flowers, and alternate, simple, exstipulate leaves. Fig. 1454. Branch of Rhus Cotinus, the Wig-tree, bearing hairs in place of flowers. Fig. 1455. Pistacia Terebinthus, the Terebinth tree, a native of the southern part of Europe and north of Africa. It yields the liquid resinous exudation called Chian Turpentine. It is supposed to be the Hebrew Alah, translated tree in Gen. xviii. 4. It is also translated oak, teil-tree, elm, and even plain (Gen. xiii. 18).

1452-1455).—Trees or shrubs, with alternate, exstipulate, dotless leaves, and small, sometimes unisexual, flowers (Fig. 1453). Sepals 3-5, united. Petals 3-5, imbricate. Stamens equal in number to the petals, and alternate with them, or twice as many or more, perigynous or attached to a disk. Ovary one-celled; styles and stigmas usually three; ovule solitary, with a long curved cord attached to a basal placenta. Fruit indehiscent, a nut or drupe. Seed exalbuminous; embryo curved. The order forms a part of the Terebinthaceæ of Jussieu. Chiefly found in tropical America, Africa, and India. Known species about 100. *Ill. Gen.* — Pistacia, Schinus, Duvaua, Melanococca, Rhus, Melanorrhœa, Stagmaria, Mangifera, Anacardium, Semecarpus, Spondias.

Fig. 1455.

1238. The plants abound in a resinous, or milky, acrid, and poisonous juice, which often becomes black in drying. The fruit, however, in some cases is eatable.

Anacardium occidentale, the Cashew-nut, has a fleshy edible peduncle supporting a nut, the kernel of which can be eaten, while the pericarp is acrid. The bark yields gum. The fruit of A. orientale is said to produce cerebral effects.

Mangifera indica produces the Mango, a highly valued tropical drupaceous fruit. The choicest kind of Mango in the East Indies is called Muldah. There are many varieties in the West Indies. Nos. 11 and 32 (being numbered so in the St. Andrews Botanical Garden, Jamaica) are among the best; the former being green-coloured, the latter yellow.

Melanorrhœa usitatissima is the source of the varnish of Martaban.

Pistacia Lentiscus and atlantica yield the resin called mastich. The former species abounds in the island of Chios, whence mastich is imported. P. Terebinthus, the Terebinth-tree (Fig. 1455) is the source of Chian turpentine. P. vera produces the Pistacia or Pistachio nut, with its green-coloured oily kernels. The Hebrew Botnim, translated nuts (Gen. xliii. 11), seem to refer to the Pistachio nuts. P. Khinjuk and P. cabulica of Stocks, yield a resin which is used for mastich in Scinde.

Rhus, the Sumach, (Fig. 1453) supplies many poisonous species, the juice of which is acrid, and causes erysipelas. R. Toxicodendron, the Poison-oak or Poison-ivy, has been used as a remedy in paralysis. R. venenata is the poison Sumach, or Poison-elder. R. typhina, R. glabra, and R. coriaria, have acid fruits and astringent barks used for tanning. R. Cotinus, Venetian Sumach, (Fig. 1453) often produces hairs in place of flower-stalks (Fig. 1454) and is called the Wig-tree. Its wood is called young fustic. R. Metopium furnishes the hog-gum of

Jamaica. Crystalline wax, or insect wax of China, Pe-la of the Chinese, is procured from Rhus succedaneum by the instrumentality of an insect of the Cicada family.

Sabia, a genus doubtfully referred to this order, is said to be allied to Menispermaceæ, and probably forms the type of a new order, Sabiaceæ.

Schinus Molle, and other plants of the order, have leaves full of resin, which is expelled with force when they are thrown into water, and the recoil gives rise to a movement of the leaf.

Semecarpus Anacardium, the marking Nut-tree, supplies the black varnish of Sylhet.

Spondias. Several of the species, as S. purpurea and S. Mombin have eatable fruit called Hog-plums.

Stagmaria verniciflua, a plant of the Indian Archipelago, supplies the acrid resin called Japan Lacquer.

1239. Nat. Ord. 72.—Amyridaceæ, the Myrrh order (Figs. 1456 and 1457).—Trees or shrubs, with alternate or opposite, compound,

Fig. 1456.

Fig. 1457.

occasionally stipulate and dotted leaves. Calyx 2-5-divided. Petals 3-5, valvate. Stamens twice as many as the petals. Ovary 1-5-celled, surrounded by an annular disk; ovules in pairs; placenta apicilar. Fruit 1-5-celled, hard and dry; exocarp splitting into valves. Seeds anatropal, exalbuminous. Some consider the order as allied to Aurantiaceæ. Natives of tropical India, Africa, and America.

Figures 1456 and 1457 illustrate the natural order Amyridaceæ.

Fig. 1456. Balsamodendron Myrrha, supposed to yield Myrrh, the Hebrew Mor (Exod. xxx. 23; Esth. ii. 12; Psalm xlv. 8; Cant. iv. 6, v. 5, 13); and the Murra or Smurna of the Greek (Matt. ii. 11; Mark xv. 23; John xix. 39). The plant has spiny branches and alternate compound leaves. Fig. 1457. Plants supposed to be the Basam, Baal-Shemen, or Balsam-trees of Scripture. They have alternate, ternate, *a*, or unequally pinnate leaves, *b*. The Hebrew Basam is translated spices in Exod. xxxv. 28; 1 Kings x. 10; Cant. v. 1, 13, vi. 2.

Known species about 50. *Ill. Gen.*—Boswellia, Protium, Balsamodendron, Elaphrium, Bursera, Icica, Canarium, Amyris.

1240. The order abounds in balsamic resin. Some of the plants are bitter, others poisonous.

Amyris hexandra and A. Plumieri are two of the sources whence Elemi is procured. A. toxifera is poisonous. Some species yield a bark which is used for paper.

Balsamodendron, Balsam-tree. This genus seems to furnish important products. B. Myrrha (Fig. 1456), or an allied species, appears to be the source of the Hebrew Mor, or the Myrrh of commerce, which is an aromatic, bitter gum-resin, containing volatile oil. The Balsam-tree, the Hebrew Basam or Baal-Shemen, translated spices in many parts of the Bible, seems to be a species of Balsamodendron (Fig. 1457). It must not be confounded with the Balm and Balm of Gilead of Scripture, the Tzeri of the Hebrew, the source of which is unknown. B. Mukul and B. pubescens produce the resin called Bdellium.

Boswellia thurifera (serrata) and B. glabra supply Olibanum, which seems to be the Hebrew Lebonah, and Greek Libanos, translated Incense or Frankincense in the Bible. The bark of B. papyrifera, an Abyssinian tree, separates in thin white layers like the Birch.

Elaphrium tomentosum supplies one of the resins called Tacamahac. E. elemiferum yields Mexican Elemi.

Icica. Several species of this genus yield balsamic resins and incense-wood. I. Icicariba supplies Brazilian Elemi. I. altissima produces the Cedar-wood of Guiana, used for making canoes.

1241. Nat. Ord. 73.—Connaraceæ, the Connarus order.—Trees or shrubs with alternate, compound, dotless, and usually exstipulate leaves. Calyx 5-parted, imbricate. Petals 5, usually imbricate. Stamens 10, perigynous or hypogynous, opposite the petals, usually united. Carpels one or more; style terminal; ovules 2, orthotropal. Fruit follicular. Seeds with or without albumen, often arillate. Tropical American plants. The aril of some Omphalobiums is eaten, and Zebra-wood is furnished by O. Lamberti. Known species 41. *Ill. Gen.*—Connarus, Omphalobium, Cnestis.

1242. Nat. Ord. 74.—Leguminosæ or Fabaceæ, the Leguminous order (Figs. 1458 to 1467).—Herbs, shrubs, or trees, with alternate,

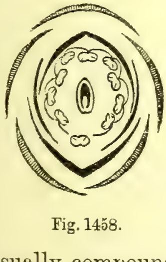

Fig. 1458.

Fig. 1459.

Fig. 1461.

Fig. 1463.

usually compound, stipulate leaves (Fig. 297, p. 128). Calyx 5-divided (Fig. 1461), hypogynous, odd segment inferior (anterior). Petals

Figures 1458 to 1467 illustrate the natural order Leguminosæ.

Fig. 1458. Diagram of the papilionaceous flower of Lathyrus, showing five divisions of the calyx with the odd segment anterior, five irregular petals, consisting of vexillum, two alæ and carinæ, the odd petal being posterior, ten stamens, diadelphous, and a one-celled ovary, which becomes the legume in

usually five, sometimes one or more abortive, papilionaceous or regular (Figs. 1459 and 1466, and Fig. 452, p. 187), odd petal (if any)

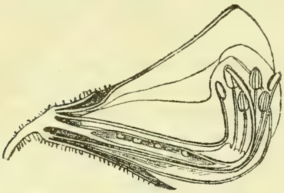

Fig. 1460.

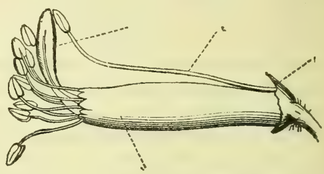

Fig. 1462.

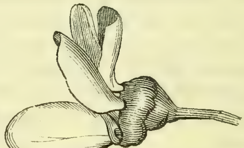

Fig. 1466.

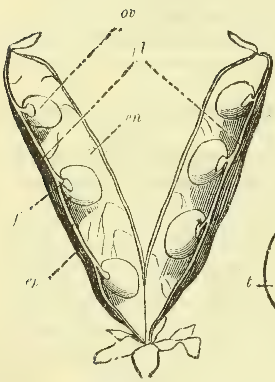

Fig. 1464.

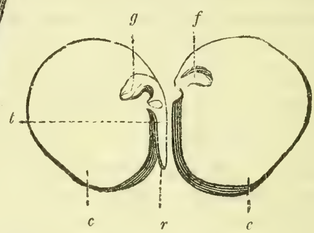

Fig. 1465.

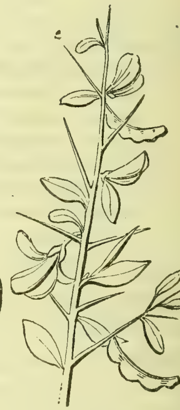

Fig. 1467.

superior (posterior). Stamens definite or indefinite, perigynous, rarely hypogynous, distinct or united in one or more bundles (Figs. 1460, 1462). Ovary superior, one-celled, one or many-seeded, sometimes consisting of one carpel (Fig. 1463), sometimes of two or five. Style and stigma simple (Fig. 1463). Fruit a legume (Fig. 1464) or

fruit. Fig. 1459. Papilionaceous flower. Fig. 1460. Section of the flower of Lathyrus, showing the essential organs enclosed in the carina, and the vexillum above. Fig. 1461. Calyx of Lathyrus, showing five segments, with the odd one inferior or anterior. Fig. 1462. Essential organs of Lathyrus, showing nine stamens, united by filaments and one separate (diadelphous), and the pistil with its curved style in the centre. Fig. 1463. Pistil of Broom, composed of one carpel, with the coiled style, arising from the upper or ventral suture. Fig. 1464. Legume of Pea, showing dorsal and ventral suture with the ovules, *ov*, attached to the latter, *pl*, by cords, *f*; the wall of the carpel formed of three layers, *ep*, epicarp, and *en*, endocarp, with the mesocarp between them. Fig. 1465. Exalbuminous embryo of the Pea, showing two fleshy hypogeal cotyledons, *cc* (sarcolobæ), radicle, *r*, plumule, *g*, raised from a depression, *f*, and tigellus, *t*. Fig. 1466. Flower of Cercis Siliquastrum, Judas-tree, showing the vexillum or upper petal interior, as in sub-order-Cæsalpinieæ. Fig. 1467. Alhagi Maurorum, a kind of Camel's Thorn, a thorny plant, extending from the North of India to Syria, which exudes a sweetish juice. This concretes in small granular masses, which constitute Persian Manna. The plant is one of those supposed to have yielded the Manna of Scripture—Exod. xvi.; Numb. xi.

For farther illustrations of the order, see Ononis spinosa, Fig. 149, p. 62. Pinnated and stipulate leaves, Figs. 294 and 296, p. 127; Fig. 299, p. 128; and Fig. 300, p. 129. Genista monosperma, the Hebrew Rothem, Fig. 533, p. 206. Parts of papilionaceous flower, Figs. 535, 536, and 537, p. 207. Pistil of Lathyrus, Fig. 689, p. 243. Legumes of various kinds, Fig. 818, p. 276; Figs. 819-823, p. 277.

a drupe.* Seeds with or without albumen; embryo with large cotyledons (Fig. 1465). The order is a very extensive one, and the plants belonging to it are found in all parts of the world. They are most abundant in warm regions, and diminish on approaching the poles. Known species 6500.

1243. Leguminous plants have been divided into three sub-orders. —Sub-order 1. Papilionaceæ, petals papilionaceous, imbricate, upper one exterior (Figs. 1458 and 1459, and Fig. 476, p. 194). *Ill. Gen.*—Podalyria, Piptanthus, Chorozema, Pultenæa, Mirbelia, Liparia, Hovea, Borbonia, Crotalaria, Lotononis, Cytisus, Trifolium, Indigofera, Psoralea, Galega, Brongniartia, Astragalus, Vicia, Arachis, Coronilla, Hedysarum, Clitoria, Kennedya, Glycine, Dioclea, Erythrina, Phaseolus, Cajanus, Rhynchosia, Abrus, Dalbergia, Sophora.—Sub-order 2. Cæsalpinieæ, petals imbricated, upper one interior (Fig. 1466). *Ill. Gen.*—Leptolobium, Cæsalpinia, Cassia, Swartzia, Amherstia, Bauhinia, Cynometra, Dimorphandra.—Sub-order 3. Mimoseæ (Fig. 76, p. 33), petals valvate in æstivation. *Ill. Gen.*—Parkia, Mimosa, Acacia.

1244. The properties of the order are very various. Some are nutritious, others tonic and astringent, others purgative, and some poisonous. The plants supply timber, fibres, gums, dyes, and various other economical articles.

Sub-order 1. PAPILIONACEÆ, Pulse Section.—Among the plants of this sub-order may be noticed, Beans, Peas, Lentils, Kidney-beans, and Pulse of various kinds, Lupins, Clover, Lucerne, Medick, Saintfoin, Liquorice, Tragacanth, Indigo, Kino. The greater number are more or less nutritious or wholesome. There are, however, some poisonous plants, as Coronilla varia, some Gompholobiums, seeds and bark of Laburnum, seeds of Lathyrus Cicera, and L. Aphaca, roots of Phaseolus multiflorus (the Scarlet-runner), and of P. radiatus, bark of the root of Piscidia erythrina (Jamaica Dogwood), branches and leaves of Tephrosia toxicaria, and the seed of an unknown species used in Calabar for trials by ordeal. Some of the plants, as Desmodium gyrans (Fig. 311, p. 133), display remarkable irritability in their leaves (p. 493). Many have very showy flowers, which render them favourites in cultivation.

Æschynomene. A species of this genus, Æ. paludosa, supplies Indian Rice-paper, the Shola of India.

Alhagi Maurorum (Fig. 1467), Camels-thorn, is said to yield a kind of manna.

Andira inermis, Cabbage-tree. The bark is anthelmintic.

Arachis hypogæa, Ground-nut, produces a subterranean legume. Its seeds yield an oil called in India Katchung-oil. It is used for burning, and for dressing cloth.

Astragalus gummifer, verus, and other species, furnish Gum Tragacanth.

Baptisia tinctoria, the Wild Indigo of America, is used as a dye.

Butea frondosa, the Dhak-tree or Pulas of India, yields a kind of Kino. This plant in full flower is said to be a gorgeous sight. The mass of inflorescence, Dr. Hooker says, resembles sheets of flame. The bright orange-red petals contrast brilliantly with the jet-black velvety calyx.

Colutea arborescens, Bladder-Senna, is so called from its inflated legumes (Fig. 824, p. 278), and from being used as a substitute for the obovate Senna (Fig. 274, p. 122.)

Crotalaria juncea produces a fibrous bark, whence Sun or Bengal Hemp is prepared.

Cytisus (Sarothamnus) scoparius, the common Broom, acts as a diuretic.

Dalbergia Sissoo is a valuable timber-tree of India. The wood is called Sissoo and Sheeshum by the natives.

* See description of various kinds of legumes, pages 276, 277, and 278, also transformations of the pistil of Leguminous plants, p. 257.

Dipterix odorata has fragrant seeds called Tonka-beans. D. oleifera yields a fragrant seed called the Eboe-nut on the Mosquito shore.

Ervum Lens, Lentil (Fig. 251, p. 115), the Hebrew Adashim, when boiled forms a pottage of a red or chocolate colour, much valued in Egypt and Western Asia.

Geoffroya superba yields a drupaceous fruit, which is used by the Brazilians on the banks of the Rio San Francisco.

Glycyrrhiza glabra supplies Liquorice-root. Other species have similar roots, which owe their sweetness to the presence of Glycion.

Indigofera tinctoria, and I. cærulea, supply the Indigo of commerce. The peltate hairs of this genus separate it from Tephrosia.

Mavia judicialis of Bertoloni, is the Mavi of the Caffres, and yields a poisonous bark used by them as a test in judicial trials.

Mucuna pruriens and prurita, Cowitch, have legumes covered with irritating hairs, which are used mixed with syrup as a vermifuge. M. urens and M. altissima yield a black dye.

Myrospermum peruiferum of Sonsonate yields the Balsam of Peru, or St. Salvador Black Balsam, which is procured by incisions in the trunk. The fruit yields the white balsam of Sonsonate, which contains a crystalline substance called Myroxocarpine. Myrospermum toluiferum yields the Balsam of Tolu.

Pterocarpus Marsupium, an Indian tree, is the source of Malabar Kino. P. erinaceus yields a similar concrete exudation. P. Dalbergioides, and P. indicus, yield a kind of Kino in Maulmain. P. santalinus furnishes the dye called Red Sandal-wood. P. Draco yields Gum-Dragon.

Pueraria tuberosa. The tubers are collected and used for their cooling properties.

Soja hispida. The pods are used in the sauce called Soy.

Triptolomea. Several species of this genus are said to yield the Rose-wood of commerce.

Sub-order 2. Cæsalpinieæ, Senna Section.—This sub-order is characterized chiefly by purgative and by dyeing properties. Among the important plants are Senna, Tamarind, Logwood, Sappan-wood, and Camwood.

Baphia nitida yields a dye-wood called Barwood or Camwood.

Bauhinia Vahlii. The fibres of its bark are used for ropes in Kumaon.

Cæsalpinia Sappan furnishes the Sappan, Wukkum, or Bukkum-wood of Scinde, which is used as a dye. C. echinata and other species supply the Pernambuco-wood of commerce, C. brasiliensis, the Brazil-wood. Divi-divi or Libi-dibi is the twisted legumes of C. coriaria; they are astringent, and are used in tanning. The legumes of C. Papai, under the name of Pi-pi, are also mixed with those of the last mentioned species.

Cassia. The species of this genus furnish the various kinds of Senna. Alexandrian Senna contains leaves of Cassia acutifolia (Fig. 255, p. 116), and C. obovata (Fig. 253, p. 115.) Bombay or Mecca Senna is the produce of Cassia lanceolata (Fig. 252, p. 115); Tinnevelly Senna, of Cassia elongata, and C. lanceolata; Tripoli Senna, of C. æthiopica; and Aleppo Senna, of C. obovata. C. Fistula (Cathartocarpus Fistula), has an indehiscent legume, multicellular by spurious septa, and containing pulp which is secreted by the inner lining (Fig. 705, p. 247). Cassia Chamæcrista is the Sensitive Pea, or the Partridge Pea of America. Along with some other species it shows irritability in the leaves.

Ceratonia Siliqua (Fig. 771, p. 265), the Algaroba-bean or Carob-tree, has an edible legume, which is used as food for horses. Some call it St. John's Bread, from its supposed use by the Apostle in the Wilderness, under the name of Locust. It is called in Syria the Husk-tree, and its legumes are given to pigs. The fruit appears to be the Keratim or husks mentioned by St. Luke (See note, p. 265).

Copaifera. Various species yield the West Indian and Brazilian Balsam of Copaiva, which consists of a resin and oil, and is used in inflammations of the mucous membranes. C. bracteata and pubiflora furnish the Purple-Heart or Purple-Wood of Guiana, used for making musket ramrods.

Hæmatoxylon campechianum, the Logwood-tree, is used as a dye, and as an astringent in diarrhœa. The stem has often an irregularly fluted appearance.

Hymenæa Courbaril, West Indian Locust-tree, attains an enormous size, and supplies one kind of Anime resin. Its bark is vermifuge. Its wood, under the name of Locust-wood, is used by ship-carpenters. Its colour is light-yellow.

Mora excelsa is a large timber tree of Guiana, from 90 to 100 feet in height.

Poinciana pulcherrima. The bark and root are used in Mexico as a remedy in Lepra and other cutaneous diseases.

Tamarindus indica, the Tamarind-tree, contains in its pod a laxative pulp, which is a secretion from the endocarp.

Sub-order 3. MIMOSEÆ, Gum Arabic Section.—In this sub-order gummy and astringent matters prevail.

Acacia. Various species, such as A. Ehrenbergii, tortilis, vera, and arabica, yield Gum Arabic and Gum Senegal. The Wattles of Australia are species with astringent barks. A. dealbata is used for tanning. A. formosa supplies the valuable Cuba-timber called Sabicu, which was used in forming the stairs of the Crystal Palace in Hyde Park. A. Catechu furnishes a kind of Catechu or Cutch in the East Indies. The pods of A. nilotica, under the name of Neb-neb, are used by tanners. A. varians is said to have poisonous qualities. A. Seyal is the Shittah-tree or Shittim-wood of the Bible (Fig. 76, p. 33, see note). The Babul or Babool wood, used for tanning in Scinde, is got from A. arabica. Phyllodia (Fig. 319, p. 136), are found in many of the Australian Acacias.

Entada scandens. The seeds are often wafted from the West Indies to the Outer Hebrides, and to the shores of Ireland.

Mimosa pudica (Fig. 312, p. 133), and sensitiva, display remarkable irritability in their leaves (p. 493).

1245. Nat. Ord. 75.—MORINGACEÆ, the Moringa order.— This order is considered as allied to Leguminosæ, the plants differing chiefly in their petaloid sepals, stamens arising from a perigynous disk, a pod-like capsular fruit with three valves, three parietal placentas, and loculicidal dehiscence, with the seeds buried in the substance of the valves. Lindley thinks that the parietal placentation, and other characters, places the order near Violaceæ, although differing in its perigynous stamens. Trees with pinnate or tripinnate leaves, found in the East Indies and in Arabia. Known species 4. *Ill. Gen.*—Moringa.

1246. The properties of the order are usually stimulant and pungent. Some species yield a fragrant oil.

Moringa pterygosperma, Horse-radish tree, has winged seeds, beautifully arranged in the pod, the body of the seed being in the spongy valves, and the wings spreading out in three directions. The root has the taste of Horse-radish, and has been used as a stimulant and rubefacient. The bark of the tree yields gum, and its seeds are called Ben-nuts, supplying Ben-oil, used by perfumers and watchmakers.

1247. Nat. Ord. 76.—ROSACEÆ, the Rose order (Figs. 1468 to 1478).—Trees, shrubs, or herbs, with alternate, usually stipulate leaves (Fig. 1470), and regular, rarely unisexual, flowers. Calyx 4-5-lobed, sometimes calyculate, fifth lobe posterior. Petals 5 (Fig. 1471), rarely 0. Stamens definite or indefinite. Disk lining the tube of the calyx (Fig. 1472), or surrounding its orifice. Ovaries solitary or several, one-celled (Fig. 1472), with one or few anatropal ovules.

Styles lateral (Fig. 1473), or terminal. Fruit achenes (Fig. 1472), drupes (Fig. 1474) or acini, follicles (Fig. 1475), or pomes (Fig. 1478).

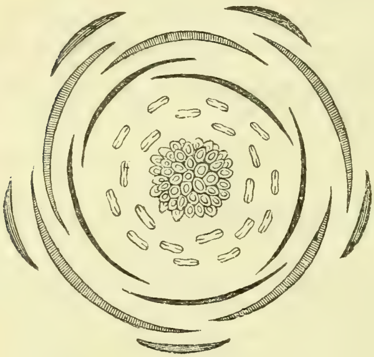

Fig. 1468.

Fig. 1470.

Fig. 1472.

Fig. 1471.

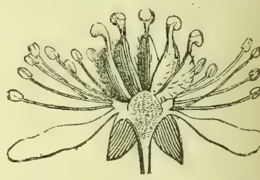

Fig. 1475.

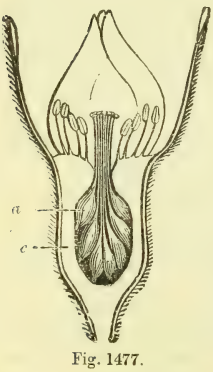

Fig. 1477.

Fig. 1473.

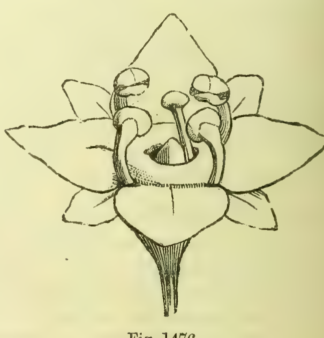

Fig. 1476.

Seeds one or more, exalbuminous, with a straight embryo having flat

Figures 1468 to 1478 illustrate the natural order Rosaceæ.

Fig. 1468. Diagram of the flower of the Strawberry, showing five outer calycine segments (epicalyx) five inner segments, odd one superior, five petals, numerous stamens and carpels. Fig. 1469. Diagram of the flower of the Rose, showing five divisions of the calyx, the odd one being superior (posterior) five petals, odd one inferior, numerous stamens and carpels. Fig. 1470. Branch of Rose, showing compound leaves and adnate stipules. Fig. 1471. Flower of Strawberry, showing five divisions of calyx, five petals, the odd one inferior. Fig. 1472. Flower of the Strawberry cut vertically, showing calyx, petals, stamens attached to the calyx, numerous one-seeded carpels on an elevated receptacle.

cotyledons (Fig. 1474). This order is generally distributed over the globe, but the species are most abundant in temperate climates, where

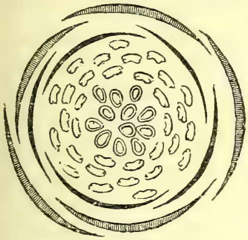

Fig. 1469.

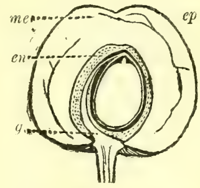

Fig. 1474.

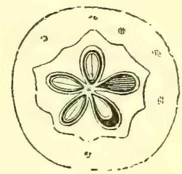

Fig. 1478.

they supply many important fruits. The known species amount to about 985.

1248. The following are the divisions of the order:—Sub-order 1. Chrysobalaneæ, trees or shrubs, carpel solitary, cohering more or less to one side of the calyx, ovules two, erect, style basilar, fruit a drupe, stipules not united to the petiole. *Ill. Gen.*—Chrysobalanus. Sub-order 2. Amygdaleæ, or Drupiferæ, trees or shrubs, with a deciduous calyx-tube, carpel solitary, free, style terminal, fruit a drupe (Fig. 852, p. 285), stipules not united to the petiole. *Ill. Gen.*—Amygdalus, Prunus, Cerasus. Sub-order 3. Roseæ, herbs and shrubs, carpels not adhering to the tube of the calyx, styles terminal or lateral, fruit achenes or follicles, stipules united to the petiole. Under this sub-order there are four tribes:—Tribe 1. Spiræidæ, fruit a whorl of follicles, not enclosed within the calycine tube (Fig. 1475). *Ill. Gen.*—Kerria, Spiræa, Neillia, Gillenia, Brayera. Tribe 2. Potentillidæ (Dryadeæ of some), calyx-tube short or nearly flat, not enclosing the fruit; fruit achenes or drupes (acini), five or more, upon a flat or convex receptacle (Fig. 424, p. 177). *Ill. Gen.*—Rubus, Fragaria, Potentilla, Sibbaldia, Geum, Dryas. Tribe 3. Sanguisorbidæ, achenes 1-2, enclosed within the dry calyx-tube, petals often 0 (Fig. 1476). *Ill. Gen.*—Alchemilla, Sanguisorba, Poterium, Agrimonia. Tribe 4. Rosidæ, achenes numerous, enclosed within the fleshy calycine tube, which is

Fig. 1473. Carpel of Strawberry (achene) with lateral style. Fig. 1474. Drupe of Cherry, with its epicarp, *ep*, fleshy mesocarp, *me*, stony endocarp, *en*, pendulous seed, *g*. Fig. 1475. Section of flower of Spiræa, showing perigynous stamens and follicular fruit. Fig. 1476. Flower of Alchemilla, with a double tetramerous calyx, four stamens, and a basilar style. Fig. 1477. Fruit of the Rose cut vertically, showing the thickened or disk-bearing calyx-tube, *c*, bearing the stamens, and enclosing the achenes, *a*, with their styles, which pass through the contracted throat of the calyx. The limb of the calyx is free above, and the petals are attached to the orifice of the calyx. Fig. 1478. Fruit of the Apple cut transversely, showing five carpels, which are enclosed in a fleshy disk-bearing calyx. The fruit may be considered as composed of carpels adhering by their back to the succulent calyx-tube which encloses them.

Additional Figures illustrating the order Rosaceæ. Leaves, stipules, and inflorescence, Fig. 302, p. 129; Figs. 373, and 375, p. 157; Fig. 613, p. 227; Fig. 395, p. 165. Calyculate calyx of Strawberry, Fig. 507, p. 200. Flowers, fruit, &c. of Drupiferæ, Fig. 683, p. 241; Fig. 612, p. 227; Fig. 770, p. 264. Follicle of Spiræa, Fig. 685, p. 242. Fruit of Rose, Fig. 425, p. 178. Stamen and style of Alchemilla, Fig. 642, p. 233; Fig. 737, p. 252. Monstrosities in Rosaceæ, Figs. 426 and 427, p. 178; Figs. 428, 429, and 430, p. 181.

contracted at the orifice (Fig. 1477). *Ill. Gen.*—Rosa. To these may be added the tribe Quillaieæ, with capsular fruit and winged seeds, as in the genera Quillaia and Lindleya ; and the tribe Neuradeæ, with the calyx adherent to a ring of ten carpels, and a pendulous seed, as in the genus Neurada. Sub-order 3. Pomeæ, trees or shrubs, carpels 1-5, adhering more or less to the tube of the calyx and to each other; fruit a pome (Fig. 1478, and 776, p. 267) ; stipules not united to the petiole. *Ill. Gen.*—Cydonia, Pyrus, Mespilus, Cotoneaster, Cratægus.

1249. Astringent properties are exhibited by the bark and root of most of the plants of the order. Prussic acid occurs in the sub-orders Amygdaleæ and Pomeæ. Many of the plants supply edible fruits.

Sub-order 1. Chrysobalaneæ. — This sub-order is a tropical one, and produces edible, plum-like fruits.

Chrysobalanus Icaco, the Cocoa-plum, is a West Indian stone-fruit. C. luteus yields a similar fruit in Sierra Leone. The bark and leaves of the former have been used as an astringent in diarrhœa.

Sub-order 2. Amygdaleæ, or Drupiferæ.—Hydrocyanic acid is present in the leaves, flowers, and seeds of the plants of this sub-order. Their bark is astringent, and yields gum. The fruit is in many cases edible.

Amygdalus communis, the Almond-tree (Figs. 858 and 859, p. 286), is a native of Asia and Barbary, and is cultivated extensively to the south of Europe. It is the Hebrew Luz and Shaked. There are two varieties,—one producing sweet, and the other bitter almonds. The kernels of the former contain a fixed oil and emulsine, while those of the latter contain in addition a nitrogenous substance called Amygdaline, which, by combination with emulsine, produces a volatile oil and Prussic acid. The hydrocyanated oil of Bitter-almonds is used in the same way as Prussic acid. It sometimes gives rise to Urticaria. A. persica produces the Peach, and a variety yields the Nectarine.

Cerasus serotina, Black Cherry, is a large tree. The wood is used in America for cabinet-making. The bitter tonic and astringent bark, containing hydrocyanic acid, is employed in medicine under the name of Prunus virginiana. But Prunus (Cerasus) virginiana is a shrub with astringent fruit, and is called Choke-Cherry. C. Laurocerasus, Cherry-laurel, or common Bay-laurel, yields a hydrocyanated oil. Cherry-laurel water is employed medicinally as an anodyne and sedative. C. avium is the Wild-cherry, a variety of which is used in the preparation of Kirschenwasser. The kernels of species of Cerasus impart flavour to noyau, ratafia, cherry-brandy, and maraschino.

Prunus communis is the source of the common Plum. Varieties of this species are said to produce the Sloe (Fig. 148, p. 62) and Bullace. P. lusitanica is the Portugal laurel, a well-known evergreen. P. Armeniaca is the Apricot.

Sub-order 3. Roseæ.—The plants in this section are chiefly characterised by astringent and febrifugal properties. They have frequently edible fruits, such as the Strawberry, the Raspberry, and the Bramble or Blackberry.

Brayera anthelmintica, Cusso or Kousso, an Abyssinian plant, is used as a vermifuge.

Potentilla Tormentilla has an astringent root used for tanning. Many other Potentillas (Cinquefoils) have astringent and febrifugal qualities.

Quillaia saponaria is remarkable for its saponaceous bark, which abounds in saponine, and is used for soap.

Rosa canina, Dog-rose, yields an astringent fruit employed in diarrhœa. R. gallica, French or Provins Rose, is used in a similar way. R. centifolia, the common Cabbage-rose, and its varieties R. damascena and R. moschata, yield a fragrant essential oil, called Attar of Roses, which is distilled from the petals. Dr. Hooker states, that 20,000 flowers of Roses (R. damascena) at Ghazepore are required to make a rupee weight of the attar, which sells for £10.

Spiræa Ulmaria, Meadow-sweet, has fragrant flowers, which are said to yield Prussic-acid. From the root of S. Kamtschatica a strong liquor is prepared in Kamtschatka.

Sub-order 4. Pomeæ.—Edible fruits are furnished by this sub-order, and the seeds yield Prussic-acid. Among the fruits are the Apple (Pyrus Malus), Pear (P. communis), Medlar (Mespilus germanica), Quince (Cydonia vulgaris), Loquat (Eriobotrya japonica). The Hawthorn, Service-tree, and Mountain-ash are also included in this sub-order.

1250. Nat. Ord. 77.—Calycanthaceæ, the Calycanthus order.—Shrubs with quadrangular stems, having four woody axes surrounding the central one, opposite, entire, exstipulate leaves, and solitary lurid flowers. Calyx of numerous coloured sepals confounded with the petals, and all united below into a fleshy tube, bearing numerous stamens on its rim. Outer stamens extrorse; inner, sterile. Ovaries several, one-celled, adherent to the calycine tube; ovules one or two. Fruit, achænia enclosed by the calyx. Seed exalbuminous; cotyledons convolute. The plants are found in North America and Japan. Their flowers have an aromatic fragrance, and their bark is sometimes used as a carminative. Calycanthus floridus, Carolina Allspice, furnishes a bark which is sometimes used in place of Cinnamon. There are 6 known species. *Ill. Gen.*—Calycanthus, Chimonanthus.

1251. Nat. Ord. 78.—Lythraceæ, the Loosestrife order.—Herbs, rarely shrubs, often with quadrangular branches, with usually opposite, and entire exstipulate leaves. Among these exalbuminous perigynous orders it is distinguished by its tubular calyx enclosing a 2-6-celled ovary which is free from it, its united styles, membranous capsular fruit, and stamens inserted on the calycine tube below the petals. The plants are chiefly tropical; some are found in Europe and in North America. Species 300. *Ill. Gen.* — Peplis, Ammannia, Lythrum, Cuphea, Lawsonia, Lagerströmia.

Fig. 1479.

1252. Astringency is met with in many plants of the order. Some of them furnish dyes.

Cuphea. In the species of this genus the placenta bursts through the ovary and floral envelopes, and appears as an erect process bearing the young seeds.

Fig. 1479. Lawsonia inermis, the Henna of the Arabs, supposed to be the Hebrew Kopher or Copher, translated Camphire in the Song of Solomon, i. 14, and iv. 13.

Lagerströmia Reginæ has winged seeds, which are said to be narcotic.

Lawsonia inermis (Fig. 1479), is supposed to be the Kopher of the Hebrew, translated Camphire in the Song of Solomon. It is the Henna or Alkanna of Cyprus and Egypt, which is used in the East for dyeing the nails, the palms of the hand, and the soles of the feet, of an iron-rust colour. The plant is also prized for the fragrance of its flowers. It is employed for dyeing morocco leather.

Lythrum Salicaria, Purple Loosestrife, a British plant, found also in New Holland, has been prescribed in diarrhœa.

1253. Nat. Ord. 79.—Rhizophoraceæ, the Mangrove order.—Trees or shrubs, with simple, opposite leaves, having deciduous interpetiolary stipules. Calyx adherent, with 4-12 valvate lobes. Petals 4-12. Stamens twice or thrice as many. Ovary 2-4-celled, with 2 pendulous ovules in each cell. Fruit monospermal, indehiscent, crowned by the calyx. Seed exalbuminous; embryo germinating in the pericarp. The plants grow in the unhealthy maritime swamps of the tropics. Known species 21. *Ill. Gen.*—Rhizophora, Kandelia.

1254. Mangroves have usually astringent barks, employed as febrifuges and for tanning. Some are used for dyeing black.

Rhizophora Mangle, the Mangrove tree (Fig. 123, p. 53), has remarkable aerial roots, which descend into the mud at the mouths of rivers, and raise the stem of the plant upwards. The fruit of the plant is edible. The bark is used for tanning.

1255. Nat. Ord. 80.—Vochysiaceæ, the Vochysia order.—Trees or shrubs, with their young branches often quadrangular, leaves entire, usually opposite and stipulate. Sepals 4-5, upper one spurred. Petals 1-5, unequal. Stamens 1-5. Fruit a triquetrous, 3-celled capsule, with a central placenta. Seeds exalbuminous, usually winged. Found in equinoctial America. Some of the plants are timber trees. Known species upwards of 50. *Ill. Gen.*—Qualea, Vochysia.

1256. Nat Ord. 81.—Combretaceæ, the Myrobalan order.—Trees or shrubs, with alternate or opposite, entire, exstipulate leaves, often apetalous. They are distinguished from the orders near them by their one-celled ovary, containing 2-4 suspended ovules, but only a single seed in the fruit, and convolute cotyledons. Natives of tropical regions. Known species 200. *Ill. Gen.*—Bucida, Terminalia, Getonia, Conocarpus, Combretum, Quisqualis, Gyrocarpus.

1257. The plants of this order have astringent properties. Some species are cultivated for ornament; others yield timber.

Combretum alternifolium. From the bark of this plant a gummy matter exudes.

Terminalia belerica yields a fruit known by the name of Myrobalan. T. Chebula produces a similar fruit. Both are used as astringents. T. Catappa has edible seeds. T. alata has an astringent and febrifugal bark. T. Benzoin has a milky juice which, when dried, is used as incense.

1258. Nat. Ord. 82.—Melastomaceæ, the Melastoma order.—Trees, shrubs, or herbs, with opposite, ribbed leaves, and showy flowers. The anthers are long, rostrate, and bent down parallel to the filaments in æstivation, lying in spaces between the calyx and ovary. The plants differ from Lythraceæ in the calyx-lobes not being valvate, and from Myrtaceæ in the leaves not being dotted. Memecylon has sometimes been made the type of a separate order on account of its adherent calyx, ribless leaves, and convolute cotyledons. The plants are chiefly tropical. Known species about 2000. *Ill. Gen.*—Centradenia, Lasiandra, Melastoma, Osbeckia, Rhexia, Medinilla, Sonerila, Miconia, Clidemia, Memecylon, Mouriria.

1259. The plants of this order possess a slight degree of astringency. Some yield dyes, others edible fruits. None are poisonous.

Melastoma. The succulent fruit of many of this species is eaten, and the generic name implies that it dyes the mouth of a black colour. M. malabathrica has been employed medicinally in diarrhœa.

Mouriria Puse produces an edible fruit the size of a small Plum.

1260. Nat. Ord. 83.—ALANGIACEÆ, the Alangium order.—Trees or shrubs, with branches often spiny, leaves entire, alternate, exstipulate, and without dots. Calyx adherent, 5-10-toothed. Petals 5-10, linear, reflexed. Stamens equal in number to the petals, or two or four times as many; filaments villous at the base; anthers adnate, linear. Fruit a drupe adherent to the calyx. Seed anatropal, pendulous, albuminous; cotyledons flat. Natives of India and North America. Many of the plants supply timber; others have edible fruits. Some are aromatic. Known species 8. *Ill. Gen.*—Alangium, Marlea, Nyssa.

1261. Nat. Ord. 84.—PHILADELPHACEÆ, the Syringa order.—Shrubs, with opposite, deciduous, exstipulate, dotless leaves. Calyx adherent, 4-10-lobed, valvate. Petals alternate with the calycine segments. Stamens indefinite. Styles distinct or united. Fruit a half-inferior 4-10-celled capsule, with an axile placenta. Seeds albuminous. The species are scattered over Europe, North America, and India. The flowers of Philadelphus coronarius, common garden Syringa, have an overpowering odour, and yield an oil. It is called Mock Orange in America. The leaves of the plant taste like Cucumbers. The leaves of the species of Deutzia, especially D. scabra, are covered with beautiful star-like hairs or scales. The known species of the order amount to 25. *Ill. Gen.*—Philadelphus, Decumaria, Deutzia.

1262. Nat. Ord. 85.—MYRTACEÆ, the Myrtle order (Figs. 1480

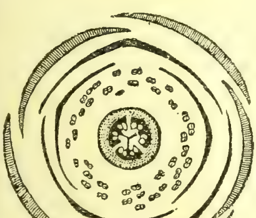

Fig. 1480.

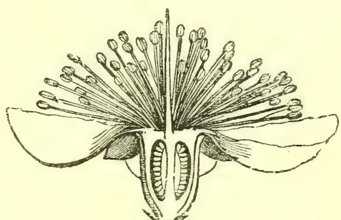

Fig. 1481.

to 1482).—Trees or shrubs, with entire, exstipulate, usually opposite

Figures 1480 to 1482 illustrate the natural order Myrtaceæ.

Fig. 1480. Diagram of the flower of Myrtus, showing five segments of the calyx, five petals with quincuncial æstivation, numerous stamens, a three-celled ovary with seeds attached to a central pla-

and dotted leaves (Fig. 1482), often having an intramarginal vein. Calyx adherent (Fig. 1481), 4-5-cleft, sometimes operculate. Petals 4-5, sometimes none. Stamens usually ∞ (Fig. 1481), with long filaments and ovate anthers. Style simple. Fruit baccate in true Myrteæ and capsular in Leptospermeæ. Seeds usually numerous, exalbuminous. Tropical and sub-tropical plants. Known species 1300. *Ill. Gen.*—Melaleuca, Eucalyptus, Metrosideros, Leptospermum, Babingtonia, Punica, Psidium, Pimenta, Myrtus, Caryophyllus, Eugenia, Jambosa.

Fig. 1482.

1263. The plants of this order are generally aromatic, and yield a pungent volatile oil. Some of them are astringent, others yield gummy and saccharine matter.

Caryophyllus aromaticus, the Clove plant. The unexpanded flower-buds constitute the Cloves of commerce. The roundish projection of the Clove is the unexpanded petals, which are surrounded by the tubular calyx. The name is a corruption of the French *clou*, and indicates the resemblance of this spice to a nail. The properties of Cloves are due to an aromatic pungent volatile oil.

Eucalyptus. The species of this genus have an operculate calyx, and their bark often separates in layers. They constitute the Gum-trees of Australia, which supply a large quantity of tannin. E. resinifera yields, on incision, an astringent matter called Botany-Bay Kino. E. mannifera exudes a sweet substance resembling manna. E. dumosa is often covered with a saccharine matter called Lurp, produced by the attack of a Coccus. E. robusta has cavities in its stem containing a red gum. What is called a Box-flat in Australia is one covered with Eucalypti.

Eugenia Pimenta bears an aromatic fruit, having the flavour of Cloves, Cinnamon, and Nutmeg, and which, when dried, constitutes Allspice, Pimento, or Jamaica Pepper. E. acris also supplies Pimento. E. malaccensis and E. Jambos produce the Rose-apples of the East. E. cauliflora supplies an edible fruit in Brazil, called Jaboticaba.

Leptospermum. The leaves of some of the species, as L. scoparium, are used in Australia as a substitute for Tea.

Melaleuca minor. Its leaves furnish the green pungent oil of Cajeput, which dissolves caoutchouc, and which has been used externally as a rubefacient, and internally as a stimulant and carminative. The leaves of some species are used as Tea.

Metrosideros. Some of the species supply hard and heavy timber, from which the clubs and other weapons of the South Sea Islanders are made.

Myrtus communis, the common Myrtle (Fig. 1482), is the most northern species of

centa. Fig. 1481. Flower of Myrtle cut vertically, showing adherent calyx, separate petals, numerous stamens inserted into the calyx, inferior ovary with ovules, and a simple style. Fig. 1482. Myrtus communis, the common Myrtle, the Hadas of the Hebrew, as noticed in Neh. viii. 15; Isaiah xli. 19, lv. 13; Zech. i. 8, 10, 11.

the order. Its buds and berries have been used as spices. A fragrant distilled water is prepared from the flowers. The plant is the Hadas of the Bible.

Psidium. Species of this genus supply the fruit called Guava. The chief sources are P. pyriferum, P. pomiferum, and P. Cattleyanum. P. pygmæum yields a fine-flavoured fruit, the size of a Gooseberry.

Punica Granatum, the Pomegranate, is the Rimmon of Scripture.* The fruit has a peculiar structure (Figs. 865, 866, p. 288). Various parts have been used medicinally, (especially for the cure of tape-worm), such as the bark of the root, the crimson flowers called Cytinus by Dioscorides, the double flowers or Balaustium, and the rind of the fruit or the Malicorium of the Romans. The latter is said to form the principal material for tanning morocco leather. Some look upon Punica as an osculant genus connecting Myrtaceæ with Lythraceæ and Onagraceæ, and forming the type of a distinct order.

1264. Nat. Ord. 86.—Chamælauciaceæ, the Fringe-Myrtle order. —Small heath-like bushes, with evergreen leaves abounding in oil. Allied to Myrtaceæ, but differing in their fringed or feathery calyx, sterile staminal row, and 1-celled ovary. They are fragrant New Holland plants. Known species 50. *Ill. Gen.*—Calytrix, Chamælaucium, Darwinia.

1265. Nat. Ord. 87.—Lecythidaceæ, the Monkey-pot order.—Large trees, with stipulate leaves and showy flowers. Allied to Myrtaceæ, but distinguished by their large almond-like seeds, their alternate, dotless leaves, and by their stamens being in part collected into a hooded plate. The fruit is a woody capsule, often with circumscissile dehiscence (Fig. 1483). Natives of the warm regions of South America. Known species 38. *Ill. Gen.* —Couratari, Lecythis, Bertholletia, Couroupita.


Fig. 1483.

1266. Many of the plants yield edible seeds. Their seed-vessels are sometimes used as cups and bowls, and their wood is put to economic uses.

Bertholletia excelsa. The seeds of this tree are the Brazil, Castanha, or Para nuts of the shops. The tree often attains a height of 120 feet.

Couroupita guianensis is called the Cannon-ball tree, from the form of its seed-vessel. It is called Wild Apricot in Cayenne.

Lecythis ollaria is one of the largest trees in the Brazilian forests. Its seed-vessel receives the name of Monkey-pot. The seeds are called Sapucaya nuts, and are much relished by monkeys, which are sometimes entrapped by the capsule when grasping the nuts. The liber separates easily into numerous layers. A small-fruited Lecythis is called by the Indians Macacarecuya or Monkey's drinking-cup.

1267. Nat. Ord. 88.—Barringtoniaceæ, the Barringtonia order. —Trees or shrubs referred by most authors to the Myrtle alliance, but distinguished by the presence of a large quantity of albumen, alternate, dotless, and often serrated leaves. The fruit is pulpy. Natives of the tropics. The bark of some of the plants is bitter and tonic. Known species 28. *Ill. Gen.*—Barringtonia, Careya, Gustavia.

Fig. 1483. Pyxidium or operculate capsule of Lecythis ollaria. It is called Monkey-pot. The seeds in the interior are eaten by monkeys.

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* The Pomegranate is noticed in various parts of the Bible, as in Exod. xxviii. 33; Num. xx. 5; Deut. viii. 8; 1 Kings vii. 18, 20, 42; Cant. viii. 2, &c. Its acid juice was used as a cooling sherbet. The English name is derived from the pomum granatum (grained apple) of the Romans.

1268. Nat. Ord. 89.—ONAGRACEÆ, the Evening-Primrose order (Figs. 1484 and 1485).—Herbs or shrubs, with alternate or opposite, simple, exstipulate, dotless leaves, and showy tetramerous flowers. Calyx superior, tubular, limb 4-lobed, valvate. Petals usually 4, twisted in æstivation. Stamens epigynous, generally 4 or 8; pollen triangular (Fig. 1485). Ovary 2-4 celled; styles united; stigma capitate or 4-lobed. Fruit capsular or baccate. Seeds exalbuminous. Chiefly natives of the temperate parts of America. Known species 450. *Ill. Gen.*—Jussiæa, Isnardia, Œnothera, Godetia, Clarkia, Epilobium, Fuchsia, Lopezia, Circæa, Gaura.

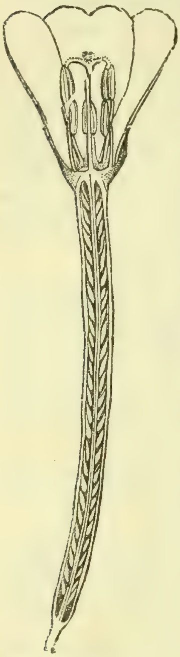

Fig. 1484.

Fig. 1485.

1269. The plants of this order have mucilaginous and astringent properties. Some yield edible roots and fruits.

Epilobium, Willow-herb (Fig. 1484). The species have an elongated 4-valved capsule, and comose seeds.

Fuchsia is remarkable for its coloured calyx and succulent subacid fruit.

Œnothera, Evening Primrose, is so called, because many of the species open their flowers at night. Œ. biennis and other species are cultivated on account of their edible roots.

1270. Nat. Ord. 90.—HALORAGEACEÆ, the Mare's-tail order.—Herbs or undershrubs, often aquatic, with alternate, opposite, or whorled leaves, and small, frequently incomplete flowers. They may be regarded as an imperfect form of Onagraceæ, from which they are distinguished by their minute calyx, and their solitary pendulous seeds. They are frequently apetalous, and the stamens are sometimes reduced to one. They are found in all quarters of the globe. Known species 70. *Ill. Gen.*—Hippuris, Myriophyllum, Haloragis, Trapa.

Fig. 1486.

1271. Some of the plants of the order yield edible seeds; others have a fragrant odour.

Hippuris vulgaris, common Mare's-tail, has a beautiful necklace-like arrangement of cells in its stem, with large air cavities.

Figures 1484 and 1485 illustrate the natural order Onagraceæ.

Fig. 1484. Flower of Epilobium, showing the long pod-like ovary adherent to the tube of the calyx, the epigynous petals and stamens, with the single style and papillose lobed stigma. Fig. 1485. Triangular pollen of Œnothera, with a single pollen tube portruded.

Fig. 1486. Trapa natans, belonging to the order Halorageaceæ. It is called Water-chestnut (Marron d'eau of the French). Its petioles are inflated in order to float the plant; and its seeds are edible.

Trapa natans, the Water-Chestnut (Fig. 1486), furnishes edible seeds, which are said to have constituted the food of the ancient Thracians. T. bicornis has a remarkable horned fruit like the head of a bull. The plant abounds in shallow lakes in China, and is called Ling by the Chinese, who use the seeds for food. The seeds of T. bispinosa are eaten in India. The species of this genus have unequal cotyledons.

1272. Nat. Ord. 91.—Loasaceæ, the Chili-Nettle order.—Herbs with rigid or stinging hairs, opposite or alternate, exstipulate leaves, and showy flowers. Calyx adherent, limb 4-5-parted. Petals 5 or 10, often cucullate. Stamens ∞, distinct or united in bundles. Ovary 1-celled, with several parietal placentas; style single. Fruit capsular or succulent. Seeds albuminous. American plants, some of which receive the name of Chili-Nettles on account of the stinging property of their hairs. Known species 75. *Ill. Gen.*—Mentzelia, Bartonia, Loasa, Gronovia.

1273. Nat. Ord. 92.—Cucurbitaceæ, the Gourd order (Figs. 1487

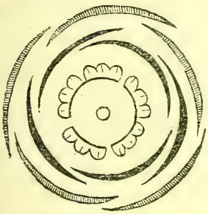
Fig. 1487.

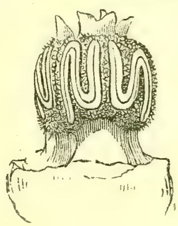
Fig. 1491.

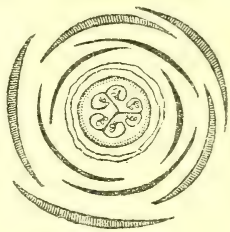
Fig. 1488.

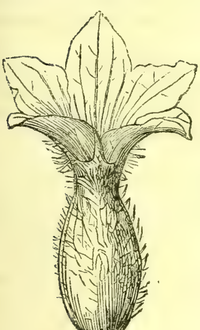
Fig. 1490.


Fig. 1489.

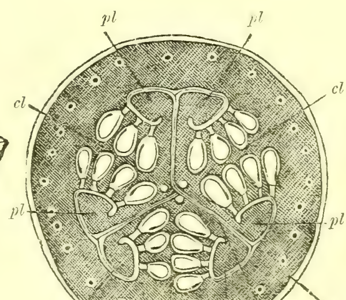

Fig. 1492.

to 1493).—Succulent climbing plants, with extra-axillary tendrils (in place of stipules), alternate, palmately-veined, scabrous leaves, and

Figures 1487 to 1493 illustrate the natural order Cucurbitaceæ.

Fig. 1487. Diagram of the male flower of the Melon, showing five divisions of the calyx, five imbricate segments of the corolla, five stamens with sinuous anthers, four of the stamens being united in pairs, and the fifth one free; in the centre is seen the abortive ovary. Fig. 1488. Diagram of

unisexual flowers. Calyx adherent, limb 5-toothed (Fig. 1490) or obsolete. Petals 4-5, usually united, reticulated (Fig. 1489). Stamens generally 5, distinct or combined; anthers long and sinuous (Fig. 1491). Ovary 1-celled, inferior, with 3 parietal placentas (Fig. 1492); stigmas thick, dilated or fringed. Fruit a pepo (page 288). Seeds flat, exalbuminous; cotyledons leafy. Chiefly natives of hot countries; they abound in India and South America. Known species about 300. *Ill. Gen.*—Anguria, Bryonia, Citrullus, Ecbalium, Momordica, Luffa, Lagenaria, Cucumis, Cucurbita, Coccinia, Trichosanthes, Telfairia, Feuillæa, Sicyos.


Fig. 1493.

1274. The plants of the order may be said in general to possess a certain degree of acridity, which is sometimes so marked as to give rise to drastic purgative qualities. In many cases, however, as in the Melon, the Cucumber, the Vegetable Marrow, Gourd, Pumpkin, and Squash, the fruit is edible when cultivated. The seeds are usually harmless.

Bryonia alba and B. dioica have large roots, which are powerful purgatives. Their young shoots are used as potherbs.

Citrullus (Cucumis) Colocynthis, Coloquintida, or Bitter Apple (Fig. 1493), has a round fruit, the pulp of which is the Colocynth of the shops. It is supposed to be one of the plants included under the Hebrew word Pakyoth, and translated Wild Gourds in Scripture, 2 Kings iv. 39.

Cucumis sativus (Fig. 869, p. 289), yields the common Cucumber. It is the Hebrew Kishuim (Numb. xi. 5; Is. i. 8). C. Melo (Fig. 322, p. 137, Fig. 327, p. 139) is the Common Melon, one of the plants referred to in Scripture under the name Abattachim.

Cucurbita Citrullus, the Water Melon (Fig. 870, p. 289), is supposed to be one of the plants included under the Hebrew Abattachim, translated Melons in Scripture (Numb. xi. 5). The juice of its fruit is cool and refreshing. C. maxima, the Red Gourd, C. Pepo or Benincasa cerifera, the White Gourd, and C. ovifera, Vegetable Marrow, are used as culinary vegetables.

Ecbalium purgans (Momordica* Elaterium), is called Squirting Cucumber, on account of the elastic mode in which its seeds are scattered (page 413). The feculence deposited from the juice of the fruit constitutes the hydragogue cathartic called Elaterium.

Lagenaria vulgaris, Bottle Gourd, is so called on account of the fruit being used as bottles, after the pulp and seeds have been removed.

the female flower of the Melon, showing a similar arrangement of the floral envelopes, an abortive circle of stamens, and the ovary, with three parietal curved placentaries sending processes towards the centre. Fig. 1489. Male flower of the Melon, showing the gamosepalous hairy calyx, with a five-toothed limb, and five reticulated petals. Fig. 1490. Female flower of the Melon, showing the adherent hairy calyx, with its toothed limb, and five reticulated imbricate petals. Fig. 1491. Stamens of the Melon, with anfractuose (sinuous) anthers, and appendages projecting above the lobes. (See Pollen, Figs. 653, 654, p. 234). Fig. 1492. Transverse section of the Pepo of the Melon, showing the three parietal placentaries, *pl*, which send processes, *s*, from the circumference or back of the carpels, *t*, towards the centre. The divisions between the carpels are marked, *cl*. Fig. 1493. Citrullus or Cucumis Colocynthis. The Colocynth plant, with its palmately-veined leaves, cirrhose stipules on one side of the leaf, and pulpy fruit or Pepo.

* A true Momordica has a solitary bract on the peduncle, which this plant wants.

Luffa fœtida. The fruit, when ripe, consists of entangled fibres, which are divided into three parietal masses.

Sechium edule furnishes the fruit called Chocho, which is esculent.

Telfairia pedata has edible seeds as large as Chestnuts, and having the flavour of Almonds.

1275. Nat. Ord. 93.—PAPAYACEÆ, the Papaw order (Fig. 1494).—Trees or shrubs often having an acrid milky juice, with alternate, lobed, long-petioled leaves, and unisexual flowers. The plants are distinguished from Cucurbitaceæ by not climbing, and by having a free ovary with 5 placentas and albuminous seeds. The natural order Pangiaceæ may be included, which differs only in having a polypetalous corolla and scales attached to the throat of the female flower. Papayaceæ are chiefly found in South America; Pangiaceæ in India. Known species about 30. *Ill. Gen.*—Carica, Modecca, Pangium, Hydnocarpus.

1276. Many of the Papaw-worts have an acrid milky juice, while the Pangiads are poisonous.

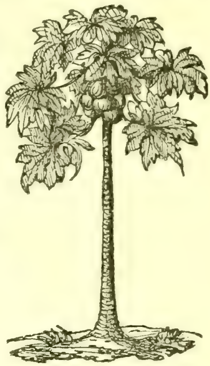

Fig. 1494.

Carica Papaya (Fig. 1494), the Papaw-tree, has an edible fruit. The juice of the unripe fruit is said to render meat tender, and to act medicinally as a vermifuge. The leaves are used in Panama as a substitute for soap. C. digitata is reputed poisonous in Brazil.

Hydnocarpus venenatus, is so called on account of its poisonous narcotic fruit, which is used in Ceylon for intoxicating fish.

1277. Nat. Ord. 94.—BELVISIACEÆ, the Belvisia order.—Shrubs, with simple, alternate, leathery, exstipulate leaves. Calyx, a thick coriaceous cup, with 5 segments, valvate. Corolla of 3 distinct gamopetalous rings, the first being large and conspicuous, and consisting of 5 lobes, each with 7 ribs and 7 teeth, the second being a narrow membrane cut into sharp pointed segments, the third being an inconspicuous membranous cup finely cut. Stamens 20, in an erect cup-like form, unequally united. Disk fleshy, cup-like, covering the ovary, and standing as high as the stigma. Ovary 5-celled; ovules 2 in each cell, suspended from an axile placenta; style and stigma pentagonal. Fruit a large round berry crowned by the calyx. Seeds large and reniform. Natives of tropical Africa. The pulp of the fruit is eatable, and the rind contains so much tannin as to be used for making ink; the wood is soft, and contains numerous dotted vessels. Bentham considers the order as a section of Myrtaceæ, while Lindley considers it as allied to Rhizophoraceæ. Known species 4. *Ill. Gen.*—Asteranthos, Napoleona (Belvisia).

1278. Nat. Ord. 95.—PASSIFLORACEÆ, the Passion-flower order.

Fig. 1494. Carica Papaya, the Papaw-tree, belonging to the natural order Papayaceæ. It is a South American tree, with large lobed leaves supported on long petioles. The fruit is borne at the upper part of the stem.

—Herbs or shrubs usually climbing by tendrils, with alternate, stipulate, sometimes glandular leaves. Calyx of 5 sepals, united below, the throat bearing 5 petals and filamentous or annular processes. Stamens 5, monadelphous, surrounding the gynophore; anthers extrorse. Ovary free from the calyx, 1-celled; styles 3, club-shaped. Fruit mostly fleshy, stalked, 1-celled, with 3 parietal polyspermous placentas. Seeds albuminous, arillate. They are common in tropical America. Known species 210. *Ill. Gen.*—Paropsia, Passiflora, Tacsonia.

1279. Astringent and narcotic qualities appear to prevail in the order. Many of the species, however, produce edible fruits.

Paropsia edulis, a Madagascar plant, has an eatable fruit.

Passiflora, Passion-flower, so called from a fancied resemblance in the parts of the flowers to the appearances presented on Calvary at the Crucifixion. P. quadrangularis produces the large Granadilla, a well-known West Indian fruit. Other species of Passiflora, such as P. maliformis, P. edulis, and P. laurifolia, also furnish fruit which is used as a dessert. The roots of P. quadrangularis, and the flowers of P. rubra are narcotic, while the leaves of P. laurifolia are bitter and anthelmintic.

Tacsonia mollissima, and T. tripartita, have edible fruits.

Some include the genera Malesherbia and Gynopleura in this order. By Lindley they are placed in a separate order, Malesherbiaceæ, Crownworts, differing from Passionworts in their non-climbing habit, in the want of stipules and aril, and in the styles arising from the back of the ovary. There are four species which are natives of Chili and Peru.

1280. Nat. Ord. 96.—Turneraceæ, the Turnera order.—Herbs, sometimes shrubby plants, having a Cistus-like habit, with alternate, exstipulate, pubescent leaves. Calyx 5-lobed, bearing 5 petals and 5 stamens. Ovary free, 1-celled, with 3 parietal placentas and 3 styles which are often forked or multifid at the apex. Fruit a 3-valved capsule. Seeds albuminous, strophiolate at one side. The plants have astringent, tonic, and occasionally aromatic qualities, and are natives of South America and the West Indies. Known species 60. *Ill. Gen.*—Turnera, Piriqueta.

1281. Nat. Ord. 97.—Portulacaceæ, the Purslane order.—Succulent herbs or shrubs, with alternate or opposite, entire, exstipulate leaves. Calyx of 2 coherent sepals. Petals 5. Stamens variable in number, sometimes opposite the petals; anthers versatile. Ovary 1-celled, formed of 3 united carpels. Fruit capsular, usually dehiscent by valves or by a lid (Fig. 1495). Seeds numerous, albuminous, attached to a central placenta; embryo peripherical. This order has the stamens sometimes hypogynous, and it has been placed near Caryophyllaceæ by some authors. The plants are found in dry places, in various parts of the world, more particularly in South America and at the Cape of Good Hope. Known

Fig. 1495.

Fig. 1495. Seed-vessel of Portulaca, Purslane, opening by a lid. Seeds attached to a central placenta.

species 190. *Ill. Gen.*—Portulaca, Grahamia, Talinum, Calandrinia, Claytonia, Montia.

1282. Esculent and antiscorbutic qualities prevail in the order. Some have showy flowers, which are ephemeral.

Claytonia tuberosa has a tuberous root, which is eaten in Siberia. C. perfoliata is used as a potherb in North America.

Portulaca oleracea, common Purslane, has been long celebrated as an esculent vegetable. It has antiscorbutic qualities.

1283. Nat. Ord. 98.—Illecebraceæ or Paronychiaceæ, the Knotwort order.—Herbaceous or suffruticose plants, with opposite or alternate, often clustered, sessile, entire, stipulate leaves, and minute flowers. Sepals 3-5, distinct or cohering. Petals small, sometimes 0. Stamens opposite the sepals, if equal to them in number. Ovary superior; styles 2-5. Fruit dry, 1-3-celled, indehiscent or opening by 3 valves. Seeds either numerous and attached to a free axile placenta, or solitary and pendulous from a cord attached to a basal placenta. Seeds albuminous; embryo curved. This order is by some placed near Caryophyllaceæ, from which it differs in the presence of scarious stipules and in its perigynous stamens. The plants are natives chiefly of barren places in the South of Europe and north of Africa, and their properties are astringent. In this order some include Scleranthus, Basella, Melloca, and a few allied genera, embracing in all 26 species. These differ, however, from Knotworts in the absence of petals and stipules. Lindley looks upon them as allied to Chenopodiaceæ, and places them in distinct orders, Scleranthaceæ and Basellaceæ. The known species of Knotworts are about 100. *Ill. Gen.*—Corrigiola, Herniaria, Illecebrum, Loefflingia, Paronychia, Polycarpon, Spergula, Spergularia.

1284. Nat. Ord. 99.—Crassulaceæ, the Stonecrop order (Figs. 1496-1499).—Succulent herbs or shrubs, with exstipulate leaves and cymose, often secund flowers (Fig. 1497). Sepals 3-20, more or less combined. Petals 3-20, separate or united. Stamens equal in number to the petals, or twice as many. Carpels 1-celled, of the same number as the petals, having hypogynous scales at their base (Fig. 1499, and Fig. 678, p. 240). Fruit follicular. Seeds numerous, albuminous. Natives of dry places in all parts of the world. Known species 450. *Ill. Gen.*—Tillæa, Crassula, Bryophyllum, Cotyledon, Echeveria, Sedum, Sempervivum, Penthorum.

1285. Acridity prevails in many plants of this order. Some species are refrigerant, others astringent.

Bryophyllum calycinum (Fig. 334, p. 141), has a gamopetalous corolla, and produces marginal buds on its leaves.

Sedum Telephium has been employed in diarrhœa as an astringent. S. acre, Biting Stonecrop (Fig. 1497), possesses acridity, and has emetic and purgative properties.

Sempervivum tectorum, Houseleek, constantly bears ovules instead of pollen. It contains malate of lime, and is reputed a cooling remedy.

Under this order some include the Chilian genera, Francoa and Tetilla, containing five species. Others place them in a distinct order, Francoaceæ, differing from the Stonecrop order in the absence of scales, in their consolidated ovary, and in their minute embryo in the base of much albumen.

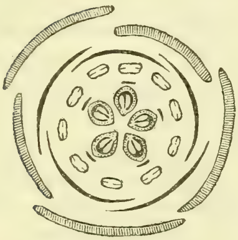

Fig. 1496.

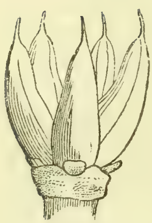

Fig. 1499.

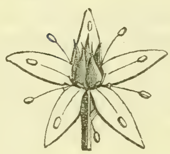

Fig. 1498.

Fig. 1497.

1286. Nat. Ord. 100.—Mesembryanthemaceæ or Ficoideæ, the Fig-Marigold order (Figs. 1500 to 1502).—Succulent shrubs or herbs, with opposite simple leaves and often showy flowers. Sepals 4-8, more or less united. Petals and stamens ∞. Capsule usually many-celled, opening in a stellate manner (Figs. 1501 and 1502); placenta central or parietal. Seeds numerous, albuminous; embryo curved or spiral. Natives of the hot sandy plains of the Cape of Good Hope; a few also are found in Europe, South America, and China. Known species 375. *Ill. Gen.*—Mesembryanthemum, Glinus, Orygia, Lewisia.

1287. Some of the plants are esculent, others furnish alkaline matter, while a few are diuretic.

Lewisia rediviva has great powers of vitality. Its root is farinaceous, and is used as food in Oregon.

Mesembryanthemum crystallinum is called the Ice-plant, on account of the watery vesicles on its surface. It is burned along with other species to furnish soda. The watery fluid on the leaves of the Ice-plant, according to Voelcker, consists

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Figures 1496 to 1499 illustrate the natural order Crassulaceæ.

Fig. 1496. Diagram of Sedum, Stonecrop, showing five sepals, five petals, ten stamens in two rows, and five carpels with hypogynous scales. Fig. 1497. Sedum acre, Biting Stonecrop, with its secund yellow flowers in a racemose cyme. Fig. 1498. Flower of Sedum acre, showing five petals, ten stamens in two verticils, and five carpels forming the pistil. Fig. 1499. Fruit of Sedum acre, consisting of five follicles with glands at their base. See also Fig. 678, p. 240.

of organic matter (albumen, malic acid, &c.), chloride of Sodium, Potash, Magnesia, and Sulphuric Acid. M. Tripolium shows well the stellate capsule opening, when moisture is applied (Fig. 1501). M. edule, called Hottentot's-Fig, has esculent leaves. Other species are used as potherbs.

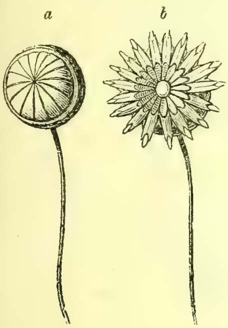

Fig. 1501.

Fig. 1500.

Fig. 1502.

1288. Nat. Ord. 101.—Tetragoniaceæ, the Tetragonia order.—Succulent plants nearly allied to Fig-Marigolds, but differing in the want of petals and in having definite stamens. The fruit is either an indehiscent nut or a pyxidium. They are found in the South Sea Islands, the Mediterranean, and the Cape of Good Hope. Many of them are saline, others are esculent. Tetragonia expansa is used as Spinage in New Zealand. Known species 65. *Ill. Gen.*—Tetragonia, Aizoon, Sesuvium.

1289. Nat. Ord. 102.—Cactaceæ, the Cactus order (Figs. 1503 to 1508).—Succulent often spiny herbs, with remarkable stems, which are angular, two-edged, or leafy, and have their woody matter often arranged in a wedge-like manner. Calyx of numerous sepals combined and epigynous. Petals indefinite. Stamens ∞, with long filaments. Ovary 1-celled, with parietal placentas ; style single ; stigmas

Figures 1500 to 1502 illustrate the natural order Mesembryanthemaceæ.

Fig. 1500. Mesembryanthemum falciforme, one of the Fig-Marigolds, with its fleshy scimitar-like leaves, and numerous petals, which expand and close under the influence of light and darkness. Fig. 1501. Seed-vessel of Mesembryanthemum Tripolium? *a*, seed-vessel closed, *b*, seed-vessel opened in a stellate manner under the influence of moisture. Fig. 1502. Ripe capsule of Mesembryanthemum. The carpels separating and spreading out in a stellate manner.

several. Fruit baccate. Seeds exalbuminous. Natives of America.

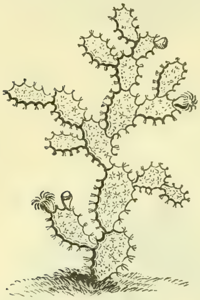

Fig. 1503.

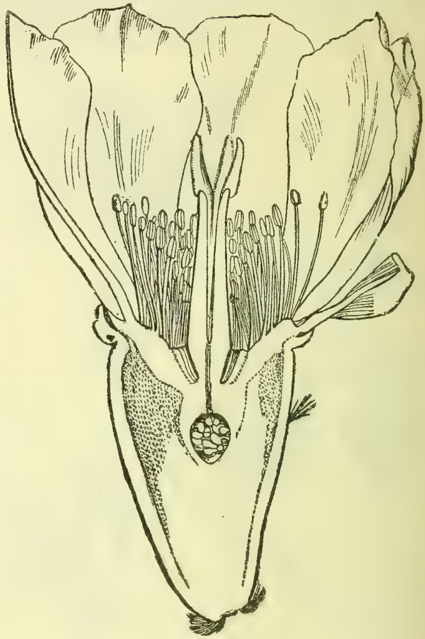

Fig. 1507.

Fig. 1504.

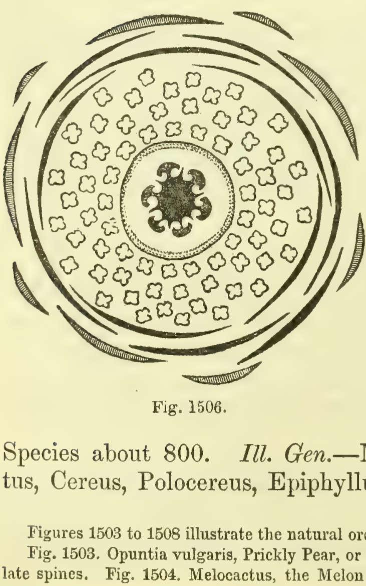

Fig. 1506.

Fig. 1508.

Fig. 1505.

Species about 800. *Ill. Gen.*—Melocactus, Mammillaria, Echinocactus, Cereus, Polocereus, Epiphyllum, Rhipsalis, Opuntia, Pereskia.

Figures 1503 to 1508 illustrate the natural order Cactaceæ.

Fig. 1503. Opuntia vulgaris, Prickly Pear, or Indian Fig, with its succulent jointed stem and stellate spines. Fig. 1504. Melocactus, the Melon Cactus, with its rounded and angular stem. Fig.

1290. The fruit of many of the Indian Figs is subacid and refreshing. In some instances, it is sweetish and insipid. The stems of some of the species are eaten by cattle. The plants of the Cactus tribe present remarkable stems; sometimes spherical (Fig. 1504), sometimes articulated or jointed (Figs. 1503 and 1505), and sometimes assuming the form of a tall upright polygonal column. From their succulent nature, the plants thrive in hot and dry situations. To some of the plants the name of "vegetable fountains in the desert" has been applied. Some attain the size of trees, being 32 feet high and 3 feet in circumference.

Cereus grandiflorus is a night-flowering plant, so is also C. nycticalus and some other species (pp. 532 and 546).

Echinocactus. Some of the species attain an enormous size. E. Visnaga or platyceras, at Kew, measured 9 feet in height, 9½ in circumference, and weighed a ton. The number of spines and bristles was reckoned at 51,000. On the top of the plant a woolly matter is produced called Muff Cactus. Seemann counted 8360 spines on E. Wislazenii.

Melocactus, the Melon Cactus (Fig. 1504). In the dry plains of South America the animals suffering from thirst seek the Melon Cactus, and after tearing off its formidable spines, refresh themselves with its abundant juice.

Opuntia cochinellifera, the Nopal plant (Fig. 1505), affords nourishment to the Coccus Cacti or Cochineal insect in Mexico and Peru. The female insect is gathered just before the laying of the eggs. Some years ago Humboldt estimated the value of Cochineal exported annually from South America at £500,000. Britain consumed £275,000 worth. O. vulgaris, the common Prickly Pear (Fig. 1503), is so called from the spiny nature of its pyriform fruit. The fruit of O. Tuna forms a carmine pigment.

Pereskia aculeata supplies an edible fruit, sometimes called Barbadoes Gooseberry.

Polocereus senilis, Old-Man Cactus, is so called from resembling a grey head in appearance. In Kew it attained a height of 14-16 feet, and had 72,000 spines.

1291. Nat. Ord. 103.—Grossulariaceæ, the Gooseberry order (Figs. 1509 to 1511).—Shrubs which are either spiny or prickly (Fig. 1509) or unarmed, with alternate palmately-lobed leaves (Fig. 1510) without true stipules. Calyx-tube adherent to the ovary, limb 4-5-lobed, sometimes coloured. Petals small, 5. Stamens 5. Ovary 1-celled, with 2 parietal placentas; styles more or less united. Fruit a berry (Fig. 777, p. 267), crowned with the remains of the flower, with two parietal placentas (Fig. 1511). Seeds numerous, albuminous; embryo minute. Natives of the temperate regions of Europe, Asia, and America. Species about 100. *Ill. Gen.*—Ribes, Polyosma.

1292. Wholesome plants, furnishing often edible fruits, containing malic and other organic acids.

Ribes Grossularia, the Gooseberry; R. nigrum, the Black Currant; R. rubrum, the

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1505. Opuntia cochinellifera, the Cochineal or Nopal Cactus, with the male Coccus. The female insect dried constitutes the Cochineal. The plantations of this Cactus are called Nopaleries. Fig. 1506. Diagram of the flower of Opuntia, showing numerous sepals and petals, which pass insensibly into each other, indefinite stamens (often 300 or 400), and a one-celled ovary formed of several carpels, with parietal placentas. Fig. 1507. Section of the flower of Opuntia, showing the floral envelopes, the epigynous stamens attached to the upper part of the calycine tube, the ovary and style. Fig. 1508. Ovary, style, and stigma of Cereus grandiflorus.

Red Currant, furnish valuable fruits. R. sanguineum, R. fuchsioides, and other species, are showy garden shrubs.

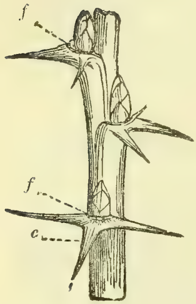

Fig. 1509.

Fig. 1511.

Fig. 1510.

1293. Nat. Ord. 104.—ESCALLONIACEÆ, the Escallonia order.—Evergreen shrubs, often odoriferous, with alternate exstipulate leaves, allied to the last order, and differing from it in their capsular bicarpellary fruit, epigynous disk, axile placentas, and oily albumen. By some they are placed among Saxifrages, from which they differ in their simple style and oily albumen. Natives chiefly of South America. Escallonias attain a high elevation on the mountains. Species 60. *Ill. Gen.*—Escallonia, Itea.

1294. Nat. Ord. 105.—SAXIFRAGACEÆ, the Saxifrage order (Figs. 1512 to 1514).—Herbs with alternate leaves (Fig. 1512). Calyx of 4-5 more or less cohering sepals. Petals 5 or 0. Stamens 5-10. Ovary more or less completely inferior, consisting of 2 carpels which diverge at the apex (Fig. 1514). Fruit a 1 or 2-celled capsule. Seeds numerous; embryo straight in fleshy albumen. Natives of northern alpine districts. Some extend very high; thus Saxifraga Boussingaulti reaches to nearly 16,000 feet on Chimborazo. Some grow on rocks, old walls, in woods, or near streams. They have generally cæspitose leaves and glandular stems, and their flowers are usually white, sometimes yellow or red. Saxifraga aizoides adorns the Highland streams with its rich yellow blossoms; and S. oppositifolia, with its red flowers, forms a rich covering of the mountain rocks in early summer. Their properties are astringent. Heuchera americana is called alum-root on account of its astringency. Species 310. *Ill. Gen.*—Saxifraga, Chrysosplenium, Heuchera, Mitella, Tiarella, Astilbe.

Figures 1509 to 1511 illustrate the natural order Grossulariaceæ.

Fig. 1509. Branch of Ribes Grossularia, Gooseberry, showing the spines produced from the pulvinus or cushion, *c*, close to the scars of the leaves, *f f*, from the axil of which buds are produced. Fig. 1510. Cluster of flowers of Ribes rubrum, Red Currant, with a palmate leaf at the base. Fig. 1511. Baccate fruit of Ribes Grossularia, showing seeds attached to two parietal placentas, and immersed in pulp secreted by the endocarp.

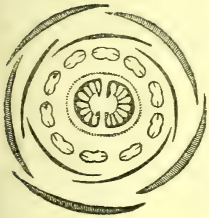

Fig. 1513.

Fig. 1512.

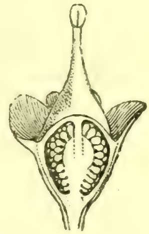

Fig. 1514.

1295. Nat. Ord. 106.—HYDRANGEACEÆ, the Hydrangea order.—Shrubs with simple exstipulate leaves, often considered as a sub-order of Saxifragaceæ, but differing in their opposite leaves, their tendency to form abortive radiant flowers, and in the carpels being often more than two. Natives of the temperate regions of Asia and America. Hydrangeas from China and Japan are commonly cultivated. Some of the species are used instead of Tea. Species 45. *Ill. Gen.*—Hydrangea, Adamia, Bauera.

1296. Nat. Ord. 107.—CUNONIACEÆ, the Cunonia order.—Trees or shrubs allied to Saxifragaceæ, and differing in their shrubby growth, opposite leaves, and interpetiolar stipules. The latter character separates them from Hydrangeas, which are exstipulate. Natives of the Cape of Good Hope, South America, the East Indies, and Australia. Their properties are astringent. Species 100. *Ill. Gen.*—Weinmannia, Cunonia, Belangera.

1297. Nat. Ord. 108.—BRUNIACEÆ, the Brunia order.—Heath-like shrubs, with small, rigid, entire leaves. Calyx usually superior, 5-cleft. Petals and stamens 5; anthers extrorse. Ovary 1-3-celled, with 1-2 suspended ovules in each cell; style simple or bifid. Fruit either dehiscent and 2-celled, or indehiscent and 1-celled. Seeds solitary or in pairs; embryo minute, in fleshy albumen. Natives chiefly of the Cape of Good Hope. Species 65. *Ill. Gen.*—Brunia, Staavia, Grubbia, Ophiria.

Figures 1512 to 1514 illustrate the natural order Saxifragaceæ.

Fig. 1512. Saxifraga tridactylites, Rue-leaved Saxifrage, with wedge-shaped, trifid leaves, and flowers in a racemose cyme. Fig. 1513. Diagram of the flower of Saxifraga tridactylites, with 5 divisions of the calyx, 5 petals, 10 stamens in 2 rows, and a bicarpellary pistil with numerous ovules. Fig. 1514. Carpel of Saxifrage, cut vertically, shewing the adherent calyx, the beak of the carpel or style and stigma, and the ovules attached to the placenta.

1298. Nat. Ord. 109.—HAMAMELIDACEÆ, the Witch-Hazel order. —Trees or shrubs, with alternate, feather-veined leaves, having deciduous stipules. Calyx 4-5-divided. Petals 4, 5, or 0. Stamens 8; anthers introrse. Ovary 2-celled, inferior; ovules solitary or several; styles 2. Fruit a 2-valved loculicidal capsule. Seeds pendulous, albuminous. Natives of North America, Asia, and Africa. Rhodoleia Championi is a showy plant, with red involucral leaves, found in China. Hamamelis virginica furnishes edible oily seeds. *Ill. Gen.* —Hamamelis, Fothergilla, Sedgwickia, Rhodoleia.*

1299. Nat. Ord. 110.—UMBELLIFERÆ or APIACEÆ, the Umbelli-

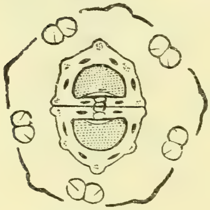
Fig. 1516.

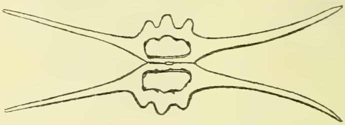
Fig. 1518.

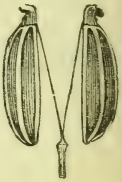
Fig. 1519.


Fig. 1515.

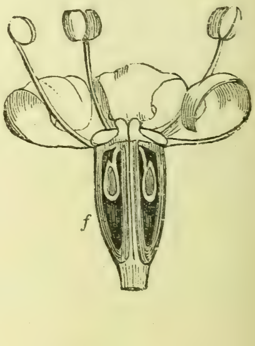

Fig. 1517.

ferous order (Figs. 1515 to 1519).—Herbs with solid or hollow stems,

Figures 1515 to 1519 illustrate the natural order Umbelliferæ.

Fig. 1515. Coriandrum sativum, the Coriander plant, with its compound leaves, sheathing petioles, and flowers in compound umbels. It is the Gad of Scripture (Exod. xvi. 31; Num. xi. 7). Fig. 1516. Diagram of the flower of Fœniculum vulgare, common Fennel. The calyx limb is obsolete; there are 5 petals, 5 alternating stamens, and a cremocarp consisting of two achenes or mericarps united by

* Gardner gives a new definition of the natural order Hamamelidaceæ in Hook. Jour. Nov. 1849. He includes—1. Altingieæ, comprising Liquidambar, Sedgwickia, and Bucklandia. 2. Hamameleæ, comprising Fothergilla, Helwingia, Hamamelis, &c. 3. Brunieæ, comprising Brunia, &c.

alternate leaves generally compound and sheathing at the base, and umbellate, involucrate flowers (Fig. 1515). Calyx adherent to the bicarpellary ovary, limb 5-toothed or obsolete. Petals 5, inflexed at the point, often unequal, the outer ones being radiant. Stamens 5, alternate with the petals, and inserted with them on the outside of an epigynous disk or stylopod (Fig. 1517). Styles 2. Fruit a cremocarp (diachænium), the 2 carpels or mericarps separating when ripe by their inner faces or commissure, and being suspended by a forked carpophore (Fig. 1519); the carpels marked with ribs or ridges called juga and intervening spaces called valleculæ, and often containing vittæ (Figs. 1516 and 1518). Seed solitary, pendulous; embryo minute, in the base of horny albumen. The Sections formed from the nature of the albumen, whether flat or curved, are not now adopted, inasmuch as they are found to be unsatisfactory. In the genera, the ridges on the fruit, the presence or absence of vittæ, and the form of the albumen, are taken into account. The umbels are sometimes reduced to a sort of head by the absence of peduncles. Natives of the northern parts of the northern hemisphere, and found high on the mountains of the tropics. Species 1520. *Ill. Gen.*—Hydrocotyle, Mulinum, Sanicula, Eryngium, Cicuta, Apium, Pimpinella, Bupleurum, Æthusa, Crithmum, Pachypleurum, Angelica, Ferula, Peucedanum, Heracleum, Siler, Cuminum, Thapsia, Daucus, Elæoselinum, Caucalis, Scandix, Smyrnium, Coriandrum.

1300. The properties of Umbelliferous plants are various. Some are harmless and esculent, such as the Carrot and Parsnip; others are acro-narcotic poisons, as Hemlock; a third set are antispasmodic, owing to the presence of a gum resin containing a fetid sulphur oil, such as Assafœtida; while a fourth set are carminative from containing a volatile oil, as Caraway and Coriander.

1. Harmless Umbelliferæ, used as esculents.

Anthriscus Cerefolium, Chervil.
Apium graveolens, Celery.
Arracacha esculenta, Arracacha.
Bunium flexuosum, Earth-nut.
Carum Bulbocastanum, Pig-nut.
Crithmum maritimum, Samphire.
Daucus Carota, Carrot (Fig. 377, p. 158).
Eryngium campestre, Eryngo root.
Eryngium fœtidum, Culantra of Panama.
Fœniculum vulgare, Fennel (Figs. 1516 and 1517).
Haloscias (Ligusticum) scoticum, Scottish Lovage.
Pastinaca sativa, Parsnip.
Petroselinum sativum, Parsley.
Prangos pabularia, Fodder, in Tartary.
Sium Sisarum, Skirret.
Smyrnium Olusatrum, Alexanders.

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their faces, with 5 primary ridges or juga, and valleculæ between them. There are 4 vittæ on each side marked by dots between the ridges, and 2 on each side of the commissure. The albumen is solid, not furrowed or involute at the suture. Fig. 1517. Flower of Fennel cut vertically, showing the obsolete calyx limb, the inflected petals and the stamens outside the stylopod or epigynous disk, 2 short styles, 2 achenes, *f*, with a single pendulous ovule in each. Fig. 1518. Transverse section of cremocarp or fruit of Angelica, showing the 2 hemicarps or achenes forming it. There are 5 ridges on each achene, and the two lateral ones expand into long wings. The albumen is solid. Fig. 1519. The fruit of Fennel, separating into 2 achenes suspended by the split carpophore. Styles stylopod, and the ridges of the fruit are seen.

2. Poisonous Umbelliferæ, containing acrid and narcotic principles.

Æthusa Cynapium, Fool's Parsley (Fig. 379, p. 159), said to have produced narcotic symptoms, when taken by mistake for Parsley. It has a deflexed involucel.

Cicuta virosa, Water Hemlock or Cowbane, an aquatic plant with large air-cells at the lower part of the stem. The roots of C. maculata have caused fatal poisonous effects in America.

Conium maculatum, Hemlock, used medicinally as an anodyne, contains a very active volatile oleaginous alkali called Conia, which causes death by paralysing the muscles of respiration.

Œnanthe Crocata, Hemlock-Dropwort or Dead-tongue, a reputed poison, but, like many other Umbellifers, not found by Christison to be poisonous in all circumstances. Much depends apparently on the locality. Œ. Phellandrium, Fine-leaved Water-Dropwort, another species said to be poisonous.

3. Gum-resinous Umbelliferæ, often having a fetid odour.

Dorema Ammoniacum, or Diserneston gummiferum, a Persian plant, yields gum Ammoniac.

Ferula persica probably supplies a kind of Assafœtida. Another species seems to be the source of Sagapenum. F. orientalis yields a fetid resin in Morocco. The roots of some species of Ferula are farinaceous and esculent.

Narthex Assafœtida, a plant found in Persia and Affghanistan, furnishes the true Assafœtida. It has leaves resembling the Pæony, and its vittæ form a sort of network on the surface of the fruit.

Opoidia galbanifera and Galbanum officinale, have each been thought to yield Galbanum, mentioned in Scripture under the name Chelbenah (Exod. xxx. 34). It seems to be the Chalbane and Metopion of Dioscorides. Its source, however, is not determined.

Opoponax Chironum, or Pastinaca Opoponax, produces the gum-resin called Opoponax.

4. Aromatic and Carminative Umbelliferæ, containing volatile oil.

Archangelica officinalis, Angelica. The root and fruit are aromatic and stimulant. The tender shoots are made into an aromatic sweetmeat.

Anethum graveolens, Dill (Fig. 376, p. 158), the Greek Anethon, translated Anise in Scripture (Matt. xxiii. 23).

Carum Carui, Caraway, the achenes of which are sold under the name of Caraway seeds.

Coriandrum sativum, Coriander (Fig. 1515), the Hebrew Gad. The achenes or mericarps are sold as Coriander seeds.

Cuminum Cyminum, Cummin (Fig. 347, p. 148), the Hebrew Cummin or Kammon (Is. xxviii. 25, 27), the Greek Kuminon (Matt. xxiii. 23).

Daucus Carota, Carrot. The achenes are aromatic, and are said to be diuretic. The boiled root is often used to make poultices.

Fœniculum vulgare or F. dulce, common Fennel, and F. panmorium in India.

Levisticum officinale, Lovage, yields a gum resin resembling Opoponax. The achenes are used to make an aromatic liqueur.

Pimpinella Anisum, Anise, a different plant from the Anise of our version of the Bible, which is really Dill.

1301. Nat. Ord. 111.—Araliaceæ, or Hederaceæ, the Ivy order (Fig. 1520).—Trees, shrubs, or herbs with the habit of Umbelliferæ, from which they differ in having the ovary composed of more than 2 carpels which do not separate in fruit, but become drupaceous or baccate, and in having fleshy in place of horny albumen. They are found in tropical and sub-tropical regions. Species about 160. *Ill.*

Gen.—Panax, Aralia, Hedera, Adoxa, Gunnera, and perhaps Helwingia.

1302. The properties of the order are aromatic, stimulant, and tonic.

Adoxa Moschatellina, tuberous Moschatell, has its stamens split so that each half bears a one-celled anther.

Aralia racemosa and other species yield an aromatic gum-resin. A. nudicalis is called Wild Sarsaparilla in North America. A. papyrifera, Bok-shung of China, found in the island of Formosa, is the plant which supplies the Chinese Rice paper.

Casimiroa edulis, Zapote blanco, yields an edible fruit in Mexico.

Gunnera scabra has astringent roots which are used for tanning.

Hedera Helix, common Ivy (Fig. 1520, and Fig. 124, p. 53). Its black berries are emetic and purgative.

Helwingia ruscifolia, a Japan esculent, is referred to this order by Dr. Hooker. Lindley places it in a separate unisexual order, Helwingiaceæ, in his Garryal alliance.

Panax Schinseng is the Asiatic Ginseng root, extravagantly prized by the Chinese as a stimulant and restorative. P. quinquefolium, exported to them from America, is also used.

Fig. 1520.

1303. Nat. Ord. 112.—CORNACEÆ, the Cornel order.—Chiefly trees or shrubs, with leaves almost always opposite and exstipulate; flowers in cymes or in involucrate heads. Calyx adherent, limb 4-toothed. Petals 4, valvate in æstivation. Stamens 4, alternate with the petals. Styles united into one. Ovary 2-celled; ovules solitary, pendulous. Fruit a 2-celled drupe. Embryo in fleshy albumen. Natives of the temperate regions of Europe, Asia, and America. Species 40. *Ill. Gen.*—Benthamia, Cornus, Aucuba.

1304. The plants of this order have tonic and febrifugal properties. Some are astringent.

Aucuba japonica is a commonly cultivated Japan shrub, remarkable for its variegated leaves (p. 491).

Cornus, Dogwood. The bark of various species, as C. florida, C. sericea, and C. cir-

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Fig. 1520. Hedera Helix, Ivy, illustrating the natural order Araliaceæ. It is the Kissos of the Apocrypha (2 Maccabees vi. 7).

cinata, are used as substitutes for Cinchona in the United States. C. mascula, the Cornelian Cherry, has an austere fruit. C. suecica of the Scottish Highlands is tonic.

2. MONOPETALÆ OR GAMOPETALÆ.

1305. Nat. Ord. 113.—Loranthaceæ, the Mistleto order (Fig. 1521).—Parasitic shrubs with articulated branches, opposite, exstipulate fleshy leaves, and hermaphrodite or unisexual flowers. Calyx tube adherent to the ovary, bracteated. Corolla of 4-8 united petals. Stamens 4-8, opposite the petals. Ovary 1-celled; ovule solitary, pendulous. Fruit inferior, succulent. Albumen fleshy. In place of one order, Miers makes two, Loranthaceæ and Viscaceæ. Loranthus, which is the type of the first, has showy dichlamydeous hermaphrodite flowers, lengthened stamens, and an ovary containing a solitary suspended ovule; while Viscum, the type of the second, has small, monochlamydeous, diœcious flowers, with nearly sessile stamens, and an ovary containing 3 ovules attached to a free central placenta, one of the ovules only being perfected in the baccate fruit. Viscaceæ is placed near Santalaceæ. Natives chiefly of the equinoctial regions of Asia and America; a few are European and African. Known species 412. *Ill. Gen.*—Myzodendron, Viscum, Loranthus, Nuytsia.

Fig. 1521.

1306. Astringent properties prevail in the order. The plants are truly parasitic, and they have often a peculiar woody structure with scalariform vessels. Occasionally 2 or 3 embryos are produced in the seed.

Loranthus. The species have very showy flowers. T. tetrandrus yields a black dye in South America.

Myzodendron has long feathery seminal processes, which enable the seeds to float in the air, and afterwards aid in holding them on the branches of other plants until the radicle protrudes. The wood is deposited in concentric circles, separated by a broad zone of parenchyma, with large medullary rays. There is a great amount of scalariform tissue (Flor. Antarct. i. 298).

Nuytsia floribunda, an Australian plant, has bright orange-coloured flowers, and has been called the Fire-tree.

Viscum album, the Mistleto (Fig. 1521), produces a viscid matter in its fruit, which is used for bird-lime. This substance causes the seed of the plant to adhere to the Oak, Apple, or other trees on which it grows. Spirals are found in the part of the viscid matter next to the seed. The Druids performed peculiar ceremonies in taking this sacred plant from the Oak.

1307. Nat. Ord. 114.—Caprifoliaceæ, the Honeysuckle order (Figs. 1522 and 1523).—Shrubs or herbs, often twining, with oppo-

Fig. 1521. Viscum album, the Mistleto, a parasitic plant, illustrating the natural order Loranthaceæ. By some it is placed in a Monochlamydeous order called Viscaceæ.

site, exstipulate leaves (Fig. 1522). Calyx adherent to the ovary, limb 4-5-cleft, usually bracteated. Corolla regular or irregular. Stamens 4-5, alternate with the corolline lobes. Ovary 3-5-celled; stigmas 3-5 (Fig. 1523). Fruit usually a berry, 1 or many-celled, crowned by the calyx-lobes. Albumen fleshy. Natives chiefly of the northern parts of Europe, Asia, and America. Known species 220. *Ill. Gen.*—Linnæa, Abelia, Symphoricarpus, Leycesteria, Caprifolium, Lonicera, Viburnum, Sambucus.


Fig. 1522.


Fig. 1523.

1308. Some of the plants are astringent, others have emetic and purgative properties. Many have showy and fragrant flowers.

Linnæa borealis, two-flowered Linnæa, is a plant of northern climates, named after Linnæus. The leaves in Sweden are used as a diaphoretic.

Lonicera Periclymenum, common Honeysuckle or Woodbine, possesses emetic and purgative qualities. L. Caprifolium (Fig. 1522) has well-marked connate leaves.

Sambucus nigra, common Elder (Fig. 1523 and Fig. 396, p. 166). Its flowers yield a volatile oil, and the berries are used in making a kind of wine. Its leaves and inner bark have purgative qualities. The tree has been generally distributed over the globe. It accommodates itself to the piercing cold of Lower Canada and to the sultry sun of Trinidad and Barbadoes.

Symphoricarpus racemosus, a common garden shrub, has a white fruit which receives the name of Snowberries.

Viburnum Opulus, Gueldres Rose, is said to be emetic and cathartic. The inner bark of V. Lantana is acrid.

1309. Nat. Ord. 115.—CINCHONACEÆ, the Cinchona order (Figs. 1524 to 1527).—Trees, shrubs, or herbs with simple opposite leaves, interpetiolar glandular stipules (p. 46), and cymose inflorescence (Fig. 1524). Calyx adherent, entire, or toothed. Corolla regular. Stamens attached to the corolla. Ovary 2-celled; style 1. Fruit inferior, separating into 2 cocci, or indehiscent and dry, or succulent (Fig. 1526). Seeds definite and erect or ascending, or indefinite and attached to a central placenta; embryo small, in horny albumen. Chiefly found in tropical regions. Known species 2500. *Ill. Gen.*—Opercularia, Anthospermum, Spermacoce, Cephaelis, Psychotria, Coffea, Ixora, Mitchella, Guettarda, Hamelia, Isertia, Hedyotis, Oldenlandia, Pentas, Portlandia, Cinchona, Exostemma, Nauclea, Gardenia, Mussænda.

1310. This extensive order furnishes many important products. The plants have tonic, stimulant, febrifugal, emetic, and purgative

Figures 1522 and 1523 illustrate the natural order Caprifoliaceæ.

Fig. 1522. Lonicera Caprifolium, perfoliate Honeysuckle, with its upper connate leaves and cymose clusters of flowers. Fig. 1523. Pistil of Sambucus nigra, common Elder, with the ovary partially adherent to the tube of the calyx, which has a five-lobed limb. Three stigmas at the summit of the ovary.

properties. Some species are said to have intoxicating and even poisonous qualities. Many of the plants of the order have flowers remarkable for their beauty and odour.

Fig. 1524.

Fig. 1525.

Fig. 1526.

Fig. 1527, *a*.

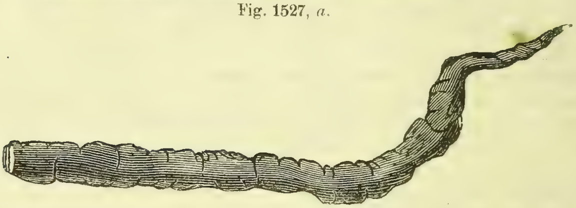

Fig. 1527, *b*.

Cephaelis Ipecacuanha (Fig. 1525), has an annulated root (Fig. 138, p. 57), which is the Ipecacuan of the Pharmacopœias. It is emetic and diaphoretic, and contains a principle called Emetine.

Cephalanthus, on account of its remarkable capitulate clusters of flowers, has received the name of Button-Bush.

Chiococca densifolia, Cahinca Root, and C. anguifuga, are reputed in Brazil as efficacious in snake bites, and powerfully emeto-cathartic.

Cinchona (Fig. 1524) is the genus which furnishes the species of Peruvian-bark trees. They contain three important alkalies, Quinine, Quinidine, and Cinchonine, combined with Kinic acid, and a peculiar variety of tannin. Some of these have a brown, and others have a white epidermis, the former being the most valuable. The most important varieties in English commerce are—Yellow or Calisaya bark, yielded by Cinchona Calisaya. Crown or Loxa Bark, by C. condaminea var. vera. Cusco Bark, by C. pubescens var. Pelletieriana. Gray or Huanuco Bark.

Figures 1524 to 1527 illustrate the natural order Cinchonaceæ.

Fig. 1524. Cinchona, the genus whence the order is named. It embraces the species of Peruvian or Jesuit's Bark. The plants have opposite leaves and interpetiolar stipules, with a 2-celled seed-vessel, and flowers in corymbose cymes. Fig. 1525. Cephaelis Ipecacuanha, with its annulated root (See Fig. 138, p. 57). Fig. 1526. Coffea arabica, the Coffee tree, a native of Arabia and the confines of Abyssinia. It has a succulent reddish-brown fruit and horny albumen, which, when roasted, supplies the beverage called Coffee. Fig. 1527, *a*. Root of Psychotria emetica, one of the false Ipecacuan roots. It is called striated or black Ipecacuan. *b*, Root of Richardsonia emetica, called White or Amylaceous Ipecacuan.

by C. nitida and C. micrantha. Huamalies or Rusty Bark, by C. condaminea var. Chatmarguera. Fibrous Carthagena Bark, by C. condaminea var. lancifolia. Hard Carthagena bark, by C. cordifolia, and Red Bark by an undetermined species. Quinine is got chiefly from Calisaya Bark, Cinchonine from Cusco, and Grey Bark, and Quinidine from several of the inferior kinds, such as the fibrous Carthagena Bark. The region of South America inhabited by Cinchonas extends over 29° of lat. according to Weddell. It represents a narrow riband, which, with its bends, describes a vast curve, following the direction of the great Cordillera of the Andes, commencing with the 19th parallel south, and generally coinciding with its eastern slope, where it maintains an elevation varying a little according to latitude, but confined within the limit of 7000-8000 feet. The middle of this curve, which is at the same time its most western limit, and nearest the coast line, is situated near Loxa, in longitude 82° west of Paris; its lower extremity touches upon long. 62°, and its upper disappears about 70°. As the bark is becoming scarce, it is of importance to extend the cultivation of the trees. C. Calisaya or the yellow bark tree has been introduced by Royle into India; some specimens were sent from the Edinburgh Botanic Garden grown from seeds supplied by Mr. Pentland.

Coffea arabica (Fig. 1526), the Coffee tree, has a succulent fruit of a reddish-brown colour when ripe. The fruit contains two seeds, which are enclosed in an endocarp called the parchment of the coffee. The hard albumen is used to furnish the well-known beverage. It contains a bitter principle called Caffeine, which is identical with Theine. The import of Coffee into Britain in 1852 was 54,377,254 lbs., of which 35,044,376 were for home consumption.

Coprosma microphylla yields the fruit called native currants in Australia.

Coutarea latiflora perhaps yields the variety of Copalchi Bark, imported from Chili under the name of Natri.

Exostemma. The species of this genus yield various kinds of false Cinchona. They have exserted stamens, while in the Cinchona the stamens are included.

Gardenia is a beautiful genus of plants extensively cultivated in hothouses for their odoriferous properties. One is called Cape Jasmine.

Genipa. Species of this genus supply edible fruits. Some yield a dye.

Guettarda speciosa is said to produce Zebra-wood, which is imported in small planks from the West Indies.

Morinda citrifolia. Its root furnishes the dye called Sooranjee, which contains a crystalline colouring matter called Morindine.

Oldenlandia umbellata. The bark of the root, under the name of Chay or Che root, is used to dye red, purple, and orange-brown.

Psychotria emetica (Fig. 1527, *a*), yields a spurious kind of Ipecacuan, called striated or black Ipecacuan.

Richardsonia scabra and R. emetica (Fig. 1527, *b*), produce the spurious Ipecacuan called white or amylaceous.

Uncaria Gambir. An astringent extract called Gambeer is prepared by the Malays from the leaves. It is a kind of Catechu.

1311. Nat. Ord. 116.—GALIACEÆ or STELLATÆ, the Madder order (Figs. 1528 to 1530).—Herbs agreeing in most points with Cinchonaceæ, and often included with them in a common order called Rubiaceæ. The chief distinguishing marks are their square stems, verticillate and exstipulate leaves. The name Stellatæ is derived from the star-like arrangement of the leaves. Some look upon the verticils as made up

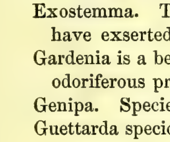

Fig. 1529.

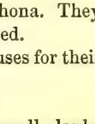

Fig. 1530.

Figures 1528 to 1530 illustrate the natural order Galiaceæ or Stellatæ.

Fig. 1528. Branch of Rubia tinctoria, Madder, showing quadrangular stem, verticillate leaves,

partly of true leaves and partly of stipules. Natives of the northern parts of the northern hemisphere and of high mountains in South America and Australia. Known species 320. *Ill. Gen.* — Vaillantia, Galium, Rubia, Crucianella, Asperula, Sherardia.


Fig. 1528.

1312. The plants supply important dyes. Some have tonic and diuretic properties, and the horny albumen is occasionally used for Coffee.

Asperula odorata, Woodruff, acquires fragrance when dried.

Galium Aparine, Goose-grass or Cleavers, is a very rough-stemmed species, the albumen of which has been employed as a substitute for Coffee. Its juice has been recommended in cutaneous diseases.

Rubia tinctorum, Madder root, a most important dye-stuff, is extensively cultivated in the south of Europe and in Holland. By particular manipulation, it gives the colour called Turkey red. Several colouring matters are got from it, probably all produced from a single yellow principle which exists in the living plant. The roots of R. cordifolia (Munjista) furnish the dye called Munjeet in India.

1313. Nat. Ord. 117.—VALERIANACEÆ, the Valerian order (Figs. 1531 to 1536).—Herbs with opposite exstipulate leaves and cymose inflorescence (Fig. 1531). Calyx superior, limb obsolete or forming a kind of pappus. Corolla tubular, 3-6 lobed, sometimes spurred at the base (Fig. 1533). Stamens 1-5, inserted on the corolla (Fig. 624, p. 229). Ovary with one cell and 2 abortive ones; ovule solitary. Fruit dry and indehiscent, with 1 fertile cell, sometimes pappose (Fig. 1534). Seed suspended (Figs. 624, p. 229, and 727, p. 251), exalbuminous. Natives of temperate climates in Europe, Asia, and America. Species 185. *Ill. Gen.*—Patrinia, Nardostachys, Valerianella, Fedia, Centranthus, Valeriana.

1314. Many of the plants in the order are strong-scented or aromatic, owing to the presence of a peculiar volatile oil. In medicine, they are employed as tonics and antispasmodics.

Centranthus ruber, Red Valerian (Fig. 556, p. 210), has one stamen and a spurred corolla. Its leaves are used as a salad.

Nardostachys Jatamansi (Figs. 1535 and 1536) appears to be the plant which sup-

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and cymose clusters of flowers. Fig. 1529. Diagram of the flower of Madder with the rim-like calycine limb, 5 parts of the corolla, 5 stamens, and a 2-celled and 2-seeded ovary. Fig. 1530. Pistil of Madder, with the adherent calyx-tube, obsolete limb in the form of a mere rim at the top of the ovary, 2 styles and 2 stigmas.

plied the Nerd or Nard of the Hebrews and the Nardos of the Greeks, and which is rendered in our translation of the Bible by the word Spikenard.

Fig. 1535.

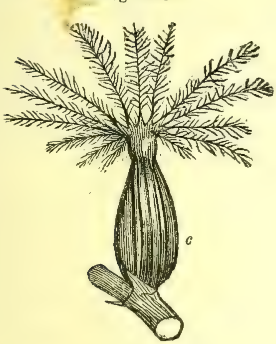

Fig. 1534.

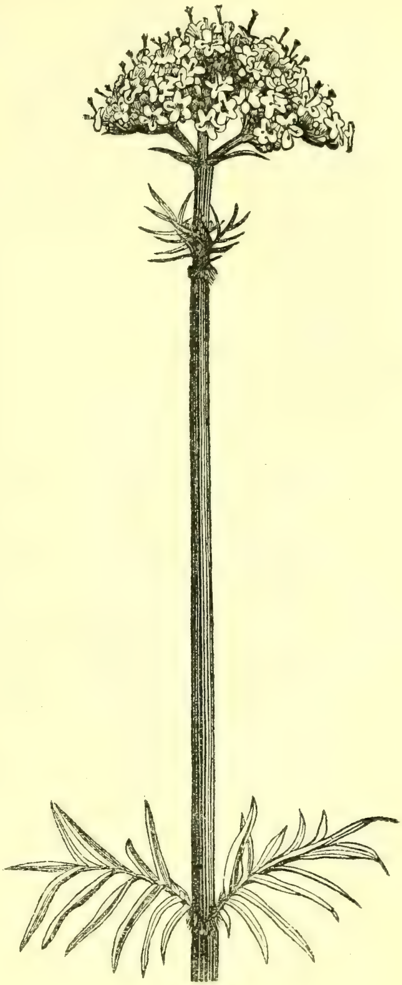

Fig. 1531.

Valeriana officinalis (Fig. 1531) furnishes the Valerian root of the druggists, which

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Figures 1531 to 1536 illustrate the natural order Valerianaceæ.

Fig. 1531. Valeriana officinalis, common Valerian, with impari-pinnate leaves, and flowers in a corymbose cyme. Fig. 1532. Diagram of Valerian, showing calycine feathery pappus, 5 lobes of the corolla, one gibbous, 3 stamens, and one perfect ovarian cell with a single ovule. Fig. 1533. Flower of Valerian, with adherent calycine tube, obsolete limb which becomes pappose, irregular corolla gibbous at the base and with a 5-lobed limb, 3 stamens, and one style with 3 stigmas. Fig. 1534. Fruit of Centranthus ruber, Red Valerian, indehiscent, containing one perfect seed (2 others being abortive), and having a feathery pappose calyx-limb at the apex. Fig. 1535. Nardostachys Jatamansi, the plant which supplied the ancient Spikenard. It is the Hebrew Nerd or Nard (Cant. i. 12, and iv. 13, 14), and the Greek Nardos (Mark xiv. 3; John xii. 3). Fig. 1536. The appearance of Spikenard, as taken from a druggist's shop in London, and figured by Dr. Royle.

yields Valerianic acid, and is used as an antispasmodic in nervous affections. V. Phu, celtica, sitchensis, Saliunca, and other species, have similar properties.

Fig. 1536.

Fig. 1532.

Fig. 1533.

Valerianella olitoria is called Lamb's Lettuce, on account of being used as a salad.

Fig. 1537.

1315. Nat. Ord. 118.—Dipsaceæ, the Teazel order (Fig. 1537). —Herbs or undershrubs, with opposite or whorled, exstipulate leaves, and flowers in capitula surrounded by an involucre (Fig. 1537). Calyx adherent, membranous, surrounded by an involucel. Corolla tubular, with an oblique 4-5-lobed limb. Stamens 4, anthers distinct. Ovary 1-celled; ovule pendulous. Fruit dry, indehiscent, crowned by the pappus-like calyx. Seed albuminous. Natives of the south of Europe, the Mediterranean, and the Cape of Good Hope. Species 150. *Ill. Gen.*—Morina, Dipsacus, Cephalaria, Knautia, Scabiosa.

1316. Some of the species are used in dressing cloth. Astringent qualities reside in some of the plants.

Dipsacus Fullonum, Fuller's Teazel. The dried heads, with their uncinate spiny

Fig. 1537. Head of flowers of Scabiosa purpurea, belonging to the natural order Dipsacaceæ. There are numerous flowers on a common receptacle, with an involucre surrounding them. The anthers are not united as in Compositæ.

bracts, are used by fullers. D. sylvestris, Wild Teazel, has connate leaves, which form by their union a cavity capable of containing a considerable quantity of water.

Scabiosa, Scabious. Many of the species are showy, and cultivated in gardens. S. succisa has astringent properties.

1317. Nat. Ord. 119.—Calyceraceæ, the Calycera order.—A small order of herbs with alternate exstipulate leaves, and capitate flowers, intermediate between Dipsacaceæ and Compositæ, differing from the former in their united filaments and partially united anthers, and from the latter in their pendulous ovule, albuminous seed, and in their anthers. They inhabit the cooler parts of South America. *Ill. Gen.*—Boopis, Calycera, Acicarpha.

1318. Nat. Ord. 120.—Compositæ or Asteraceæ, the Composite

Fig. 1539.

Fig. 1538.

Fig. 1543.

Fig. 1545.

order (Figs. 1538 to 1549).—Herbs or shrubs with alternate or opposite, exstipulate leaves, and hermaphrodite or unisexual flowers (called

Figures 1538 to 1549 illustrate the natural order Compositæ and its sub-orders Cichoraceæ, Cynarocephalæ, and Corymbiferæ.

Fig. 1538. Capitulum of Calendula officinalis, garden Marigold, showing the ligulate or semiflosculous florets of the circumference or the ray, and the tubular or flosculous florets of the centre or disk. All the florets form one indefinite inflorescence with centripetal expansion. Fig. 1539. Marigold head seen below, so as to display the involucre, *i*, composed of phyllaries surrounding the florets. Fig. 1540. Tubular or flosculous flower (floret) of Senecio Jacobæa, common Ragwort, taken from the

florets) collected into dense capitula on a common receptacle (Figs. 1538, 1547), and surrounded by a set of bracts (called phyllaries),

Fig. 1540.

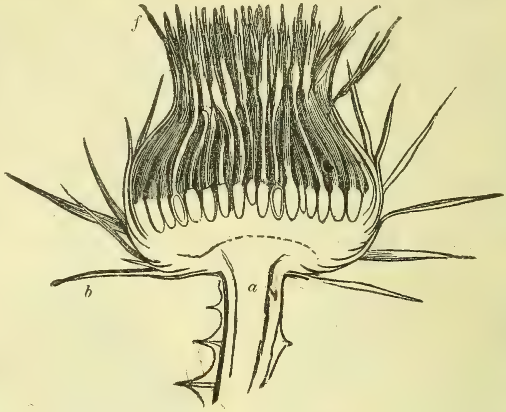


Fig. 1547.

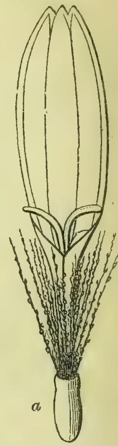


Fig. 1541.

Fig. 1546.

Fig. 1542.

Fig. 1544.

Fig. 1549.

forming an involucre (Fig. 1539), the separate florets being often furnished with bractlets in the form of chaff (called squamæ or

disk of the capitulum, showing achene, *a*, with superior pappose calyx, *c*, tubular corolla, united anthers, and forked style, *s*. Fig. 1541. Female ligulate or semiflosculous flower (floret) of Ragwort, taken from the ray of the capitulum, showing the achene, *a*, with the superior pappose calyx, the strap-shaped corolla, and the forked style. Fig. 1542. Tubular floret of Helianthus annuus, the Sunflower, showing the achene, with the adherent calycine tube, the superior bristly limb, the 5-lobed corolla, and the 5 stamens combined by their anthers (synantherous) round the style. Fig. 1543. Style of Achillæa Millefolium, Milfoil, forking so as to form 2 papillose stigmatic surfaces, which are curved outwards. Fig. 1544. Pistil of Chrysanthemum, Ox-eye, showing the inferior ribbed achene, *o*, the obsolete calyx limb, the long style, *s*, dividing at the apex, *t*. Fig. 1545. Achene of Tragopogon porrifolius, Salsafy, with the calyx limb in the form of persistent feathery (plumose) pappus. Fig. 1546. Cichorium Intybus, Chicory

*

paleæ). Calyx adherent, limb entire or toothed, or mostly expanded into a pappus (Fig. 1540). Corolla regular (Fig. 1542), or irregular (Fig. 1541). Stamens 5; anthers syngenesious (Fig. 1540). Ovary single; style 1, bifid at the apex when fertile (Fig. 1544); stigmas on the inner surface of each branch of the style (Fig. 1543). Fruit an achene, crowned with the limb of the calyx (Fig. 1545). Seed solitary, erect, exalbuminous; embryo straight. The plants are found in all parts of the world. In warm countries they sometimes assume arborescent forms. Known species between 9000 and 10,000. *Ill. Gen.*—Scolymus, Lapsana, Hyoseris, Hypochæris, Scorzonera, Lactuca, Hieracium, Vernonia, Eupatorium, Aster, Bellis, Chrysanthemum, Senecio, Cynara, Carduus, Mutisia.

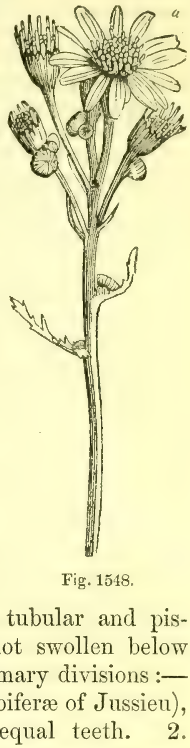


Fig. 1548.

1319. The plants of this very extensive order have been variously divided by authors. They were included by Linnæus in his class Syngenesia, the divisions of which are given at page 720. By Jussieu the following divisions have been established:—1. Cichoraceæ, the florets all ligulate and perfect. 2. Cynarocephalæ, the florets all tubular, homogamous, or those of the ray neuter; style swollen below its branches. 3. Corymbiferæ, florets of the same head all homogamous (usually tubular); or those of the circumference filiform or tubular and pistilliferous, or ligulate; style of the perfect florets not swollen below its branches. De Candolle gives the following primary divisions:—1. Tubulifloræ (embracing Cynarocephalæ and Corymbiferæ of Jussieu), hermaphrodite flowers tubular, with 5, rarely 4, equal teeth. 2. Labiatifloræ, hermaphrodite flowers, or at least the unisexual ones, two-lipped. This includes chiefly some peculiar American genera. 3. Ligulifloræ (Cichoraceæ of Jussieu), all the florets hermaphrodite and ligulate. Under these sub-orders De Candolle formed tribes from the form and nature of the style and stigma, attention being paid to the mode in which the branches of the style separate, the nature and extent of the papillæ, and the hairs on the stigmatic surface and on the style, &c.

1320. The properties of Composite plants are various. Bitterness

plant, with its compound flowers and large root, which is often mixed with Coffee. The plant illustrates the sub-order Cichoraceæ. Fig. 1547. Capitulum of Onopordum Acanthium, called Scotch Thistle by gardeners, showing the involucre, *b*, receptacle, *a*, and florets, *f*. It illustrates the sub-order Cynarocephalæ (see also Centaurea, Fig. 392, p. 163). Fig. 1548. Corymbose capitula of Senecio Jacobæa, common Ragwort. It illustrates the sub-order Corymbiferæ. Fig. 1549. Artemisia judaica, one of the plants supposed to be the Absinthium of the New Testament, translated Wormwood (Rev. viii. 11). This species, and perhaps A. romana and A. Abrotanum, may be implied in the Hebrew Laanah translated Wormwood (Deut. xxix. 18; Jer. ix. 15, xxiii. 15; Lam. iii. 15, 19; Amos v. 7, and also vi. 12, where it is translated Hemlock).

Additional figures illustrating Compositæ. Florets of Chrysanthemum and Achillæa, Fig. 491, p. 197; Fig. 543, p. 208; Fig. 553, p. 209; and Fig.55 4, p. 210. Receptacle and pappus of Dandelion, Fig. 365, p. 154.

seems to prevail in the order to a greater or less degree. This is accompanied with tonic, stimulant, aromatic, or even narcotic qualities.

Sub-order 1. CICHORACEÆ, Chicory or Lettuce Section (Fig. 1546).—The plants in this division abound in a milky juice, which has bitter, diuretic, and narcotic properties. Some are esculent vegetables and salads. They are most abundant in cold regions. Many of the plants exhibit in a marked degree the phenomena of opening and closing their capitula (page 531).

Cichorium Intybus, Chicory, or Wild Succory (Fig. 1546), is much cultivated, especially in France and Germany. Its roots are used as a substitute for Coffee, or as an addition to it. The admixture, without due indication of it, is forbidden in Britain. The leaves are made to yield a blue dye. C. Endivia is the Endive or garden Succory, the leaves of which are used as a salad when etiolated.

Lactuca virosa, Wild Lettuce, gives out abundantly a white juice which, when inspissated, constitutes the anodyne narcotic called Lactucarium, or Lettuce-opium. L. sativa, common Lettuce, also yields a similar juice, but by cultivation as a salad it loses much of its narcotic property. Both plants contain a neutral active principle called Lactucin.

Leontodon Taraxacum, common Dandelion (Fig. 361, p. 153), has a milky juice which, when concrete, has been used medicinally as a diuretic, and economically as Coffee. It contains a bitter crystalline principle, Taraxacine.

Scorzonera hispanica. The root, under the name of Scorzonera, is used as a vegetable. The roots of S. deliciosa are eaten in Sicily.

Tragopogon porrifolius, Salsafy, is also cultivated on account of its edible root. When cooked it has the taste of oysters.

Sub-order 2. CYNAROCEPHALÆ, the Artichoke or Thistle Section (Fig. 1547, and Fig. 392, p. 163).—The plants in this division are usually bitter and tonic. Some are esculent.

Arctium, Burdock. The roots of species of this genus have been employed medicinally as substitutes for Sarza.

Aucklandia Costus. This plant is found in Cashmere, and its root is said to be the ancient Costus, celebrated for its virtues. The root has an aromatic pungent odour, and is used for incense. It is known in Northern India under the name of Koosht. In Bengal it is called Puchak.

Carduus, Thistle. Many different species have been dignified with the name of Scotch Thistle. It is probable that a common species such as C. lanceolatus is most deserving of the name. Some have fixed on doubtfully native species, such as C. Marianus (Silybum Marianum), to represent Scotland; and at present gardeners employ for this purpose a Thistle belonging to another genus, Onopordum Acanthium (Fig. 1547).

Carthamus tinctorius, Safflower. The dried flowers yield a pink dye.

Cynara Scolymus, common Artichoke. The succulent receptacle is the part used for food. C. Cardunculus, Cardoon, is another esculent vegetable.

Sub-order 3. CORYMBIFERÆ, the Chamomile Section (Fig. 1548).—The plants of this division are bitter and aromatic. They usually contain more or less of a volatile oil.

Anacyclus Pyrethrum, Pellitory of Spain, is used medicinally to promote the flow of saliva. A. officinarum has similar properties.

Anthemis nobilis, Chamomile. The odoriferous flowers are used for fomentation. A warm watery infusion of them acts as an emetic and diaphoretic. The extract and cold infusion are bitter tonic.

Arnica montana, Leopard's-bane, or Mountain Tobacco, has been given in nervous diseases as an acrid stimulant.

Artemisia Absinthium, Wormwood, is bitter stomachic. A. Contra, Vahliana, and other species (Fig. 1549), are used as anthelmintics, under the name of Wormseed. Some of the species are used in the preparation of beer, vinegar, and liqueurs such as the Crême d'Absinthe.

Celmisia coriacea, a New Zealand plant, has a woolly epidermis on its leaves, which is spun into threads and woven into fabric.

Ceradia furcata is a peculiar coral-like plant, found on the west coast of Africa, and yielding a resinous matter called African bdellium.

Dahlia variabilis has been made by cultivation to assume all varieties of colour. Both tubular and ligulate florets become quilled. The plant belongs to the xanthic series, and hence we have not a blue Dahlia.

Gnaphalium. Many species of this and other allied genera, in consequence of their dry involucres, constitute what are called everlasting flowers. G. orientale is much used in Pere-la-Chaise. Many beautiful species are brought from the Cape of Good Hope.

Helianthus annuus, common Sunflower. Its achenes have been used for Coffee. H. tuberosus is the well-known Jerusalem (Girasole) Artichoke.

Helichrysum cochleariforme, or a species closely allied to it, is given in infusion to consumptive patients at the Cape of Good Hope, under the name of Boschesh Tea.

Inula Helenium, Elecampane, is an aromatic plant which has been used as a tonic and diuretic. It contains a starchy matter called Inuline.

Lychnophora Pinaster is a peculiar Composite plant, having the appearance of a Scotch Fir. A species on the mountains of Minas Geraes in Brazil, is a shrub six feet high, having horizontal branches and narrow leaves six inches long. The whole plant except the upper side of the leaves is covered with a dense coat of long brownish-coloured wool, which is often collected and used for beds and pillows.

1321. Nat. Ord. 121.—Brunoniaceæ, the Brunonia order.—Herbs with radical exstipulate leaves, and capitulate, involucrate flowers supported on scapes. Calyx free, in 5 divisions. Corolla 5-parted, inserted at the base of the calyx. Stamens inserted with the corolla. Ovary 1-celled; ovule solitary; stigma enclosed in a 2-valved cup. Fruit a utricle, enclosed in the hardened calycine tube. Seed erect, exalbuminous. Australian plants. Species 2. *Ill. Gen.*—Brunonia.

1322. Nat. Ord. 122.—Goodeniaceæ, the Goodenia order.—Herbs, rarely shrubs, not lactescent, with scattered exstipulate leaves, and distinct, not capitate flowers. Calyx usually superior, 3-5-divided. Corolla more or less superior, usually irregular, with a split tube and a 5-parted lipped limb; æstivation conduplicate. Stamens 5, separate. Ovary 1-2-celled; placenta free, central; stigma surrounded by an indusium. Fruit capsular or drupaceous. Seeds albuminous. Natives chiefly of Australia and the islands of the southern ocean. Species about 150. *Ill. Gen.*—Selliera, Goodenia, Leschenaultia, Scævola, Dampiera.

1323. Some of the plants are used as esculent vegetables, and their pith is employed for economical purposes.

Scævola Taccada is the plant which furnishes the Rice-paper of the Malay Archipelago. Its leaves, when young, are eaten as pot-herbs. Its fruit is drupaceous.

1324. Nat. Ord. 123.—Stylidiaceæ, the Stylewort order (Fig. 1550).—Herbs or undershrubs, with scattered or whorled exstipulate leaves. Calyx adhe-

Fig. 1550.

Fig. 1550. Stylidium tenuifolium, slender-leaved Stylewort, with its narrow scattered leaves.

rent, with 2-6 divisions. Corolla usually irregular, 5-6-divided; æstivation imbricate. Stamens 2; filaments united with the style into a column; anther-lobes on the top of the column lying over the stigma. Ovary usually 2-celled, often with 1 or 2 epigynous glands in front. Fruit usually a 2-celled and 2-valved capsule. Seeds albuminous. Peculiar plants, remarkable for their gynandrous structure and for their irritable column (p. 557). Natives chiefly of the swamps of Australia. Species 121. *Ill. Gen.*—Stylidium, Forstera.

1325. Nat. Ord. 124.—CAMPANULACEÆ, the Hare-bell order (Figs. 1551 to 1555).—Lactescent herbs or undershrubs, with alternate exsti-

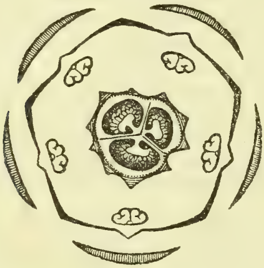


Fig. 1551.

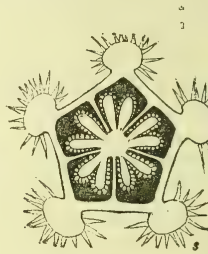


Fig. 1555.

Fig. 1552.

Fig. 1554.

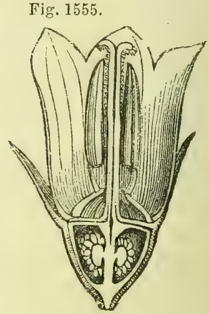


Fig. 1553.

pulate leaves, and usually showy blue or white flowers (Fig. 394, p. 165). Calyx superior, limb commonly 5-cleft, persistent (Fig. 1553). Corolla regular, companulate, usually 5-lobed, marcescent (Fig. 1552). Stamens 5, distinct. Style with collecting hairs (Fig. 1554 and Fig. 109, p. 45). Fruit a 2 or many celled capsule, loculicidal, dehiscing by openings at the sides or by valves at the apex. Seeds numerous,

panicled cymose flowers, irregular epigynous corolla, and irritable column, formed by the union of stamens and style. The column projects from the flower, and, when irritated, moves from one side of the flower to the other.

Figures 1551 to 1555 illustrate the natural order Campanulaceæ.

Fig. 1551. Diagram of the flower of Campanula Rapunculus, Rampion, showing 5 divisions of the calycine limb, 5 reduplicately-valvate divisions of the corolla, 5 stamens, alternating with the corolline lobes, and a 3-celled ovary. Fig. 1552. Bell-shaped corolla of Campanula Rapunculus with superior calyx. Fig. 1553. Vertical section of the flower of Campanula Medium; superior calyx, ovary with central placenta and numerous seeds, stamens with filaments dilated at the base, and anthers applied to the collecting hairs on the style. Fig. 1554. Style with collecting hairs. Fig. 1555. Section of ovary of Campanula Medium, showing 5 cells and numerous ovules attached to processes proceeding from the central placenta.

albuminous, attached to a central placenta (Fig. 1555). Chiefly natives of the northern parts of Europe, Asia, and North America. Those with capsules opening by lateral pores appear to be natives of the northern hemisphere; those with apicilar valves, of the southern. Known species 500. *Ill. Gen.*—Jasione, Lightfootia, Canarina, Wahlenbergia, Prismatocarpus, Phyteuma, Campanula, Specularia, Musschia, Cyphia.

1326. The Bellworts have an acrid milky juice, but occasionally the young shoots and roots are cultivated as articles of food.

Campanula, Hare-bell, has many species which are admired for their beauty. C. Rapunculus, Rampion, is used as an esculent vegetable.

Cyphia glandulifera. Its tubers are farinaceous, and are eaten in Abyssinia. Those of C. digitata are used by the Hottentots.

1327. Nat. Ord. 125.—Lobeliaceæ, the Lobelia order.—Lactescent herbs or shrubs, with alternate, exstipulate leaves. Calyx superior, limb often 5-lobed. Corolla irregularly 5-lobed, often deeply cleft. Stamens 5, epigynous, synantherous. Stigma fringed. Fruit capsular, 1 or more celled, dehiscing at the apex. Seeds numerous, albuminous. Natives chiefly of tropical or subtropical climates. Species 375. *Ill. Gen.*—Clintonia, Lobelia, Tupa, Siphocampylus, Delissea, Colensoa.

1328. The Lobeliads have usually an acro-narcotic milky juice, and hence the species are often poisonous. The milky juice is sometimes used for caoutchouc.

Lobelia inflata, a North American species, is used medicinally under the name of Indian Tobacco. Its properties are antispasmodic and sedative, as well as expectorant and emetic. The root of L. syphilitica has emetic properties. L. urens, a native of the South of England and other parts of Europe, has blistering qualities.

Tupa. Some of the species are said to be dangerous poisons.

Fig. 1556.

1329. Nat. Ord. 126.—Styracaceæ or Symplocaceæ, the Storax order (Fig. 1556).—Trees or shrubs, with alternate, exstipulate leaves, usually with stellate tomentum. Calyx free, persistent, with 5 or 4 lobes, or entire. Corolla 5 or 10 divided. Stamens definite or indefinite, arising from the corolla, more or less cohering. Ovary 3-5-celled. Ovules partly erect and partly pendulous. Fruit succulent, enclosed by the calyx, often unilocular by abortion. Seeds albuminous. Miers divides this into two orders, Styracaceæ and Symplocaceæ, the former differing in their uniserial stamens,

Fig. 1556. Styrax officinale, the Storax tree, a native of Syria and Arabia. It seems to be the Hebrew Libneh, translated Poplar, Gen. xxx. 37, and Hos. iv. 13.

linear anthers, superior ovary, free central placenta, one-seeded drupe, and stellate hairs. Sparingly distributed, chiefly in tropical and sub-tropical regions. Species about 120. *Ill. Gen.*—Styrax, Halesia, Pamphilia, Symplocos, Hopea.

1330. Some of the plants are bitter and aromatic, others yield a fragrant stimulant resin.

Halesia. The species are natives of America, and from the appearance of their flowers receive the name of Snow-drop trees.

Styrax Benzoin, a tree of the Malay Archipelago, produces the concrete balsamic exudation Benzoin, which is employed medicinally as an expectorant, and is also used for incense. S. officinale (Fig. 1556), a native of Syria, produces the resin called Storax, which is prescribed as a pectoral remedy. The tree is probably the Hebrew Libneh, translated in our version of the Bible, Poplar. Both these balsamic resins contain Benzoic acid. A fragrant secretion from S. reticulata is also used as frankincense.

Symplocos tinctoria has sweet leaves, which are used as a dye. The leaves of S. Alstonia are sometimes employed as Tea.

1331. Nat. Ord. 127.—Columelliaceæ, the Columellia order.—Evergreen shrubs or trees, with opposite exstipulate leaves and yellow flowers. Calyx adherent, 5-parted. Corolla rotate, 5-8-parted. Stamens 2, on the corolla. Anthers sinuous. Disk epigynous. Fruit a 2-celled polyspermal capsule. Seeds albuminous. A small and doubtful order, placed by Lindley in his Cinchonal Alliance. Natives of Mexico and Peru. Species 3. *Ill. Gen.*—Columellia.

1332. Nat. Ord. 128.—Vacciniaceæ, the Cranberry order.—Shrubs with alternate exstipulate leaves. Calyx superior. Corolla 4-6-lobed. Anthers biporose, with appendages. Fruit succulent, 4-10-celled. Seeds albuminous. The order differs from Ericaceæ chiefly in its epigynous calyx. Natives of temperate regions, and found often in sub-alpine swamps. Species 200. *Ill. Gen.*—Gaylussacia, Oxycoccus, Vaccinium, Thibaudia.

1333. Astringent properties prevail in the order. The berried fruit is subacid and eatable.

Oxycoccus palustris (Vaccinium Oxycoccus), a marsh plant, produces the Cranberry in Britain. O. macrocarpa is the American Cranberry.

Thibaudia. The species help to form the shrubby region of the Andes. The fruit of some is used as food, and for making wine.

Vaccinium Myrtillus is the Bilberry or Blaeberry. V. Vitis Idæa, Red Whortleberry or Cowberry, is used as a substitute for the Cranberry. V. uliginosum produces the Black Whortleberry of Highland districts.

1334. Analysis of the natural orders of Calycifloral Exogens, with references to the numbers of the orders in the preceding pages.

A. POLYPETALOUS ORDERS.

I. Flowers Polyandrous. Stamens more than 20.

1. Ovary wholly superior.

a. Leaves exstipulate (without stipules).

Carpels more or less distinct or solitary.

Ovules suspended or ascending .... Rosaceæ, 76.

Ovule attached by a cord to the base of the cell ... Anacardiaceæ, 71.

Carpels combined into a solid pistil, with more placentas than one.
Calyx of two sepals cohering at the base .... Portulacaceæ, 97.
Calyx of more than two sepals, tubular, permanent Lythraceæ, 78.
b. Leaves stipulate (with stipules).
Carpels more or less distinct or solitary.
Calyx with the odd lobe inferior .... Leguminosæ, 74.
Calyx with the odd lobe superior .... Rosaceæ, 76.
Carpels combined into a solid pistil, with more placentas than one.
Placentas in the axis .... Portulacaceæ, 97.
2. Ovary inferior, or partially so.
a. Leaves exstipulate.
Placentas parietal.
Petals definite, distinct from the calyx, hooded ...... Loasaceæ, 91.
Petals indefinite, passing into the sepals .... Cactaceæ, 102
Placentas in the axis.
Leaves with transparent dots.
Ovary 1-celled, cotyledons not distinct .... Chamælauciaceæ, 86.
Ovary more than 1-celled, cotyledons distinct ... Myrtaceæ, 85.
Leaves without dots.
Petals indefinite .... Mesembryanthemaceæ, 100.
Petals definite.
Petals linear, reflexed .... Alangiaceæ, 83.
Petals round and concave.
Style one, stigma capitate .... Barringtoniaceæ, 88.
Styles and stigmas more than one .... Philadelphaceæ, 84.
b. Leaves stipulate.
Carpels more or less distinct or solitary.
Carpels covered by the calyx .... Rosaceæ, 76.
Carpels combined into a solid pistil.
Leaves opposite .... Rhizophoraceæ, 79.
Leaves alternate; fruit a pyxis .... Lecythidaceæ, 87.

II. Flowers Oligandrous. Stamens fewer than 20.

1. Ovary wholly superior.
a. Leaves exstipulate.
Carpels more or less distinct or solitary.
Carpels, each with a hypogynous scale .... Crassulaceæ, 99.
Carpels without hypogynous scales.
Carpels several, all perfect .... Calycanthaceæ, 77.
Carpels solitary, or all but one imperfect.
Leaves dotted .... Amyridaceæ, 72.
Leaves not dotted.
Plants with resinous juice .... Anacardiaceæ, 71.
Plants without resinous juice .... Connaraceæ, 73.
Carpels combined (at least by their ovaries) into a solid pistil.
Placentas parietal.
Flowers unisexual .... Papayaceæ, 93.
Flowers hermaphrodite .... Turneraceæ, 96.
Placentas in the axis.
Styles distinct to the base.
Carpels, each with a hypogynous scale .... Crassulaceæ, 99.
Carpels two, without scales............................ Saxifragaceæ, 105.
Styles more or less combined.
Calyx imbricate.
Sepals two .... Portulacaceæ, 97.

Sepals more than two.
Ovules ascending .... Celastraceæ, 68.
Ovules suspended.................................. Bruniaceæ, 108.
Calyx valvate or open.
Stamens opposite to the petals, isomerous ... Rhamnaceæ, 70.
Stamens alternate with the petals, if isomerous Lythraceæ, 78.
b. Leaves stipulate.
Carpels distinct or solitary.
Fruit leguminous; odd sepal inferior .... Leguminosæ, 74.
Fruit not leguminous; odd sepal superior .... Rosaceæ, 76.
Carpels combined (at least by their ovaries) into a solid pistil.
Placentas parietal.
Flowers with a ring of appendages (abortive petals) Passifloraceæ, 95.
Flowers without a ring of appendages .... Moringaceæ, 75.
Placentas in the axis.
Styles distinct to the base.
Petals minute.. Illecebraceæ, 98.
Petals conspicuous.
Leaves opposite .... Cunoniaceæ, 107.
Leaves alternate .... Saxifragaceæ, 105.
Styles more or less combined.
Calyx imbricate.
Flowers spurred .... Vochysiaceæ, 80.
Flowers not spurred.
Leaves simple .... Stackhousiaceæ, 67.
Leaves compound .... Staphylæaceæ, 69.
Calyx valvate or open.
Stamens opposite to the petals, isomerous ... Rhamnaceæ, 70.
Stamens alternate with the petals, if isomerous Amyridaceæ, 72.
2. Ovary inferior, or partially so.
a. Leaves exstipulate.
Placentas parietal.
Fruit baccate .... Grossulariaceæ,103.
Placentas in the axis.
Flowers in umbels.
Styles two .... Umbelliferæ, 110.
Styles three or more .... Araliaceæ, 111.
Flowers not in umbels.
Carpel solitary.
Plants parasitic .... Loranthaceæ, 113.
Plants not parasitic.
Petals linear, reflexed .... Alangiaceæ, 83.
Petals oblong.
Plants with resinous juice .... Anacardiaceæ, 71.
Plants without resinous juice.
Cotyledons convolute .... Combretaceæ, 81.
Cotyledons flat .... Halorageaceæ, 90.
Carpels more than one.
Calyx limb minute, inconspicuous.................. Halorageaceæ, 90.
Calyx limb evident.
Carpels divaricating at the apex.
Leaves alternate; herbs .... Saxifragaceæ, 105.
Leaves opposite; shrubs .... Hydrangeaceæ,106.
Carpels not divaricating, combined.
Calyx valvate.
Embryo curved .... Tetragoniaceæ, 101.
Embryo straight.

Stamens opposite the petals, isomerous............ Rhamnaceæ, 70.
Stamens alternate with the petals, if isomerous.
Albumen none .... Onagraceæ, 89.
Albumen copious .... Cornaceæ, 112.
Calyx not valvate.
Stamens doubled downwards, anthers elongated, leaves ribbed .... Melastomaceæ, 82.
Stamens not doubled down, anthers short.
Seeds very numerous, minute .... Escalloniaceæ, 104.
Seeds few, 1-4 .... Bruniaceæ, 108.

b. Leaves stipulate.
Placentas parietal.
Stipules cirrhose .... Cucurbitaceæ, 92.
Placentas in the axis.
Stamens opposite the petals, isomerous ... . Rhamnaceæ, 70.
Stamens alternate with the petals, if isomerous.
Leaves opposite.. Rhizophoraceæ, 79.
Leaves alternate ....Hamamelidaceæ, 109.

B. GAMOPETALOUS ORDERS.

1. Ovary superior.

a. Leaves exstipulate.
Carpel solitary.
Stigma with a cuplike indusium.............. Brunoniaceæ, 121.
Carpels more than one.
Carpels distinct.. Crassulaceæ, 99.
Carpels combined.
Flowers unisexual .... Papayaceæ, 93.
Flowers hermaphrodite .... Styracaceæ, 126.

b. Leaves stipulate.
Stipules minute .... Stackhousiaceæ, 67.

2. Ovary inferior.

a. Carpel solitary.
Anthers united.
Ovule pendulous .... Calyceraceæ, 119.
Ovule erect... Compositæ, 120.
Anthers free.
Fruit a single achene, without any rudimentary ones.
Fruit crowned with the calyx, and covered with an involucel .... Dipsacaceæ, 118.
Fruit not crowned, and without involucel.. Loranthaceæ, 113.
Fruit an achene, with the rudiments of two others .... Valerianaceæ, 117.

b. Carpels more than one.
Leaves exstipulate.
Anthers united .... Lobeliaceæ, 125.
Anthers free.
Stamens two .... Columelliaceæ, 127.
Stamens more than two.
Anthers opening by pores .... Vacciniaceæ, 128.
Anthers opening by slits.
Stigma with an indusium .... Goodeniaceæ, 122.
Stigma without an indusium.
Flowers pentandrous or tetrandrous.
Leaves alternate .... Campanulaceæ, 124.

Leaves opposite	Caprifoliaceæ, 114.
Leaves verticillate	Galiaceæ, 116.
Flowers polyandrous	Belvisiaceæ, 94.
Flowers gynandrous	Stylidiaceæ, 123.
Leaves stipulate.	
Stipules interpetiolary	Cinchonaceæ, 115.
Stipules cirrhose	Cucurbitaceæ, 92.

In some Calycifloral Exogens the insertion of the stamens is so near the base of the calyx, that it is difficult to separate them from Thalamifloral Exogens. This may be seen in Leguminosæ and Portulacaceæ. Occasionally the petals are abortive, so that the plants become monochlamydeous. The orders in which this anomaly occurs are:—Celastraceæ, Rhamnaceæ, Amyridaceæ, Leguminosæ, Rosaceæ, Lythraceæ, Combretaceæ, Myrtaceæ, Halorageaceæ, Passifloraceæ, Portulacaceæ, Illecebraceæ, Tetragoniaceæ, Saxifragaceæ, Cunoniaceæ, and Loranthaceæ.

SUB-CLASS 3.—COROLLIFLORÆ.

1. HYPOSTAMINEÆ.

1335. Nat. Ord. 129.—Ericaceæ, the Heath order (Figs. 1557 to 1559.)—Shrubs or undershrubs with evergreen, rigid, entire, whorled

Fig. 1557.

Fig. 1558.

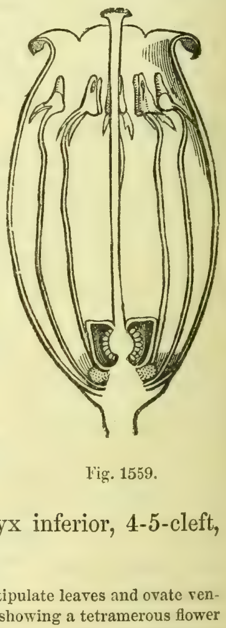


Fig. 1559.

or opposite, exstipulate leaves (Fig. 1557). Calyx inferior, 4-5-cleft,

Figures 1557 to 1559 illustrate the natural order Ericaceæ.

Fig. 1557. Erica cinerea, fine-leaved Heath, showing its entire exstipulate leaves and ovate ventricose corolla with a 4-divided limb. Fig. 1558. Diagram of Erica, showing a tetramerous flower having 4 divisions of the calyx and corolla, 8 stamens, and a 4-valved capsule. Fig. 1559. Vertical section of the flower of Erica, showing calyx, corolla, hypogynous stamens with porose, appendiculate anthers, and ovary with axile placenta and numerous ovules.

persistent. Corolla 4-5-cleft. Stamens 8-10 or twice these numbers, hypogynous (Fig. 1559). Anthers 2-celled, biporose, with appendages. Ovary surrounded by a disk or scales. Fruit capsular, rarely baccate. Seeds numerous, with an adherent testa, and cylindrical embryo in the axis of fleshy albumen. There are 2 divisions of the order, according to Lindley.—1. Ericeæ, fruit loculicidal, rarely septicidal or berried; buds naked. 2. Rhododendreæ, fruit capsular, septicidal; buds scaly, resembling cones. They abound at the Cape of Good Hope, and occur also in Europe, America, and Asia. There are about 850 known species. *Ill. Gen.*—Erica, Macnabia, Calluna, Menziesia, Phyllodoce, Dabœcia, Andromeda, Clethra, Epigæa, Gaultheria, Arbutus, Enkianthus, Arctostaphylos, Azalea, Kalmia, Rhodothamnus, Rhododendron, Befaria, Ledum.

1336. Some of the Heathworts are astringent, others have edible fruit, and others, such as species of Rhododendron, Kalmia, and Ledum, are poisonous. The species of Erica have no active properties.

Andromeda polifolia, found in marshes in Britain, is said to be poisonous.

Arbutus Unedo bears a fleshy fruit like a Strawberry, and hence it is called the Strawberry tree. It is common on the islands at the Lakes of Killarney. It is recommended as an astringent in Leucorrhœa.

Arctostaphylos Uva-Ursi, Bearberry, is an astringent. An infusion of its leaves is prescribed in discharges from the mucous membrane of the bladder. The plant grows at considerable elevations on the British mountains, and also comes down to near the sea level. The berries of A. alpina are used as food.

Azalea pontica is said to be the plant which supplied poisonous honey in the retreat of the 10,000, as mentioned by Xenophon.

Calluna vulgaris, the common Heather. This genus differs from Erica in having a septicidal capsule.

Erica. This genus has its maximum at the Cape of Good Hope. It has been remarked by Humboldt, that of the 430 known species of Erica, only one has been discovered across the whole extent of the New World from Pennsylvania and Labrador to Nootka Sound and Alashka. In Britain there are six species; of these, E. Tetralix and cinerea (Fig. 1557), are common everywhere, E. mediterranea and Mackayi are confined to Connemara in Ireland, while E. ciliaris and vagans are found both in England and Ireland.

Rhododendron Chrysanthum, found in Siberia, has marked narcotic properties. R. ferrugineum and hirsutum, under the name of Rose of the Alps, form a shrubby belt on the Swiss mountains. Some Rhododendrons, such as R. Dalhousiæ, are epiphytic. R. nivale was found by Dr. Hooker on the mountains of the Thibetan frontier, at an elevation of 16,000 to 18,000 feet. Major Madden says that R. arboreum in Kumaon attains a height of 40 feet, with a circumference of 16 feet.

1337. Nat. Ord. 130.—Pyrolaceæ, the Wintergreen order.—Herbs, with simple leaves, generally included as a sub-order of Ericaceæ, but distinguished by their habit, their more or less declinate styles, loose testa, and minute embryo at the base of fleshy albumen. Natives of northern countries. Chimaphila umbellata is tonic and diuretic. Species 20. *Ill. Gen.*—Cladothamnus, Chimaphila, Pyrola.

1338. Nat. Ord. 131.—Monotropaceæ, the Fir-Rape order.—Parasitic plants of a brown colour, allied to Pyrolaceæ, but differing in their scaly stems, in the longitudinal dehiscence of their anthers, and in their minute embryo being at the apex of the albumen. They are also considered by many as a sub-order of Ericaceæ, from which their habit, their antherine dehiscence, loose testa, and minute embryo, separate them. Chiefly found parasitic on Firs in Europe, Asia, and North America. Species 10. *Ill. Gen.*—Monotropa, Hypopithys.

1339. Nat. Ord. 132.—Epacridaceæ, the Epacris order.—Shrubby plants, with usually alternate, simple, and parallel-veined leaves, having overlapping bases;. flowers commonly pentamerous. They represent the Heaths in Australia, and differ from Ericaceæ principally in having one-celled anthers without appendages. Natives of the Indian Archipelago and Australia. They are cultivated for the beauty of their flowers. The baccate species supply edible fruits in general. Astroloma humifusum is called Tasmannian Cranberry, and Leucopogon Richei is one of the plants called native Currants. Species 320. *Ill. Gen.*—Epacris, Sprengelia, Dracophyllum, Styphelia, Acrotriche.

2. EPICOROLLÆ OR EPIPETALÆ.

1340. Nat. Ord. 133.—Ebenaceæ, the Ebony order (Fig. 1560).—Trees or shrubs not lactescent, with alternate, exstipulate, coriaceous, entire leaves, and polygamous flowers. Calyx 3-7-cleft, persistent. Corolla 3-7-cleft, often pubescent. Stamens usually twice or quadruple the number of the corolline segments; anthers with longitudinal dehiscence. Ovary 3 or several celled; style with as many divisions; ovules 1 or 2 in each cell, pendulous. Fruit a round or oval berry; seeds large and bony, albuminous. Chiefly tropical plants. Many are found in India, a few in colder climates. Species 160. *Ill. Gen.*—Royena, Diospyros, Maba, Cargilia.

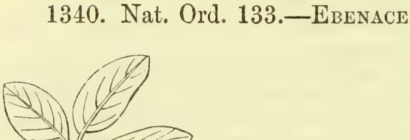


Fig. 1560.

1341. The trees of this order are remarkable for their hard and valuable timber. The bark of some of the species is astringent, while the fruit is in many cases eatable.

Diospyros. The heartwood of several species of this genus constitute different kinds of Ebony. D. Ebenus (Fig. 1560) furnishes the Mauritius Ebony; D. Melanoxylon, the Ebony of Coromandel; D. Ebenaster, the bastard Ebony of

Fig. 1560. Diospyros Ebenus, the Ebony tree, belonging to the Nat. Ord. Ebenaceæ. It seems to be the Hebrew Hobnim, translated Ebony in Ezek. xxvii. 15.

Ceylon; and D. hirsuta, the variegated Calamander wood of Ceylon. D. Kaki produces an edible plum-like fruit called in Japan Keg-fig. D. virginiana, the Persimmon, has an austere fruit, which becomes sweet in the progress of ripening, more especially after frost. The bark of the tree is astringent.

1342. Nat. Ord. 134.—AQUIFOLIACEÆ or ILICACEÆ, the Holly order (Fig. 248, p. 112).—Evergreen trees or shrubs, with coriaceous, exstipulate leaves, and small axillary flowers. Calyx of 4-6 sepals. Corolla 4-6-parted. Stamens 4-6, alternate with the corolline segments; anthers dehiscing longitudinally. Ovary 2-6-celled; a single pendulous ovule in each cell. Fruit fleshy, containing from 2 to 6 nucules. Embryo minute in fleshy albumen. Natives of various parts of the world, but sparingly distributed. Species 110. *Ill. Gen.* —Cassine, Ilex, Prinos, Byronia.

1343. Bitter, tonic, astringent, and emetic properties exist in the order. Some are used in the same way as tea.

Ilex Aquifolium, the common Holly (Fig. 248, p. 112), has a tonic bark, which has been used in intermittents. Its berries cause vomiting and purging. Bird-lime is obtained from its bark. I. paraguayensis is called Maté in South America, where its leaves are used for tea, which is called Congonha. They contain Theine. The plant is used universally throughout Brazil, Uraguay, Paraguay, the Plate District, Chili, and Peru. The leaves of I. vomitoria are used in the preparation of the black drink of the Creek Indians.

Prinos verticillatus is used as a tonic in North America.

1344. Nat. Ord. 135.—SAPOTACEÆ, the Sapodilla order.—Trees or shrubs, often with milky juice, alternate, coriaceous, entire, exstipulate leaves, and hermaphrodite flowers. Calyx 4-8-parted. Corolla 4-8-cleft, sometimes with numerous segments. Stamens definite, half of them petaloid and sterile; anthers extrorse. Ovary 4-12-celled, with a single pendulous ovule in each cell; style 1. Fruit baccate. Seeds with a bony testa, usually albuminous. Natives of the tropics chiefly. Species 212. *Ill. Gen.*—Chrysophyllum, Sapota, Achras, Isonandra, Bassia, Mimusops.

1345. The fruit of many of the plants of this order is edible. The bark is bitter and febrifugal. Some furnish caoutchouc, and others fatty matter.

Achras Sapota produces the edible Sapodilla Plum; A. mammosa, the fruit called Marmalade. The seeds of the former are aperient, and its bark is febrifugal.

Bassia butyracea has an oily fruit which furnishes a kind of butter used in Nipal. The Shea, or Galam butter of Mungo Park, is the product of another species. The flowers of Bassia latifolia, the Mahoua, are collected after they fall, and are used for food, and for the distillation of spirits. A single tree will yield 200 to 400 lbs. of flowers. The fruit of B. longifolia gives oil for lamps.

Chrysophyllum. The species of this genus supply fruit for dessert. C. Cainito is the Star-apple.

Isonandra Gutta is the Taban-tree, which furnishes Gutta Percha.

Mimusops. The species have edible fruits, some of which, as that of M. Elengi, are said to be excellent. The flowers of this plant are aromatic, and its seeds are oily.

1346. Nat. Ord. 136.—MYRSINACEÆ, the Myrsine order.—Trees or shrubs, with coriaceous, exstipulate, smooth leaves, and flowers often marked with glandular dots or lines. Calyx and corolla 4-5-cleft. Stamens 4-5, opposite the corolline segments, occasionally 5 alternate sterile ones. Ovary unilocular, with a free central placenta in which the ovules are imbedded. Fruit fleshy. Seeds 1 or more, with horny albumen. The plants are said to resemble Primulaceæ in everything except their arborescent habit, fleshy fruit, and pitted placenta. They are limited in their geographical range, and abound in islands with an equable temperature, as the islands of the Indian Ocean, Mauritius, Bourbon, and Madagascar. Many of them are handsome evergreen shrubs. The seeds of Theophrasta Jussiæi supply flour for bread in St. Domingo, and the fruit of Myrsine africana is mixed with barley for the food of asses in Abyssinia. Species about 320. *Ill. Gen.*—Mæsa, Embelia, Myrsine, Ardisia, Jacquinia, Theophrasta.

1347. Nat. Ord. 137.—JASMINACEÆ, the Jasmine order.—Shrubs, often twining, with opposite or alternate, usually compound leaves. Calyx and corolla regular, with 5-8 divisions. Stamens 2, included within the hypocrateriform corolla. Ovary 2-celled. Fruit a double berry or capsule. Seeds with little or no albumen and a straight embryo. Natives principally of tropical India. They are remarkable for their fragrance. The oil of Jasmine is obtained from Jasminum officinale and J. grandiflorum. The flowers of Nyctanthes Arbor-tristis are valued as a perfume in India. Species 100. *Ill. Gen.*—Jasminum, Nyctanthes, Monodora.

1348. Nat. Ord. 138.—OLEACEÆ, the Olive order (Figs. 1561 to 1564.)—Trees or shrubs with opposite, simple, or pinnate leaves. Calyx persistent, sometimes 0. Corolla 4-cleft, sometimes of 4 petals connected in pairs, sometimes 0. Stamens usually 2 (Fig. 1563). Ovary 2-celled; ovules 2, pendulous in each cell. Fruit fleshy (Fig. 1562) or dry, often 1-seeded by abortion (Fig. 1564.) Seeds albuminous; embryo straight. Natives of temperate climates. Species 130. *Ill. Gen.*—Chionanthus, Olea, Phillyrea, Ligustrum, Fraxinus, Ornus, Syringa.

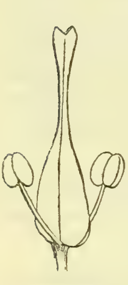


Fig. 1563.

Fig. 1564.

1349. Some of the plants of the order have emollient and laxative properties; others are bitter, tonic, and febrifugal. Some supply oil, others manna.

Fraxinus excelsior, the Ash. This is distinguished by its samaroid fruit. It yields a sweet secretion. Its bark is febrifugal. Its leaves have been recommended in gout and rheumatism.

Figures 1561 to 1564 illustrate the natural order Oleaceæ.

Fig. 1561. Olea europæa, Olive tree. Fig. 1562. Branch of Olea europæa, Olive, with drupes. The plant is often used in Scripture to mark a fertile country (Deut. vi. 11, viii. 8, xxviii. 40, &c.) The wood was used for making the Cherubim and for doors and posts (1 Kings vi. 23, 31, 32). Fig. 1563.

Olea europæa (Figs. 1561, 1562, and Fig. 81, p. 36), the Olive, has a drupaceous fruit which yields, on expression, Olive Oil. The finest oil is imported from

Fig. 1561.

Fig. 1562.

Florence and Provence. Its bark is reputed tonic, and exudes a resin which contains a crystalline principle, olivine. It is the Hebrew Zait or Sait, and the Greek Elaia, frequently mentioned in Scripture. Two varieties of Olive-trees are distinguished, the long-leaved, which is cultivated in the South of France and Italy, and the broad-leaved in Spain. The wild Olive, called by the Greeks Agrielaia, was a low spiny tree, the branches of which were grafted on the cultivated Olive (Rom. xi. 17, 24). Olive trees attain a great age. Some of those in Palestine are calculated at 2000 years old. The tree is one of the earliest mentioned in the Bible (Gen. viii. 11). Its oil and wood were highly prized. Olea fragrans is used in China to perfume tea.

Ornus rotundifolia is called Manna-ash, on account of its sweet exudation, to which the name of manna is given at the present day. A similar product is yielded by O. europæa.

Fig 1565.

1350. Nat. Ord. 139.—Salvadoraceæ, the Salvadora order (Fig. 1565).—Small trees or shrubs, with

Naked (Achlamydeous) flower of Fraxinus excelsior, the Ash, showing 2 stamens and a 2-celled pistil. Fig. 1564. Samaroid fruit of the Ash, laid open to show the solitary anatropal pendulous ovule filling the single perfect cell.

Fig. 1565. Salvadora persica, belonging to the natural order Salvadoraceæ. It is the Greek Sinapi, translated Mustard in the New Testament (Matt. xiii. 31, xvii. 20; Mark iv. 31; Luke xiii. 19, xvii. 6). The Arabic name for mustard, Khardal, is applied at the present day to this tree in Palestine, and its seeds are used in the same way as mustard.

opposite leaves and minute panicled flowers. Calyx of 4 minute sepals. Corolla 4-partite. Stamens 4. Ovary superior. Fruit baccate, 1-celled. Seed solitary, exalbuminous. The order is considered by Plauchon as allied to Oleaceæ. Natives of Syria and India. *Ill. Gen.*—Salvadora, Bouea.

1351. The plants are acrid and stimulant, and some of them have properties like Mustard.

Salvadora persica (Fig. 1565) appears to be the Mustard-plant of Scripture. It has a small seed which grows into a tree. It is found in Persia, Arabia, Palestine, and North Africa, and seems to be different from the Indian plant, which is S. Koenigii or S. indica.

1352. Nat. Ord. 140.—Asclepiadaceæ, the Milkweed order (Figs.

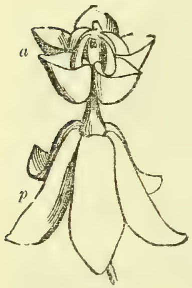


Fig. 1566.

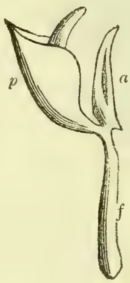


Fig. 1567.

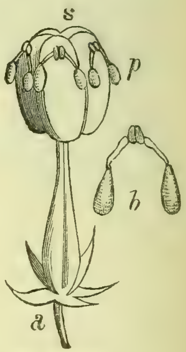


Fig. 1568.

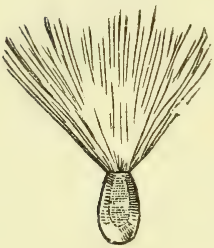


Fig. 1569.

Fig. 1570.

1566 to 1570).—Lactescent, often twining shrubs or herbs, having

Figures 1566 to 1570 illustrate the natural order Asclepiadaceæ.

Fig. 1566. Flower of Asclepias, showing the united stamens surrounding the pistils. The stamens have horn-like appendages, *a*, which form a staminal crown. The sepals and petals, *p*, are reflexed. Fig. 1567. One of the stamens of Asclepias removed, showing the filament, *f*, the anther, *a*, containing pollen masses, and the peculiar staminal appendage, *p*. Fig. 1568. Pistil of Asclepias, *a*, with pollen masses, *p*, adhering to the stigma, *s*. Pollen masses, *b*, detached from the stigma, united by a gland-like body. Fig. 1569. Comose seed of Asclepias. Fig. 1570. Stapelia variegata, one of the Carrion flowers, so called from their fetid odour. The plant has a resemblance to a Cactus or Euphorbia in its stem and branches.

entire, usually opposite leaves, with interpetiolar stipulary cilia. Calyx 5-divided. Corolla 5-lobed, æstivation imbricate, rarely valvate. Stamens 5; filaments usually connate; pollen in wax-like masses (Fig. 1568, *b*), cohering in pairs and attached to glands at the five angles of the stigma (Fig. 1568, *p*), which is common to the two styles. Fruit consisting of two follicles, containing numerous comose seeds (Fig. 1569), with thin albumen. Chiefly tropical plants, found in Africa, India, and America. Species about 920. *Ill. Gen.*—Hemidesmus, Periploca, Secamone, Solenostemma, Calotropis, Cynanchum, Asclepias, Gonolobus, Stephanotis, Dischidia, Hoya, Ceropegia, Stapelia.

1353. The Asclepiads have acrid, stimulating, purgative, diaphoretic, and emetic properties. Most of the species have milky juice containing caoutchouc.

Asclepias tuberosa, the Butterfly-weed or Pleurisy-root, is employed medicinally in North America as a laxative and diaphoretic. A. curassavica is called Wild Ipecacuan in the West Indies, on account of its emetic qualities. Some species of Asclepias are called in America Wild Cotton, on account of the hairs attached to their seeds. A. tenacissima yields Jetee or Tongoose fibre.

Calotropis gigantea is the Mudar plant of Bengal. The bark is employed medicinally as an emetic and diaphoretic. It contains a substance, mudarine, remarkable as being less soluble in hot than in cold water. It is said to yield Yercum fibres. C. procera (Hamiltonii), is another species which supplies Mudar; specimens of which have been transmitted to the Botanical Museum at Edinburgh by Lieutenant R. Maclagan.

Cynanchum monspeliacum has a purgative juice which is used at Montpellier to adulterate Scammony. C. vincetoxicum, which is emeto-cathartic, derives its name from supposed virtues as an antidote to poisons.

Dischidia Rafflesiana, a twining plant of India, is furnished with ascidia.

Gomphocarpus fruticosus, is called Argel in Syria, and is said to be used as an adulteration of Senna. It sometimes receives the name of Silk-plant. G. pedunculatus has an edible root.

Gymnema lactiferum yields a bland milk, and is called the Cow-plant of Ceylon.

Hemidesmus indicus is called Indian Sarsaparilla, because its roots are used in India as a substitute for that drug. It contains a solid volatile matter, which gives it aromatic qualities.

Hoya. The species of this genus, from the peculiar appearance of their flowers, are denominated Wax-plants.

Marsdenia tinctoria supplies a blue dye resembling indigo.

Periploca mauritiana yields the purgative secretion called Bourbon Scammony.

Solenostemma (Cynanchum) Argel. The leaves of this plant are used for adulterating Alexandrian Senna.

Stapelia (Fig. 1570). The species of this genus have fetid flowers (p. 547).

1354. Nat. Ord. 141.—Apocynaceæ, the Dogbane order (Figs. 1571–1573).—Trees or shrubs, usually milky, allied to the Asclepiadaceæ, and differing from them in the contorted æstivation of the corolla, distinct filaments (Fig. 1572), granular pollen, and a peculiar hourglass-like stigma (Fig. 1573). Natives of the tropics of Asia, America, and Africa. Species 570. *Ill. Gen.*—Allamanda, Carissa, Cerbera, Tanghinia, Urceola, Vinca, Plumiera, Balfouria, Strophanthus, Nerium, Apocynum, Echites, Cleghornia, Mandevilla.

1355. Many of the plants are poisonous, some are drastic purgatives. The bark is sometimes tonic and febrifugal. The milky juice of several species supplies caoutchouc. Vinca, the Periwinkle, is the only British genus in the order.

Fig. 1571.

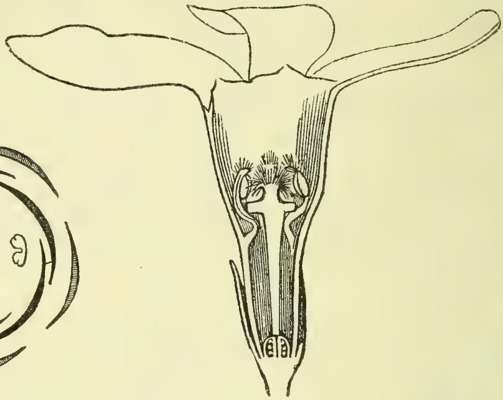


Fig. 1572.

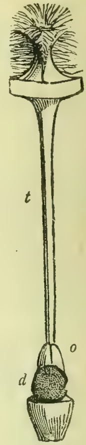


Fig. 1573.

Apocynum cannabinum has emetic roots. A. androsæmifolium has similar qualities.

Aspidosperma excelsum supplies the peculiarly fluted yarroura-wood, fine specimens of which are seen in the Edinburgh Museum of Economic Botany. It is used for making paddles in Guiana. The wood was formerly imported into Glasgow, and used for gin rollers in the machinery sent to Demerara for cleaning cotton.

Collophora. Two species on the banks of the Rio Negro yield a bland milky juice. One of the species is called Cuma-i, Sorveira, or Cow-tree. Its milk is sweet and viscid, and, when dry, resembles caoutchouc.

Nerium oleander, Rose-Bay (Fig. 234, p. 106), is said to be the Rhodon of the Apocrypha, translated Rose. It is a poisonous plant with showy flowers. Its stamens have feathery prolongations from the connective (Fig. 648, p. 233). N. odorum has similar qualities.

Plumieria Mulongo has soft and white wood, which is used for making spoons and other articles in the Amazon district.

Roupellia grata produces what is called Cream-fruit in Sierra Leone.

Tabernæmontana utilis is the Cow-tree of Demerara, the milky juice of which is nutritious.

Tanghinia venenata yields the famous ordeal poison of Madagascar, called Tanghin.

Urceola elastica receives its specific name from yielding caoutchouc.

Vahea madagascariensis and V. gummifera, also furnish caoutchouc.

Wrightia tinctoria supplies a blue dye like Indigo.

1356. Nat. Ord. 142.—LOGANIACEÆ or SPIGELIACEÆ, the Strychnia order (Fig. 1574).—Shrubs, herbs, or trees, with opposite, entire,

Figures 1571 to 1573 illustrate the natural order Apocynaceæ.

Fig. 1571. Diagram of the flower of Vinca, Periwinkle, showing 5 divisions of the calyx, alternating with five of the twisted corolla, 5 stamens alternating with the corolline segments, and 2 carpels forming the pistil. Fig. 1572. Vertical section of the flower of Vinca, showing the stamens attached to the gamopetalous corolla, and the peculiar stigma. Fig. 1573. Pistil of Vinca separated, showing the remarkable stigma, *s*, covered with hairs, and having an hourglass contraction in the middle. Ovary, *o*, with disk, *d*, style, *t*.

stipulate leaves. Calyx inferior, 4-5-parted. Corolla 4 5 or 10-cleft; æstivation convolute or valvate. Stamens varying in number, not always isomerous with the corolla. Fruit a 2-celled capsule, with loose placentas, or a berry, or succulent, with 1 or 2 nucules. Seeds usually peltate, albuminous. Chiefly tropical. Known species 170. *Ill. Gen.*—Spigelia, Strychnos, Gardneria, Logania, Fagræa, Potalia.

Fig. 1574.

1357. The plants of this order are highly poisonous. They produce tetanic convulsions and narcotism. Some of them are used medicinally as active remedies in certain kinds of palsy. Intense bitterness is met with in some of the species, and in very moderate doses they act as tonics.

Ignatia amara, St. Ignatius's Bean, produces convulsions and death. In very small doses it is tonic.

Spigelias are said to be acro-narcotic. The root and leaves of S. marilandica, Carolina Pink-root, and of S. Anthelmia, are used as vermifuges, but they require to be administered cautiously.

Strychnos is a very poisonous genus. The peltate seeds of S. Nux-Vomica (Fig. 1574), produce powerful effects on the spinal marrow, and cause death by tetanus. They contain the alkaloid called Strychnia, which in doses of $\frac{1}{8}$ of a grain, is given in cases of paraplegia, unaccompanied with head symptoms. Another poisonous alkaloid called Brucia, also exists in the seed. The fruit is about the size and colour of a small orange, having a brittle shell, enclosing a pulp. Its bark constitutes false Angustura. The bark of the root of S. Tieuté supplies the Java poison called Upas Tieuté, while S. toxifera is said to be the basis of the famous Woorali, Ourari, or Uirari poison. S. cogens is used to poison arrows in Panama and Darien. Other species, such as S. pseudoquina, are chiefly bitter and tonic, and have been prescribed in cases of intermittent fever. The bark of the latter is known as Copalche bark. S. potatorum is the Clearing-nut of India used to clarify muddy pond or river water.

1358. Nat. Ord. 143.—GENTIANACEÆ, the Gentian order (Figs. 1575 to 1577, and Fig. 369, p. 155).—Herbs, rarely shrubs, with opposite, entire, exstipulate, usually ribbed leaves, and showy variously-coloured flowers. Calyx divided (Fig. 486, p. 196), persistent. Corolla persistent, imbricate, induplicate, often twisted in æstivation, sometimes with a fringed limb. Stamens alternate with the corolline segments. Ovary of 2 carpels, placed to the right and left of the axis, one-celled, with 2 parietal, often introflexed, placentas (Fig. 1577); style 1; stigmas 2. Fruit a capsule or berry. Seeds numerous, with fleshy albumen and a minute embryo. Natives of almost all parts of the world. Some are found at an elevation of 16,000 feet, others in hot tropical plains. Species about 460. *Ill. Gen.*—Gentiana, Swertia, Agathotes, Chironia, Exacum, Cicendia,

Fig. 1574. Strychnos Nux-Vomica, the Poison-nut or Koochla, a tree abounding on the Malabar and Coromandel coasts. It has opposite ribbed leaves, a round fruit, *b*, of a reddish colour, about the size of a small orange. The seeds, *c*, are circular, flat, and umbilicated on one surface. They contain abundant albumen, *d*, and a small embryo.

Erythræa, Sabbatia, Chlora, Lisianthus, Menyanthes, Villarsia, Limnanthemum.

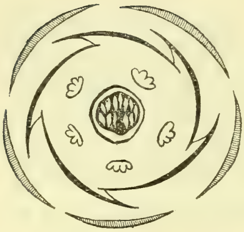


Fig. 1575.

Fig. 1576.

Fig. 1577.

1359. Bitterness is the property which prevails generally in this order. Occasionally the species have emetic and narcotic qualities.

Agathotes Chirayta of the Himalaya, is used in medicine as a tonic and stomachic.

Erythræa Centaurium, common Centaury, a native of Britain, has similar properties.

Frazera Walteri, a North American plant, has a bitter root, which is used as a substitute for Calumba.

Gentiana lutea, the yellow Gentian of the Alps, is a medicinal plant. Its root is used as a bitter tonic.

Menyanthes trifoliata, Bog-bean or Buck-bean, is a native bitter. Its rhizome is employed in the same way as Gentian, and it has been recommended as a substitute for hops.

1360. Nat. Ord. 144.—Bignoniaceæ, the Trumpet-flower order. —Trees or twining or climbing shrubby plants, with exstipulate, usually opposite and compound leaves, and showy, often trumpet-shaped flowers. Their woody stem is sometimes divided in a cruciform manner. Calyx entire or divided, often spathaceous. Corolla with a swollen throat, and a more or less irregular 4-5-lobed limb. Stamens 5, unequal, one generally abortive; sometimes didynamous. Ovary surrounded by a disk, 2-celled; carpels anterior and posterior; placentas in the axis. Fruit a 2-valved, often pod-like capsule, divided by a spurious placental dissepiment. Seeds winged, exalbuminous; embryo with broad leafy cotyledons. Natives of America.

Figures 1575 to 1577 illustrate the natural order Gentianaceæ.

Fig. 1575. Diagram of the flower of Gentiana, showing five parts of the calyx, five imbricate divisions of the corolla, five stamens, and a bicarpellary ovary, with numerous ovules. Fig. 1576. Vertical section of the flower of Gentiana acaulis, showing divided calyx, induplicate corolla, epicorolline stamens, bicarpellary ovary, one-celled, with numerous ovules attached to parietal placentas. Fig. 1577. Capsule of Gentian, showing the two carpels with parietal placentas and ovules. The carpels are placed to the right and left of the axis.

The bark of Jacaranda bahamensis, Palo de Baba, is used in the isthmus of Panama as an anthelmintic. Bignonia Chica supplies a red dye called Carajune, used by the Indians of South America for painting their bodies and their arrows. Species 450. *Ill. Gen.*—Bignonia, Calosanthes, Tecoma, Jacaranda, Eccremocarpus.

1361. Nat. Ord. 145.—GESNERACEÆ, the Gesnera order (including Cyrtandraceæ).—Herbs or shrubs, often growing from scaly tubers, with rugose, usually opposite and whorled exstipulate leaves, and showy flowers. Calyx half-adherent, 5-parted. Corolla more or less irregular, 5-lobed. Stamens 2, or 4, didynamous, with the rudiment of a fifth; anthers often combined. Ovary 1-celled, surrounded by a disk in the form of glands or a ring. Fruit capsular or succulent, 1-celled, with 2 lobed parietal placentas to the right and left of the axis. Seeds numerous, albuminous. They are natives of various parts of the world, chiefly the warmer regions of America. The succulent fruits are occasionally eatable, and some of the species yield a dye. Species 270. *Ill. Gen.*—Columnea, Gesnera, Niphæa, Achimenes, Gloxinia, Æschynanthus, Didymocarpus, Chirita, Streptocarpus, Ramondia, Rhabdothamnus, Christisonia, Championia, Cyrtandra.

1362. Nat. Ord. 146.—CRESCENTIACEÆ, the Calabash-tree order. —Small trees, with exstipulate leaves, and flowers growing out of the old stems and branches. The plants are allied to Bignoniaceæ, from which they differ in their parietal placentas, their wingless seeds, fleshy cotyledons, and in the pulpy contents of their woody indehiscent fruit. Natives of tropical regions. Crescentia Cujete, the Calabash-tree, has a gourd-like fruit with a hard shell which is used for bottles. The fruit sometimes attains a diameter of two feet, and is used as a float in crossing rivers in Africa. Colea cauliflora receives its specific name from the mode in which its flowers appear on the naked stem. Species 34. *Ill. Gen.*—Crescentia, Parmentiera, Colea.

1363. Nat. Ord. 147.—PEDALIACEÆ, the Pedalium order.—Glandular herbs, with exstipulate leaves and large bracteated flowers. They are allied also to Bignoniaceæ, from which they differ in their parietal placentation, their wingless seeds with a papery episperm. From Crescentiaceæ they are distinguished by the want of pulp in the fruit. The ovary, at first 1-celled, sometimes becomes divided by placental septa into 4 or 6 cells. Natives of tropical countries, especially Africa. Species about 25. *Ill. Gen.*—Martynia, Pedalium, Uncaria, Pretræa, Sesamum.

1364. The plants of the order have generally a heavy odour. Their seeds yield oil as well as starchy matter.

Martynia proboscoidea has remarkable hooked appendages to its fruit.

Sesamum orientale. The seeds of this plant are called Teel seeds, and yield a fixed oil, which is sometimes used under the name of Gingilee oil, to adulterate oil of Almonds.

Uncaria. This name indicates the hooked nature of the fruit. U. procumbens is called the Grapple-plant at the Cape.

1365. Nat. Ord. 148.—POLEMONIACEÆ, the Phlox order (Figs.

1578 and 1579).—Herbs, with opposite or alternate leaves. Calyx 5-cleft. Corolla regular, 5-lobed, convolute. Stamens 5, alternate with the corolline lobes; pollen blue. Ovary superior, 3-celled; style 1; stigma trifid. Capsule 3-celled, 3-valved, valves separating from the axis. Seeds albuminous, often with a mucous covering containing spiral threads, which spread out in coils when water is applied (page 19). Natives chiefly of the temperate parts of America. Polemonium cæruleum (Fig. 1579) is commonly cultivated under the name of Greek Valerian. Species 104. *Ill. Gen.*—Phlox, Collomia, Gillia, Leptosiphon, Polemonium, Cantua, Cobæa.

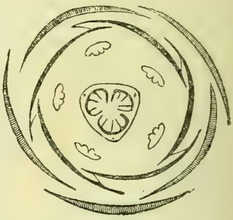


Fig. 1578.

Fig. 1579.

1366. Nat. Ord. 149.—Hydrophyllaceæ, the Hydrophyllum order.—Herbs or small trees, usually with alternate and lobed hispid leaves. Calyx 5-cleft, often with appendages, persistent. Corolla regular, somewhat bell-shaped. Stamens 5, alternating with the corolline lobes. Ovary superior, with 2 parietal placentas, which often line the ovary; styles 2. Fruit a 2-valved, 1-celled, or spuriously 2-celled capsule, filled with a large placenta. Seeds reticulated; embryo small in hard albumen. Natives chiefly of the temperate parts of America. Some species are tropical. Species 75. *Ill. Gen.*—Hydrophyllum, Nemophila, Eutoca, Phacelia, Hydrolea, Nama, Codon.

1367. Nat. Ord. 150.—Diapensiaceæ, the Diapensia order.—Prostrate shrubby plants, with crowded heath-like exstipulate leaves and solitary terminal flowers. They are in many respects allied to Polemoniaceæ, from which they differ chiefly in their imbricated bracts, transversely 2-celled anthers, and peltate seeds. These characters with the 3-celled ovary also separate them from Hydrophyllaceæ. Natives

Figures 1578 and 1579 illustrate the natural order Polemoniaceæ.

Fig. 1578. Diagram of the flower of Polemonium cæruleum, showing five divisions of the calyx, five convolute lobes of the corolla, five alternating stamens, and a tricarpellary ovary. Fig. 1579. Polemonium cæruleum, Greek Valerian, or Jacob's ladder, with its pinnate leaves, cymose inflorescence, and rotate corolla.

of northern Europe and North America. Species 2. *Ill. Gen.*—Diapensia, Pyxidanthera.

1368. Nat. Ord. 151.—Convolvulaceæ, the Convolvulus order (Figs. 1580 to 1582, and Figs. 140 and 141, p. 59).—Herbs or shrubs,

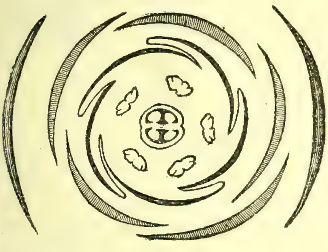


Fig. 1580.

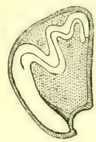


Fig. 1582.

Fig. 1581.

usually twining (Fig. 141, p. 59) and lactescent, with alternate, exstipulate leaves and regular flowers (Fig. 1581), having a unifloral or multifloral cymose inflorescence. Calyx 5-divided, imbricated, persistent. Corolla plaited. Stamens 5, alternate with the corolline lobes. Ovary free, 2-4-celled; ovules 1-2 in each cell, erect; styles united, often divided at the apex. Capsule 2-4-celled, sometimes by absorption 1-celled, septifragal. Seeds large, with mucilaginous albumen; embryo curved (Fig. 1582), with crumpled cotyledons. Chiefly natives of the tropics. Species about 665. *Ill. Gen.*—Evolvulus, Calystegia, Convolvulus, Exogonium, Ipomœa, Quamoclit, Batatas, Pharbitis, Dichondra.

1369. The order is characterised by purgative properties, and it contains some important medicinal plants.

Convolvulus, Bindweed, has many showy species, the roots of which yield a resinous exudation, having cathartic properties. C. Scammonia is the source of the purgative gum-resin, Scammony. The root of C. sepium, called also Calystegia sepium, yields a similar product. C. Batatas (Batatas edulis), on the other hand, has a saccharine root, which is called Sweet Potato.

Exogonium (Ipomœa) Purga is the plant which yields Jalap. It is a native of Mexico, and can be cultivated in the open air in many parts of Britain.

Ipomœa macrorhiza has large edible farinaceous roots. I. Orizabensis yields an inferior kind of Jalap, known as fusiform, or light Jalap.

Pharbitis Nil, called Merchai in Bengal, has purgative seeds.

1370. Nat. Ord. 152.—Cuscutaceæ, the Dodder order (Figs. 1583 and 1584).—Leafless parasitic twining herbs, generally reckoned a sub-order of Convolvulaceæ. They are marked by scales alternat-

Figures 1580 to 1582 illustrate the natural order Convolvulaceæ.

Fig. 1580. Diagram of the flower of Calystegia (Convolvulus) sepium, Great Bindweed, showing two bracts, five divisions of the calyx, five lobes of the plaited campanulate corolla, five stamens, and a two-celled ovary, with two ovules in each cell. Fig. 1581. Convolvulus Scammonia, the Scammony plant, found in Greece and the Levant. The concrete milky juice of the large root constitutes Scammony, which is imported from Smyrna. The root of Calystegia sepium (Fig. 140, p. 59), supplies a spurious kind of Scammony. Fig. 1582. Seed of Calystegia sepium cut vertically, showing the curved embryo and plaited cotyledons, with the mucilaginous albumen. See also Fig. 1311, p. 730, which illustrates the affinities of the order.

ing with the corolline lobes, and a filiform spiral acotyledonous embryo. The seeds germinate in the usual way, and afterwards the plants become true parasites. Some of them destroy Flax, Clover, and other crops (page 696). They are also purgative in their qualities. Natives of temperate regions. Species 50. *Ill. Gen.*—Cuscuta, Epilinella, Lepidanche.

Fig. 1583.


Fig. 1584.

1371. Nat. Ord. 153.—CORDIACEÆ, the Sebesten order.—Trees with alternate, exstipulate, rough leaves. Calyx 4-5-toothed. Corolla 4-5-cleft, regular. Stamens alternate with the corolline segments; anthers versatile. Ovary superior, 4-8-celled; stigma 4-8-cleft. Fruit drupaceous, 4-8-celled, with a single exalbuminous seed in each cell, pendulous by a long cord. Embryo with plaited cotyledons. The drupes of Cordia Myxa and C. latifolia are called Sebesten plums, and are used as food. The bark is tonic. The plants of this order are natives of the tropics. Species 180. *Ill. Gen.*—Cordia, Myxa, Varronia, Sebestena.

1372. Nat. Ord. 154.—BORAGINACEÆ, the Borage order (Figs. 1585 to 1588).—Herbs or shrubs with round stems, alternate, rough leaves, and flowers in scorpioidal cymes (Fig. 1585). Calyx 4-5-divided, persistent. Corolla usually regular, usually 5-cleft (Fig. 1586), imbricate, often with faucial scales (Fig. 1587). Stamens alternate with the corolline segments. Ovary 4-lobed; style basilar (Fig. 1588). Fruit 2 or 4 distinct achenes. Seed exalbuminous. The plants were called Asperifoliæ from their rough leaves. Natives of the northern temperate regions principally. Species 683. *Ill. Gen.*—Cerinthe, Echium, Borago, Symphytum, Lycopsis, Anchusa, Onosma, Pulmonaria, Myosotis, Asperugo, Cynoglossum, Omphalodes.

1373. Demulcent mucilaginous qualities pervade the order. Some of the plants yield a dye, others are used as pot-herbs.

Anchusa tinctoria, Alkanet, as well as other plants of the order, yields a reddish brown dye, which is procured from its roots.

Borago officinalis, Borage, when steeped in water, imparts coolness to it.

Mertensia maritima, a sea-shore plant, has leaves which taste like oysters.

Myosotis palustris is the Forget-me-not. It is a marsh species, with spreading hairs.

Figures 1583 and 1584 illustrate the natural order Cuscutaceæ.

Fig. 1583. A species of Cuscuta or Dodder, a parasitic plant, destructive to crops of Flax and Clover. Suckers are seen on its twining stem, by means of which it attaches itself to living plants. (See page 696). Fig. 1584. Section of the seed of Dodder, showing the filiform spiral acotyledonous embryo surrounding the fleshy albumen.

Symphytum asperrimum, a native of the Caucasus, has been cultivated in Britain as forage. It is particularly recommended as supplying nourishment for pigs.

Fig. 1585.

Fig. 1586.

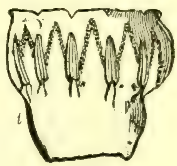
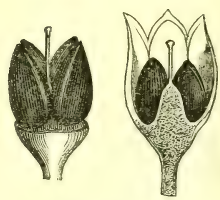


Fig. 1587.



a *b*

Fig. 1588.

1374. Nat. Ord. 155.—Ehretiaceæ, the Ehretia order.—The plants of this order are often reckoned a sub-division of the Borage order, from which they differ in their terminal style, proceeding from a concrete 4-celled ovary, and their drupaceous fruit. Some of them, as the Peruvian Heliotrope, have a fragrant odour. They are generally tropical trees or shrubs. Species 297. *Ill. Gen.*—Ehretia, Tournefortia, Heliotropium.

1375. Nat. Ord. 156.—Nolanaceæ, the Nolana order.—Herbaceous or shrubby plants with alternate exstipulate leaves, having characters in common both with Convolvulaceæ and Boraginaceæ. Their distinguishing characters are their straight inflorescence, valvate calyx, plaited corolla, ovary composed of 5 or more separate carpels, variously combined, united styles, somewhat capitate stigma, and embryo curved

Figures 1585 to 1588 illustrate the natural order Boraginaceæ.

Fig. 1585. Myosotis palustris, Forget-me-not, showing gyrate or scorpioidal inflorescence, alternate leaves, round stem, rotate corolla. Fig. 1586. Flower of Symphytum, Comfrey, with a five-partite hairy calyx, and a five-lobed tubular-campanulate corolla. Fig. 1587. The same laid open to show epicorolline stamens and scales between them. Fig. 1588. Fruit of Myosotis; *a*, four achenes with basilar style; *b*, fruit cut vertically, showing two achenes attached to the axis, whence the style appears to proceed.

Farther illustrations of Boraginaceæ:—Corolla of Myosotis, stamens and scales, Fig. 544, p. 208; Fig. 623, p. 229. Flower of Lycopsis arvensis, Fig. 560, p. 211. Stamen and appendage in Borage, Fig. 631, p. 230. Pistil of Cerinthe, Fig. 700, p. 246. Fruit of Symphytum, Fig. 739, p. 253. Also Fig. 1311, p. 730, which shows the affinities of the order.

in a small quantity of albumen. South American plants. Species 35. *Ill. Gen.*—Nolana, Alona, Sorema.

1376. Nat. Ord. 157.—Solanaceæ, the Potato order (Figs. 1589 and 1590).—Herbs or shrubs with alternate, often geminate leaves, cymose, generally extra-axillary inflorescence, and isomerous flowers. Calyx and corolla, with 5, rarely 4, partitions. Corolline lobes nearly equal, æstivation valvate or induplicato-valvate. Stamens 5, very rarely 1 sterile; anthers opening by slits or pores (Fig. 1589). Ovary generally bilocular; style simple; stigma 2-lobed or clavate. Fruit capsular or baccate (Fig. 1590), with 2 cells, rarely more from placental septa. Seeds albuminous; embryo curved (curvembryeæ) or straight (rectembryeæ). Natives of various parts of the world, and abundant within the tropics. *Ill. Gen.*—Metternichia, Cestrum, Habrothamnus, Jaborosa, Iochroma, Physalis, Capsicum, Witheringia, Solanum, Lycopersicon.

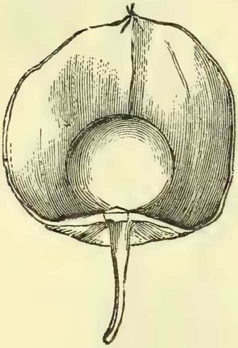


Fig. 1590.


Fig. 1589.

1377. The plants of this order do not display the marked narcotic properties of the next order, and their juice, according to Dr. T. Anderson, does not cause dilatation of the pupil. Some of them yield edible tubers and fruit, others are tonic, pungent, and stimulant.

Capsicum. The species of this genus yield Cayenne-pepper and Chillies, which are acrid and irritant: C. annuum is the common Capsicum, the fruit of which is not so pungent as that of C. frutescens, C. minimum, and C. baccatum, which receive the name of Bird-pepper. There are numerous varieties of Capsicum.

Lycopersicon esculentum produces the Tomato, or Love-apple, which is used for sauce.

Physalis peruviana yields an edible berried fruit called Peruvian Winter Cherry. It is surrounded by the enlarged and inflated calyx. Physalis alkekengi, Winter Cherry, has a showy red, accrescent calyx (Fig. 1590, and Fig. 500, p. 199).

Puneeria coagulans is the Puneer plant of Khorasan. The dried fruit is sold in the Indian bazaars under the name of Puneer-já-fotá (Puneer cardamoms), as a carminative and stomachic. It is regarded as the true Hub-ul-Kaking of Arabian and Persian writers. The dried berries are also used for coagulating milk, and for making cheese.

Solanum tuberosum, the Potato, has starchy tubers. S. Dulcamara, Bitter-sweet, or woody Nightshade, is used as a diaphoretic in cutaneous diseases. S. melongena and S. ovigerum, produce edible fruits known by the name of Egg-apples. S. pseudoquina acts as a tonic and febrifuge. The berries of S. nigrum are edible, and so are those of S. quitöense, under the name of Quito Oranges. The fruit of Solanum laciniatum is eaten in Australia under the name of Kangaroo-apple. Solanum sanctum, according to Forskall, is used in Arabia for coagulating milk. Some suppose that the Hebrew word Chedek, translated Thorns in

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Figures 1589 and 1590 illustrate some characters in the natural order Solanaceæ.

Fig. 1589. Anthers of Solanum, opening by pores at their apex. Fig. 1590. Accrescent calyx of Physalis cut vertically, showing the baccate fruit.

See also Fig. 1311, p. 730, for the affinities of the order.

Prov. xv. 19, and Brier in Micah vii. 4, refers to this species, which is called by some Solanum spinosum. The Hebrew words Besha, translated Cockle in Job xxxi. 40, and Beushim, translated Wild Grapes in Is. v. 2, are supposed to refer to a species of Solanum, either S. incanum or S. nigrum.

1378. Nat. Ord. 158.—ATROPACEÆ, the Deadly Nightshade order (Figs. 1591 to 1596).—This order agrees in most respects with the

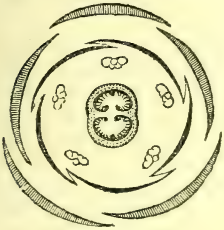
Fig. 1591.

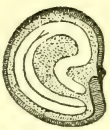
Fig. 1595.

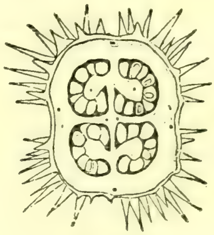
Fig. 1594.

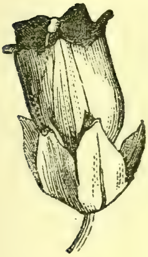
Fig. 1592.


Fig. 1596.

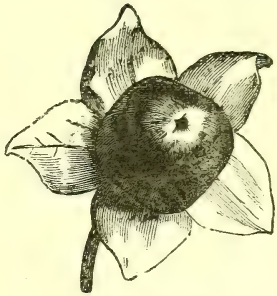
Fig. 1593.

last, of which it may be considered a section. Miers makes it a separate order, distinguished from Solanaceæ by its corolline æstivation being more or less imbricate (Fig. 1591), never valvate. The lobes of the corolla are somewhat unequal. Stamens 5, of which sometimes 1, very rarely 3, are sterile; anthers dehisce longitudinally. The geographical distribution is similar to that of Solanaceæ. The two orders contain about 1000 known species. *Ill. Gen.*—Nicotiana, Datura, Brugmansia, Duboisia, Salpiglossis, Browallia, Petunia, Nierembergia, Hyoscyamus, Scopolia, Anisodus, Atropa, Nicandra, Mandragora, Lycium, Solandra, Franciscea.

1379. The plants of this order are in general narcotic poisons. Their juice has the property of causing dilatation of the pupil.

Figures 1591 to 1596 illustrate the natural order Atropaceæ.

Fig. 1591. Diagram of the flower of Nicotiana Tabacum, Tobacco, showing five divisions of the calyx, five imbricate corolline lobes, five stamens alternating with these lobes, and a dimerous ovary. Fig. 1592. Flower of Atropa Belladona, Deadly Nightshade, showing a five-divided calyx and a five-lobed campanulate corolla. Fig. 1593. Baccate fruit of Belladonna, with persistent calyx. Fig. 1594. Dimerous ovary of Datura Stramonium, Thorn-Apple. It becomes four-celled by placental prolongations forming spurious septa. Fig. 1595. Albuminous seed of the Thorn-Apple, with curved embryo, cut vertically. Fig. 1596. Pyxidium of Hyoscyamus niger, Henbane, showing the operculum or lid by which the two-celled capsule opens.

Atropa Belladona, Deadly Nightshade or Dwale (Figs. 1592-93), has shining brownish-black berries. It contains an alkaloid, Atropia, to which its narcotic properties are due.

Datura Stramonium, Thorn-apple, is so called from its spiny capsule (Fig. 797, p. 272), which is spuriously four-celled (Fig. 1594 and Fig. 711, p. 248). The leaves and seeds contain a narcotic alkaloid Daturia. It, as well as other species, such as D. Tatula, Metel, and ferox, are smoked in asthmatic cases. D. sanguinea, under the name of Florispondio, is used in the Isthmus of Panama to produce excitement.

Hyoscyamus niger, Henbane (Fig. 498, p. 199), is a viscid biennial, having a peculiar odour. Its flowers are dingy yellow, and display purple venation. The seed-vessel is a pyxidium (Fig. 1596). The juice dilates the pupil. Similar properties are possessed by other species, as H. albus.

Fig. 1597.

Mandragora officinalis, the Mandrake (Fig. 862, p. 287), stimulates the nervous system. The root is supposed to be the Hebrew Dudaim, translated Mandrakes in the Scripture (page 287). Some think that M. autumnalis of Bertoloni, a plant with deep mazarin blue flowers, is the real Mandrake of Scripture. It is a native of the South of Italy and the Levant.

Nicotiana Tabacum supplies American Tobacco. This plant has reddish funnel-shaped flowers (Fig. 528, p. 205; Fig. 541, p. 207; Fig. 415, p. 175). Its leaves contain an oleaginous alkaloid, Nicotina, and a concrete volatile oil, Nicotianina. N. persica is the source of Shiraz or Persian Tobacco. The leaves of N. rustica constitute the Syrian Tobacco. The import of unmanufactured Tobacco into Britain in 1852, was 33,205,635 pounds.

1380. Nat. Ord. 159.—OROBANCHACEÆ, the Broom-rape order (Figs. 1597 and 1311, p. 730).—Leafless, scaly herbs, parasitic on the roots of other plants. Calyx 4-5-toothed, persistent. Corolla with an irregular or bilabiate limb, imbricate. Stamens 4, didynamous. Ovary 1-celled, with 2 or more parietal placentas; the 2 carpels forming the ovary placed to the right and left of the axis. Fruit a capsule, covered by the withered corolla, 1-celled, 2-valved. Seeds albuminous, minute. Natives of Europe, middle and northern Asia, North America, and the Cape of Good Hope. Species about 120. *Ill. Gen.*—Epiphegus, Orobanche, Lathræa, Æginetia, Obolaria.

1381. The properties of the order are bitter, astringent, and escharotic.

Fig. 1597. Orobanche Eryngii, a kind of Broom-rape parasitic on the root of Eryngium.

Epiphegus virginiana, Beech-drops, is a native of North America. Its root is used as an application to cancerous sores. Hence it receives the name of Cancer-root.

Orobanche, Broom-rape. The species of this genus are parasitic on the roots of different plants. O. major grows on the Broom and Furze; O. minor on Clover; O. Hederæ on Ivy. The stems of Orobanches have a large central cellular portion, surrounded by numerous fibro-vascular bundles arranged in a circle without any medullary rays. Their roots present a central vascular region composed of about four bundles, forming, on a transverse section, a sort of cross. At the lower part of the stem a tuber exists, which gives off buds. Orobanches are attached to the roots of other plants, and they appear to be truly parasitic, although, from the existence of tubers and roots, they are considered by Henfrey as deriving nourishment also in the ordinary way. In O. minor, Henfrey traced the root of the Trifolium, to which it is attached, into the substance of the tuber, its fibro-vascular structures ramifying in the substance of the parasite.

1382. Nat. Ord. 160.—Scrophulariaceæ, the Figwort order (Figs.

Fig. 1598.

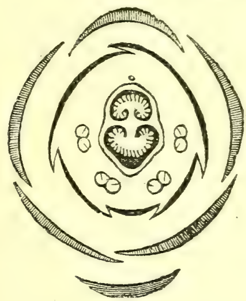

Fig. 1599.

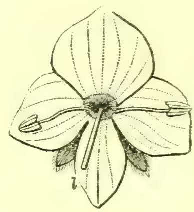

Fig. 1600.

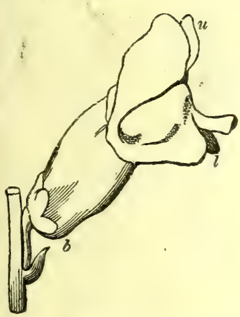

Fig. 1601.

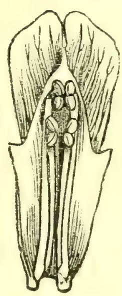

Fig. 1602.

Fig. 1604.

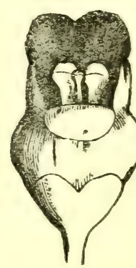

Fig. 1603.

1598 to 1604).—Herbs or undershrubs with opposite, whorled, or alternate leaves, and anisomerous flowers. Calyx of 5 or 4 parts.

Figures 1598 to 1604 illustrate the natural order Scrophulariaceæ.

Fig. 1598. Diagram of the unsymmetrical, slightly irregular, flower of Veronica, with four divisions of the calyx, four of the corolla, imbricate, two stamens, and a bilocular ovary. Fig. 1599. Diagram of the flower of Antirrhinum majus, Frogsmouth, showing single bract below, five divisions of the irregular calyx, five segments of the irregular personate corolla, four perfect stamens, and a rudiment of a fifth above the ovary, a two-celled ovary composed of two carpels placed posteriorly and anteriorly as regards the axis. Fig. 1600. Irregular flower of Veronica, Speedwell, with two stamens. Fig.

Corolla irregular (Figs. 1600 and 1601), lobes unequal, imbricate in æstivation. Stamens 2 (Fig. 1600) or 4, didynamous (Fig. 1602), rarely 5, or with a rudimentary fifth (Fig. 1603). Ovary bilocular, carpels anterior and posterior. Fruit capsular, rarely baccate, usually 2-celled (Fig. 1604). Seeds albuminous, with a straight or slightly curved embryo. Natives of all parts of the world, cold as well as hot. Some are root-parasites, as Eyebright, Cow-wheat, and Yellow-rattle. Species about 1800. *Ill. Gen.*—Calceolaria, Verbascum, Linaria, Antirrhinum, Collinsia, Schizanthus, Pentstemon, Mimulus, Limosella, Sibthorpia, Digitalis, Veronica, Bartsia, Euphrasia, Rhinanthus, Pedicularis, Melampyrum.

1383. The Figworts are more or less suspicious in their properties. Some are acrid, others sedative. There are many showy garden plants in this order.

Digitalis purpurea, Foxglove (Fig. 558, p. 211), is used medicinally as a diuretic and sedative of the heart's action. The officinal parts are the leaves and seeds. Its active principle, Digitaline, is said to be 100 times as powerful as the powder of the dried plant.

Mimulus, Monkey-flower. The species of this genus, and of others in the order, have irritable bilamellar stigmas (page 565). M. luteus, a Chilian plant, has become naturalised in Britain.

Verbascum Thapsus, Mullein, is sometimes called Flannel-flower. Its woolly hairs are used for tinder.

Veronica officinalis. The leaves are bitter and astringent, and are made into tea on the Continent. The plant has been called Thé de l'Europe.

1384. Nat. Ord. 161.—Labiatæ or Lamiaceæ, the Labiate or

Fig. 1608.

Fig. 1609.

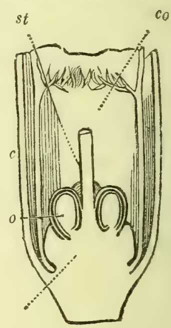

Fig. 1610.

Dead-nettle order (Figs. 1605 to 1610).—Herbs or undershrubs* with

1601. Irregular personate flower of Antirrhinum majus, Frogsmouth. Fig. 1602. Vertical section of flower of Frogsmouth, showing four didynamous stamens attached to the corolla. Fig. 1603. Irregular lipped flower of Scrophularia, Figwort, with a transverse staminodium or abortive fifth stamen. Fig. 1604. Two carpels, forming the fruit of Scrophularia, Figwort. The carpels are placed anteriorly and posteriorly as regards the axis.

Additional illustrations of Scrophulariaceæ:—Veronica, Fig. 340, p. 145. Antirrhinum, Fig. 551, p. 209; Fig. 810, p. 274; and Fig. 663, p. 236. Linaria, Fig. 557, p. 210. The affinities of the order are shown in Fig. 1311, p. 730.

Figures 1605 to 1610 illustrate the natural order Labiatæ.

Fig. 1605. Diagram of the flower of Lamium album, White Dead-nettle, showing five segments of

* Hyptis membranacea of Bentham attains in Brazil a height of 20 or 30 feet.

tetragonal stems, opposite, exstipulate, often aromatic leaves, and flowers in verticillasters (Fig. 1606). Calyx tubular, persistent, 5 or

Fig. 1605.

Fig. 1607.

Fig. 1606.

10-toothed (Fig. 1607) or bilabiate. Corolla bilabiate. Stamens 4, didynamous (Fig. 1608), or by abortion 2 ; anthers 2-celled, or 1-celled by abortion (Fig. 1609). Ovary deeply 4-lobed, on a disk (Fig. 1610) ; style basilar ; stigma bifid. Fruit 1-4 achenes, enclosed by the calyx. Seeds erect, with little or no albumen. Natives of temperate climates. Species 2350. *Ill. Gen.*—Lavandula, Lycopus, Salvia, Monarda, Origanum, Thymus, Hyssopus, Melissa, Prunella, Nepeta, Melittis, Lamium, Stachys, Ballota, Phlomis, Teucrium, Ajuga.

1385. Labiate plants have no deleterious qualities. They are generally aromatic and fragrant. Some are tonics. Many of them, such as Lavender, Mint, Thyme, Sage, Rosemary, Marjoram, Basil, Savoury, and Hyssop, are used as carminatives and antispasmodics, and are cultivated in gardens for culinary purposes. Many contain a kind of stearoptine like camphor. Oils are procured from the leaves of most of the species, and to these their fragrance is due.

Lavandula vera is the plant which yields oil of Lavender. L. latifolia gives oil of Spike.

Lycopus europæus, Gipsy-wort, and L. virginicus, Bugle-weed, are used as astringents and sedatives.

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the calyx, five segments of the bilabiate corolla, two of which form the upper lip and three the lower, four stamens, didynamous, and four-parted ovary. Fig. 1606. Lamium album, with tetragonal stem, opposite leaves, and flowers in verticillasters. Fig. 1607. Irregular calyx of Lamium. Fig. 1608. Irregular bilabiate corolla of Lamium, showing upper and under lip and didynamous stamens. Fig. 1609. Distractile connective of Salvia, Sage, with one antherine lobe, *a*, perfect, the other, *b*, sterile. Fig. 1610. Vertical section of flower of Salvia, showing two of the achenes, *o*, with the single style, *st*, the corolla, *co*, the calyx, *c*, and the discoid receptacle, *r*.

Additional illustrations of Labiatæ :—Flower of Lamium, Fig. 547, p. 208 ; Fig. 605, p. 222. Flower of Teucrium, Fig. 550, p. 209. Flower of Ajuga reptans, Fig. 548, p. 208.

Mentha. The species of this genus are the various kinds of Mint, as Spearmint, Peppermint, and Penny-royal. Mentha sylvestris is the Greek Heduosmon, translated Mint in Scripture (Fig. 407, p. 171).

Pogostemon Patchouly is said to furnish the perfume called Patchouli or Puchá-pát, which is exported from Penang.

Salvia, Sage, is used as a stomachic, and is sometimes employed in the form of tea. The distractile connective of species of Salvia with their one-celled anther (Fig. 1609), and their spiral cells, have been already noticed (pages 19 and 223).

1386. Nat. Ord. 162.—Verbenaceæ, the Vervain order (Figs. 1611 and 1612, and Fig. 1311, p. 730).—Herbs, shrubs, or trees, with exstipulate, usually opposite leaves, resembling much the Labiatæ in their characters and differing in their achenes being concrete, their style terminal, and their leaves usually not containing receptacles of oil. Corolla generally irregular. Stamens 4, didynamous, or 2; anthers 2-celled. Seeds erect or ascending; radicle inferior. Natives both of tropical and of temperate regions. In the order are included the Myoporaceæ, which differ only in their seeds being pendulous and in the radicle of the embryo being superior. Species about 700. *Ill. Gen.*—Verbena, Stachytarpheta, Lippia, Lantana, Tectona, Premna, Clerodendron, Vitex, Myoporum, Avicennia.

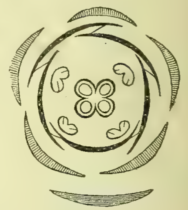

Fig. 1611.

1387. Bitter, tonic, as well as aromatic properties are found in the Vervains. Verbena was supposed to have many valuable qualities, and was an object of superstitious regard among the Druids.

Fig. 1612.

Aloysia (Lippia) citriodora, is commonly cultivated under the name of Sweet Verbena, on account of its fragrance.

Avicennia tomentosa, and other species, grow in salt swamps, and send out abnormal roots like the Mangrove. The bark of some is used for tanning.

Gmelina arborea, Ghumbar or Gomar, is a timber tree of India.

Stachytarpheta jamaicensis has tonic qualities. Its leaves are sometimes used for tea.

Tectona grandis is the Teak-tree of India (Saguan or Segoon teak), the wood of which is hard and durable, and is used for ship-building. It is sometimes called Indian Oak. The wood resists well the attacks of Limnoria terebrans when exposed to the action of sea water.

Vitex negundo, V. Agnus castus, and V. trifolia, have acrid fruit, which is sometimes used for Pepper.

1388. Nat. Ord. 163.—Selaginaceæ or Globulariaceæ, the Globularia order.—A small group of herbaceous or shrubby plants,

Figures 1611 and 1612 illustrate the natural order Verbenaceæ.

Fig. 1611. Diagram of the flower of Verbena, Vervain, showing a bract below the flower, 5 segments of the calyx, 5 divisions of the corolla, 4 stamens didynamous, and a 4-celled ovary, consisting of 4 concrete 1-ovuled carpels. Fig. 1612. Flowering spike of Verbena, Vervain, showing slightly irregular flowers.

with alternate exstipulate leaves and bracteated flowers resembling Verbenaceæ, from which they differ in their 1-celled anthers, pendulous ovules, and superior radicle. Globularia has a solitary carpel. Allied to this order and Vervains is a small group, Stilbaceæ, of which the Cape genus Stilbe is the type; they have slightly irregular flowers, with 4 or 5 stamens, one often abortive, anthers 2-celled, ovary 2-celled, style terminal, fruit 1-seeded, seed erect, embryo inferior. Some of the species of Selaginaceæ are fragrant. They are natives of the Cape of Good Hope chiefly; some are European. Species 120. *Ill. Gen.*—Selago, Globularia.

1389. Nat. Ord. 164.—Acanthaceæ, the Acanthus order (Fig. 1311, p. 730).—Herbs or shrubs, with simple, opposite, exstipulate leaves and bracteated showy flowers. Calyx of 5 sepals, distinct or combined, persistent. Corolla usually irregular, lipped. Stamens 4, didynamous, often 2 by abortion. Ovary of 2 carpels, placed anterior and posterior; placentas parietal, but extending to the axis; style 1. Fruit a 2-celled capsule, opening by elastic valves. Seeds 1, 2, or many in each cell, attached to hooked placental processes, exalbuminous. Chiefly tropical plants, some of them, as Justicia, Ruellia, Aphelandra, and Hexacentris, remarkable for the beauty of their flowers. The lobed and sinuated leaves of Acanthus furnished the ornaments of the Corinthian capital. Species 1450. *Ill. Gen.*—Thunbergia, Ruellia, Goldfussia, Strobilanthes, Barleria, Acanthodium, Gendarussa, Lankesteria.

1390. Nat. Ord. 165.—Lentibulariaceæ, the Bladderwort order.—Herbs growing in water or in wet places, with radical leaves which are either undivided or cut into filiform root-like segments bearing little bladders, and irregular showy flowers. Calyx divided, persistent. Corolla bilabiate, irregular. Stamens 2, included; anthers 1-celled. Ovary superior, 1-celled; placenta free, central; ovules ∞. Fruit a 1-celled capsule. Seeds exalbuminous. Found in various parts of the world, most abundant in the tropics. The name Butterwort, applied to Pinguicula, is said to indicate its property of giving consistence to milk. Utricularia nelumbifolia grows in the water which collects in the bottom of the leaves of a large Tillandsia in Brazil. This Utricularia sends out runners and shoots, and often in this way unites several plants of Tillandsia. The leaves are peltate, more than 3 inches across, and the flowering stem is 2 feet long. Species 175. *Ill. Gen.*—Utricularia, Pinguicula.

1391. Nat. Ord. 166.—Primulaceæ, the Primrose order (Figs. 1613 to 1616).—Herbs with opposite, or alternate, or whorled, exstipulate leaves, and flowers often on scapes. Calyx 5-cleft, rarely 4-cleft, regular, persistent. Corolla regular, 5 or 4-cleft, very rarely 0 (as in Glaux). Stamens opposite the corolline segments. Ovary superior, 1-celled, with a free central placenta (Fig. 1614); style 1; stigma capitate (Fig. 699, p. 246); ovules mostly indefinite, and amphitropal. Fruit a capsule opening by valves or a lid (Fig. 1615). Seeds peltate, albuminous; embryo straight (Fig. 1616), transverse.

The plants abound in cold and in northern regions. Species 215. *Ill. Gen.*—Androsace, Primula, Cortusa, Cyclamen, Dodecatheon, Sol-

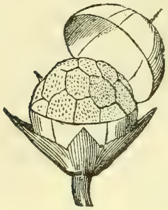

Fig. 1615

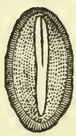

Fig. 1616.

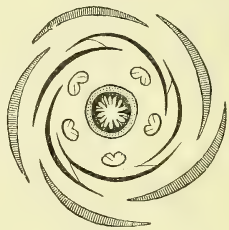

Fig. 1613.

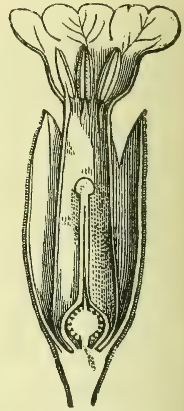

Fig. 1614.

danella, Glaux, Lysimachia, Trientalis, Centunculus, Anagallis, Hottonia, Samolus.

1392. Sedative, diaphoretic, and even drastic purgative plants are found in this order.

Anagallis arvensis, Scarlet Pimpernel (Fig. 232, p. 105; Fig. 487, p. 197), has a capsule opening by circumscissile dehiscence (Fig. 1615). Its flowers close in cloudy weather (page 532).

Cyclamen europæum (Fig. 360, p. 152), and other species, are called Sowbread, on account of their tubers being eaten by pigs.

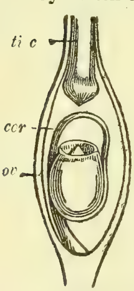

Fig. 1617.

Primula. In this genus are included the various species of Primrose, Cowslip, Oxlip, and Auricula. The flower of Primula veris, Cowslip, are sedative, and are used in making a kind of wine. The yellow Primula Auricula of the Alps is the origin of the cultivated Auriculas.

1393. Nat. Ord. 167.—Plumbaginaceæ, the Leadwort order (Fig. 1617).—Herbs or undershrubs, with alternate or clustered, entire, exstipulate leaves, which are somewhat sheathing, and flowers in panicles or in heads. Calyx tubular, plaited, persistent. Corolla salver-shaped, with a 5-parted limb, or composed of 5 unguiculate petals. Stamens opposite the lobes of the gamopetalous corolla,

Figures 1613 to 1616 illustrate the natural order Primulaceæ.

Fig. 1613. Diagram of the flower of Cyclamen europæum, Sowbread, showing 5 imbricate divisions of the calyx, 5 contorted divisions of the corolla, 5 stamens opposite the corolline segments, and a 1-celled pistil, with a free central placenta, and numerous ovules. Fig. 1614. Vertical section of the flower of Primula, showing calyx, corolla, epicorolline stamens, pistil with unilocular ovary, single style and capitate stigma. Fig. 1615. Capsule of Anagallis arvensis, Scarlet Pimpernel, opening with a lid, by circumscissile dehiscence. Fig. 1616. Seed of Anagallis, cut vertically, showing fleshy albumen and straight embryo.

Fig. 1617. Ovary of Armeria maritima, Sea-pink, cut vertically; showing the ovule, *ov*, with its coverings, suspended by a cord or funiculus, *cor*, which rises from the bottom of the cell. The conducting tissue of the style, *tisc*, passes for a certain extent into the ovary.

and hypogynous or attached to the claws of the polypetalous corolla. Ovary superior, 1-celled, with a single ovule pendulous from a long funiculus which arises from the base of the cell (Fig. 1617); styles 5, separate or partially united. Fruit a utricle, or opening by 5 valves. Seed inverted, albuminous. Found in salt marshes and on the sea-coasts of temperate regions; some are tropical. The species have tonic, astringent, and acrid properties; some cause blistering. Plumbago europæa, Toothwort, is used for toothache. P. toxicaria supplies the principal ingredient of a poison used in Mozambique by the Caffres. Species 231. *Ill. Gen.*—Statice, Armeria, Plumbago.

Fig. 1618.

1394. Nat. Ord. 168.—PLANTAGINACEÆ, the Ribgrass order (Fig. 1618).—Herbs having usually ribbed and radical leaves, with spiked, occasionally unisexual flowers. Calyx 4-parted, persistent. Corolla scarious and persistent, 4-parted. Stamens 4, alternate with the corolline segments; filaments long and slender. Ovary of one carpel, 2 rarely 4-celled by placental prolongations; style 1. Fruit a membranous pyxis with a free placenta. Seeds 1, 2, or many, albuminous. The plants are generally distributed, but are chiefly natives of temperate climates. They have bitter and astringent properties. The seeds of some are demulcent. Species 120. *Ill. Gen.*—Littorella, Plantago.

1395. Analysis of Corollifloral Exogens, with references to the numbers of the orders in the preceding pages.

A. HYPOSTAMINEÆ.

1. Ovary composed of one carpel.
   - Stigma with an indusium .... Brunoniaceæ, 121.
2. Ovary composed of more than one carpel.
   - *a.* Anthers opening by pores.
     - Seeds with a loose testa. Herbs .... Pyrolaceæ, 130.
     - Seeds with a firm testa. Shrubs.
       - Anthers 2-celled, with appendages .... Ericaceæ, 129.
       - Anthers 1-celled, without appendages .... Epacridaceæ, 132.
   - *b.* Anthers opening by slits.
     - Leafy resinous plants .... Rutaceæ, 63.
     - Scaly brown parasites .... Monotropaceæ, 131.

B. EPISTAMINEÆ OR EPICOROLLÆ.

1. Flowers Regular.
   1. Ovary having three, four, or five lobes (achenes in fruit).
      - Inflorescence scorpioidal .... Boraginaceæ, 154.
      - Inflorescence straight .... Nolanaceæ, 156.
   2. Ovary not divided into lobes.
      - *a.* Compound ovary formed by four, five, or more carpels.
        - Stamens opposite to the corolline divisions.

Fig. 1618. Spike of Plantago, Ribgrass, showing numerous sessile flowers on a common elongated axis.

Styles five, rarely three or four.................................. Plumbaginaceæ, 167.
Style one.
Trees or shrubs, with fleshy fruit.......................... Myrsinaceæ, 136.
Herbs, with capsular fruit .... Primulaceæ, 166.
Stamens alternate with the coralline divisions.
Carpels separate .... Anonaceæ, 4.
Carpels combined.
Ovules erect or ascending.
Æstivation of corolla imbricate......................... Sapotaceæ, 135.
Æstivation of corolla plaited........................... Convolvulaceæ,151.
Ovules pendulous.
Embryo large, amygdaloid .... Sapotaceæ, 135.
Embryo small, not amygdaloid.
Stamens twice as many as the coralline divisions .... Ebenaceæ, 133.
Stamens the same number as the coralline divisions .... Aquifoliaceæ, 134.

b. Compound ovary formed by three carpels.
Herbs with angular, oval, or winged seeds................ Polemoniaceæ, 148.
Prostrate undershrubs with peltate seeds ... . Diapensiaceæ, 150.

c. Compound ovary formed by two carpels.
Stamens two.
Corolla 4-cleft .... Oleaceæ, 138.
Corolla 5-8-divided, hypocrateriform .... Jasminaceæ, 137.
Stamens four or more.
Inflorescence scorpioidal.
Fruit capsular ....Hydrophyllaceæ, 149.
Fruit drupaceous.. Ehretiaceæ, 155.
Inflorescence not scorpioidal.
Leaves alternate.
Style dichotomous, fruit drupaceous ....Cordiaceæ, 153.
Style not dichotomous, fruit capsular, follicular, or baccate.
Leaves with interpetiolar ciliary stipules Asclepiadaceæ, 140.
Leaves without stipules or cilia.
Ovules definite, æstivation plaited .... Convolvulaceæ,151.
Ovules indefinite.
Æstivation valvate or induplicato-valvate Solanaceæ, 157.
Æstivation imbricate, or some modification of it ....Atropaceæ, 158.
Leaves opposite or whorled, or clustered.
Anthers united to the stigma .... Asclepiadaceæ, 140.
Anthers free from the stigma.
Leaves stipulate, often 3-5-ribbed .... Gentianaceæ, 143.
Leaves exstipulate.
Stigma with an hour-glass contraction, æstivation contorted .... Apocynaceæ, 141.
Stigma without a contraction, æstivation valvate .... Loganiaceæ, 142.
Leaves absent. Scaly parasites .... Cuscutaceæ, 152.

d. Ovary formed by one carpel.
Fruit spuriously 2-celled .... Plantaginaceæ,168.
Fruit 1-celled and 1-seeded .... Salvadoraceæ, 139.

II. Flowers Irregular.

1. Ovary having four lobes.
Flowers in verticillasters, fruit achenes .... Labiatæ, 161.

2. Ovary not divided into lobes.
  a. Ovary formed by one carpel .... Selaginaceæ, 163.
  b. Ovary formed by two carpels.
    Fruit of 4 concrete achenes .... Verbenaceæ, 162.
    Fruit of two concrete achenes .... Selaginaceæ, 163.
    Fruit capsular or succulent.
      Placentas parietal.
        Seeds winged .... Bignoniaceæ, 144.
        Seeds not winged.
          Leafy plants.
            Cotyledons minute, radicle long .... Gesneraceæ, 145.
            Cotyledons large and fleshy, radicle short.
              Fruit drupaceous or capsular .... Pedaliaceæ, 147.
              Fruit woody, with a pulpy interior ...... Crescentiaceæ, 146.
          Leafless plants.
            Scaly brown parasites .... Orobanchaceæ, 159.
      Placentas in the axis.
        Seeds albuminous. .... Scrophulariaceæ, 160.
        Seeds exalbuminous.
          Seeds with wings.. Bignoniaceæ, 144.
          Seeds without wings, attached to hard placental processes .... Acanthaceæ, 164.
      Placentas free, central .... Lentibulariaceæ, 165.

In the natural orders Oleaceæ and Primulaceæ, apetalous and even achlamydeous species are met with, which therefore belong properly to the sub-class Monochlamydeæ. Among Ericaceæ, Pyrolaceæ, Monotropaceæ, Epacridaceæ, Primulaceæ, and Plumbaginaceæ, there occur polypetalous species with hypogynous stamens, which consequently belong properly to the sub-class Thalamifloræ.

SUB-CLASS 4.—MONOCHLAMYDEÆ OR APETALÆ.

1. ANGIOSPERMÆ.

a. SPERMOGENÆ,

Having true Seeds with a Dicotyledonous Embryo.

1396. Nat. Ord. 169.—Nyctaginaceæ, the Marvel of Peru order (Fig. 1619).—Herbs or shrubs with opposite leaves, and involucrate, often showy flowers. Perianth tubular and funnel-shaped, the limb plaited, coloured, and separating from the hardened base, which encloses the one-celled utricular fruit, and appears to be incorporated with it. Stamens hypogynous, 1-20. Embryo coiled round mealy albumen (Fig. 1619). Natives of warm regions. Their roots are purgative, as seen in the case of Mirabilis Jalapa. Mirabilis

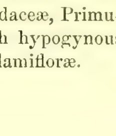

Fig. 1619.

Fig. 1619. Fruit of Nyctago or Mirabilis Jalapa, cut vertically, showing the peripherical embryo coiled round mealy albumen, with the inferior radicle pointing to the foramen.

dichotoma, the Marvel of Peru, is called Four-o'clock plant, from opening its flowers about that time in the afternoon. Species about 100. *Ill. Gen.*—Boerhaavia, Mirabilis, Bugainvillia, Pisonia.

1397. Nat. Ord. 170.—AMARANTHACEÆ, the Amaranth order.—Herbs or shrubs with opposite or alternate, exstipulate leaves, and capitate or spiked, bracteated coloured flowers, which are occasionally unisexual. Perianth of 3-5 scarious sepals. Stamens 5, hypogynous, distinct or monadelphous; anthers often 1-celled. In other respects resembling Chenopodiaceæ. Most common within the tropics. They have mucilaginous properties. Some are used as potherbs, and many of them are cultivated on account of their dry, persistent, and finely coloured bracts and perianth. Amaranths are known in gardens by the name of Princes Feather (A. hypochondriacus) and Love-lies-bleeding (A. caudatus). Celosia cristata, the Cockscomb, has astringent properties. Species 486. *Ill. Gen.*— Celosia, Amaranthus, Achyranthes, Polycnemum, Gomphrena.

1398. Nat. Ord. 171.—CHENOPODIACEÆ, the Goosefoot order (Fig. 1620).—Herbs or undershrubs, with exstipulate, alternate, and occasionally opposite leaves, and small herbaceous, often unisexual flowers. Perianth divided deeply, sometimes tubular at the base, persistent. Stamens inserted into the base of the perianth, and opposite to its divisions. Ovary free, 1-celled, with a single ovule attached to its base. Fruit a utricle or achene, sometimes succulent. Embryo coiled round mealy albumen, or spiral without albumen. Inconspicuous plants, found in waste places in various parts of the world, chiefly in extra-tropical regions. Species 510. *Ill. Gen.*—Salicornia, Atriplex, Halimus, Obione, Spinacia, Blitum, Beta, Suæda, Schoberia, Salsola.

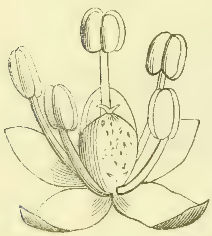

Fig. 1620.

1399. Many of the plants of this order are used as potherbs, for instance, Spinage, Garden Orach, and Beet. Soda is supplied by some of the species of Salicornia and Salsola growing on the sea shore. Anthelmintic and antispasmodic properties are also met with in the order.

Beta vulgaris, common Beet, is cultivated in France for the sake of its sugar. B. vulgaris *var.* campestris, Mangold Wurzel, is used as food for cattle.

Chenopodium Quinoa is a Peruvian plant, the seeds of which are used as food. Voelcker says, that the meal prepared from them is very nutritious. C. Bonus Henricus, English Mercury, is a good substitute for Spinage. C. anthelminticum yields a kind of worm-seed oil.

1400. Nat. Ord. 172.—BASELLACEÆ, the Basella order.—A small order of climbing, herbaceous, and shrubby tropical plants, closely allied

Fig. 1620. Flower of Chenopodium, Goosefoot, showing the perianth, consisting of five parts united at the base, five stamens opposite the segments of the perianth, ovary single, superior, with two styles.

to Chenopodiaceæ, and differing chiefly in their coloured double perianth, and in their stamens being attached to its sides. Some species of Basella are used as Spinage. Melloca tuberosa has a tuberous root, which is used in Peru as a substitute for the Potato. Species 12. *Ill. Gen.*—Basella, Melloca (Ullucus).

1401. Nat. Ord. 173.—Scleranthaceæ, the Knawel order.—Inconspicuous weeds, often included among the Illecebraceæ, but differing from that order in their apetalous flowers, exstipulate leaves, hardened tube of the perianth inclosing the 1-celled fruit, and perigynous stamens. They seem to be more nearly allied to Chenopodiaceæ. They occur in barren places in various parts of the world. Species 14. *Ill. Gen.*—Scleranthus, Habrosia.

1402. Nat. Ord. 174.—Phytolaccaceæ, the Poke-weed order.—Herbs or undershrubs with alternate, exstipulate, often dotted leaves, and racemose flowers. Perianth of 4-5 leaves, often petaloid. Stamens hypogynous or nearly so, indefinite, or 4-5 and then alternate with the divisions of the perianth. Ovary of 1 or many united one-seeded carpels; styles and stigmas distinct. Fruit either succulent or dry. Embryo curved round mealy albumen. Many of the plants are American. They have acrid, emetic, and purgative qualities. The berries of Phytolacca decandra, Poke or Pocan, yield a deep purple juice. Its root is emetic, and is used in rheumatic and syphilitic pains. The young shoots are eaten as Asparagus. Gyrostemon, a genus with unisexual flowers, is considered as a type of an allied order, Gyrostemonaceæ. Species 64. *Ill. Gen.*—Phytolacca, Schollera.

1403. Nat. Ord. 175.—Petiveriaceæ, the Petiveria order.—A small order of plants separated from Phytolaccaceæ on account of their stipulate leaves, exalbuminous seeds, straight embryo, and convolute cotyledons. Tropical American plants. They have acrid properties and an alliaceous odour. Species 10. *Ill. Gen.*—Petiveria, Seguiera.

1404. Nat. Ord. 176.—Polygonaceæ, the Buckwheat order (Figs. 1621 to 1625).—Herbs, rarely shrubs, with alternate leaves, ochreate stipules, and occasionally unisexual flowers. Perianth often coloured. Stamens definite, and inserted into the base of the perianth (Fig. 1623). Ovary formed of 3 carpels, 1-celled, containing a single orthotropal ovule (Fig. 1625). Fruit a triangular nut, often covered by the perianth (Fig. 1624). Embryo usually on one side of mealy albumen. Generally distributed both in cold and warm climates. Species about 500. *Ill. Gen.*—Eriogonum, Oxyria, Rheum, Polygonum, Fagopyrum, Coccoloba, Rumex, Triplaris, Brunnichia.

1405. Acid, astringent, and purgative qualities are met with in the plants of this order.

Coccoloba uvifera, Sea-side-grape, yields an astringent matter like Kino. Its fruit, covered by the succulent perianth, is in clusters like grapes.

Fagopyrum esculentum, and other species, are cultivated as Buckwheat. Their fruit supplies nutritious food in many northern countries. Buckwheat is sown in Britain in order to give food for pheasants.

Polygonum Bistorta has a twisted rhizome, which is used as an astringent. P. Hydropiper is acrid, and hence its name Water-pepper. The roots of P. viviparum are used by the Esquimaux as food.

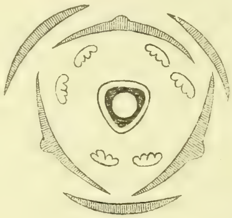

Fig. 1621.

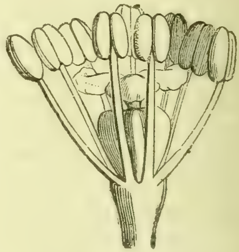

Fig. 1623.

Fig. 1622.

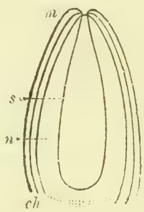

Fig. 1625.

Fig. 1624.

Rheum. Various species of this genus yield the different kinds of Rhubarb. The true officinal species is still unknown. It grows in the very centre of Thibet, a region not usually visited by scientific travellers. R. palmatum is generally said to be the plant which supplies Russian or Turkey Rhubarb. Among the other species may be noticed R. undulatum, R. rhaponticum, R. compactum, R. Emodi, and R. Webbianum. The two latter supply Rhubarb in India. The root of all of these has more or less cathartic properties combined with a certain degree of astringency. The petioles are used in tarts. Oxalic acid exists in the juice, and crystals of oxalate of lime give grittiness to the roots.

Rumex alpinus, called Monk's-rhubarb, has been used as a substitute for true Rhubard. R. Acetosa, R Acetosella, and R. scutatus, have oxalic acid in their leaves. R. Patientia (Fig. 1622), was formerly cultivated as a subacid potherb. The fruit of this or R. orientalis is used for packing Smyrna opium.

1406. Nat. Ord. 177.—Begoniaceæ, the Begonia order.—Herbs or succulent undershrubs, with alternate oblique stipulate leaves, and

Figures 1621 to 1625 illustrate the natural order Polygonaceæ.

Fig. 1621. Diagram of the flower of Rumex, Dock, showing a six-partite perianth, in two alternating rows, six stamens in pairs, and a one-celled ovary formed of three carpels. Fig. 1622. Flowering branch of Rumex Patientia, showing cymose clusters, with the two rows of the perianth, the inner large and covering the fruit. Fig. 1623. Flower of Rheum, with perianth removed, showing nine stamens, which are inserted into the base of the perianth, and are arranged in alternating rows of three, a single tricarpellary ovary with three styles and three disk-like stigmas. Fig. 1624. Fruit of Rumex cut vertically, showing the triquetrous achene closely invested by the inner segments of the perianth, two out of the three styles, and the arcuate embryo on one side of farinaceous albumen. Fig. 1625. Orthotropal ovule of Polygonum, embryo-sac, *s*, nucleus, *n*, chalaza, *ch*, and foramen, *m*. —See also Fig. 755, p. 256; Fig. 757, p. 259; and Fig. 767, p. 264.

cymose, pink, unisexual flowers. Perianth superior, coloured, with 4 divisions in the male flower, and 5-8 in the female. Stamens ∞, distinct, or united; anthers collected into a head. Ovary winged, 3-celled, with 3 placentas meeting in the axis. Fruit capsular, winged, 3-celled. Seeds ∞, exalbuminous, reticulated. Found in the East and West Indies, and in South America. They are said to have bitter and astringent qualities. Begonias receive the name of Elephant's-ear from the appearance of their oblique leaves. Their succulent stalks are sometimes used like Rhubarb. Species 159. *Ill. Gen.*—Begonia, Eupetalum.

1407. Nat. Ord. 178.—Lauraceæ, the Laurel order (Figs. 1626 to 1631; also Fig. 242, p. 109, and Fig. 246, p. 111).—Trees with

Fig. 1628.

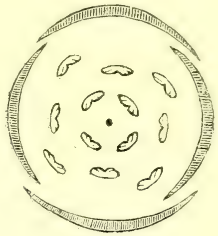

Fig. 1626.

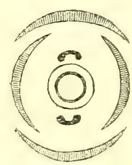

Fig. 1627.

exstipulate, usually alternate, dotted leaves. Perianth 4-cleft (Figs. 1629 and 1631), or 6-cleft in 2 rows. Stamens often 8-12, the 3 or 4 innermost being abortive staminodia, and the outer fertile; filaments sometimes bearing glands (Fig. 1630); anthers 2-4-celled, opening by recurved valves. Ovary superior, 1-celled, with 1 or 2 pendulous ovules. Fruit a berry or drupe; pedicel often thickened; seed solitary, exalbuminous; embryo with large cotyledons. Tropical plants.

Figures 1626 to 1631 illustrate the natural order Lauraceæ.

Fig. 1626. Diagram of the male or staminiferous flower of Laurus nobilis, Sweet Bay, showing four divisions of the perianth, twelve stamens in three rows, some fertile, some abortive, and the abortive pistil as a point in the centre. Fig. 1627. Diagram of the female or pistilliferous flower of Laurus nobilis, showing a four-divided perianth, and a one-celled ovary in the centre, with two abortive stamens. Fig. 1628. Laurus nobilis, the Sweet Bay or the victor's Laurel. It is supposed to be the Ezrach of the Bible (Ps. xxxvii. 35). The tree attains a height of twenty to thirty feet, and is common in the south of Europe, Spain, Italy, Greece, and the Levant. Fig. 1629. Staminiferous flower of Laurus nobilis, with a four-divided perianth, twelve stamens in three rows, some with introrse.

Species 450. *Ill. Gen.*—Cinnamomum, Camphora, Persea, Nectandra, Oreodaphne, Sassafras, Benzoin, Tetranthera, Laurus.

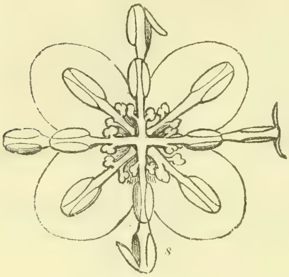

Fig. 1629.

Fig. 1630.

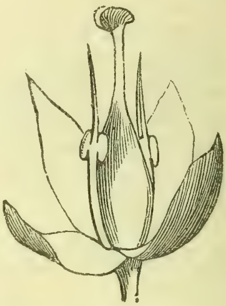

Fig. 1631.

1408. Aromatic and fragrant plants, yielding fixed as well as volatile oils and camphor. Some have tonic and febrifugal barks; others supply edible fruits. The timber of some of the plants is valuable. One of the Lauraceæ, called Itauba, according to Spruce, is the most valuable timber for shipbuilding which the Amazon affords. Its range seems to be from the mouth of the Tapajoz to that of the Rio Negro.

Camphora officinarum, a tree found in China and Japan, supplies camphor, which is procured from the wood by distillation and sublimation. Camphor-wood is used for entomological cabinets.

Cassytha, Dodder-Laurel, is by Lindley considered the type of a new order Cassythaceæ. The species differ from the Lauraceæ in being leafless scaly parasites, and their fruit is enclosed in a succulent calyx.

Cinnamomum zeylanicum (Fig. 242, p. 109), is the Cinnamon-tree, the bark of which constitutes the Cinnamon of commerce. It is the Kinnamon or Kinnamomum of the Bible (see note, p. 109). The tree attains a height of about 30 feet. It has acuminated tricostate leaves, the ribs coming into contact at the base, but not uniting. The best Cinnamon is procured from branches three years old. C. Cassia (Fig. 246, p. 111), supplies the Cassia-bark; the Kiddah or Cassia of Scripture (Exod. xxx. 24; Ps. xlv. 8; Ezek. xxvii. 19). It has oblong-lanceolate triplicostate leaves. Cassia buds seem to be also the produce of this tree. C. Culilawan, a native of Amboyna, yields a bark having the flavour of Cloves. The same flavour exists in the leaves of the true Cinnamon-tree.

Dicypellium caryophyllatum, a Brazilian tree, is the source of the Clove-bark of commerce, which is used as a spice.

Laurus nobilis, Sweet-bay (Fig. 1628), yields a concrete green oil, called Oil of Bays. Its branches were used to crown the victors in the ancient games. It seems to be the Ezrach of the Bible, translated green Bay-tree. The leaves are aromatic.

Nectandra Rodiæi (N. leucantha var. N. ab. E.), called Bibiru or Sipiri, yields the Bebeeru-bark, which contains an antiperiodic alkaloid Bebeerine. Its wood is called Green-heart, and is used in ship-building as well as in constructing piers. The wood seems to resist the attacks of animals in the sea (p. 449). N. Puchury

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others with extrorse anthers opening by hinged valves. Near the base of the inner filaments stalked glands are seen. Fig. 1630. Stamen of the same flower, showing hinged valves and two stalked glands at the base of the filament. Fig. 1631. Female flower of Laurus nobilis, with 4 divisions of the perianth, a single pistil in the centre, and two abortive stamens.

produces an aromatic seed, the cotyledons of which are imported under the name of Sassafras-nuts, or Pichurim-beans. They are used for flavouring chocolate.

Persea gratissima has an edible fruit known as the Avocado-pear. P. indica is the Vinatico of Madeira, and yields a kind of coarse mahogany.

Sassafras officinale, a large American tree, is used as a diaphoretic. Its root is the officinal part.

1409. Nat. Ord. 179.—Atherospermaceæ, the Plume-Nutmeg order.—Trees, with opposite exstipulate leaves, and bracteated unisexual flowers. Perianth tubular, divided at the top into segments, in 2 rows, the inner partly petaloid. Stamens numerous, inserted in the bottom of the perianth; filaments with scales at their base; anthers with valvular dehiscence. In the female flowers, there are often abortive stamens in the form of scales. Carpels numerous, each having a single erect ovule. Fruit achenes, enclosed in the tube of the perianth, having persistent feathery styles. Seed solitary, erect; embryo minute in the base of fleshy albumen. Fragrant plants from Australia and Chili. Species 4. *Ill. Gen.*—Atherosperma, Laurelia.

1410. Nat. Ord. 180.—Myristicaceæ, the Nutmeg order.—Tropical trees, with alternate, exstipulate leaves, and unisexual flowers. Perianth 3-4-cleft, valvate. Stamens 3-12, distinct or monadelphous; anthers extrorse, often united. In the female flowers, the perianth is deciduous. Carpels 1 or many, each with a single erect anatropal ovule. Fruit succulent, 2-valved. Albumen ruminate. Some regard this order as an apetalous unisexual form of Anonaceæ. Natives of the tropical parts of India and America. Species 35. *Ill. Gen.*—Myristica, Pyrrhosa.

1411. The plants of this order are acrid and aromatic. Their bark yields a red juice.

Myristica moschata is the Nutmeg-tree of the Moluccas. The fruit is drupaceous and dehisces, so as to display the scarlet mace, which consists of a reticulated arillode covering the shell in which the seed or Nutmeg is enclosed. A fatty matter and a volatile oil are procured from the Nutmeg. The average quantity of Nutmegs annually sold by the Dutch East India Company in Europe during the last century, has been estimated at 250,000 lbs., besides about 100,000 lbs. sold in India. Of Mace the average quantity sold in Europe has been reckoned at 90,000 lbs. per annum, and 10,000 lbs. in India. In 1814, when the Moluccas were in possession of the English, the number of Nutmeg-trees planted out was estimated at 570,500, of which 480,000 were in bearing, including 65,000 monœcious trees. The produce of the Moluccas has been reckoned at from 600,000 to 700,000 lbs. per annum, of which one-half goes to Europe, and about one-fourth that quantity of Mace. The annual consumption of Nutmegs in Britain is said to be 140,000 lbs. The South American species of Nutmeg have been much increased by the discoveries of Hostmann in Surinam, and of Gardner and Spruce in Brazil. There are in all thirteen known South American Myristicæ. They are lofty trees, producing seeds which have aromatic properties similar to those of the Eastern species. They are coarser, however, and the chief use made of them is the extraction of wax for making candles; and their bark yields an acrid medicinal oil too coarse to be used otherwise than for external application. M. madagascariensis is the source of the wild Nutmeg of Madagascar. M. Otoba produces the Brazilian Nutmeg, and M. spuria the false Nutmeg of the Indian

Archipelago. The name of Nutmeg has been also given to the fruit of some Lauraceous plants.

1412. Nat. Ord. 181.—Monimiaceæ, the Monimia order.—Trees or shrubs, with opposite, exstipulate leaves, and unisexual flowers, resembling Atherospermaceæ, from which they differ chiefly in the anthers dehiscing longitudinally, in the ovule being pendulous, and in the want of feathery styles to the fruit. The plants are chiefly South American. They are aromatic. Species 40. *Ill. Gen.*—Monimia, Citrosma, Boldoa.

1413. Nat. Ord. 182.—Proteaceæ, the Protea order.—Shrubs or small trees, with hard, dry, exstipulate leaves. Perianth divided into 4, valvate. Stamens 4, placed on the segments of the perianth. Ovary of one superior carpel, containing 1 or more ovules; fruit dehiscent or closed. Seed exalbuminous; embryo straight. Natives of Australia and the Cape of Good Hope chiefly. Leucadendron argenteum is the Silver-tree or Witteboom of the Cape; it has a silky covering of its leaves. Protea grandiflora is called Wagenboom. It attains a height of 8-14 feet, and, along with other Proteaceæ, supplies the principal fuel of Simon's Town, Cape of Good Hope. Species 650. *Ill. Gen.*—Leucadendron, Protea, Conospermum, Franklandia, Persoonia, Grevillia, Knightia, Telopea, Lomatia, Stenocarpus, Banksia.

1414. Nat. Ord. 183.—Elæagnaceæ, the Oleaster order.—Trees or shrubs, usually lepidote (Fig. 108, p. 45), with exstipulate leaves, and unisexual, rarely hermaphrodite, flowers. Male flowers in the axil of scales; perianth of 2-4 leaves, sometimes united; stamens 3, 4, or 8. In ♀ and ☿ flowers perianth tubular, with a fleshy disk. Ovary free, 1-celled, with a single ascending ovule. Fruit a crustaceous achene, enclosed in the succulent perianth. Found chiefly in the northern hemisphere. Many are cultivated for their silvery scaly foliage (Fig. 108, p. 45). The scales are beautiful microscopic objects. Some of the species yield edible succulent fruit. Hippophaë rhamnoides, Sea Buckthorn, is a spiny plant which thrives on the sea shore, and forms an excellent fence. Elæagnus parvifolia, small-leaved Oleaster, bears clusters of red edible berries, mottled with scales. Species 30. *Ill. Gen.*—Shepherdia, Hippophaë, Elæagnus.

1415. Nat. Ord. 184.—Penæaceæ, the Penæa order.—Shrubs with opposite exstipulate leaves. Perianth inferior, bracteated, salver-shaped, limb 4-lobed. Stamens 4 or 8, inserted on the perianth. Ovary 4-celled, with 4 appendaged stigmas. Fruit a 4-celled capsule. Seed exalbuminous; embryo with minute cotyledons. Evergreens, found at the Cape of Good Hope. Some yield a gum-resin called Sarcocol. Species 21. *Ill. Gen.*—Penæa, Sarcocolla, Geissoloma.

1416. Nat. Ord. 185.—Thymelæaceæ, the Mezereon order.—Shrubby plants with stipulate leaves, and ☿ rarely ♂ ♀ flowers. Perianth coloured, tubular, with a 4-5 lobed imbricate limb. Stamens often twice as many as the lobes of the perianth, and inserted on its tube. Carpel solitary, superior, with a single pendulous ovule. Fruit nut-like or drupaceous. Seed with or without albumen; embryo straight. Natives both of cold and of warm climates in various parts of the world. Species 300. *Ill. Gen.*—Dirca, Daphne, Passerina, Pimelea, Gnidia, Thymelina, Lagetta, Hernandia.

1417. The plants of this order possess acrid, irritant, and occasionally narcotic qualities. The bark of many of them is tough and tenacious, so as to be used for cordage.

Daphne cannabina has a fibrous inner bark, which is used for ropes and for the manufacture of paper. This paper in India is said to resist the attacks of many insects. D. Mezereum, Mezereon, is a spring-flowering plant, the bark of which is used in cutaneous diseases, and also as an application for toothache. D. Laureola, Spurge Laurel, has an irritant bark, and its berries are poisonous. The flowers of D. odora and other species have a delightful perfume.

Dirca palustris, called Leather-wood, Moose-wood, and Wickopy, is a North American plant, the twigs of which are used as thongs. Its fruit is narcotic.

Lagetta lintearia is called Lace-bark tree, on account of the beautiful meshes of its inner bark.

1418. Nat. Ord. 186.—Aquilariaceæ, the Aquilaria order (Fig. 1632).—Trees with exstipulate leaves. Perianth tubular, with a 4-5-lobed imbricate limb. Stamens usually 8-10, inserted into the throat of the perianth. Ovary superior, 2-celled, with 2 suspended ovules. Fruit a 2-valved capsule, or succulent. Seeds exalbuminous. Natives of the tropical parts of Asia. Species 10. *Ill. Gen.*—Aquilaria, Gyrinopsis, Leucosmia.

1419. Some of the plants yield resinous matter, which is used as a stimulant.

Fig. 1632.

Aquilaria Agallochum (Fig. 1632), and A. ovata or malaccensis, supply the Aloes-wood or Eagle-wood, which contains a fragrant resin, used in India as a remedy for gout. It appears to be the Ahalim or Ahaloth of the Old Testament, and the Aloe of the New, translated Aloes.

1420. Nat. Ord. 187.—Chailletiaceæ, the Chailletia order.—Trees or shrubs with alternate stipulate leaves. Perianth 5-parted; æstivation induplicato-valvate. Stamens in two rows, 5 outer sterile, petaloid, alternate with the divisions of the perianth, 5 inner fertile, with glands at their base. Ovary superior, 2-3 celled; ovules 2, pendulous. Fruit 1-3-celled, dry. Seeds solitary, exalbuminous. This order is more properly placed near Celastraceæ. The plants are con-

Fig. 1632. Aquilaria Agallochum, the plant which yields Aloes-wood, Agila-wood, or Eagle-wood. It appears to be referred to in Psalm xlv. 8; Prov. vii. 17; Cant. iv. 14, under the name of Ahalim, and in John xix. 39, under the name of Aloe. Lign Aloes of Numb. xxiv. 6, is probably the same tree.

sidered dichlamydeous, some being polypetalous, others gamopetalous. Chailletia toxicaria has a poisonous fruit called Ratsbane in Sierra Leone. Natives of tropical America and Africa, and of the East Indies. Species 26. *Ill. Gen.*—Chailletia, Moacurra, Tapura.

1421. Nat. Ord. 188.—Samydaceæ, the Samyda order.—Trees or shrubs with alternate, stipulate, usually dotted leaves. Perianth 4-5-parted; æstivation imbricate. Stamens inserted into the tube of the perianth, 2, 3, or 4 times as many as its divisions, some of them occasionally sterile; filaments united. Ovary superior, 1-celled, with numerous ovules. Fruit a leathery, 1-celled, 3-5-valved capsule. Seeds albuminous, arillate, attached to parietal placentas. Tropical, chiefly American plants, with astringent bark and leaves. Species 80. *Ill. Gen.*—Samyda, Casearia, Candelabria.

1422. Nat. Ord. 189.—Homaliaceæ, the Homalium order.—Trees or shrubs with alternate leaves with or without stipules. Perianth infundibuliform, with 5-15 gland-bearing divisions, and alternating petaloid scales. Stamens inserted on the perianth, either singly or in bundles of 3 or 6. Ovary adherent, 1-celled; ovules numerous, pendulous; placentas 3-5, parietal; styles 3-5. Fruit a capsule or berry. Seeds albuminous. Lindley thinks this order has true petals, and he places it between Loasaceæ and Cactaceæ. Tropical plants of India, Africa, and America, having astringent properties. Species 30. *Ill. Gen.*—Homalium, Blackwellia, Trimeria, Nisa.

Fig. 1633.

1423. Nat. Ord. 190.—Santalaceæ, the Sandal-wood order (Fig. 1633).—Trees, shrubs, or herbs with alternate, entire, exstipulate leaves, and small flowers, sometimes ♂ ♀. Perianth adherent, 4-5-cleft, valvate. Stamens 4-5, inserted into the throat of the perianth, opposite its segments. Ovary 1-celled; ovules 1-4; placenta central. Fruit monospermal, dry, or succulent. Seed albuminous. Found in Europe, Asia, America, and Australia, Species 110. *Ill. Gen.*—Thesium, Osyris, Fusanus, Santalum.

1424. Some of the species are astringent, others yield edible fruit. The wood is in some instances fragrant, and the bark is tough and tenacious.

Fusanus acuminatus, the Quandang nut, has an edible fruit.

Pyrularia oleifera (pubera), Buffalo-tree, yields a nut from which a fixed oil is procured.

Fig. 1633. Santalum album, Sandal-wood tree of India, which may be the Almug or Algum tree of the Bible (1 Kings x. 11, 12; 2 Chron. ii. 8; ix. 10, 11).

Santalum album (Fig. 1633), a Malabar tree, from 25 to 30 feet high, produces Sandal-wood, which is used as a perfume in China, and in India as an astringent. It may probably be the Hebrew Almuggim or Algummim, translated Almug or Algum trees in the Bible. Other species, as S. Freycinatium, yield fragrant woods.

Thesium linophyllum, and other species of Bastard Toadflax, are parasitic on the roots of other plants.

Some put the natural order Viscaceæ here, separating it from Loranthaceæ. It is said to agree with Santalaceæ in its apetalous flowers, valvate æstivation, and stamens opposite the segments of the adherent perigone, ovary unilocular, placenta central, but differs in its opposite leaves, diœcious flowers, and in the form of its embryo. The order includes such parasitic genera as Viscum, or the Mistleto, and Myzodendron.

1425. Nat. Ord. 191.—ARISTOLOCHIACEÆ, the Birthwort order (Figs. 1634 to 1637).—Herbs or climbing shrubby plants, with alternate leaves, solitary or clustered brown or greenish coloured ☿ flowers, and wood arranged in separable wedges. Perianth tubular (Fig. 508, p. 200), adherent (Fig. 1636), valvate. Stamens 6-12, epigynous, distinct or adherent to the style and stigmas (Fig. 1637). Ovary 3-6-celled; ovules ∞; stigmas radiating. Fruit a 3-6-celled polyspermal capsule or berry. Seeds albuminous; embryo minute. Found in various parts of the world,

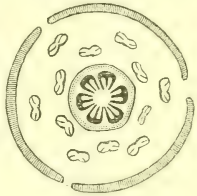

Fig. 1634.

Fig. 1635.

Fig. 1637.

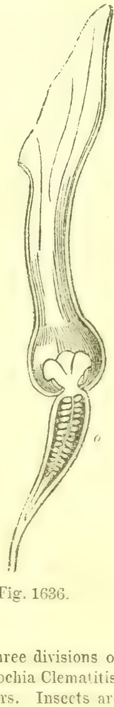

Fig. 1636.

Figures 1634 to 1637 illustrate the natural order Aristolochiaceæ.

Fig. 1634. Diagram of the flower of Asarum europæum, Asarabacca, showing three divisions of the perianth, nine stamens in three rows, and a three-celled ovary. Fig. 1635. Aristolochia Clematitis, common Birthwort, showing its cordate leaf, and clustered axillary irregular flowers. Insects are

but abundant in the tropical parts of South America. Species 130. *Ill. Gen.*—Asarum, Aristolochia, Bragantia, Trichopodium.

1426. Birthworts have pungent, aromatic, stimulant, and tonic properties. Some have been celebrated for their effects on the uterus, others as antidotes for snake-bites.

Aristolochia, Birthwort. Various species, as A. longa, A. rotunda, A. Clematitis (Fig. 1635), and A. indica, have been used as emmenagogues; the root being the officinal part. The root of A. serpentaria, Virginian Snake-root, formerly of repute in typhus fever, and also in cases of snake-bite, is a valuable stomachic. Lindley thinks that the celebrated Guaco of the Columbians may be A. anguicida. The roots of many of the species are said to stupify snakes. A. cordata has a crimson-coloured flower 17 inches in diameter.

Asarum europæum, Asarabacca (Fig. 283, p. 124), has acrid properties. Its leaves and roots are used as a medicinal snuff. Asarum canadense is called Wild Ginger or Canada Snake-root.

1427. Nat. Ord. 192.—NEPENTHACEÆ, the Pitcher-plant order (Fig. 1638, and Fig. 331, p. 141).—Herbaceous or suffruticose plants, with alternate leaves, having calyptrimorphous ascidia at their extremities, wood in separable wedges, and racemose diœcious flowers. Perianth inferior, 4-leaved, imbricate. Stamens columnar, with anthers collected into a head. Ovary superior, tetragonal, 4-celled; ovules ∞, ascending. Fruit a 4-celled, 4-valved capsule, loculicidal. Seeds with a loose testa, albuminous. Found in marshy ground in the East Indies and China.* Voelcker found that the fluid in the unopened pitcher of Nepenthes distillatoria, grown in the Edinburgh Botanic Garden, contained malic and a little citric acid, chloride of potassium, soda, lime, and magnesia. Species 8 or 10. *Ill. Gen.*—Nepenthes.

Fig. 1638.

1428. Nat. Ord. 193.—DATISCACEÆ, the Datisca order.—Herbs or trees, with alternate exstipulate leaves, and ♂ ♀ flowers. Perianth, 3-4 divided, adherent to the ovary. Stamens 3-7, ovary unilocular, with 3-4 polyspermous parietal placentas. Fruit a 1-celled capsule opening at the apex. Seeds strophiolate, exalbuminous.

required for impregnation (page 559). Fig. 1636. Flower of Aristolochia laid open, to show the inferior ovary with numerous ovules, and the irregular, adherent perianth. Fig. 1637. Flower of Aristolochia, with the non-adherent part of the perianth removed, showing the epigynous essential organs with the inferior ovary, the stamens united with the styles on a column, and the radiating stigmas above.

Fig. 1638. Flowering branch of Nepenthes distillatoria, the Pitcher-plant, belonging to the natural order Nepenthaceæ. The racemose flowers are seen with the operculate ascidia at the end of the leaves.—(See page 141).

* These plants are grown in great perfection by the Messrs. Veitch at Exeter, who have sent specimens of the pitchers to the Museum of Economic Botany at Edinburgh.

The plants are scattered over various parts of the world, chiefly in the northern hemisphere. Bitter and purgative properties are met with in the order. Some yield fibres. Species 4. *Ill. Gen.*—Datisca, Tetrameles, Tricerastes.

1429. Nat. Ord. 194.—Empetraceæ, the Crowberry order.—Shrubs, with heath-like, evergreen, exstipulate leaves, and small axillary unisexual flowers. Perianth of 4-6 hypogynous persistent scales, the innermost sometimes petaloid and united. Stamens 2-3, alternate with the inner row of scales. Ovary free, on a fleshy disk, 2-9-celled; ovules solitary. Fruit fleshy, with 2-9 nucules. Seed solitary, ascending; embryo with an inferior radicle. A small group, allied to Euphorbiaceæ, and distinguished chiefly by its ascending seeds and inferior radicle. Natives chiefly of the northern parts of Europe and America. Their leaves and fruit are often subacid. Empetrum nigrum, Crowberry, has black watery fruit, which is refreshing on the hills. Species 4. *Ill. Gen.*—Empetrum, Corema, Oakesia, Ceratiola.

1430. Nat. Ord. 195.—Euphorbiaceæ, the Spurgewort order

Fig. 1639.

Fig. 1640.

(Figs. 1639 to 1646).—Trees, shrubs, or herbs, with opposite or alternate, often stipulate leaves, and involucrate, unisexual, sometimes

Figures 1639 to 1646 illustrate the natural order Euphorbiaceæ.

Fig. 1639. Buxus sempervirens, the Box-tree, with its aggregated monœcious flowers, the female, with three styles. It is the Teashur of the Bible.—(See note to page 101). Fig. 1640. Young stem of Ricinus communis, Castor Oil plant, with alternate, peltate leaves, having a radiating venation. It seems to be the Kikayon of the Scripture, translated Gourd in the book of Jonah.—(See also Fig. 249.

achlamydeous flowers (Fig. 1641). Perianth, when present, inferior, lobed, with glandular, scaly, or petaloid appendages. Stamens definite or ∞, separate (Fig. 1642), or united in one or more bundles (Fig. 1645). Ovary 1, 2, or 3 or more-celled; ovules 1 or 2, suspended.

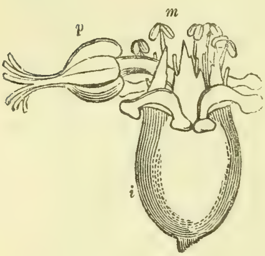

Fig. 1641.

Fig. 1642.

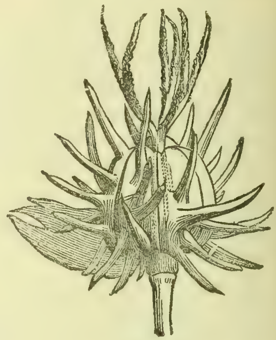
Fig. 1646.


Fig. 1645.

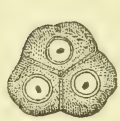
Fig. 1643.

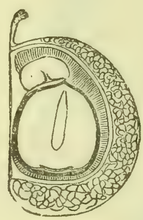
Fig. 1644.

Fruit usually tricoccous (Figs. 1643 and 1646), the carpels separating with elasticity, sometimes fleshy and indehiscent. Seeds albuminous, often arillate. Embryo with a superior radicle (Fig 1644). Lindley considers this a dichlamydeous order, and as becoming monochlamydeous or achlamydeous by abortion. The plants abound in equinoctial America. Some are found in North America, Africa, India, and Europe. Species 2500. *Ill. Gen.*—Euphorbia, Poinsettia, Hura, Stillingia, Cœlebogyne, Mercurialis, Acalypha, Siphonia, Jatropha, Ricinus, Rottlera, Croton, Crozophera, Cluytia, Andrachne, Xylophylla, Phyllanthus, Buxus.

1431. The plants of the order are generally acrid and poisonous,

p. 113, and note). Fig. 1641. Involucre, *i*, of Euphorbia, containing numerous naked male flowers, *m*, and one female, *p*, supported on a stalk, and having three forked styles at the summit of the three-celled ovary. Fig. 1642. Single achlamydeous male flower of Euphorbia, with a scale, *b*, at the base of the peduncle, *p*; the thickening near the top shows the point where the peduncle and stamen join. The latter bears a dithecal anther. Fig. 1643. Section of tricoccous fruit of Euphorbia. Fig. 1644. Section of a single carpel of the tricoccous fruit, shewing the pericarp, the strophiolate seed, and the embryo in the axis of fleshy albumen, with a superior radicle. Fig. 1645. Polyadelphous stamens of the male flower of the Castor Oil plant. Fig. 1646. Tricoccous spiny fruit of the Castor Oil plant.

For further illustrations, see Fig. 264, p. 117; Fig. 506, p. 200; and Fig. 610, p. 226.

abounding in a milky juice. Starchy matter is procured from many of the species, as well as oils and caoutchouc.

Buxus sempervirens, the Box-tree. The Hebrew Teashur (Fig. 1639, and Fig. 402, p. 169) is a native of most parts of Europe, and grows well in England, as at Boxhill. The wood imported from the Levant is prized by wood engravers. The leaves are purgative. The wood of B. balearica, Turkey-box, is also much used.

Croton Eleuteria produces a tonic bark known by the name of Cascarilla. Other species, as C. pseudo-quina, C. nitens, supply a similar bark; the former is called Copalche bark, a name which is also given to the bark of Strychnos pseudoquina in Brazil. The seeds of C. Tiglium yield, by expression, Croton-oil, which is a drastic purgative in doses of one or two drops.

Crozophora tinctoria yields Turnsole, a purple dye, which is made blue by Ammonia.

Euphorbia Lathyris, Caper-spurge (Fig. 609, p. 225), has been used as a purgative. A cathartic oil is procured from its seeds. E. officinarum is the source of the purgative resin called Euphorbium. E. antiquorum and E. canariensis appear also to be sources whence Euphorbium is procured. Some of these plants have a Cactus-like aspect; other Euphorbias have showy scarlet involucres, and some are very spiny, forming impenetrable hedges in Africa and India. The juice of E. phosphorea is said by Martius to give out light (p. 677). The roots of E. pilosa and E. palustris have been used as purgatives in cases of hydrophobia. Cattimandoo, a substance analogous to Gutta Percha, is procured in India from a species of Euphorbia, according to Dr. Hunter The root of E. Ipecacuanha is used as an emetic.

Hippomane Mancinella, Manzanillo de playa of Panama, is the famous Manchineel, the juice of which is a virulent poison. The fruit is beautiful, and looks like an apple.

Hura crepitans, Sandbox tree, or Savilla of Panama, has an acrid juice. Its fruit consists of 15 carpels, which separate with great force, and with a loud noise.

Janipha Manihot, or Manihot utilissima of Pohl, is the Cassava or Manioc plant. Its root contains much starchy matter, along with a narcotic poison, which can be removed by washing. In the variety called Bitter Cassava, there is a bitter matter mixed with the starch, while in the Sweet Cassava, called J. Lœflingii by some, there is no bitterness. The starch is used under the name of Cassava and Brazilian Arrow-root, and when prepared on hot plates and granulated, it is called Tapioca. In Rio, Cassava is called Farinha de Mandiocca.

Jatropha Curcas (Curcas purgans), Physic-nut, Coquillo, and J. multifida, have acrid cathartic seeds. The leaves of the latter are said to be used as a culinary vegetable in Panama, their poisonous qualities being destroyed by boiling.

Mercurialis, Dog-mercury, has only two carpels in its fruit. It acts as an emetic and cathartic.

Oldfieldia africana is the tree which supplies the African Teak or Oak, which is highly valued as timber. Its weight is said to be 60 or 70 lbs. the cubic foot, while that of Oak and Malabar Teak seasoned is 49 lbs. only.

Omphalea triandra is a Guiana plant, the juice of which turns black, and is used as Ink.

Ricinus communis, Castor-oil plant, called also Palma Christi and Pentadactylon (Fig. 1640; Fig. 249, p. 113, and Fig. 264, p. 117), sometimes attains a great size in warm climates. Its seeds yield Castor-oil by expression in the cold. The plant is supposed to be the Kikayon of the Bible, translated Gourd.

Rottlera tinctoria has a mealy covering of its fruit, which yields a scarlet dye. The root also supplies a similar pigment. Red grandular dots are seen in the leaves.

Stillingia sebifera is the Tallow-tree of China. Its seeds yield a fatty matter, which is used for candles. The seeds are boiled and beaten to separate the tallow. As imported it is a hard whitish solid oil, which fuses at about 80°

Siphonia elastica, a tree of Guiana and Brazil, yields a large quantity of milky juice containing caoutchouc. The bottle India-rubber is prepared from it.

Xylophylla produces flowers on the edges of leafy peduncles. This also occurs in other genera.

1432. Nat. Ord. 196.—SCEPACEÆ, the Scepa order.—Trees, with alternate stipulate leaves and unisexual flowers, resembling Euphorbiaceæ, and differing chiefly in being amentiferous. The perianth is 4, 5, or 6-leaved; stamens 2-5; ovary 2-celled, ovules in pairs; seeds arillate, often buried in hairs. Natives of India. Species 6. *Ill. Gen.*—Scepa, Lepidostachys.

1433. Nat. Ord. 197.—CALLITRICHACEÆ, the Starwort order.—Aquatic herbs, with opposite leaves, and minute axillary unisexual achlamydeous flowers. Stamen 1, rarely 2; anther reniform, 1-celled. Ovary solitary, tetragonal, 4-celled; ovules solitary in each cell; styles 2. Fruit 4-celled, 4-seeded, indehiscent. Seeds peltate, albuminous; embryo with a superior radicle. Natives of still waters in Europe and North America. Species 6. *Ill. Gen.*—Callitriche.

1434. Nat. Ord. 198.—CERATOPHYLLACEÆ, the Hornwort order.—Aquatic herbs, with verticillate leaves and monœcious flowers. Perianth inferior, 10-12-cleft; anthers sessile, 12-20; ovary 1-celled, with 1 pendulous ovule. Fruit an achene; seed exalbuminous; embryo with an inferior radicle. Found in ditches in various parts of the world. Species about 6. *Ill. Gen.*—Ceratophyllum.

1435. Nat. Ord. 199.—URTICACEÆ, the Nettle and Hemp order (Figs. 1647 to 1652).—Trees, shrubs, or herbs, with watery juice and alternate stipulate leaves (Fig. 1647), often covered with asperities or stinging hairs (Fig. 107, p. 45). Flowers unisexual, rarely ☿, scattered or collected into heads or catkins. Perianth divided (Fig. 1650); stamens definite, opposite the lobes of the perianth, and inserted into its base (Fig. 1650); filaments sometimes curved and elastic (Figs. 626 and 627, p. 229); ovary superior, 1-celled, with a solitary ovule (Fig. 1651); fruit indehiscent, with a single seed. Embryo straight, hooked, or spiral, with or without albumen; radicle superior (Fig. 1652).

1436. There are two divisions of this order. Sub-order 1. Urticeæ, the true Nettles; plants having often stinging hairs, and elastic curved filaments; seed erect, albuminous; embryo straight. Dispersed over every quarter of the globe. Species about 300. *Ill. Gen.*—Urtica, Böhmeria, Pilea, Parietaria, Rousselia. Sub-order 2. Cannabineæ, the Hemp and Hop tribe; rough plants, with erect filaments, suspended exalbuminous seed, and hooked or spiral embryo. Natives chiefly of temperate regions. Species 2. *Ill. Gen.*—Cannabis, Humulus.

1437. Some of the plants have caustic juice connected with stinging hairs; others yield valuable fibres. Occasionally narcotic qualities are present.

Sub-order 1. URTICEÆ, Nettleworts.—Many of the plants in this division follow the footsteps of man, and are thus scattered over the world. In the young state some Nettles are used as potherbs. Useful fibres are often furnished by their inner bark.

Böhmeria nivea supplies the fibres whence Chinese grass-cloth is made. The manufactured material is used for jackets, dresses, and sailcloth in India (See page 23). B. Puya is put to a similar use in Nipal and Sikkim.

Fig. 1647.

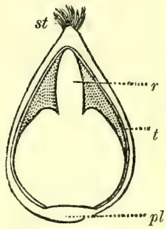

Fig. 1652.

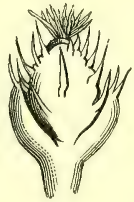

Fig. 1651.

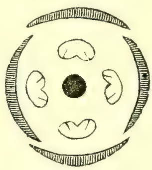

Fig. 1648.

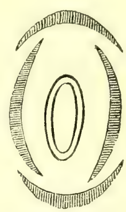

Fig. 1649.

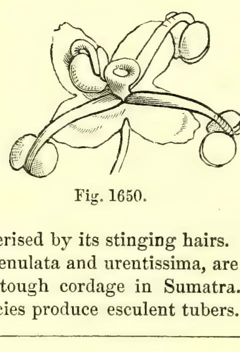

Fig. 1650.

Urtica, the Nettle (Fig. 107, p. 45), is well characterised by its stinging hairs. The effects produced by some species, such as U. crenulata and urentissima, are very severe and lasting. U. tenacissima yields a tough cordage in Sumatra. U. gigantea attains a height of 20 feet. Some species produce esculent tubers. The

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Figures 1647 to 1652 illustrate the natural order Urticaceæ.

Fig. 1647. Parietaria officinalis, Pellitory of the Wall, with alternate leaves and clustered unisexual flowers. Its filaments are curved and elastic (see Figs. 626 and 627, p. 229). Fig. 1648. Diagram of the barren flower of Urtica, Nettle, showing four parts of the perianth, four stamens opposite them, and the abortive pistil. Fig. 1649. Diagram of the fertile flower of Urtica, Nettle, showing four divisions of the perigone (perianth), two of which may be reckoned bracts, and a single-celled ovary in the centre, containing one ovule. Fig. 1650. The male (barren) flower of the Nettle, showing the perianth, four stamens with curved elastic filaments, and two-celled (dithecal) anthers; in the centre is seen the rudiment of a pistil. Fig. 1651. Fertile (female) flower of the Nettle, showing two divisions of the perianth, the one-celled one-seeded ovary, and the penicillate sessile stigma at the top. Fig. 1652. Achene of the Nettle, cut vertically, showing the penicillate stigma, *st*, the single erect ovule, *t*, attached to the placenta, *pl*, and the embryo with its superior radicle, *r*. There is very little albumen, the embryo occupying nearly the whole cavity of the seed.

Hebrew words Kimosh and Kimshon have been doubtfully translated Nettles in Prov. xxiv. 31; Is. xxxiv. 13; and Hos. ix. 6.

Sub-order 2. Cannabineæ, Hempworts, are celebrated for their tenacious fibres, as well as for their tonic and narcotic qualities.

Cannabis sativa (Fig. 47, p. 23, and Fig. 574, p. 216) is the common Hemp plant, which has been cultivated from the earliest times for the purposes of manufacture. The fibres are imported in large quantity from Russia. An Indian variety, C. indica, possesses powerful narcotic qualities. Its leaves are covered with a resinous matter called Churrus. The names of Bhang, Gunjah, and Haschisch, are given to the dried plant in different states. Bhang is much used for intoxication in India. The Indian variety, when grown in Britain, does not possess narcotic qualities; although the plant grows well, and attains a height of 10 feet or more, it does not produce the resinous varnish on the leaves. Under the name of Diamba, the plant is found in the interior of tropical Western Africa, near the Congo or Zaire river. It is used for the purpose of intoxication, and is sold under the names of Maconie and Makiah, terms, as Hooker remarks, having a similarity to the Greek word Mekon meaning Poppy. The Majoon of Calcutta, the Rupouchari of Cairo, and the Dawamese of the Arabs, are also preparations of Hemp, used for intoxication.

Humulus Lupulus, the Hop (Fig. 352, p. 149), is cultivated on account of its bitter principle, Lupulin, which exists in the resinous scales (Fig. 110, p. 45) surrounding the fruit. The plant has tonic aud hypnotic properties. Its stem twines from left to right (Fig. 142, p. 59). Upwards of 20,000 tons of Hops were gathered in England in 1850.

1438. Nat. Ord. 200.—Artocarpaceæ, the Bread-fruit and Mulberry order (Figs. 1653 to 1659).—Trees (Fig. 1654) or shrubs, with

Fig. 1653.

Fig. 1654.

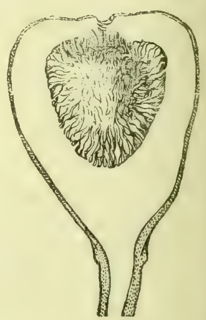


Fig. 1658.

a milky juice, and alternate lobed leaves, having large stipules (Fig. 1653). The flowers are ♂ ♀, and are collected into dense heads or

Figures 1653 to 1659 illustrate the natural order Artocarpaceæ.

Fig. 1653. Artocarpus incisa, the Bread-fruit tree, with its pinnatifid leaves, spike of male flowers, *a*, and dense head of female flowers, *b*, forming the anthocarpous or polygynœcial fruit. Fig. 1654. Galactodendron utile, the Cow-tree of Demerara, which yields a nutritive milky sap. Fig. 1655. Male flower of Morus nigra, Black Mulberry, shewing four stamens opposite the four segments of the perianth, and the rudimentary pistil in the centre. Fig. 1656. Fruit of the Mulberry, consisting of numerous female flowers united into a succulent mass. It is a polygynœcial or anthocarpous fruit. Fig. 1657. The ovary of the Mulberry cut vertically, shewing its single cell, with a solitary pendulous

catkins. The plants are considered by many as a section of Urticaceæ, from which they differ chiefly in being lactescent, in their fruit being

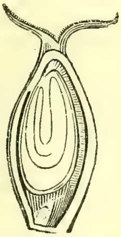


Fig. 1657.

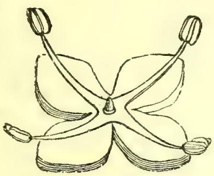


Fig. 1655.


Fig. 1659.

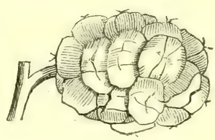


Fig. 1656.

a sorosis (Fig. 1653, *b*), or syconus (Fig. 1658). Perianth divided (Fig. 1655), often awanting; ovary 1-celled; ovules erect or pendulous (Fig. 1657). Fruit polygynœcial or anthocarpous, consisting of achenes immersed in the persistent fleshy perianths (Fig. 1656), or situated upon (Fig. 1659) or within large fleshy receptacles (Fig. 1658). Seeds albuminous or exalbuminous; embryo straight or hooked (Fig. 1657).

1439. There are two divisions of this order. Sub-order 1. Artocarpeæ, the Bread-fruit tribe, with flowers in dense heads, fruit usually a sorosis, seed erect or pendulous, with a variable quantity of albumen, embryo straight; natives of the tropics. Species about 60. *Ill. Gen.*—Brosimum, Antiaris, Artocarpus, Cecropia, Conocephalus, Treculia, Pyrenacantha. Sub-order 2. Moreæ, the Mulberry and Fig tribe, with flowers in heads, spikes, or catkins, fruit a sorosis or syconus, seed pendulous, embryo hooked, albumen fleshy; natives both of temperate and tropical climates. Species 184. *Ill. Gen.*—Morus, Broussonetia, Maclura, Ficus, Urostigma, Sycomorus, Caprificus, Dorstenia, Trophis.

1440. The plants of this order supply, in many instances, edible fruits; their milky juice often abounds in caoutchouc, and, in some

ovule, and a hooked embryo lying in fleshy albumen—the radicle being folded on the cotyledons, and pointing to the foramen which is at the top. The style is bifid, its lobes unequal. Fig. 1658. Polygynœcial or anthocarpous fruit of Ficus Carica, the Fig, being a hollow receptacle, containing numerous flowers in its interior. Fig. 1659. Fruit of Dorstenia, the Contrayerva plant, consisting of a receptacle bearing numerous female flowers, which are united to form a polygynœcial or anthocarpous fruit.

instances, is bland and nutritious, while their inner bark supplies fibres. Bitter, tonic, as well as acrid and poisonous properties, are found in the order.

Sub-order 1. Artocarpeæ, the Bread-fruit tribe.—Edible fruits and virulent poisons are found in this Sub-order.

Antiaris toxicaria is a large tree, whence the Javanese poison called Upas-Antiar is obtained, and which owes its activity to a peculiar principle Antiarin. It is often confounded with the Upas-Tjetteck, which is got from Strychnos Tieuté, and contains Strychnia. A. saccidora is a gigantic tree, having a trunk 18 feet in circumference at the base. Its seeds are intensely bitter, and are found by Dr. Maclagan to contain a crystalline bitter matter. Its inner bark has tenacious fibres, which are used for cordage and matting. The tree is common in the jungles near Coorg, where the people manufacture curious sacks from it. A branch is cut corresponding to the length and breadth of the sack wanted. It is soaked a little, and then beaten with clubs until the liber separates from the wood. The liber, in the form of a sack, is then turned inside out until the wood is sawed off, with the exception of a small piece left to form the bottom of the sack. These sacks are in general use among the villagers for carrying rice.

Artocarpus incisa, the Bread-fruit tree (Fig. 1653), has large pinnatifid leaves, while A. integrifolia, the Jak or Jack-fruit, has undivided leaves. The former is the finer fruit; the latter often attains a large size, weighing 30 or more pounds.

Brosimum Namagua, according to Seemann, has a fibrous bark, which is used in Panama for garments, beds, ropes, and sails.

Cecropia peltata has hollow branches, which are made into wind-instruments. Its bark also furnishes cordage. Its leaves are said to be a favourite food of the sloth.

Galactodendron utile, the Palo de Vaca, or Cow-tree of South America (Fig. 1654), has a waxy emulsive juice, which is nutritive.

Phytocrene is a peculiar genus, which has been put by Arnott and Miers in a separate Dichlamydeous order Phytocrenaceæ, perhaps allied to Icacinaceæ and Ebenaceæ. It is a climbing shrub, with large medullary rays and intervening bundles of open ducts. It has unisexual flowers, with sepals and petals, fruit consisting of a large mass of aggregated drupes, and seed with copious albumen. The plant is called Water-vine, on account of the quantity of watery fluid which is discharged from its porous wood when wounded.

Piratinera guianensis, Buracurra or Paira, the Snake-wood or Letter-wood of Demerara, has beautiful markings, which render it valuable for furniture. A large specimen is seen in the Museum of Economic Botany at Edinburgh. It is a tree 60 to 70 feet high, and 2 to 3 feet in diameter; milk exudes from the bark. The outer part of the wood is white and very hard; the heart-wood which, in the largest trees, is not more than 6 or 7 inches in diameter, is of great weight, hardness, and solidity, of a beautiful deep-red, variegated with black spots of different sizes and figures, and hence its name.

Sub-order 2. Moreæ, Mulberries and Figs.—Edible fruits and caoutchouc are supplied by this sub-order. Tonic, emetic, acrid, and cathartic properties also occur.

Broussonetia papyrifera, the Paper-mulberry, is used in China and Japan for the manufacture of Crape-paper.

Dorstenia Contrayerva, and other species (Fig. 1659), have a stimulant, tonic, and diaphoretic rhizome, which is used medicinally under the name of Contrayerva-root.

Ficus Carica, the common Fig (Fig. 782, p. 268, and Fig. 1658), is used as a laxative and as a cataplasm (Is. xxxviii. 21). It is the Teenah, the first tree mentioned by name in Scripture (see reference in note, p. 268). Turkey Figs are imported from Smyrna in small boxes called drums. The number of Figs imported into Britain in 1851 was nearly 700 tons.

Maclura tinctoria supplies the yellow dye-wood called Fustic. M. aurantiaca, the Osage Orange, has its fruit filled with a yellow matter, which is used as a dye.

Morus nigra, the Black Mulberry (Fig. 774, p. 266, and Fig. 1656), appears to be the Greek Sykaminos, translated Sycamine-tree in the Bible. The Hebrew word translated Mulberry in Scripture, seems to refer to a species of Poplar—(See references in note, p. 266). The leaves of Morus alba, the White Mulberry, and other species, are used for feeding silk-worms. Its root is used as a vermifuge.

Sycomorus antiquorum (Ficus Sycomorus) is the Sycamore Fig, the Hebrew Shikmoth and Shikmim, and the Greek Sykomoros* (Fig. 775, p. 266). The wood is very durable, and is said to have been used in the construction of mummy cases —(See references in note, p. 266).

Urostigma (Ficus) elasticum (Macrophthalma elastica of Gasparrini), and other species, supply caoutchouc abundantly. U. religiosum is the sacred Fig or Pippul-tree of India. U. indicum (benghalense) is the Banyan-tree of India (Fig. 121, p. 52). Some of the species when injured by the attack of cocci, give out a kind of gum lac.

1441. Nat. Ord. 201.—Ulmaceæ, the Elm order.—Trees or shrubs with scabrous, alternate, stipuled leaves, and ☿ or ♂ ♀ flowers in loose clusters. Perianth inferior, membranous, campanulate and irregular. Stamens definite, attached to the base of the perianth. Ovary 1-2-celled; ovules solitary, pendulous; stigmas 2. Fruit 1 or 2-celled, indehiscent, dry, or drupaceous. Seed solitary, without or with little albumen. There are two sections of this order:—Sub-order 1. Celtideæ, Nettle-trees, with a 1-celled ovary and amphitropal ovules. Sub-order 2. Ulmeæ, true Elms, with a 2-celled ovary and anatropal ovules. Natives chiefly of northern countries. Species 60. *Ill. Gen.*—Celtis, Planera, Ulmus.

1442. Bitter and astringent properties exist in the bark and fruit of some of the plants of this order. Many are valuable timber-trees.

Celtis occidentalis, Nettle-tree, or Sugar-berry, produces astringent drupes, which are used in dysentery. The fruit is sometimes called Hackberries. C. orientalis has slightly aromatic qualities. The young branches of C. australis are used in mucous discharges.

Ulmus, Elm, has a samaroid fruit. U. campestris, the English Elm, has small leaves, while U. montana, Wych, or Scotch Elm, has large leaves. The latter alone flowers and fruits freely in Scotland. A variety is called the Weeping Elm. The inner bark of U. campestris is astringent; that of U. fulva, the slippery Elm of North America, is mucilaginous, and is used in decoction as a demulcent. Elm wood is soft and tough, and resists well the action of water.

1443. Nat. Ord. 202.—Stilaginaceæ, the Stilago order.—Trees or shrubs with alternate, stipuled leaves, and minute ♂ ♀ flowers in scaly spikes. They are allied to Urticaceæ, and are chiefly distinguished by their large disk and vertical antherine cells, opening transversely, and having a fleshy connective. Their fruit is drupaceous, and seed suspended and albuminous. Natives of the East Indies and of Madagascar. The drupes of Antidesma pubescens, and of Stilago Bunias, are sub-acid and edible. Species about 20. *Ill. Gen.*—Antidesma, Stilago, Falconeria, Stilaginella.

* From two Greek words, signifying Fig and Mulberry, the tree resembling the former in its fruit, and the latter in its leaves.

1444. Nat. Ord. 203.—LACISTEMACEÆ, the Lacistema order.—Shrubs with alternate, simple stipuled leaves, and ☿ or ♂ ♀ flowers in axillary catkins. Perianth free, divided, with a large bract. Stamen 1, hypogynous; connective separating antherine cells, which open transversely. Disk often fleshy. Ovary 1-celled; placentas parietal. Fruit a 1-celled 2-3-valved capsule, loculicidal. Seeds suspended, arillate, albuminous. Natives of the tropical woods of America. Species 6. *Ill. Gen.*—Lacistema, Synzyganthera.

1445. Nat. Ord. 204.—PODOSTEMONACEÆ, the River-weed order.—Submersed aquatic herbs, with capillary or minute leaves, which are often densely imbricated. They have the aspect of Mosses or Liverworts. Flowers usually ☿. Perianth imperfect or 0, sometimes of 3 parts, with a spathe. Stamens 1, or many, hypogynous. Ovary 2-3-celled; placenta parietal or axile. Fruit a 2-3-valved capsule. Seeds numerous, exalbuminous; embryo orthotropal. Chiefly natives of South America. Some of the species are used for food. Species about 100. *Ill. Gen.*—Hydrostachys, Lacis, Podostemon, Tristicha, Weddelina.

1446. Nat. Ord. 205.—CHLORANTHACEÆ, the Chloranthus order.—Herbs or undershrubs, with jointed stems, opposite simple leaves, sheathing petioles, interpetiolar stipules, and spiked ☿ or ♂ ♀ flowers. Scaly bract, no perianth. Stamens definite, lateral, 1 or more; anthers 1-2-celled, with a fleshy connective. Ovary 1-celled; ovule orthotropal. Fruit drupaceous. Seed pendulous; embryo minute, at the apex of fleshy albumen; no vitellus. Natives of the warm regions of India and America chiefly. They have aromatic and stimulant properties. The leaves of Chloranthus inconspicuus are sometimes used to perfume tea. The roots of C. officinalis are used as fragrant antispasmodics and stimulants. Species 15. *Ill. Gen.*—Hedyosmum, Ascarina, Chloranthus, Sarcandra.

1447. Nat. Ord. 206.—SAURURACEÆ, the Lizard's-tail order.—Marshy herbs, with alternate, stipuled leaves, ☿ spiked flowers, each supported on a scale. Perianth 0. Stamens 3-6, hypogynous, club-shaped, persistent. Ovaries 3-4, distinct or united. Ovules few, orthotropal. Fruit of 4 achenes, or a 3-4-celled capsule. Embryo in a vitellus, outside mealy albumen, at the apex of the seed. Natives of North America, China, and Northern India. Their properties are acrid. Species 7. *Ill. Gen.*—Saururus, Houttuynia.

1448. Nat. Ord. 207.—PIPERACEÆ, the Pepper order (Figs. 1660 and 1661).—Shrubs or herbs with jointed stems, usually opposite or verticillate leaves, stipules sometimes present, flowers ☿ in spikes, each supported on a bract, no perianth. Stamens 2 or more; ovary free, 1-celled; ovule 1, erect, orthotropal. Fruit somewhat fleshy, indehiscent, 1-celled, 1-seeded. Seed erect; embryo in a vitellus or fleshy sac outside the albumen, and at the apex of the seed. The stems of Pepper have a peculiar arrangement of the woody matter in wedges and not in concentric zones. Natives of tropical regions, especially in America and Asia. Species 600. *Ill. Gen.*—Peperomia, Macropiper, Chavica, Cubeba, Piper, Artanthe.

1449. The plants of this order are pungent and aromatic, owing

Fig. 1660.

Fig. 1661.

to the presence of an acrid resin, an oil, and a crystalline matter called Piperin. Some possess narcotic qualities, others are astringent.

Artanthe elongata, a native of South America, has styptic leaves, which are used as astringents under the name of Matico. They are employed to arrest hemorrhage, an effect which is perhaps partly mechanical. Other species of Artanthe, as A. adunca and crocata, are used as aromatics.

Chavica Roxburghii, and other species (Fig. 1660), produce Long-pepper, which is the dried female spikes. The leaves of C. Betle are chewed by the Malays as stimulants.

Cubeba officinalis, and other species, produce the aromatic pungent fruit called Cubebs, used in arresting mucous and other discharges. The plant contains a resin, volatile oil, and a principle called Cubebin. C. canina and C. borboniensis are allied species, which probably also supply Cubeb-pepper.

Macropiper methysticum has a thick rhizome which, under the name of Ava or Kava, is celebrated for its intoxicating and narcotic qualities.

Piper nigrum (Fig. 1661) is a climbing East Indian plant, the dried unripe fruit of which constitutes Black-pepper. White-pepper is the ripe fruit with the dark outer fleshy covering washed off. These Peppers are used as condiments and stimulants.

1450. Nat. Ord. 208.—Myricaceæ, the Gale order (Fig. 1662). — Amentiferous shrubs or small trees, with resinous glands, alternate leaves, and unisexual flowers. Perianth 0. Stamens 2-8, usually in the axil of a bract; anthers 2-4-celled. Ovary

Fig. 1662.

Figures 1660 and 1661 illustrate the natural order Piperaceæ.

Fig. 1660. Branch of Piper longum, a species of Chavica, perhaps C. Roxburghii, showing its spiked female flowers, which, when dried, constitute Long Pepper. The leaves are cordate acute. Chavica peepuloides and C. officinarum, as well as the species already mentioned, supply the officinal Long Pepper, according to Miquel. See his Systema Piperacearum Nova Acta xxi. and Suppl. Fig. 1661. Piper nigrum, the plant which yields Black and White Pepper, with its spiked flowers and cordato-acuminate leaves.

Fig. 1662. Myrica cerifera, Wax Myrtle, Bay Myrtle, or Candleberry bush, one of the Myricaceæ. It has alternate simple leaves, and bears male and female flowers in catkins. Its succulent fruit is covered with a waxy secretion, hence its specific name.

1-celled, with hypogynous scales; ovule solitary, orthotropal; stigmas 2. Fruit drupaceous, often covered with wax, and with adherent fleshy scales. Seed solitary, erect, exalbuminous; embryo with superior radicle. Found both in temperate and in tropical countries. Species about 20. *Ill. Gen.*—Myrica, Comptonia.

1451. The plants have aromatic, tonic, and astringent properties. Tannic and benzoic acids, as well as wax, resin, and oil, are procured from different species.

Comptonia asplenifolia, Sweet Fern, is used in North America in diarrhœa. Its bark is astringent and aromatic, and its leaves contain glandular dots.

Myrica Gale, Gale, or Scotch or Dutch Myrtle, is common in moist heathy grounds in Britain. When boiled it supplies a kind of wax which floats on the surface of the water. It yields an oil. The berries of M. cerifera, Wax Myrtle or Candleberry (Fig. 1662), furnish a greenish-coloured wax when put into hot water. Other species yield wax. The fruit of M. Sapida is slightly acid and eatable.

1452. Nat. Ord. 209.—Salicaceæ, the Willow order (Figs. 1663 to 1670).—Amentiferous trees or shrubs, with alternate, simple,

Fig. 1663.

Fig. 1664.

stipuled leaves, sometimes with petiolary glands, and ♂ ♀ flowers. Perianth 0, or cup-like. Stamens 2-30. Ovary superior, 1-celled;

Figures 1663 to 1670 illustrate the amentiferous natural order Salicaceæ.

Fig. 1663. Salix ægyptiaca, a species of Willow found in Palestine, and supposed by some to be the Hebrew Tzaphtzapha, translated Willow-tree in Ezek. xvii. 5. Fig. 1664. Branch of Salix, Willow, with an amentum or catkin of male flowers. Fig. 1665. Branch of Willow, with a spike of fe-

ovules numerous, erect, attached to the bottom of the cell, or to the base of 2 parietal placentas; stigmas 2. Fruit leathery, 1-celled,


Fig. 1665.

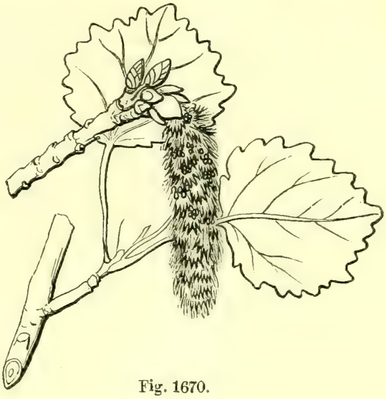


Fig. 1670.


Fig. 1669.


Fig. 1668.

Fig. 1666.

Fig. 1667.

2-valved, polyspermal. Seeds covered with basal silky hairs, exalbuminous; embryo erect, with an inferior radicle. Chiefly found in northern regions; some grow on the high mountains of South America, others in antarctic regions. Salix arctica and polaris extend further north than any other woody plants. S. herbacea is the smallest British species. Species 220. *Ill. Gen.*—Salix, Populus.

1453. The plants of this order are useful timber trees, and they are employed for various economical purposes. Their bark is tonic and

male flowers. Fig. 1666. Single male flower of a Willow, showing the single bract, *br*, bearing 2 stamens, with a gland, *g*, at the base. The flower is called naked or achlamydeous. Fig. 1667. Single female flower of a Willow, with bract, *br*, bearing a stipitate or stalked ovary, with 2 stigmas, *st*, at the summit, and a gland, *g*, at the base. The flower is also naked. Fig. 1668. Comose seed of the Willow, showing the hairs proceeding from its base. Fig. 1669. Populus alba, the White Poplar tree, or Abele. Fig. 1670. Populus tremula, the trembling Poplar or Aspen, with its rounded crenato-dentate leaves, long petioles flattened laterally, and amentum or catkin. It is supposed to be one of the plants included under the Hebrew words Baca and Becaim, and translated either Baca or Mulberry trees in Scripture.—See references in note, p. 134.

astringent. The downy matter surrounding the seeds is used for stuffing cushions, and for making paper.

Populus, Poplar, contains many important species, such as P. alba, White Poplar or Abele (Fig. 1669), the bark of which is febrifugal, P. monilifera, Black Italian Poplar, P. tremula, trembling Poplar or Aspen (Fig. 1670), supposed to be the Baca and Becaim of Scripture, translated Mulberry trees (p. 134), P. fastigiata and dilatata, the Lombardy Poplar, which is common in plantations, P. nigra, Black Poplar, and P. balsamifera, Balsam Poplar, erroneously supposed by Linnæus to yield the balsamic resin called Tacamahac. The Hebrew word Libneh, translated Poplar (Gen. xxx. 37, and Hos. iv. 13), is supposed to refer to the Storax tree (See Nat. Ord. Styracaceæ, p. 841). Layard says, the only trees within the limits of Assyria sufficiently large to furnish beams to span a room 30 or 40 feet wide, are the Palm and the Poplar. Their trunks still form the roofs of houses in Mesopotamia. The boats now employed on the lower part of the Tigris and Euphrates, are constructed of planks taken from a species of Poplar, probably Populus euphratensis.

Salix is the genus which contains the various species of Willow, Sallow, and Osier, used for basket-work and charcoal, as well as medicinally. The bark of S. alba, S. Helix, S. purpurea, S. fragilis, S. capræa, S. pentandra, and many other species, contains a bitter tonic principle called Salicin. S. babylonica is the Weeping-willow, supposed to be the Hebrew Oreb or Orebim, written also Arab and Arabim, and translated Willows (Lev. xxiii. 40; Job xl. 22; Ps. cxxxvii. 2; Is. xv. 7, and xliv. 4). In all these passages allusion is made to the trees as growing by the brooks, the water courses, and the rivers. In Job. xl. 17, the same word is translated Cedar.

1454. Nat. Ord. 210.—ALTINGIACEÆ or BALSAMIFLUÆ, the Liquidambar order.—Amentiferous unisexual trees, with alternate, stipuled leaves, and involucrate catkins. Anthers ∞, nearly sessile, with a few minute scales. Ovaries 2-celled, collected into a round mass, each with a few scales; styles 2; ovules ∞, amphitropal. Fruit, consisting of 2-celled capsules, enclosed in scales, and forming a sort of cone. Seeds winged, peltate, albuminous; embryo inverted, radicle superior. Natives of the warmer parts of India and America; also found in the Levant. Species 3. *Ill. Gen.*—Liquidambar.

Fig. 1671.

1455. Fragrant and balsamic properties are met with in this order. The bark of some of the plants is bitter.

Liquidambar styraciflua, L. orientale, and other species, yield a balsamic juice called Liquidambar, often confounded with liquid Storax.

1456. Nat. Ord. 211.—BETULACEÆ, the Birch order (Fig. 1671).—Amentiferous trees or shrubs, with alternate, simple, stipuled, often feather-veined leaves, and unisexual flowers, which have small

Fig. 1671. Betula alba, the common Birch, an amentiferous tree, belonging to the natural order Betulaceæ. Its male flowers, *a*, are produced in scaly catkins, and they have no proper perianth; its female flowers, *b*, are in scaly spikes or catkins, and are also naked.

scales in place of a perianth. Stamens opposite the scales. Ovary 2-celled; ovules 1 in each cell, pendulous, anatropal; stigmas 2. Fruit dry, indehiscent, 1-celled, 1-seeded. Seed exalbuminous; radicle superior. In Alnus there is a 4-leaved membranous perianth. Chiefly found in northern and cold regions. Species 65. *Ill. Gen.*—Betula, Alnus.

1457. The plants of this order are usually timber trees with deciduous leaves. Their bark is tonic and astringent.

Alnus glutinosa, Alder, grows in moist places. Its wood resists well the action of water, and hence has been used for the piles of bridges. The Rialto at Venice is built on Alder piles, and so are many houses in Amsterdam. The bark is used as an astringent gargle, as well for dyeing and tanning. Sabots are made of the wood. A. incana is used in Kamtschatka for building and for fuel, and bread is manufactured from its bark.

Betula alba and glutinosa, the common Birch, adds much interest to the mountain landscape. An empyreumatic oil procured from the white rind is used in preparing Russia leather, and gives to it a peculiar odour. A wine is made from the saccharine sap. The wood is tough and white, and is used for charcoal. The bark of B. papyracea is used in North America for making boats and various other articles. B. nigra, Black Birch, has hard and valuable timber. It, as well as B. lenta, yields sugar. The bark of B. Bhajapaltra is used in some parts of India as paper.

1458. Nat. Ord. 212.—Corylaceæ or Cupuliferæ, the Hazel

Fig. 1672.

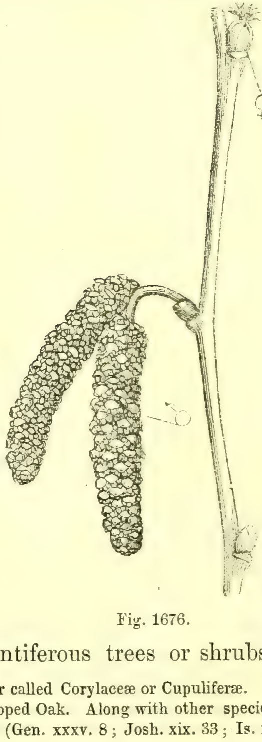


Fig. 1676.

and Oak order (Figs. 1672 to 1676). Amentiferous trees or shrubs,

Figures 1672 to 1676 illustrate the amentiferous natural order called Corylaceæ or Cupuliferæ.

Fig. 1672. Quercus Ægilops or Valonia, the great Prickly-cupped Oak. Along with other species of Oak, it is included in the Hebrew word *Allon,* translated Oak (Gen. xxxv. 8; Josh. xix. 33; Is. ii·

with simple, alternate, stipulate, often feather-veined leaves, and monœcious flowers (Fig. 1676). Barren flowers in catkins. Sta-

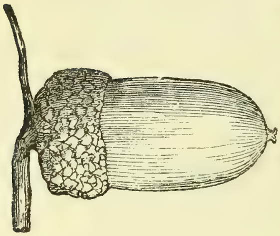


Fig. 1674.

Fig. 1673.

Fig. 1675.

mens 5-20, inserted in the base of scales, or of a membranous valvate perianth. Fertile flowers aggregate (Fig. 1676, ♀), or on a spike. Ovary, with several cells (Fig. 1675) crowned by the remains of an adherent perianth enclosed in an involucre or cupula (Fig. 257, p. 116). Ovules in pairs or solitary, pendulous or peltate; stigmas several. Fruit a glans (Fig. 1674, and Fig. 778, p. 267); seed solitary, exalbuminous. The plants abound in the forests of temperate regions in the form of Oaks, Hazels, Beeches, and Chestnuts. Species about 280. *Ill. Gen.* — Corylus, Carpinus, Ostrya, Fagus, Castanea, Quercus, Lithocarpus, Callæocarpus.

1459. The plants of this order afford valuable timber and edible seeds. Astringency also prevails in a marked degree in the bark.

Carpinus Betulus, the Horn-beam, has white, hard, and tough wood, which is used in turning, and for implements of husbandry. Its wood burns like a candle. The inner bark yields a yellow dye.

Castanea vulgaris, or C. vesca, the Spanish Chestnut (Fig. 1131, p. 438), is much cultivated on account of its timber. Its nuts also are used as food in the South of Europe. About 50,000 bushels are imported annually into Britain. The famous Castagno dei cento cavalli of Mount Ætna seems to be composed of several trunks. C. americana produces a small sweet Chestnut, which is occasionally imported from the United States.

Corylus Avellana, the common Hazel (Fig. 1676, and Fig. 351, p. 149), yields excellent charcoal for drawing. It grows wild in the forests of the temperate parts of Europe, and in many parts of Asia. There are many varieties of Hazel-nut, such as the White and Red Filbert, the great and clustered Cob, and the Barce-

13; vi. 13; xliv. 14; Hos. iv. 13; Amos ii. 9; Zech. xi. 2). Another Hebrew word Alah, translated also Oak, is supposed to be the Terebinth tree, noticed under Anacardiaceæ (p. 797). Fig. 1673. Quercus infectoria, the species which is said to produce the Aleppo galls. These are caused by the puncture of the ovipositor of the Diplolepis or Cynips Gallæ-tinctorum. In the blue state the galls contain the larva, in the white perforated state the insect has escaped. Fig. 1674. Acorn of the Oak, called glans. The ovary is surrounded by a cup, consisting of united bracts (p. 149; see also Fig. 778, p. 267). Fig. 1675. Transverse section of the young acorn, shewing its three carpels, with two ovules in each. Two of the carpels and five of the ovules are obliterated during the growth of the fruit, which thus becomes unilocular and monospermal. Fig. 1676. Flowering branch of Corylus Avellana, the Hazel or Hasel, bearing male flowers ♂ in catkins (amentiferous), and female flowers ♀ in rounded clusters. The latter in a mature state are seen in Fig. 351, p. 149.

lona nut. In 1850, the import of nuts into Britain, according to Archer, was above 140,000 bushels. Nuts yield an oil which is used by watchmakers and by artists.

Fagus sylvatica, the common Beech, supplies timber for various purposes. Its fruit, under the name of Beech-mast, is eaten by pigs. F. ferruginea of North America has edible fruit. F. antarctica is an antarctic species, while F. Forsteri is found at Tierra del Fuego, and is evergreen.

Ostrya virginica yields hard timber, and has been called Iron-wood in America.

Quercus Robur is the common British Oak (Fig. 269, p. 120), the bark of which is used for tanning and as an astringent remedy. There are two varieties, one with stalked acorns (Fig. 1674 and Fig. 778, p. 267), and another (Q. sessiliflora) with sessile fruit. Some consider these as species, and describe an intermediate one. The cups of Quercus Ægilops (Fig. 1672, and Fig. 257, p. 116) are used by dyers under the name of Valonia. The tree is called the great Prickly-cupped Oak. It is a handsome tree in the Levant. It is said that 150,000 cwt. of Valonia are annually imported into Britain. Along with other species of Oak, such as Q. Ilex Evergreen Oak, Q. Grammuntia holly-leaved Montpelier Oak, Q. crinita hairy-cupped Oak, and Q. coccifera or Kermes Oak, it is included probably in the Hebrew word Allon, translated Oak in Scripture. The galls produced by attacks of insects on the Oaks, and especially on Q. infectoria (Fig. 1673), a native of Asia Minor, are used for tanning and for making ink. The outer part of Q. Suber (Fig. 173, p. 72) constitutes Cork. Q. tinctoria yields the Quercitron bark, used as a yellow dye. Quercus coccifera, the Kermes Oak (Fig. 1308, p. 699), derives its name from a species of coccus which adheres to the branches, and forms reddish balls about the size of a pea. These yield a crimson dye which was formerly much in request. The dye was used by the Hebrews, and seems to be referred to in the word translated Scarlet in Is. i. 18, and Lam. iv. 5, which also means a kind of worm. Up to 1851 the number of known species of Oak was estimated at 230. They are found principally in the northern hemisphere. The number of species belonging to Europe, Asia, and Africa, is reckoned about 110, and the American species upwards of 100. In Europe, north of the Alps, there are only 2 or 3 deciduous species. In southern Europe there are 18, mostly evergreen. Q. esculenta, Ilex, and Ballota in the south of Europe, Asia Minor, and northern Africa, and Q. Hindsii in America, yield edible fruit. Q. Phellos, Bannisteri, tinctoria, palustris, rubra and coccinea, do not ripen their fruit until the second year. The two latter have blood-red leaves in autumn. Q. Ilex is by some supposed to be the Hebrew Tirzah, translated Cypress in the Scripture.

1460. Nat. Ord. 213.—Casuarinaceæ, the Beefwood order.—Leafless trees, with pendulous, jointed, striated, sheathed branches, and spikes or heads of unisexual flowers proceeding from bracts. Barren flowers in spikes, and whorled round a jointed rachis. Perianth 2-leaved, with 2 alternating bracts. Stamen 1, carrying up the united 2 leaves of the perianth in the form of a lid. Fertile flowers, capitate, without a jointed rachis, and naked. Ovary 1-celled; ovules 1 or 2, orthotropal; styles 2. Fruit, winged achenes, combined into a bracteated cone. Seed exalbuminous; episperm with spiral cells; radicle superior. Tropical or sub-tropical plants, having the aspect of Equisetums. They abound in Australia. Their wood is hard and heavy, and on account of its colour is called Beefwood. The bark of some of the species of Casuarina is tonic and astringent. C. quadrivalvis is called She-oak. Species about 30. *Ill. Gen.*—Casuarina.

1461. Nat. Ord. 214.—Platanaceæ, the Plane order (Figs. 1677 to 1679).—Amentiferous trees or shrubs, with alternate, deciduous,

Fig. 1678.

Fig. 1679.

palmate, or toothed, stipulate leaves, and unisexual naked flowers in globose catkins (Fig. 1678). Barren flowers—Stamens single, mixed with scales. Fertile flowers—Ovary 1-celled; style thick and subulate. Ovules 1-2, orthotropal, suspended. Nuts clavate, with a persistent style. Seeds usually solitary and albuminous; radicle inferior. Natives of the Levant and North America chiefly. They are fine trees, but their timber is not durable. Platanus orientalis, Oriental Plane (Figs. 1677 and 1678), has palmate leaves resembling those of the common Sycamore. It grows in the western part of Asia, and extends as far east as Cashmere. Its wood is fine-grained and hard, and when old it acquires dark veins so as to resemble walnut wood. The tree was valued for its shade by the Greeks and Romans, and it was held sacred in the east. It seems to be the Hebrew Armon, translated

Fig. 1677.

Figures 1677 to 1679 illustrate the natural order Platanaceæ.

Fig. 1677. Platanus orientalis, the Oriental Plane, supposed to be the Hebrew Armon, translated Chestnut-tree in the Bible (Gen. xxx. 37; Ezek. xxxi. 8). Fig. 1678. Branch of Platanus orientalis, showing the globose clusters or catkins of female flowers. Fig. 1679. Platanus occidentalis, the American Plane-tree. It is called Button-ball in America, from the form of its catkins.

Chestnut in Scripture. P. occidentalis (Fig. 1679) has timber of a reddish colour. Species about 6. *Ill. Gen.*—Platanus.

1462. Nat. Ord. 215.—JUGLANDACEÆ, the Walnut order (Figs. 1680 to 1684).—Trees with alternate, pinnate (Fig. 1680), stipuled

Fig. 1680.

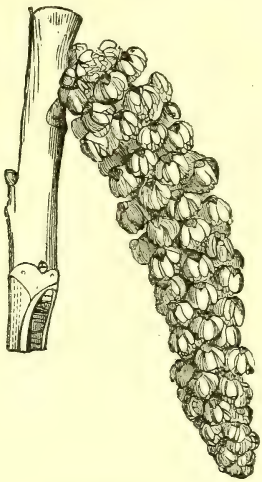


Fig. 1681.

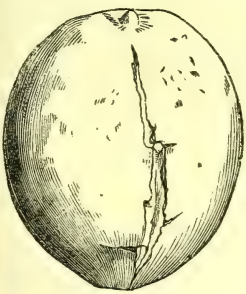


Fig. 1682.

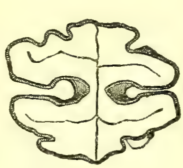


Fig. 1684.

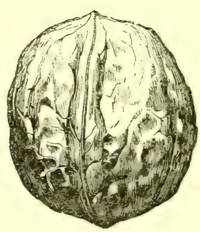


Fig. 1683.

leaves, and unisexual flowers. ♂: Amentiferous (Fig. 1681). Perianth

Figures 1680 to 1684 illustrate the natural order Juglandaceæ.

Fig. 1680. Branch of Juglans regia, the Walnut-tree, with an impari-pinnate leaf and a cluster of drupaceous fruit. It appears to be the Hebrew Egoz, translated nuts in Scripture (Song of Solom. vi. 11). Fig. 1681. Amentum or catkin of the Walnut-tree, containing numerous male flowers amidst scales or bracts. Fig. 1682. Entire drupaceous fruit of the Walnut-tree. It is sometimes called a Tryma (p. 285). The Greeks called it Karuon or Karuon basilikon, royal nut; also Persikon or Persian. The name Juglans means Jupiter's nut, Jovis glans. Fig. 1683. The Walnut, with the epicarp and mesocarp removed, showing the hard 2-valved endocarp, which sends processes inwards from its inner surface. Fig. 1684. Exalbuminous seed or kernel of the Walnut, cut transversely, showing the divisions which correspond to the hard projections of the endocarp or shell. The seed is 4-lobed at its apex and base.

2-3-6-parted, with a scaly bract. Stamens 3 or more. ♀: In terminal clusters or in loose racemes, with distinct or united bracts. Perianth adherent, 3-5-divided. Ovary 2-4-celled at the base, unilocular at the apex. Ovule solitary, orthotropal, and erect; style 1 or 2. Fruit a tryma (Fig. 1682), endocarp stony and often 2-valved (Fig. 1683). Seed exalbuminous, 2-4-lobed at the base, and partly divided by partial dissepiments (Fig. 1684). Natives chiefly of North America. Some are found in the East Indies, Persia, and the Caucasus. Species 27. *Ill. Gen.*—Juglans, Carya, Pterocarya, Engelhardtia, Fortunæa.

1463. The plants are fine trees with edible oily seeds and an acrid bark. Purgative qualities are found in some of the species.

Carya alba, the common Hickory-tree, produces an eatable nut. The wood is tough and elastic. The seeds of C. amara are very bitter. C. olivæformis produces an elliptical nut called the Peccan-nut, which is used like the Walnut.

Juglans regia, the Walnut-tree (Fig. 1680), is a graceful wide-spreading tree, affording a grateful shade. It seems to be the Egoz of Scripture, translated Nuts. The Walnut, according to Royle, extends from Greece and Asia Minor, over Lebanon and Persia, as far as Cashmere. The outer covering of the fruit is astringent, and the spermoderm when fresh is bitter. Its seeds yield a drying oil in large quantity. Its leaves when bruised have an agreeable odour. The wood of J. nigra, Black Walnut, has a fine brown colour, and is valued in carpentry. J. cinerea supplies the Butter-nut of Canada.

1464. Nat. Ord. 216.—Garryaceæ, the Garrya order.—Shrubs with opposite, exstipulate leaves, and amentiferous unisexual flowers, surrounded by united bracts. ♂: Perianth of 4 leaves, alternating with 4 stamens. ♀: Perianth adherent, bidentate. Ovary 1-celled; styles 2; ovules 2, pendulous with long cords. Fruit a 2-seeded berry. Embryo minute in the base of fleshy albumen. The wood is not arranged in circles, and there is an absence of dotted vessels. Natives chiefly of the temperate parts of America. Species 6. *Ill. Gen.*—Garrya, Fadgenia.

b. SPOROGENÆ OR RHIZANTHÆ,

Having Spore-like Seeds with an Acotyledonous Embryo.

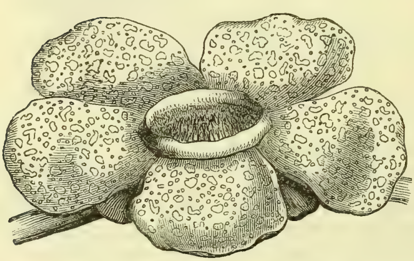


Fig. 1685.

1465. Nat. Ord. 217.—Rafflesiaceæ, the Rafflesia order (Fig. 1685).—Stemless and leafless parasites, consisting only of ☿ or ♂ : ♀ flowers growing on the branches of trees. Perianth superior, with a 5-parted limb, thickened processes or calli either distinct or united into a ring, being attached to

Fig. 1685. Rafflesia Arnoldi, a Rhizanth or Rhizogen, belonging to the natural order Rafflesiaceæ. It is parasitic on a species of Cissus. The perianth has a 5-lobed limb. The throat shows a projecting ring. In the interior is the column bearing the essential organs of reproduction.

the throat of the tube. The essential organs are combined in a column (synema) which adheres to the tube of the perianth. Anthers 2-celled, either distinct and opening by vertical apertures, or combined together, so as to become a multicellular mass opening by a common pore. Ovary 1-celled, placentas parietal. Fruit indehiscent. Seeds ∞; embryo cellular, undivided. East Indian and South American plants, parasitic on species of Cissus and on some Leguminosæ. Species 16. *Ill. Gen.*—Rafflesia, Sapria, Apodanthes, Pilostyles.

1466. Some of the plants are said to be styptic. Their perianth has a fungoid appearance.

Rafflesia Arnoldi, a Sumatra parasite, is capable of containing twelve pints of fluid in its cup. The flower is said sometimes to have a weight of 14 lbs. R. Patma is employed as an astringent and styptic in Java. R. Horsfieldi, R. Cumingi, and R. Rochussenii, have similar properties.

1467. Nat. Ord. 218.—CYTINACEÆ, the Cistus-rape order.—Root-parasites, having ☿ or ♂ ♀ flowers, which are either solitary and stemless, or proceed from bracts arising from a scaly stalk. Perianth has a tubular form, and a 3-6-lobed limb. Anthers sessile, 2-celled, opening longitudinally. Ovary inferior, 1-celled; placentas parietal. Fruit containing pulp. Seeds ∞, immersed in pulp, and with a leathery covering; embryo undivided. Natives of the south of Europe and the Cape of Good Hope. Parasitical on the roots of Cistus, and on those of some succulent plants. Astringency is a property of some of the plants. Some exhale a peculiar animal odour. Species 7. *Ill. Gen.*—Cytinus, Hydnora, Hypolepis.

1468. Nat. Ord. 219.—BALANOPHORACEÆ, the Balanophora order. —Leafless root-parasites, with tubers or rhizomes, whence proceed naked or scaly peduncles, bearing heads of unisexual bracteated flowers, mixed with filaments. ♂: Flowers generally white. Perianth tubular, 3-5-lobed or entire. Stamens 3-5, rarely 1; anthers free or united into a multicellular mass. ♀: Perianth having its tube closely investing the ovary, and its limb 0 or bilabiate; rarely 6-leaved. Ovary 1-celled; ovule a pendulous, cellular nucleus; styles 1-2. Fruit somewhat drupaceous. Seed solitary, albuminous; embryo undivided. Parasitic on the roots of various Dicotyledons, and abounding on the mountains of tropical countries, especially the Andes and Himalaya. *Ill. Gen.*—Balanophora, Cynomorium, Sarcophyte, Lophophytum, Helosis, Corynea, Phyllocoryne.

1469. Some of the plants have styptic properties. Some have a very fetid odour; others, as Lepidophytum and Ombrophytum, are eatable.

Cynomorium coccineum, commonly called Fungus melitensis, a Maltese plant, has been long celebrated for arresting hemorrhage.

Mystropetalon is a genus of monœcious root-parasites, resembling Balanophora, and forming, according to Dr. Hooker, a distinct order, Mystropetalinæ.

2. GYMNOSPERMÆ OR GYMNOGENÆ.

1470. Nat. Ord. 220.—Coniferæ or Pinaceæ, the Coniferous or Pine order (Figs. 1686 to 1696).—Resinous trees or shrubs, with

Fig. 1686.

Fig. 1687.

disc-bearing woody tissue (Fig. 1689), linear, acerose or lanceolate, parallel-veined leaves, sometimes clustered and having a membranous sheath at the base (Fig. 1688); flowers unisexual and achlamydeous. Male flowers in deciduous catkins, each consisting of 1 stamen or of several united; anthers 2 or many-celled, dehiscing longitudinally, often crested above (Fig. 1690). Female flowers in cones; scales arising from the axil of membranous bracts supplying the place of ovaries; no style nor stigma; ovules naked, 1, 2, or several, at the base of each scale, with a large micropyle at the apex (Fig. 1693). Fruit a cone (Fig. 1692) formed of hardened scales, sometimes with

Figures 1686 to 1696 illustrate the natural order Coniferæ.

Fig. 1686. Cedrus Libani, the Cedar of Lebanon. Fig. 1687. Callitris quadrivalvis, called also Thuja articulata, the Arar-tree, which yields Thyine wood and Sandarach. Fig. 1688. Linear leaves of Pinus Strobus in a cluster of five, with a scaly sheath at the base. Fig. 1689. Punctated or disc-bearing woody tissue of a Conifer. Fig. 1690. Stamen of a Conifer, with longitudinal dehiscence, *val*, containing pollen, *pol*, and terminated by a crest at the apex. Fig. 1691. Ripe curved pollen of a Fir, with the extine separated and appearing as hemispherical portions at the extremities of the grains. Fig. 1692. Cone or fruit of Pinus sylvestris, Scotch Fir. Fig. 1693. Scale, *eca*, of a young cone separated, with two ovules, *ov*, at the base, having large micropyles, *mic*. Fig. 1694. Scale of a mature cone, with two winged seeds at the base, the micropyle, *m*, and the chalaza, *ch*. Fig.

the addition of bracts also, which either disappear, or become enlarged and lobed. Seed with a hard crustaceous spermoderm, sometimes


Fig. 1688.

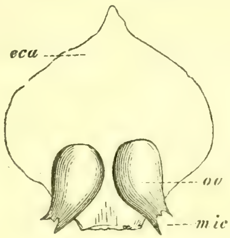


Fig. 1693.

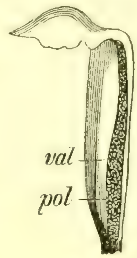


Fig. 1690.

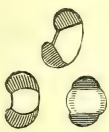


Fig. 1691.

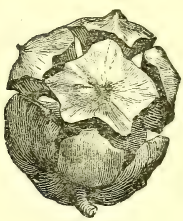


Fig. 1695.

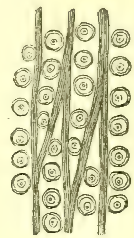


Fig. 1689.

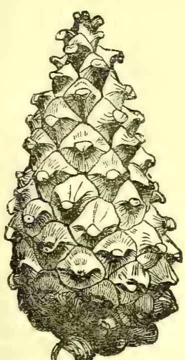


Fig. 1692.

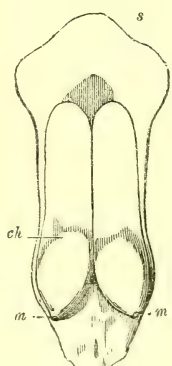


Fig. 1694.

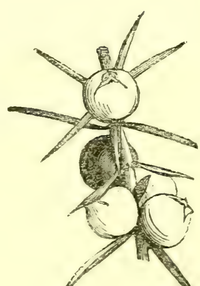


Fig. 1696.

winged (Fig. 1694, and Fig. 893, p. 297); embryo in fleshy oily albumen, sometimes polycotyledonous (Fig. 928, p. 307); radicle having no definite boundary, but losing itself among the lax cells of the albumen near the apex of the seed. Conifers are found in various

1695. Cone or fruit of Cupressus sempervirens, the Cypress. Fig. 1696. Fruiting branch of Juniperus communis, Juniper, with linear acerose leaves, and succulent cones called galbuli.

Further illustrations of Conifers. Discs on the wood, Figs. 55, 56, and 57, p. 25; Pinus Strobus, Weymouth Pine, Fig. 1123, p. 436; P. resinosa, Fig. 1124, p. 436; impregnation of Coniferæ, p. 578, *et seq.*

parts of the world, both in cold and in warm climates. They are most abundant in temperate regions, both in the northern and southern hemispheres. In the former they occur in the form of Pines, Spruces, Larches, Cedars, and Junipers, while in the latter we meet with species of Araucaria, Eutassa, and Dammara. Species 120 or more. The two following divisions have been adopted :—Sub-order 1. Abietineæ, the Fir tribe; ovules inverted, pollen oval, or curved (Fig. 1691). *Ill. Gen.*—Pinus, Abies, Picea, Larix, Cedrus, Cunninghamia, Araucaria, Eutassa, Dammara. Sub-order 2. Cupressineæ, the Cypress tribe; ovules erect, pollen spheroidal, cone occasionally succulent, forming a galbulus. *Ill. Gen.*—Juniperus, Fitzroya, Saxe-Gothæa, Thuja, Libocedrus, Cryptomeria, Cupressus, Callitris, Widdringtonia, Taxodium.

1471. Conifers supply valuable timber, and yield resin, oil, pitch, and turpentine of various kinds.

Abies includes different species of Fir and Spruce, in all of which the leaves come off singly. In the true Abies group the leaves are flat, and the scales of the cone deciduous, while in the Picea section the leaves are tetragonal, and the scales are persistent. Abies balsamea, the Balm of Gilead Fir, and A. canadensis, Hemlock Spruce, yield Canada Balsam. The leaves of the latter, along with those of Abies nigra, supply by boiling the extract used in making Spruce Beer. A. pectinata, the Silver Fir, furnishes Strasburg Turpentine. A. excelsa, Norway Spruce (Fig. 1122, p. 436), supplies common Frankincense or Thus. M. Gross has succeeded in making paper from the wood of this pine. The wood must not be too old. It is reduced to a pulp and then formed into paper. The printing-paper made from Pine-wood is said to be excellent. It is also said to be superior paper for printing in colours. Pasteboard made of it is very strong. A. Douglasii is a gigantic Pine of California, which thrives well in Britain. It attains a height of 245 feet, with a circumference of 57½ feet at 3 feet from the ground; A. grandis 224; A. trigona 300; A. alba and A. rubra 160-170 feet. The bracts of Abies bracteata, bracteated Silver Fir, have an elongated process 2 inches in length, many times longer than the scales of the cone.

Araucaria contains Chilian and Australian species, which have single-seeded scales with adherent seeds, and many-celled anthers. A. imbricata from Chili, and A. Bidwillii from Moreton Bay, have edible seeds. The latter are called Bunya-Bunya. The former tree attains the height of 234-260 feet. A. Cunninghami is the Moreton Bay pine.

Callitris quadrivalvis, the Arar-tree, appears to yield the resin called Sandarach or Pounce, used for scattering over manuscripts. According to Royle and others, it is the Thyine-wood of the Bible, and the Citron-wood of the Romans. The tree is a native of Mount Atlas and other hills on the coast of Africa. Its timber is balsamic, odoriferous, and durable. The timber-work of the roof of the Mosque, now the Cathedral of Cordova, built in the 9th century, is of this wood. In Australia there are 12 or 15 species of Callitris. They are often called Cypress-pines. C. australis is the Oyster Bay pine.

Cedrus Libani, the Cedar of Lebanon (Fig. 1686, and Fig. 1130, p. 438), is the Eres or Æres of the Bible, celebrated in the construction of the Temple of Solomon. It is a wide-spreading tree 50-80 feet high, with horizontal branches. Some of the old Cedars still exist on Lebanon. Belon, about 1550, found these Cedars 28 in number; Rawolf in 1574, 24; De la Roque in 1688, 20; Maundrell in 1696, 16; Pococke in 1744-45, 15; Lamartine in 1832, 7. C. Deodara, the Deodar, is a noble Himalayan Cedar, which some have thought to be a variety of the Cedar of Lebanon. Its wood is durable, is not liable to warp, nor is it subject to the attack of insects. Major Madden states, that in the temple at Kunawar, which is supposed to be from 600 to 800 years old, the Deodar beams were perfect. Pieces from the Zein-ul-Kadol bridge in Cashmere were only slightly decayed, although exposed to the action of water for 400 years. The Deodar is inferior to the Pinus longifolia, Cheer, in resisting pressure at right angles. Major Madden mentions Deodars 15, 20, 30, and 36 feet in girth, and 150 to 200 feet high.

Cryptomeria japonica, the Japan Cedar, is a graceful tree, a recent valuable addition to the Conifers cultivated in Britain.

Cupressus includes the various species of Cypress. C. sempervirens, common Cypress (Fig. 881, p. 293), is supposed to be the Berosh or Beroth of the Bible, translated Fir. The word Tirzah, translated Cypress in Is. xliv. 14, is supposed to refer to the Quercus Ilex or Evergreen Oak. The Cypress has a tapering form resembling the Lombardy Poplar. It attains a height of 50 or 60 feet. It is a native of the Grecian Archipelago, Asia Minor, Syria, Persia, and Palestine. Its wood is very indestructible. The gates of Constantinople, which stood for more than 1000 years, were made of this wood. It has been thought that the Etz-Gopher, Gopher-wood, mentioned in Gen. vi. 14, included the Cypress as well as other Coniferous woods. The leaves of C. thyoides, according to Lindley, are poisonous.

Dammara is represented by a species in the southern hemisphere, and by another in the northern hemisphere. The former, D. australis, is the Kaurie or Cowdie Pine of New Zealand, which attains a height of 200 feet, and supplies valuable timber for masts, as well as a hard useful resin. The latter, D. orientalis, yields the Dammar resin of India.

Eutassa excelsa (Fig. 59, p. 26) is the famous Norfolk Island Pine, which grows to the height of 181-224 feet, and the wood of which is very valuable. The wood, like that of the Araucaria, is marked by alternating double discs (Fig. 58, p. 26).

Juniperus includes the species of Juniper. They have a succulent cone called galbulus (Fig. 880, p. 292), and the fruit is familiarly designated as a berry. The fruit of J. communis (Fig. 1696), common Juniper, yields an oil which has diuretic properties, and enters into the composition of Hollands. The wood is reddish, and serves for veneering. The volatile oil procured from the branches and leaves of J. Sabina, Savin, is a very active and dangerous emmenagogue. The wood for forming Cedar pencils is got from J. bermudiana; a less valuable sort comes from J. virginiana, the Red Cedar. The latter plant is used in America as a substitute for Savin. Dr. Fleming has pointed out, that Cedar-wood cabinets are injurious to objects of natural history, as well as to instruments of different kinds. The resinous matter becomes deposited over the objects like a varnish. He recommends White American Fir as the best material. J. Oxycedrus has very durable wood, and was, according to some, used by the Greeks in carving the images of their gods. Its empyreumatic oil is used in skin diseases under the name of Huile de Cade. The Hebrew word Rothem, translated Juniper in Scripture, seems to refer to a species of Broom (Fig. 533, p. 206).

Larix includes the Larches, which have clustered deciduous leaves. L. europæa, the European Larch (Fig. 1120, p. 435), is a valuable timber tree which succeeds well in Britain. It yields venetian turpentine. A saccharine matter like Manna exudes from its branches.

Pinus includes the Pines, in which the leaves are in clusters of 2, 3, 4, or 5, surrounded by a membranous sheath at the base, which may be looked upon as the primary leaf, from the axis of which the others proceed. P. sylvestris, the Scotch Fir (Fig. 51, p. 25), supplies turpentine and pitch, which are also procured from P. Pinaster the Cluster Pine, P. palustris the Swamp Pine of Virginia, and P. Tæda the Frankincense Pine. The inner bark of the Scotch Fir supplies the Bark-bread of Norway. From the leaves of Pinus sylvestris M. Panewitz makes a hemp-like fibre, called Pine-wool, which is employed for stuffing pillows, cushions, and mattrasses. It is said to last long, and to retain its elasticity; it does not harbour insects, and does not become mouldy. It is also woven into blankets and counterpanes. A manufacture of Pine-wool is carried on near Breslau. The liquid or decoction developed by the process contains prussic acid and oleo-resinous matter. The maritime variety of P. Pinaster, called the Bourdeaux Pine, thrives well on the sea-shore, and binds together the loose sand. P. Pinea, the Stone Pine, supplies edible seeds. It is the source of Carpathian Balsam. P. Pumilio supplies Hungarian Balsam. The Hebrew word Oren, translated Ash in Is. xliv. 14, is conjectured to be a species of Pine. Pinus Fremontiana attains a height of 224 feet; P. Lambertiana 224-235; P. Strobus 160 to 200, and sometimes even 266 feet.

Sequoia gigantea is said to attain a height of 300 feet.

Taxodium distichum, the Ahuahuete of the Mexicans, the deciduous Cypress, attains the height of 120 feet, with a diameter of 32 to 40 feet, according to Humboldt (Aspects of Nature, ii. 94.)

Thuja. The species of this genus are known by the common name of Arbor-vitæ. T. occidentalis is very fragrant, while T. orientalis is not so. T. gigantea in Columbia attains the height of 180 feet.

1472. Nat. Ord. 221.—Taxaceæ, the Yew order (Figs. 1697 to 1699).—Trees or shrubs having narrow, evergreen, alternate, or distichous leaves (Fig. 1697), which are either veinless or have a forked venation. Closely allied to Coniferæ, and generally included as a section of the order, but differing in not producing true cones. They have monadelphous stamens (Fig. 1698); solitary, naked ovules, and their seed is supported on, or enclosed by, a succulent cup-shaped receptacle (Fig. 1699). They are natives of temperate regions, and abound in Asiatic countries. They are found also in Europe, New Zealand, and at the Cape of Good Hope. Known species about 60. Zuccarini estimates the species of Coniferæ and Taxaceæ at 208, of which about 160 are in the northern hemisphere, and about 50 in the southern. *Ill. Gen.* — Taxus, Podocarpus, Dacrydium, Phyllocladus, Cephalotaxus, Salisburia.

Fig. 1697.

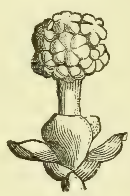


Fig. 1698.

Fig. 1699.

1473. Like the Conifers they yield valuable and durable timber, along with resinous and astringent matter. Some are poisonous.

Figures 1697 to 1699 illustrate the natural order Taxaceæ.

Fig. 1697. Distichous leaves of Taxus baccata, the Yew. Fig. 1698. Staminiferous flower of the Yew, with bracts at the base and numerous monadelphous stamens. Some consider this as one stamen divided into numerous antherine cells by the connective. Fig. 1699. Fruit of the Yew, a naked seed partially enclosed in a succulent receptacle.

Dacrydium taxifolium, the Kakaterro of New Zealand, is a lofty tree, producing valuable wood. D. cupressinum, the Dimon pine, is sometimes 213 feet high. D. Franklinii is the famous Huon pine of Australia, which attains a height of 60-100 feet, with a diameter of 2-8 feet. It yields a valuable timber.

Podocarpus Totarra, the Totarra, is said to be the most highly prized timber-tree in New Zealand. P. dacrydioides is the Kaikatia of that country; P. spicata, the Mai or Matai; and P. ferruginea, the Miro or Maira.

Salisburia adiantifolia, the Ginko, has a resinous fruit, which is used by the Chinese under the name of Pa-Kwo.

Taxus baccata, the common Yew, has a beautiful red covering of its seed. Its leaves and seeds are narcotico-acrid. The wood is very indestructible, and the tree attains a great age. Some Yews are recorded upwards of 3000 years old. The outer portion of the wood is much esteemed for making bows.

1474. Nat. Ord. 222.—Gnetaceæ, the Jointed-Fir order.—Small trees or creeping shrubs, not resinous, with jointed stems and branches, and opposite, reticulated, sometimes scaly leaves. They are closely allied to Coniferæ and Taxaceæ, and are chiefly distinguished by the want of true cones, by the male flowers having a 1-leaved perianth, by the anthers being 1-celled and porose, by a third ovular covering next the nucleus being protruded through the foramen in a style-like manner, and by their long, twisted embryonic suspensor. The episperm is succulent. Natives of temperate as well as warm regions in Europe, Asia, and South America. The seeds of several of the species are eaten. Within the succulent episperm of Gnetum urens, stinging needle-like cells exist. Species about 20. *Ill. Gen.*—Ephedra, Gnetum.

1475. Nat. Ord. 223.—Cycadaceæ, the Cycas order (Figs. 1700

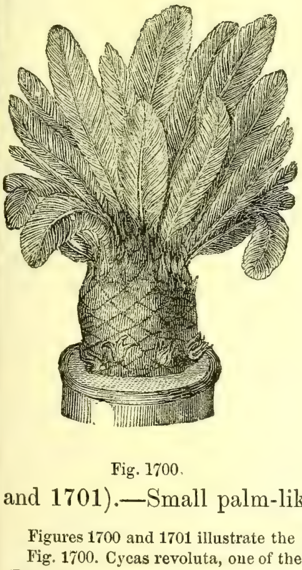


Fig. 1700.

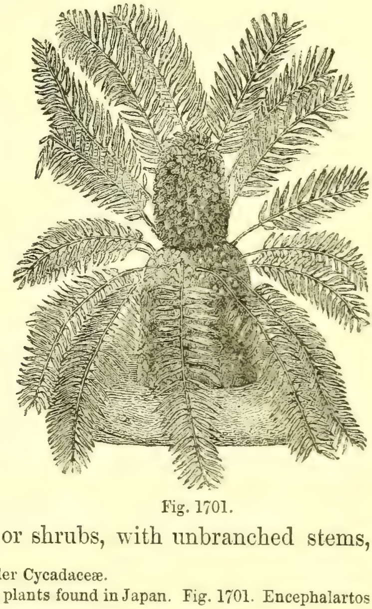


Fig. 1701.

and 1701).—Small palm-like trees or shrubs, with unbranched stems,

Figures 1700 and 1701 illustrate the natural order Cycadaceæ.

Fig. 1700. Cycas revoluta, one of the false Sago plants found in Japan. Fig. 1701. Encephalartos (Zamia) pungens, another starch-yielding Cycad.

occasionally dichotomous, marked with leaf-scars, and having large medullary rays, along with pitted woody tissue. Leaves pinnate, and usually circinate in vernation. Flowers ♂ ♀ and achlamydeous. Males in cones, the scales bearing clusters of 1-celled anthers on their lower surface. Females consisting of ovules on the edge of altered leaves, or placed below or at the base of scales. Seeds either hard, or having a soft, spongy spermoderm, sometimes polyembryonous; embryo hanging by a long suspensor in a cavity of fleshy or mealy albumen; cotyledons unequal. Natives chiefly of the tropical and temperate regions of America and Asia. Species 46. *Ill. Gen.*—Cycas, Dion, Zamia, Encephalartos, Macrozamia.

1476. Cycads have a mucilaginous juice, in which there is often much starch, which is used for food.

Cycas revoluta (Fig. 1700), a Japan species, has starchy matter in its stem, which is collected and eaten like Sago. C. circinalis, in the Moluccas, yields a similar kind of false Sago, as well as a gummy exudation resembling Tragacanth.

Dion edule derives its specific name from the fact of its starchy seeds yielding a kind of Arrow-root in Mexico.

Encephalartos is also a starch-producing genus. Many of the species supply what is called Caffre-bread. E. pungens (Fig. 1701) ripened its fruit at Chatsworth.

Zamia is also amylaceous. Some of the species supply a kind of Arrow-root in the West Indies.

1477. Analysis of the natural orders of Monochlamydeous Exogens, with references to the numbers of the orders in the preceding pages.

1. ANGIOSPERMÆ.

a. SPERMOGENÆ.

1. Achlamydeous Exogens (without a perianth).

a. Leaves exstipulate.
Flowers hermaphrodite.
Embryo in a vitellus .... Piperaceæ, 207.
Embryo not in a vitellus .... Podostemonaceæ, 204.
Flowers unisexual.
Flowers amentaceous, carpel single .... Myricaceæ, 208.
Flowers not amentaceous, carpels two or more.
Fruit indehiscent, seeds peltate .... Callitrichaceæ, 197.
Fruit usually tricoccous, seeds not peltate .... Euphorbiaceæ, 195.

b. Leaves stipulate.
Flowers hermaphrodite.
Carpel solitary.
Ovule erect, embryo in a vitellus .... Piperaceæ, 207.
Ovule suspended, no vitellus .... Chloranthaceæ, 205.
Carpels 3 or 4.
Ovule erect, embryo in a vitellus .... Sauruaceæ, 206.
Flowers unisexual.
Ovary 1-celled.
Ovules numerous, comose .... Salicaceæ, 209.
Ovules solitary or in pairs.

Ovule erect.. Myricaceæ, 208.
Ovule pendulous .... Platanaceæ, 214.
Ovary 2 or more-celled.
Seeds winged.. Altingiaceæ, 210.
Seeds not winged .... Euphorbiaceæ, 195.

2. Apetalous Exogens (having a single perianth).

a. Ovary superior.
* *Leaves exstipulate.*
Flowers hermaphrodite.
Carpel solitary.
Anther-valves recurved .... Lauraceæ, 178.
Anthers slit.
Leaves lepidote (covered with scales) .... Elæagnaceæ, 183.
Leaves not lepidote.
Perianth long or tubular.
Perianth partially hardened.
Base hardened .... Nyctaginaceæ, 169.
Tube hardened .... Scleranthaceæ, 173.
Perianth not hardened.
Stamens in the points of the perianth ... Proteaceæ, 182.
Stamens not in the points of the perianth.
Ovule orthotropal, erect .... Polygonaceæ, 176.
Ovule anatropal, pendulous .... Thymelæaceæ, 185.
Perianth short, not truly tubular, segments nearly separate to the base.
Stamens hypogynous.
Stamens alternate with the segments or ∞ Phytolaccaceæ,174.
Stamens opposite the segments.
Flowers bracteated .... Amaranthaceæ,170.
Flowers not bracteated .... Chenopodiaceæ,171.
Stamens perigynous .... Basellaceæ, 172.
Carpels more than one, either separate or combined.
Carpels several, separate .... Phytolaccaceæ,174.
Carpels several, combined into a solid pistil.
Seeds exalbuminous.
Perianth tubular.
Ovary 2-celled .... Aquilariaceæ, 186.
Ovary 4-celled .... Penæaceæ, 184.
Perianth not tubular, imperfect, or spathaceous Podostemonaceæ,204.
Seeds albuminous.
Perianth coloured, embryo peripherical ...... Phytolaccaceæ,174.
Flowers unisexual.
Carpels solitary or quite separate.
Perianth tubular.
Anthers opening by recurved valves............ Atherospermaceæ, 179.
Anthers opening longitudinally .... Myristicaceæ, 180.
Perianth open, not tubular.
Seeds exalbuminous, embryo straight.
Perianth 2-leaved .... Casuarinaceæ, 213.
Perianth many-parted .... Ceratophyllaceæ,198.
Seeds albuminous.
Embryo peripherical.................................... Chenopodiaceæ, 171.
Embryo straight .... Monimiaceæ, 181.
Carpels more than one, combined into a solid pistil.
Ovules definite.

Ovule ascending .... Empetraceæ, 194.
Ovule suspended .... Euphorbiaceæ, 195.
Ovules indefinite.
Leaves with ascidia .... Nepenthaceæ, 192.

** *Leaves stipulate.*
Flowers hermaphrodite.
Carpel solitary.
Stipules ochreate .... Polygonaceæ, 176.
Stipules simple .... Petiveriaceæ, 175.
Carpels more than one combined into a solid pistil.
Leaves with round solitary transparent dots ...... Samydaceæ, 188.
Leaves without dots.
Perianth regular, in a double row .... Chailletiaceæ, 187.
Perianth irregular, in a single row .... Ulmaceæ, 201.
Flowers unisexual.
Carpel solitary.
Antherine cells perpendicular to the filament ...... Stilaginaceæ, 202.
Antherine cells parallel to the filament.
Sap watery............ Urticaceæ, 199.
Sap milky .... Artocarpaceæ, 200.
Carpels more than one combined into a solid pistil.
Amentiferous.
Seeds arillate.
Stamen 1, connective large .... Lacistemaceæ, 203.
Stamens 2-5, connective inconspicuous......... Scepaceæ, 196.
Seeds not arillate .... Betulaceæ, 211.
Not amentiferous .... Euphorbiaceæ, 195.

b. Ovary inferior, or partially so.
* *Leaves exstipulate.*
Flowers hermaphrodite.
Ovary 3-6-celled, many-seeded .... Aristolochiaceæ, 191.
Ovary 1-celled.
Style 1 .... Santalaceæ, 190.
Styles 3-5 .... Homaliaceæ, 189.
Flowers unisexual.
Amentiferous.
Leaves alternate .... Myricaceæ, 208.
Leaves opposite.
Simple leaves............ Garryaceæ, 216.
Compound leaves............ Juglandaceæ, 215.
Not amentiferous .... Datiscaceæ, 193.

** *Leaves stipulate.*
Flowers hermaphrodite.
Style simple .... Aristolochiaceæ, 191.
Styles 3-5 .... Homaliaceæ, 189.
Flowers unisexual.
Fruit cupulate .... Corylaceæ, 212.
Fruit naked.
Simple (monogynœcial) .... Begoniaceæ, 177.
Multiple (polygynœcial) .... Artocarpaceæ, 200.

b. SPOROGENÆ OR RHIZANTHÆ.

Ovules solitary .... Balanophoraceæ, 219.
Ovules indefinite.

Anthers opening by slits .... Cytinaceæ, 218.
Anthers opening by pores .... Rafflesiaceæ, 217.

2. GYMNOSPERMÆ OR GYMNOGENÆ.

Stem jointed .... Gnetaceæ, 222.
Stem not jointed.
Leaves pinnate .... Cycadaceæ, 223.
Leaves simple.
Seeds in cones .... Coniferæ, 220.
Seeds solitary .... Taxaceæ, 221.

Among Thalamifloral Exogens, the following orders contain Monochlamydeous or Achlamydeous species:—Ranunculaceæ 1, Menispermaceæ 6, Papaveraceæ 13, Flacourtiaceæ 18, Caryophyllaceæ 28, Sterculiaceæ 31, Byttneriaceæ 32, Tiliaceæ 33, Malpighiaceæ 45, Geraniaceæ 54, Rutaceæ 63, Xanthoxylaceæ 64.

Among Calycifloral Exogens, the following orders contain Monochlamydeous or Achlamydeous species:—Celastraceæ 68, Rhamnaceæ 70, Amyridaceæ 72, Leguminosæ 74, Rosaceæ sect. Sanguisorbeæ 76, Lythraceæ 78, Combretaceæ 81, Myrtaceæ 85, Halorageaceæ 90, Cucurbitaceæ 92, Passifloraceæ 95, Portulacaceæ 97, Illecebraceæ 98, Tetragoniaceæ 101, Saxifragaceæ 105, Cunoniaceæ 107, Loranthaceæ 113.

Among Corollifloral Exogens, the following orders contain Monochlamydeous or Achlamydeous species:—Oleaceæ 138, Primulaceæ 166.

Some consider Begoniaceæ 177, Chailletiaceæ 187, Samydaceæ 188, and Homaliaceæ 189, as truly Dichlamydeous, referring them to the Thalamifloral and Calycifloral divisions of Exogens.

CLASS II.—MONOCOTYLEDONES, ENDOGENÆ, OR AMPHIBRYA.

SUB-CLASS 1.—DICTYOGENÆ.

Endogens having Net-veined Leaves, which usually disarticulate with the Stem. Woody Matter of the Rhizome disposed in a circular wedge-like manner.

1478. Nat. Ord. 224.—DIOSCOREACEÆ, the Yam order.—Twining shrubs, with epigeal or hypogeal tubers, usually alternate leaves, and small, bracteated, unisexual flowers growing in spikes. Perianth 6-cleft, in 2 rows, herbaceous, adherent. Stamens 6, inserted into the base of the perianth. Ovary inferior, 3-celled; ovules 1-2, suspended; style trifid. Fruit compressed, 3-celled, 2 cells often abortive, sometimes fleshy. Seeds albuminous; embryo in a cavity. Chiefly found in tropical countries. Tamus, however, grows in temperate regions. Species 150. *Ill. Gen.*—Tamus, Testudinaria, Dioscorea, Rajania.

1479. Acridity prevails in the order, but it is often associated with a large amount of starch.

Dioscorea. Various species of this genus, such as D. sativa, D. alata, and D. aculeata, produce edible tubers, which are known by the name of Yams, and are used like potatoes. The acrid principle in them is much diluted, and probably disappears by boiling.

Tamus communis, Black Bryony, has an acrid purgative and emetic root, and a baccate fruit of a red colour. Its young shoots are occasionally used as Asparagus, but they are not safe.

Testudinaria Elephantipes has a remarkably tuberculated tuberous stem, and has been called Elephant's-foot or Tortoise plant of the Cape. The central cellular part is eaten by the Hottentots.

1480. Nat. Ord. 225. — SMILACEÆ, the Sarsaparilla order (Figs. 1702 and 1703). — Herbs or shrubby plants, often climbing, with

Fig. 1702.

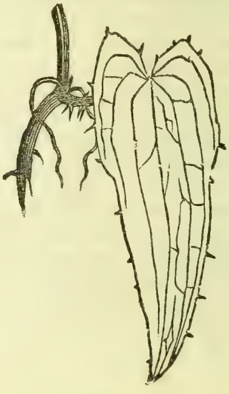


Fig. 1703.

petiolate leaves jointed to the stem, and hermaphrodite or unisexual flowers. Perianth 6-parted. Stamens 6, perigynous or hypogynous. Ovary 3-celled; stigmas 3; ovules orthotropal. Fruit a few or many-seeded berry. Seed albuminous. Natives of temperate and tropical regions. Species about 120. *Ill. Gen.*—Smilax, Ripogonum.

1481. The plants of the order have demulcent, mucilaginous, and diuretic properties.

Smilax embraces the various species of Sarsaparilla, the roots of which are used medicinally as tonics and alteratives. S. officinalis supplies Jamaica Sarsaparilla, which is the best. S. syphilitica, and probably S. papyracea, as well as S. brasiliensis, furnish the Lisbon or Brazilian Sarza; while S. medica is said to be the source of the Vera Cruz sort. S. aspera and S. excelsa are used as substitutes in the South of Europe, and many other species are employed in different parts of America and Asia. What is called China root is the produce of S. China.

1482. Nat. Ord. 226.—TRILLIACEÆ, the Trillium order.—Herbs with tubers or rhizomes, verticillate leaves, and large terminal ☿ flowers. Perianth of 6 or 8 parts, in 2 rows, the inner sometimes coloured. Stamens 6, 8, or 10, with apicilar processes. Ovary superior, 3-5-celled; placenta axile; styles 3-5. Fruit succulent, 3-5-

Figures 1702 and 1703 illustrate the natural order Smilaceæ.

Fig. 1702. Smilax rudis, with cordate acute leaves which are jointed with the stem. Fig. 1703. Reticulated leaf of Smilax, with stipulary tendrils.

celled. Seeds ∞, albuminous. Natives of the temperate parts of Europe, Asia, and North America. The properties of the order are acrid, narcotic, and emetic. Paris quadrifolia is said to be narcotico-acrid.* The rhizomes of Trilliums are often emetic. Species 30. *Ill. Gen.* —Paris, Trillium, Medeola.

1483. Nat. Ord. 227.—Roxburghiaceæ, the Roxburghia order.—Twining shrubs, with large, solitary ☿ flowers, allied to Trilliaceæ, and distinguished chiefly by their 1-celled, 2-valved fruit, with a basal placenta. Perianth 4-leaved, coloured. Stamens 4, hypogynous. Ovules anatropal. Natives of the hot parts of India. Species 4. *Ill. Gen.*—Roxburghia.

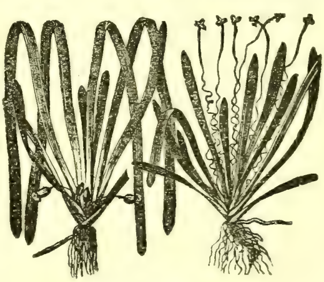
1484. Nat. Ord. 228.—Philesiaceæ, the Philesia order.—A small order, nearly allied to the last, from which it differs in its trimerous symmetry, parietal placentas, and orthotropal ovules. The plants are found in Chili, and seem to have properties like Smilax. Lapageria rosea is a showy climber. Species 2. *Ill. Gen.*—Philesia, Lapageria.

SUB-CLASS 2.—PETALOIDEÆ OR FLORIDÆ.

1. EPIGYNÆ.

Perianth adherent, Ovary inferior, Flowers usually Hermaphrodite.

1485. Nat. Ord. 229.—Hydrocharidaceæ, the Frog-bit order (Fig. 1704).—Aquatic plants, with spathaceous, ☿, or unisexual flowers. Perianth of 6 leaves, the 3 inner petaloid. Ovary 1-celled, or spuriously 3-9-celled; stigmas 3-9; placentas parietal. Fruit dry or fleshy, indehiscent; seeds exalbuminous; embryo straight, orthotropal. This order ought probably to be placed among the unisexual plants, and close to Naiadaceæ. Its perianth, however, differs from that of the plants in the division Incompletæ. Found chiefly in Europe, Asia, and North America. Movements in the cells are seen under the microscope (pages 415-16). Anacharis Alsinastrum has become naturalized in many parts of Britain, and grows so rapidly as to fill up water-courses. Vallisneria is remarkable for its mode of impregnation (p. 560). Some of the plants are esculent. Species about 25.



a Fig. 1704. *b*

Fig. 1704. Vallisneria spiralis; the male plant, *a*, the female plant, *b*.

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* The four cross leaves of this plant gave rise to its name, True-love Knot.

Ill. Gen. — Udora, Anacharis, Hydrilla, Lagarosiphon, Vallisneria, Stratiotes, Hydrocharis.

1486. Nat. Ord. 230.—ORCHIDACEÆ, the Orchis order (Figs. 1705 to 1712).— Terrestrial or epiphytic herbs or shrubs, with fibrous

Fig. 1705.

Fig. 1706.

Fig. 1710.

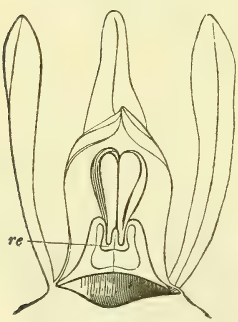


Fig. 1709.

Fig. 1711.

Fig. 1712.

(Fig. 1114, p. 426), or tuberous roots (Fig. 1706), a short stem or a pseudo-bulb (Fig. 1705), entire, often sheathing leaves, and hermaphrodite showy flowers. Perianth of 6 segments, in 2 rows (Fig. 1708), mostly coloured, one, the lowest (so situated from the twisting of the ovary) generally differing in form from the rest, and often

Figures 1705 to 1712 illustrate the natural order Orchidaceæ.

Fig. 1705. Orchideous Epiphyte, showing its peculiar flowers and pseudo-bulb. Fig. 1706. Tubercular roots of Orchis mascula, a terrestrial Orchid. The dried tubercules constitute Salep. Fig. 1707. Diagram of the flower of Orchis, *s*, *sl*, *sl*, the three divisions of the outer perianth, the first being inferior and the other two lateral; *pl*, *pl*, the two lateral divisions of the inner perianth, *ps*, the superior division or the labellum, which becomes inferior by the twisting of the ovary; *e*, the fertile stamen, with its two pollen masses in the anther-lobes, the two lateral stamens are abortive; *c*, the one-celled ovary cut transversely, having three parietal placentas. Fig. 1708. Flower of an Orchid, consisting of three outer divisions of the perianth, *s s s*, three inner, *p p l*, the latter, *l*, being the labellum, which is inferior in this figure by the twisting of the ovary; *e*, the spur of the labellum; *o*, the

spurred; it is called the labellum or lip, and has sometimes 3 marked portions,—the lowest being the hypochilium, the middle the meso-

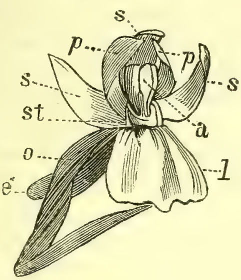


Fig. 1708.

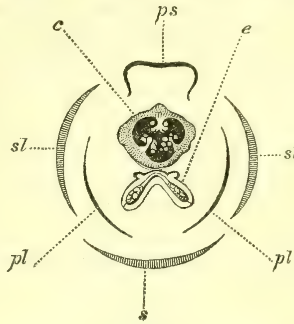


Fig. 1707.

chilium, and the upper the epichilium. By adhesion or abortion, the parts of the perianth are sometimes reduced to 5 or 3. Essential organs united on a common column or gynostemium (Fig. 1709). Stamens 3, the 2 outer, sometimes the central one, being abortive; anthers 2-4-8-celled; pollen powdery, or adhering in masses called pollinia (Fig. 1710), attached to the rostellum by a naked or saccate gland. Ovary 1-celled, with 3 parietal placentas (Fig. 1711); stigma a viscid space in front of the column. Fruit usually a 3-valved capsule, which often opens by 6 portions, owing to the midribs of the valves separating (Fig. 1712). Seeds ∞, exalbuminous, with a loose reticulated episperm; embryo solid and fleshy. This order is well distinguished by its peculiar gynandrous flowers, labellum, and pollinia. The labellum is marked by various processes or calli, which may be reckoned abortive stamens. The flowers present often remarkable insect forms, and their colours are frequently variegated in a curious manner. The flowers have frequently a strong odour. In some instances, as in Malachadenia clavata, the odour is very fetid, like carrion. The labellum sometimes exhibits movements (p. 537). Orchids are widely distributed, but are most abundant in warm moist climates. They are sometimes found at great elevations, as Oncidium nubigenum, at 14,000 feet on the Andes, and Epidendrum frigidum at from 12-13,000 feet on the Columbia mountains. Some of them are much restricted in their distribution, as may be exemplified in

twisted ovary; *st*, the stigma; *a*, the anther containing pollinia. Fig. 1709. Upper part of an Orchid flower. The outer divisions of the perianth are seen, and two of the inner, the third or labellum being removed. The two anther lobes are seen with the pollinia attached to the upper part of the stigma by viscid matter, *re*. Fig. 1710. Pollen masses of an Orchid, with their caudicles and common gland. Fig. 1711. Ovary of Orchis cut transversely, showing three parietal placentas. Fig. 1712. Fruit of Orchis, opening by three valves, each bearing placenta and ovules, and the three midribs of the carpels remaining attached at the top, so that there appear to be six valves, three spreading, ovuliferous, and three adherent without ovules.

Additional illustrations of Orchidaceæ:—Terrestrial Orchid with tubercules, Fig. 136, p. 56. Flower of Listera ovata, Fig. 539, p. 207. Orchis flower, Fig. 538, p. 207. Pollen mass and tube, Fig. 665, p. 236.

some of the Table Mountain species of Disa. The terrestrial species are usually met with in temperate climates, while the epiphytal are confined to warm regions. Spruce mentions an Orchid in Brazil nine feet high. Lindley, whose works on Orchids are standard ones, considers that there are upwards of 3000 species, of which 40 are British. *Ill. Gen.*—Pleurothallis, Liparis, Malaxis, Dendrobium, Bolbophyllum, Corallorhiza, Epidendrum, Lælia, Cattleya, Vanda, Saccolabium, Aerides, Cymbidium, Oncidium, Miltonia, Stanhopea, Gongora, Maxillaria, Lycaste, Catasetum, Orchis, Ophrys, Gymnadenia, Herminium, Disa, Arnottia, Cephalanthera, Pogonia, Vanilla, Neottia, Goodyera, Cypripedium.

1487. Fragrant, aromatic, tonic, and mucilaginous properties are met with among Orchids. The roots of some of the terrestrial species contain much bassorin, and they constitute the nutritious substance called Salep. Blue colouring matter, like indigo, is met with in the leaves and flowers of some species.

Aplectrum hyemale is called Putty-root, on account of the viscidity of its tubers.

Cypripedium, Lady's-slipper, is so called on account of its hollow labellum. The two lateral stamens are fertile, while the central one is sterile and petaloid. In consequence of union of two of the outer segments, there are only five divisions of the perianth. C. pubescens has been used as an antispasmodic in epilepsy.

Eulophia vera and E. campestris are Indian Orchids, the roots of which furnish Salep.

Orchis mascula, and other species, such as O. Morio and O. papilionacea, also yield Salep.

Vanilla planifolia and aromatica yield the fragrant Vanilla, used in confectionary and in the preparation of Chocolate. The part of the plant employed is the dried seed-vessel. Crystals, believed to be Benzoic or Cinnamic acid, are often seen on the fruit when drying. The nature of the aromatic principle is unknown. A kind of Vanilla called Chica in Panama, comes from a species of Sobralia.

1488. Nat. Ord. 231.—APOSTASIACEÆ, the Apostasia order.—A small order of herbaceous plants closely allied to Orchids, from which they differ chiefly in their regular flowers, 3-celled loculicidal fruit, and in the style being free from the stamens throughout a considerable part of its length. The column is short, and is formed by the filaments along with the lower part of the style. Natives of the hot forests of India. Species 5. *Ill. Gen.*—Apostasia, Neuwiedia, Rhyncanthera?

1489. Nat. Ord. 232.—BURMANNIACEÆ, the Burmannia order.—A small order of herbaceous plants, with tufted, radical, acute leaves, or none, and a slender stem bearing alternate bract-like leaflets. They resemble Orchids in their minute seeds with a loose reticulated episperm, their parietal placentas, and their solid embryo; and are chiefly distinguished by their regular tubular flowers, stamens 3 or 6, dehiscing transversely, free, and inserted into the tube of the coloured perianth. Natives chiefly of tropical regions in Asia, Africa, and America. Some are bitter and astringent. Species 38. *Ill. Gen.*—Burmannia, Tetraptera, Apteria, Thismia?

1490. Nat. Ord. 233.—ZINGIBERACEÆ or SCITAMINEÆ, the Ginger order (Fig. 1713).—Herbs with a rhizome, simple sheathing leaves, the veins parallel and diverging from a midrib, and flowers arising from membranous spathes. Perianth tubular, irregular, and in 3 rows, the outer (calyx) 3-lobed, the middle (corolla) and inner (staminodes) each 3-parted, with a segment differing from the rest. Stamens 3, free, the 2 lateral abortive; anthers 2-celled. Fruit a 3-celled capsule or berry. Seeds numerous, albuminous; embryo in a vitellus. Nearly all tropical plants; abundant in the East Indies. Species 250. *Ill. Gen.*—Mantisia, Zingiber, Curcuma, Roscoea, Amomum, Elettaria, Hedychium, Renealmia, Alpinia, Costus.

Fig. 1713.

1491. The plants of this order have aromatic, stimulating properties, and are used as condiments, and as stomachic remedies. Their flowers are often very gaudy, and their bracts are sometimes finely coloured.

Alpinia Galanga yields Galangale root, which has properties similar to Ginger, and contains also much amylaceous matter. A. racemosa has similar qualities.

Amomum is a genus which yields aromatic carminative seeds. The capsules of Amomum Cardamomum are called round Cardamoms; those of A. angustifolium are the Madagascar Cardamoms. Other varieties are the produce of A. maximum and A. aromaticum. A. Melegueta, called Melegueta Pepper, and A. Grana Paradisi, furnish the aromatic grains of Paradise, which are used in veterinary medicine, and also as additions to spirits and beer.

Curcuma longa has a yellow-coloured rhizome, the branches of which constitute Turmeric. It is a carminative, and enters into the composition of Curry. The rhizome of C. angustifolia supplies a kind of Arrow-root in the East Indies. Many other species yield starch.

Elettaria major is said to be the plant which furnishes Ceylon Cardamoms, while E. Cardamomum supplies those of Malabar.

Zingiber officinale, the Ginger plant, has an aromatic rhizome which, when scraped and dried in the sun, constitutes White Ginger, and when unscraped and dried after immersion in hot water, forms Black Ginger. In the young state the rhizome is fleshy, and is used as a preserve, while in its advanced state it becomes woody and starchy.

1492. Nat. Ord. 234. —MARANTACEÆ or CANNACEÆ, the Arrow-root order.—Herbaceous plants closely allied to Zingiberaceæ, from which they differ chiefly in the want of aroma, in having one of the lateral stamens fertile (the other two being abortive), in the single stamen having a petaloid filament, which bears a 1-celled anther (the other antherine lobe being sterile), in the style being petaloid, and in the embryo not being contained in a vitellus (Fig. 1276, p. 640). Natives of the tropics of America, Africa, and Asia. Species 160. *Ill. Gen.*—Maranta, Thalia, Phrynium, Calathea, Canna.

1493. Amylaceous qualities prevail in this order, and starch is prepared from many of the species.

Fig. 1713. Zingiber officinale, the Ginger plant, with its rhizome or rootstock and spathaceous flowers.

Canna indica is commonly called Indian Shot, on account of its round black seeds. The corms or rhizomes of C. coccinea, C. edulis, and C. Achiras, all yield starch, some of which is known as Tous-les-mois.

Maranta arundinacea yields Arrow-root, which is procured from its tuberous rhizome. Other species, such as M. nobilis and M. indica, also supply this starchy matter.

1494. Nat. Ord. 235.—MUSACEÆ, the Banana order (Figs. 1714 and 1715).—Plants with underground stems, their petioles forming a spurious aerial stem, their leaves having parallel veins diverging from a midrib (Fig. 1714), and their flowers being bracteated. Perianth irregular and petaloid, 6-parted in 2 rows. Stamens 6, inserted on the perianth. Anthers linear, 2-celled, often crested. Fruit a 3-celled loculicidal capsule, or succulent and indehiscent (Fig. 1715). Seeds albuminous; embryo orthotropal. Tropical plants. Species 20. *Ill. Gen.* — Heliconia, Musa, Strelitzia, Ravenala.

Fig. 1714.

Fig. 1715.

1495. Valuable plants as regards food, clothing, and other domestic purposes. They yield much nutritive food, as well as useful fibres.

Musa paradisiaca, the Plantain, and M. sapientum, the Banana, supply well-known fruits, which serve for the food of the inhabitants of many tropical countries. The plants are very productive. Some clusters contain from 150 to 180 Bananas. The fruit should be taken off the plant before it is ripe, and allowed to come to maturity in a warm place. The plant produces fruit abundantly in the Palm-House of the Edinburgh Botanic Garden. M. Cavendishii is a small species, which is also very prolific. M. textilis produces Manilla Hemp, which is used in manufacture. All the species contain abundance of spiral fibres, which are sometimes used for tinder. The young shoots are used like Cabbage.

Ravenala speciosa produces an edible seed. Its stem and leaf-stalk yield a large quantity of watery fluid, and hence it has been called Water-tree.

1496. Nat. Ord. 236. — IRIDACEÆ, the Iris order (Figs. 1716 to 1721).—Herbs with corms (Fig. 1721), rhizomes or fibrous roots, and mostly equitant leaves (Fig. 1717), and spathaceous flowers. Perianth 6-divided in 2 rows (Fig. 1718), sometimes irregular. Stamens 3, inserted at the base of the outer row of the perianth; anthers innate,

Figures 1714 and 1715 illustrate the natural order Musaceæ.

Fig. 1714. Musa sapientum, the Banana plant, with its spurious aerial stem and parallel-veined leaves. Fig. 1715. Succulent indehiscent fruit of the Banana.

extrorse. Style dividing into 3 petaloid stigmatiferous portions (Fig.

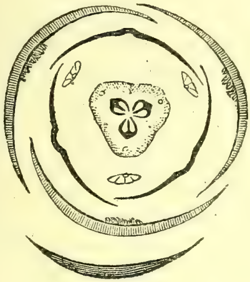


Fig. 1716.

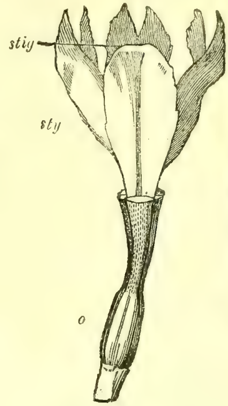


Fig. 1719.

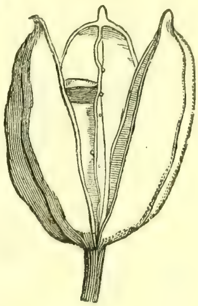


Fig. 1720.

Fig. 1718.

Fig. 1721.

1719). Capsule 3-celled, 3-valved, loculicidal (Fig. 1720). Seeds

Figures 1716 to 1721 illustrate the natural order Iridaceæ.

Fig. 1716. Diagram of the flower of Iris, showing a bract or spathe below, three outer divisions of the perianth with hairs, three inner, three stamens, and three divisions of the ovary. Fig. 1717. Equitant leaves and rhizome of Iris. Fig. 1718. Flower of Iris cut vertically, showing inferior ovary with ovules, the divisions of the perianth, and part of the style. Fig. 1719. Flower of Iris, with the

with hard albumen. Found in various temperate and warm parts of the world. Harvey says that Iridaceæ have their maximum at the Cape of Good Hope, and from September to November the face of the country glitters with blossoms of countless species of Ixia, Gladiolus, Watsonia, Babiana, and Sparaxis, of every shade of colour. Species 550. *Ill. Gen.*—Sisyrinchium, Moræa, Iris, Tigridia, Witsenia, Gladiolus, Antholyza, Watsonia, Sparaxis, Ixia, Trichonema, Crocus.

Fig. 1717.

1497. Acrid, purgative, and emetic properties are met with in some plants of the order. Some are fragrant and aromatic; others supply starch and materials for dyeing.

Crocus sativus (Fig. 1721, and Figs. 160 and 161, p. 68) is the Karcom of the Scriptures. Its dried stigmatic processes constitute Saffron, which is of a deep orange, and contains a colouring matter called polychroite. Saffron is employed as a carminative, antispasmodic, and emmenagogue, and owes its properties to a volatile oil. C. odorus is said to supply Sicilian Saffron.

Iris, Iris or Flower de Luce (Fig. 1718), contains several emetic and purgative species. The leaves of I. fœtidissima, when bruised, give out a peculiar odour, said to resemble roast-beef. I. Pseudacorus has an acrid rhizome. Its roasted seeds have been recommended as a substitute for Coffee. The rhizome of I. florentina, the Florence Iris, is the aromatic Orris-root, which has the odour of Violets, and which at the same time possesses some acridity.

1498. Nat. Ord. 237.—AMARYLLIDACEÆ, the Amaryllis order (Figs. 1722 to 1725).—Bulbous, sometimes fibrous-rooted plants, with ensiform leaves, and showy flowers, which are mostly spathaceous and on scapes (Figs. 1723 and 1724). Perianth coloured, limb 6-parted or 6-cleft, sometimes with a corona, as in Narcissus (Fig. 1725). Stamens 6, inserted at the bottom of the segments (Fig. 1725), sometimes united by a membrane, as in Pancratium; anthers introrse. Stigma 3-lobed. Fruit a 3-celled, 3-valved, loculicidal capsule, with many seeds; or a berry with 1-3 seeds, spermoderm not crustaceous; albumen fleshy; embryo with radicle next the hilum. Natives of various parts of the world, but attaining their maximum at the Cape of Good Hope. Species 400. *Ill. Gen.* — Galanthus, Leucojum, Amaryllis, Crinum,

limb of the perianth removed. The ovary, *o*, tube of perianth, *t*, upper petaloid and divided part of the style, *sty*, stigma, *stig*. Fig. 1720. Capsular fruit of Iris, opening by loculicidal dehiscence. Fig. 1721. Crocus sativus, the Saffron plant, the Karcom of the Bible (Cant. iv. 14), and the Krokos of the Septuagint, with its underground stem or corm, its tubular perianth, and narrow sheathing leaves.

Hæmanthus, Pancratium, Narcissus, Alstrœmeria, Doryanthes, Agave, Littæa, Fourcroya.

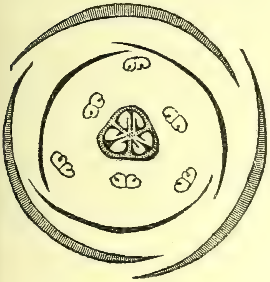


Fig. 1722.

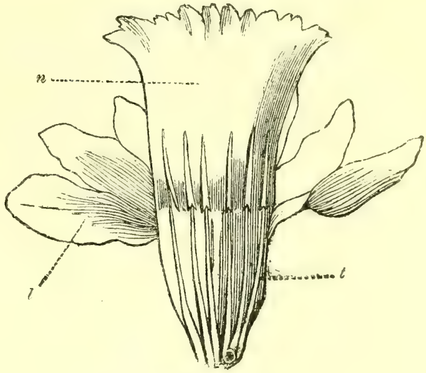


Fig. 1725.

Fig. 1723.

Fig. 1724.

1499. Many Amaryllids display poisonous properties. Some are

Figures 1722 to 1725 illustrate the natural order Amaryllidaceæ.

Fig. 1722. Diagram of the flower of Leucojum vernum, Spring Snowflake, with six divisions of the perianth, three outer and three inner, six stamens in two verticils, and a three-celled ovary with a central placenta. Fig. 1723. Narcissus Tazetta, Polyanthus-Narcissus, showing numerous flowers coming out from a scape. The plant appears to be the Hebrew Chabazzeleth, translated Rose (Cant. ii. 1; Is. xxxv. 1). Fig. 1724. Leucojum vernum, the Spring Snowflake, showing scape, spathe, inferior ovary, and six-divided perianth. Fig. 1725. Perianth of Narcissus Pseudo-narcissus, the Daffodil, cut vertically, showing tube, *t*, limb, *l*, corona, *n*, and six stamens attached to the perianth.

emetic and purgative, and some yield useful fibres. The bulbs of the Snowdrop and Snowflake are said to be emetic.

Agave americana, American Aloe, is a plant which often delays flowering for many years, and then pushes up its flowering spike with great rapidity (p. 526). The juice of the plant, just before flowering, is used in America for the manufacture of an intoxicating beverage. The Mexican Pulque is a preparation of this kind, which, according to some, is procured from Agave potatorum, called the Maguey in Mexico. The roots of the Agave are sometimes used as a substitute for Sarsaparilla. Its fibres constitute Pita Flax, and are sometimes made into paper. Its juice, as well as that of A. Saponaria, is used as a detergent. In some parts of America, as in Mexico, the Agaves are used for various useful purposes. The flowers of some are boiled and used as food. In Ecuador the spongy substance of the flower-stem of Agave americana is employed instead of tinder, and in all the schools the green leaves serve as paper. A punishment among the Aztecs was introducing the spiny points of the leaves into the skin.

Alstrœmeria. The species of this genus are remarkable for their twisted leaves. Some have much starch in their roots.

Hæmanthus toxicarius and other species have poisonous bulbs, the juice of which is used by the Hottentots for poisoning their arrows.

Narcissus Tazetta (Fig. 1723) is supposed to be the Hebrew Chabazzeleth, translated Rose in Scripture. N. Pseudo-narcissus, common Daffodil (Fig. 1725), has narcotic flowers and emetic bulbs.

1500. Nat. Ord. 238. — HYPOXIDACEÆ, the Hypoxis order. — Herbs with tuberous or fibrous roots, linear, dry, often hairy leaves, and trimerous flowers in scapes. Closely allied to Amaryllids, and differing chiefly in their strophiolate seeds, and embryo with the radicle remote from the hilum. Natives of warm regions. Species 60. *Ill. Gen.*—Curculigo, Forbesia, Hypoxis.

1501. Nat. Ord. 239. — HÆMODORACEÆ, the Blood-root order.— Perennial plants with fibrous roots, ensiform equitant leaves, and woolly hairs or scurf on their stems and flowers. Perianth tubular, 6-divided. Stamens 3, opposite the segments, or 6; anthers introrse. Ovary 3-celled, sometimes 1-celled; style and stigma simple. Fruit usually capsular and valvular, covered by the withered perianth. Embryo in cartilaginous albumen, radicle remote from the hilum. Natives of America, the Cape, and New Holland. Species 50. *Ill. Gen.*—Hæmodorum, Lachnanthes, Anigosanthus, Conostylis, Aletris, Vellozia, Barbacenia.

1502. Bitterness is found in some of the plants of the order (Aletris). Their roots are sometimes nutritious, and many of them are of a red colour, whence the name of the order.

Hæmodorum. The roots of some of the Swan River species are roasted and used for food.

Lachnanthes tinctoria has a red root, which is used for dyeing in America.

Vellozia is a remarkable Brazilian genus, the species of which have branching trunks covered with adpressed roots, and with the withered remains of the leaves. They have been called perennial or tree lilies. Along with Lichnophora, they give a decided feature to the peculiar vegetation of the mountains of Minas Geraes in Brazil.

1503. Nat. Ord. 240.—TACCACEÆ, the Tacca order. —Perennial herbs, with tuberous roots, radical curve-veined leaves, and flowers in scapes. Perianth tubular, 6-divided. Stamens 6, inserted in the base of the segments; filaments petaloid; anther below the points of the filaments. Styles 3. Fruit baccate, 1-celled, or half 3-celled. Albumen fleshy. Acrid plants found in the warmest parts of India and Africa, as well as in the South Sea Islands. The tubers of Tacca pinnatifida, and other species, yield starch, which is used as food, the acrid matter being removed by washing. It is sometimes called Otaheite Salep, or Tahiti Arrow-root. Species 8. *Ill. Gen.*—Tacca, Attaccia.

1504. Nat. Ord. 241.—Bromeliaceæ, the Pine-apple order (Fig. 1726).—American and chiefly tropical plants, with rigid, channelled, often scurfy and spiny leaves, and showy flowers. Outer perianth 3-parted, persistent; inner of 3 withering leaves. Stamens 6, inserted in the tube of the perianth; anthers introrse. Style single. Fruit capsular or succulent, 3-celled, many-seeded. Embryo minute, in the base of mealy albumen. Many of the plants grow in an epiphytic manner, and are called air plants. This is the case especially with Tillandsias. Species 170. *Ill. Gen.*—Ananassa, Bromelia, Æchmea, Billbergia, Pitcairnia, Tillandsia, Bonapartea.

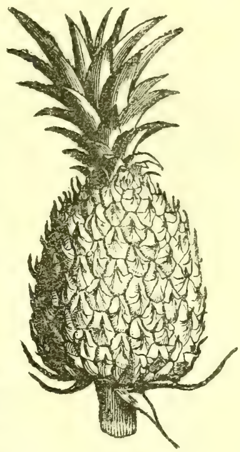


Fig. 1726.

1505. Some of the species have anthelmintic properties. Some supply edible fruit, gum, colouring matter, and valuable fibres.

Ananassa sativa, the Pine-apple or Ananas, has a polygynœcial fruit formed by the union of numerous succulent ovaries and bracts. When ripe, the fruit is sweet and finely aromatic. Archer says, that more than 200,000 Pine-apples were imported into Britain from the Bahamas in 1851. They were not equal to the British grown fruit. The fibres are used in manufacture. Specimens of cloth made from them are seen in the Edinburgh Museum of Economic Botany.

Bromelia Pinguin is used as a vermifuge in the West Indies. Its ovaries are not combined into one mass, and they illustrate well the formation of the Pine-apple. Some species yield fibres which are made into ropes.

Tillandsia usneoides, Tree-beard, appears like a mass of black fibres hanging down from the trees in South America. It has been used for stuffing birds and cushions under the name of Spanish Moss.

2. HYPOGYNÆ.

Perianth free, Ovary superior, Flowers usually Hermaphrodite.

1506. Nat. Ord. 242.—Liliaceæ, the Lily order (Figs. 1727 to 1735.)—Herbs, shrubs, or trees, with bulbs (Fig. 1728, and Fig. 162, p. 68),

Fig. 1726. The polygynœcial or anthocarpous fruit of Ananassa sativa, the Pine-apple, formed of united ovaries and bracts in a succulent state,

corms, rhizomes (Fig. 156, p. 65), or fibrous roots, simple, sheathing, or clasping leaves, and regular flowers. Perianth coloured, of 6 leaves

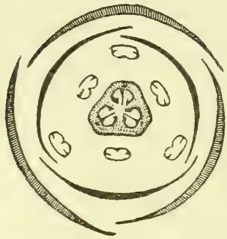


Fig. 1727.

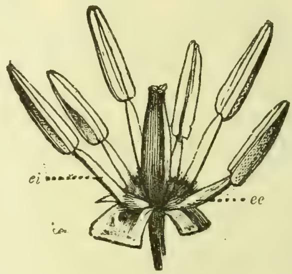


Fig. 1734.

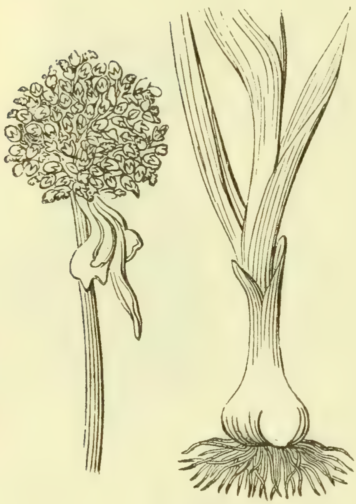


Fig. 1728.

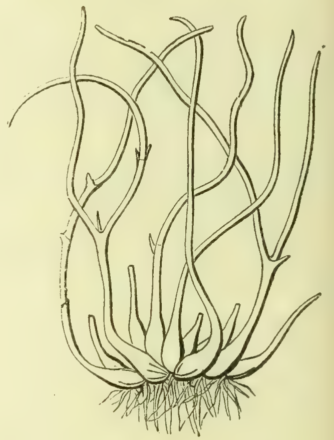


Fig. 1729.

(Fig. 1733), or 6-cleft. Stamens 6, inserted in the perianth ; anthers introrse (Fig. 1734). Ovary 3-celled (Fig. 1735); style 1 ; stigma simple or 3-lobed. Fruit trilocular, capsular, or succulent. Seeds in 1 or 2 rows, sometimes in pairs or solitary ; albumen fleshy. Natives

Figures 1727 to 1735 illustrate the natural order Liliaceæ.

Fig. 1727. Diagram of the flower of Fritillaria imperialis, Crown Imperial, showing a perianth of 6 parts, in 2 verticils, 6 stamens in two rows, and a 3-celled ovary. Fig. 1728. Allium Porrum, the Leek, with parallel-veined, sheathing leaves, bulb, umbellate cluster of flowers and spathe. It is the Hebrew Chatzir, Chazir, or Chajir, translated in the Scripture Leeks (Numb. xi. 5); grass (1 Kings xviii. 5; 2 Kings xix. 26; Job xl. 15; Ps. xxxvii. 2, &c.) ; herb (Job viii. 12); hay (Prov. xxvii. 25; Is. xv. 6); and court (Is. xxxiv. 13). The word seems to mean greens or grass in general. Fig. 1729. Allium ascalonicum, the Shallot or Eschalot, commonly cultivated in the kitchen garden. It is supposed to be the Shumim of Scripture, translated Garlic (Numb. xi. 5). Fig. 1730. Scilla or Squilla maritima, or Urginea maritima, the officinal Squill plant. Fig. 1731. Yucca gloriosa, called Adam's needle. Fig. 1732. Ruscus aculeatus, common Butcher's-broom, with bracteated flowers on phylloid peduncles. Fig. 1733. Flower of Lilium album, White Lily, with a 6-leaved perianth, 6

both of temperate and tropical regions. In the latter we meet with arborescent species, such as the Dragon-trees (Fig. 201, p. 91), and

Fig. 1730.

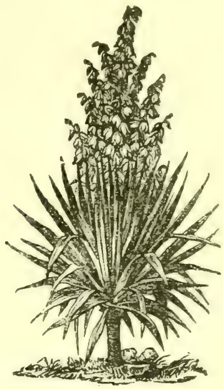


Fig. 1731.

Fig. 1733.

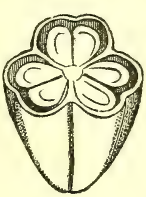


Fig. 1735.

Fig. 1732.

with succulent species, as Aloes. In temperate climes we have species of Tulip, Lily, Hemerocallis or Day-lily, Convallaria or Lily of the Valley, Fritillary, Asparagus, Polianthes or Tuberose, Hyacinth, Squill, Ornithogalum or Star of Bethlehem, Onion and Leek, Erythronium or Dog-tooth Violet. The limits of the order are not well defined, and Lindley thinks that it must be ultimately split into a number of separate orders. The species, as given by him, amount to upwards of 1200. *Ill. Gen.* — Tulipa, Gagea, Lloydia, Fritillaria, Lilium, Hemerocallis, Phormium, Aloe, Yucca, Allium, Scilla, Hyacinthus, Conanthera, Asphodelus, Anthericum, Xanthorrhœa, Wachendorfia, Asparagus, Dracæna, Ruscus, Aspidistra, Ophiopogon.

1507. The properties of the order are various. Some of the plants

stamens, and 1 style. Fig. 1734. Flower of the Tulip, with the perianth removed, showing 6 stamens, the outer row of 3, *ee*, the inner row, *ei*, surrounding the pistil with its 3-lobed stigma. Fig. 1735. Ovary of Lilium album, White Lily, cut transversely, shewing 3 cells, with the ovules packed one above another in two rows, and attached to a central placenta.

are used as emetics and purgatives, while others are stimulant and diaphoretic. Some yield resinous and astringent matter, while others supply valuable materials for manufacture. Asparagus seeds have been recommended as a substitute for coffee.

Allium Porrum, the Leek (Fig. 1728, and Fig. 164, p. 68), is the Hebrew Chatzir, the Greek Prason, the bulb of which is esculent, stimulant, and diuretic. These properties are found also in A. Cepa, the Onion, the Betzal or Betzalim of Scripture (Numb. xi. 5); A. sativum, Garlic, the Scorodon of the Greeks; A. Schœnoprasum, the Chive; A. ascalonicum, the Shallot (Fig. 1729), the Hebrew Shumin translated Garlic; and A. Scorodoprasum, the Rocambole. Most of these plants have sulphuretted oil in their composition, as well as free phosphoric acid. In warm dry countries some of these bulbous plants grow to a large size, and instead of being acrid and pungent, are bland articles of food. This is seen in the case of Portugal, Spanish, and Egyptian Onions.

Aloe is the genus which supplies the drug called Aloes. It is the inspissated juice of various species, such as A. spicata, vulgaris, socotrina, indica, and purpurascens.

Camassia esculenta, the Quamash of the North American Indians, has edible bulbs. They, as well as others, are called Biscuit-roots.

Dracæna Draco is one of the Lily tribe, which attains the size of a large tree (Fig. 201, p. 91). It yields a resin called Dragon's-blood. Many of the Dracænas have forking stems, and their bark can be separated from the wood. D. terminalis, called Ki, supplies food, and an intoxicating beverage in the Sandwich Islands. Its roots are said to be astringent.

Fritillaria imperialis (Fig. 587, p. 219), called Crown Imperial, from the mode of arrangement of its depending flowers, has nectariferous depressions at the base of the leaves of its perianth (Fig. 111, p. 46). Its fetid bulb is said to be poisonous.

Lilium chalcedonicum, the scarlet Martagon Lily (Fig. 411, p. 174), is supposed to be the Krinon or Lily of the field of the New Testament (Matth. vi. 28, and Luke xii. 27). L. bulbiferum (Fig. 163, p. 68), has bulbils or separable buds in the axils of its leaves. The bulbs of L. tenuifolium, L. kamtschaticum, and L. spectabile, are used as food in Siberia.

Ornithogalum umbellatum, the common Star of Bethlehem (Fig. 1172, p. 530), has white flowers streaked with green, and its bulb is supposed to be the Hebrew Chirionim or cab of Doves' Dung mentioned in 2 Kings vi. 25, as having been sold at a high price at the siege of Samaria.

Phormium tenax (Fig. 48, p. 24) supplies New Zealand Flax, the fibres of which are very tenacious. Its root has been used as a substitute for Sarsaparilla.

Ruscus, Butcher's-broom (Fig. 1732), is remarkable on account of its phylloid peduncles. Various species have been prescribed as diuretics.

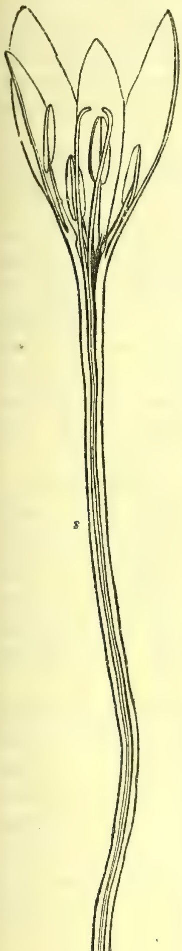
Sanseviera. Species of this genus produce African or Bowstring-hemp, which is very strong and tough.

Urginea Scilla, known as Scilla or Squilla maritima (Fig. 1730), a Mediterranean sand plant, has an acrid bulb which, when dried, constitutes the common Squill of the shops. It is used as an emetic, expectorant, and diuretic. S. indica is employed in India as a substitute.

Xanthorrhœa Hastile, X. arborea and other species, are the Grass-trees of New South Wales, which have peculiar stems covered with the bases of the leaves, and send up long spikes of flowers (p. 92). They yield a fragrant red resin called Botany-Bay gum.

Yucca gloriosa and other species, known by the name of Adam's Needle (Fig. 1731), furnish useful fibres.

1508. Nat. Ord. 243. — MELANTHACEÆ or COLCHICACEÆ, the Colchicum order (Figs. 1736 to 1739).—Herbs with bulbs, corms (Fig. 1738), or fasciculated roots, and white, green, or purple flowers, which are sometimes polygamous. Perianth petaloid, of 6 leaves,



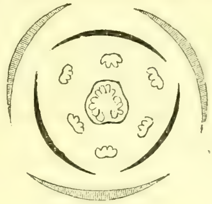


Fig. 1736.

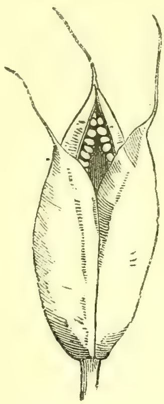


Fig. 1739.

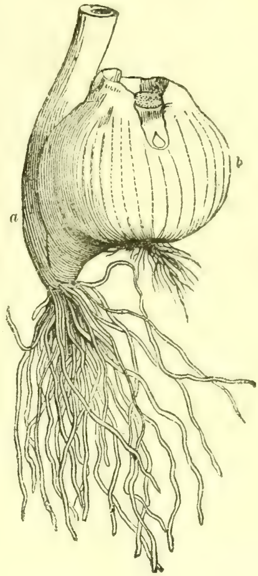


Fig. 1738.

which are either separate, or united below into a tube (Fig. 1737). Stamens 6, anthers extrorse (Fig. 636, p. 230). Ovary 3-celled; style 3-parted; capsule 3-valved (Fig. 1739, and Fig. 704, p. 247), septicidal (Colchicum), sometimes loculicidal (Uvularia). Seeds with a membranous episperm, and dense, fleshy albumen. Generally distributed over the world, but most abundant in northern countries. Species 130. *Ill. Gen.* — Tofieldia, Xerophyllum, Helonias, Asagræa, Veratrum, Melanthium, Uvularia, Bulbocodium, Colchicum.

1509. The plants of this order have acrid, emetic, purgative, and sometimes narcotic properties. They are all more or less poisonous, and nearly all seem to contain the alkaloid called Veratria.

Fig. 1737.

Figures 1736 to 1740 illustrate the natural order Melanthaceæ.

Fig. 1736. Diagram of the flower of Colchicum autumnale, Meadow Saffron, showing a 6-leaved perianth, in 2 verticils, 6 stamens, and an ovary formed of 3 carpels. Fig. 1737. Flower of Colchicum autumnale, common Meadow Saffron, showing its subterranean ovary, *o*, very long tube of the perianth, *t*, and the stamens attached to it above. Fig. 1738. Young, *b*, and old, *a*, corms of Colchicum. Fig. 1739. Capsule of Colchicum, shewing 3 cells with septicidal dehiscence.

Asagræa officinalis, found in the alpine districts of Mexico, is the chief source of the Cevadilla or Sabadilla seeds, which contain veratria, and are used in neuralgic and rheumatic affections.

Colchicum autumnale, the Meadow Saffron, or Autumn-flowering Crocus (Fig. 1737), flowers in autumn, and sends up its leaves and seed vessel during the succeeding spring. Its corms (Fig. 1738) and ripe seeds contain an alkaloid Colchicia, and are prescribed in gout and rheumatism. The corms of C. variegatum were the Hermodactyls of the Greeks and Arabians.

Veratrum album, White Hellebore, was much used by the Greeks as a purgative in mania. The plant is both acrid and narcotic. V. Sabadilla is another of the sources whence Sabadilla seeds are procured.

1510. Nat. Ord. 244. — Gilliesiaceæ, the Gilliesia order.—Bulbous herbs, with grass-like leaves, and umbellate, spathaceous flowers. Perianth of 2 portions,—outer petaloid and herbaceous, of 6 leaves, called by Lindley bracts; inner minute, either a single lobe or urceolate and 5-toothed. The latter is by some considered an abortive staminal row. Stamens 6, sometimes 3 sterile. Capsule 3-celled, 3-valved, loculicidal, polyspermal. Episperm black and brittle; embryo curved; albumen fleshy. Chilian plants. Species 5. *Ill. Gen.*— Gilliesia, Miersia.

1511. Nat. Ord. 245.— Pontederiaceæ, the Pontederia order.—Aquatic plants, with leaves sheathing at the base, petioles occasionally dilated, and spathaceous flowers, either solitary or in spikes. Perianth coloured, tubular, 6-parted, irregular, persistent. Stamens 6 or 3, perigynous; anthers introrse. Capsule sometimes slightly adherent, 3-celled, 3-valved, loculicidal. Seeds numerous; placenta central; albumen mealy. Natives of America, India, and Africa. Species 30. *Ill. Gen.*—Heteranthera, Leptanthus, Pontederia.

1512. Nat. Ord. 246.—Xyridaceæ, the Xyris order.—Swampy, rush-like plants, with ensiform or filiform radical leaves sheathing at the base. Flowers in scaly heads. Perianth of 6 parts, 3 outer glumaceous. Stamens 6, 3 fertile inserted on the inner perianth. Anthers extrorse. Ovary 1-celled; placentas parietal; ovules orthotropal. Capsule 1-celled, 3-valved, polyspermal. Albumen fleshy; embryo remote from the hilum. Tropical plants. Some species of Xyris have been used in cutaneous affections. Species 70. *Ill. Gen.* — Xyris, Abolboda, Rapatea.

1513. Nat. Ord. 247. — Philydraceæ, the Water-wort order.—Plants allied closely to Xyrids, and differing chiefly in the want of an outer perianth, in the inner perianth being 2-leaved, in having 3 stamens, 2 of which are abortive, and in the embryo being large in the axis of the albumen. The flowers have spathaceous bracts; the roots are fibrous, the stem simple, leafy, and often woolly, and the leaves sheathing at the base. Natives of New Holland and China. Species 2. *Ill. Gen.*—Philydrum, Hetæria.

1514. Nat. Ord. 248.—Commelynaceæ, the Spider-wort order.—Herbs with flat leaves, usually sheathing at the base. Outer perianth of 3 parts, herbaceous; inner also 3, coloured, sometimes cohering. Stamens 6, or fewer, hypogynous. Anthers introrse; ovary 3-celled;

placenta central; style 1. Capsule 2-3-celled, 2-3-valved, loculicidal. Seeds with a linear hilum; embryo pulley-shaped, in a cavity of the albumen, remote from the hilum. In Tradescantia the filaments are provided with jointed hairs (Fig. 95, p. 43), which show rotation in their cells (p. 417). The rhizomes of some species of Commelyna are amylaceous and edible. Species 260. *Ill. Gen.* — Commelyna, Aneilema, Tradescantia, Cyanotis, Campelia, Flagellaria.

1515. Nat. Ord. 249.—Mayacaceæ, the Mayaca order.—Mosslike plants, with narrow leaves, resembling Spider-worts, but differing in their 1-celled anthers, carpels opposite the inner divisions of the perianth, 1-celled ovary and capsule, and parietal placentas. Natives of America. Species 4. *Ill. Gen.*—Mayaca.

1516. Nat. Ord. 250. — Juncaceæ, the Rush order (Figs. 1740 to 1742).—Herbs with fasciculate or fibrous roots, fistular or flat and grooved leaves, and glumaceous (sometimes petaloid) flowers in clusters, cymes (Fig. 1741), or heads. Perianth dry, greenish or brownish, 6-parted (Fig. 1742). Stamens 6 or 3, perigynous; anthers introrse. Ovary 1 or 3-celled; ovules 1, 3, or many in each cell; style 1; stigmas

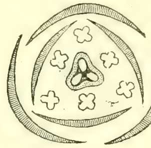


Fig. 1740.

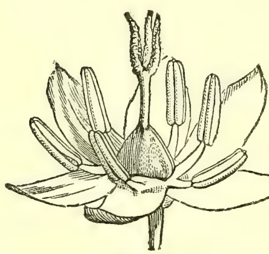


Fig. 1742.

Fig. 1741.

Figures 1740 to 1742 illustrate the natural order Juncaceæ.

Fig. 1740. Diagram of the flower of Luzula, Wood-rush, shewing 6 divisions of the perianth in 2 rows, 6 stamens, and a 3-celled ovary. Fig. 1741. Luzula nivea, with panicled cymose inflorescence. Fig. 1742. Perianth of Luzula, with 6 divisions of its glumaceous perianth, 6 stamens, pistil with 1 style and 3 stigmas.

often 3. Fruit a 3-valved loculicidal capsule, or monospermal and indehiscent. Seeds with a thin spermoderm, which often becomes gelatinous when moistened; albumen fleshy; embryo minute. Natives chiefly of cold and temperate regions. Some of the plants have been used as anthelmintics and diuretics; the cellular tissue at the base of the leaves is sometimes eaten. The leaves are used generally for mechanical purposes, to form matting and the bottoms of chairs, and the pith for the wicks of candles. In the county of Norfolk, rushes are gathered and sold in large quantities. The number of rushes at an annual sale has amounted to 5,760,000. Species 200. *Ill. Gen.* — Luzula, Juncus, Narthecium, Xerotes, Astelia, Kingia, Baxteria.

1517. Nat. Ord. 251. — PALMÆ, the Palm order (Figs. 1743 to 1751).—Arborescent plants, with a simple (Figs. 1743 and 1744),

Fig. 1743.

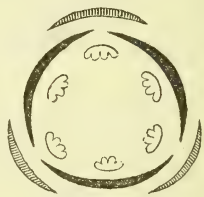


Fig. 1746.

Fig. 1747.

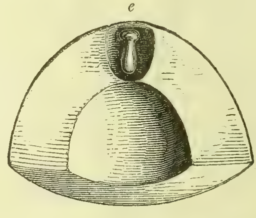


Fig. 1750.

sometimes branched stem (Fig. 1745), marked by the bases of the leaves or their scars, leaves in terminal clusters, pinnate or fan-shaped (Fig. 243, p. 109), flowers ♂ ♀ or ☿ (Figs. 1748 and 1749), on a simple or branched spadix, enclosed in a 1 or many-valved spathe (Fig. 341, p. 146). Perianth in two verticils, each of 3 parts (Figs. 1746 and 1747). Stamens usually 6, seldom 3, sometimes ∞. Ovary 1-3-celled, with a single ovule in each cell. Fruit a nut (Fig. 1277, p. 640), or drupe (Fig. 786, p. 269), or berry. Albumen carti-

Figures 1743 to 1751 illustrate the natural order Palmæ.

Fig. 1743. Phœnix dactylifera, the Date Palm, the Tamar of Scripture (Exod. xv. 27; Ps. xcii. 12. See also Fig. 187, p. 87; Fig. 786, p. 269; Fig. 1126, p. 437; and Fig. 1279, p. 641). Fig. 1744. A species of Sagus or Sago-palm. Fig. 1745. Hyphæne thebaica, the Doum Palm, with its dichotomous stem. Fig. 1746. Diagram of the ♂ flower of Chamærops, Fan-palm, shewing six divisions of the perianth and six stamens. Fig. 1747. Diagram of the ♀ flower of Chamærops, shewing six divisions of the perianth in two rows, and three cells of the ovary. Fig. 1748. Male (staminiferous) flower

laginous or hard (Fig. 903, p. 301), often ruminate, with a central cavity; embryo in a particular cavity remote from the hilum (Fig.

Fig. 1744.

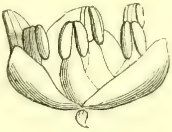


Fig. 1748.

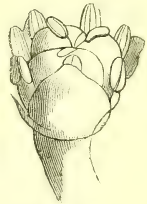


Fig. 1749.

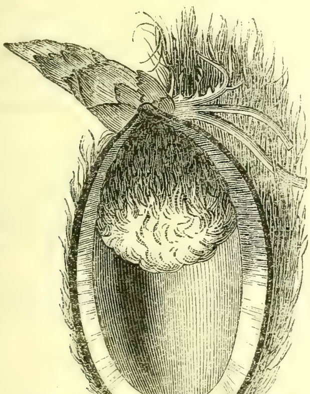


Fig. 1751.

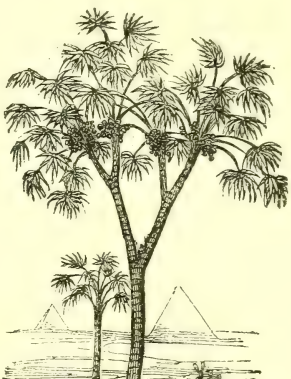


Fig. 1745.

1750), its cotyledon often becoming enlarged during germination, and filling the central cavity (Fig. 1751). Chiefly tropical plants, requiring a mean temperature of 78°.2 to 81°.5 F. Some, however, extend to temperate regions. Chamærops humilis, the dwarf Fan-palm, is found native in the south of Europe, and C. Palmetto grows in the milder parts of North America. Some have slender, reed-like stems, others attain a considerable diameter. Some have a low caudex, or a subterranean stem, while others have an erect trunk 190 feet high. Some, such as Iriartea exorhiza, send off numerous aerial roots, like the Screw-pine. Although the individual flowers are small, yet when combined on a large spadix they produce a marked effect. It has been estimated that, in

of Chamærops. Fig. 1749. Hermaphrodite flower of Chamærops. Fig. 1750. Section of seed of Coco-nut, shewing the central cavity in the albumen, and the embryo, *e*, lying in a separate cavity remote from the hilum. Fig. 1751. The Coco-nut germinating; the cotyledon becoming enlarged internally, and filling up part of the cavity.

some instances, 200,000 flowers are enclosed in one spathe.* The known species amount, according to Martius, to 582, of which 91 have fan-shaped leaves. *Ill. Gen.*—Chamædorea, Kunthia, Leopoldinia, Euterpe, Oreodoxa, Areca, Seaforthia, Harina, Saguerus, Caryota, Calamus, Plectocomia, Sagus, Mauritia, Borassus, Lodoicea, Hyphæne, Manicaria, Corypha, Livistona, Copernicia, Sabal, Chamærops, Phœnix, Acrocomia, Attalea, Elais, Cocos, Phytelephas.

1518. Palms yield numerous important products, and they are applied to a great many uses. They supply starch, sugar, oil, wax, and edible fruits; their buds are eaten like vegetables; their leaves form coverings for habitations, and materials for manuscripts, the reticulum makes coarse cloth, and the saccharine juice is sometimes fermented, so as to form a spirit called arrack, or palm-wine called toddy.

Areca Catechu furnishes the Pinang or Betel-nut, used all over the east as a masticatory. The extract of the seeds forms one of the varieties of Catechu. The large terminal bud of A. oleracea, West India Cabbage Palm (Fig. 190, p. 88), is boiled as an esculent vegetable.

Astrocaryum vulgare, the Tucum Palm, is a fibre-yielding species. Ropes and various articles are manufactured from it. The fruit of A. Murumuru is edible.

Attalea excelsa is the Urucuri Palm, according to Spruce. A. funifera supplies the hard Coquilla-nuts, the pericarp of which is used for making handles of doors, of sticks, and of umbrellas. It is said that 300,000 Coquilla-nuts were imported in 1852. The Palm also supplies fibres like Piassaba.

Borassus flabelliformis, the Palmyra Palm (Fig. 1127, p. 437), furnishes Palmyra wood.

Calamus (Rotang) Scipionum, C. Zalacca, and C. Rudentum, supply Malacca and Rattan Canes. Archer estimates the consumption of Rattan Canes in Britain at 7,500,000 annually. Partridge Canes, and those called Penang Lawyers, are also the produce of species of Calamus. C. Rudentum, the Cable Cane, is said to have a stem 500 feet long. C. Draco yields a reddish resin.

Caryota urens is one of the Palms which furnish Sugar, as well as the fermentable fluid called Toddy. It is said that this Palm will yield 100 pints of Toddy in 24 hours.

Ceroxylon Andicola (Fig. 83, p. 37), a South American Palm, produces wax on the surface of its stem.

Chamærops humilis, the only European Palm, is used in Sicily to form hats, baskets, and various useful articles. C. argentea, a Cuba Palm, supplies materials for the chip or Brazilian grass-hats.

Cocos nucifera, the Coco-nut Palm (Fig. 166, p. 70), is perhaps put to a greater number of uses than any other Palm, both as regards food, luxuries, clothing, habitations, and utensils. The sugar it supplies is called Jaggery. The very durable fibres of the covering of the fruit are manufactured into cordage, called Coir rope, and are also made into matting, door-mats, and scrubbing brushes. Its wood is used in manufactures under the name of Porcupine-wood. The albumen of the seeds yields the concrete Coco-nut oil, extensively used for making candles and soap. From seven to ten nuts are said to be the average produce of a spathe. The Coco-nut Palm begins to bear (after being transplanted) in 13-16 years, and continues in vigour 40 years. By slicing its spadix, the juice, called Callu, or toddy, is procured. This is either boiled to yield Jaggery, or is fermented and distilled to furnish Arrack. In a productive season the Coco-nut Palm pushes out a new spadix every month.

Copernicia cerifera, the Carnauba Palm, has its stem marked by the bases of the

* For remarks on the structure of Palm stems, and illustrations, see p. 88, *et seq.*; for measurements of Palms, see pp. 439 and 440; and for the germination of Palms and illustrations, see p. 639. See also Martius' large work on Palms, and Wallace on the Palm-trees of the Amazon.

leaves, which are arranged in a beautiful spiral manner. It also supplies wax from the lower surface of its leaves.

Elais guineensis (Fig. 82, p. 37) supplies the solid Palm-oil imported from Africa. It is procured by bruising the fruit. E. Melanococco yields a similar product.

Euterpe montana is called Mountain Cabbage-Palm, because the young leaf-bud is used as an esculent vegetable. E. edulis, Assai or Assai-zeiro, yields a pulpy fruit, from which a grateful beverage is prepared.

Hyphæne thebaica, the Doom-Palm of Egypt (Fig. 1745), has a dichotomous trunk. The pericarp of its fruit has the taste of gingerbread, and is edible. The plant yields a resin called Egyptian Bdellium.

Leopoldinia Piassaba yields the fibres called Piassaba or Piaçava, as well as Monkey-grass and Para-grass, which are used for brushes.

Lodoicea seychellarum (Fig. 1277, p. 640), a Palm of the Seychelles islands, produces the fruit called Double Coco-nut.

Manicaria saccifera, Bussu, has a sack-like spathe, which is used for caps and for making cloth.

Mauritia vinifera, the Muriti-Palm, and M. flexuosa, yield a kind of Palm-wine.

Maximiliana regia is a fine South American Palm, the large spathe of which is used as a ready-made basket for carrying earth, clay, and farinha. A specimen is seen in the Edinburgh Botanical Museum.

Metroxylon læve, a native of Borneo and Sumatra, is one of the sources of the starchy matter called Sago. The starch exists in the cellular tissue of the stem, and after being washed out is granulated. A single Palm will yield 600 to 800 lbs.

Phœnix dactylifera (Fig. 1743, Fig. 187, p. 87, and Fig. 1126, p. 437), the Date-Palm, is a species which grows in the northern parts of Africa. It supplies a nutritious fruit (Fig. 786, p. 269). It is the Palm referred to in Scripture under the name of Tamar. Dates are imported into Britain from Barbary and Egypt, and are usually of the variety called Tafilat. There are said to be 46 varieties of Date cultivated in the oasis of Fezzan. Richardson says, that 19-20ths of the population of Fezzan, in Africa, live on Dates during nine months of the year, and that many of the animals also feed on them. P. sylvestris, Wild Date, yields sugar in Bengal.

Phytelephas macrocarpa, Pallipunta, and Homoro, or Tagua of the Indians, a Palm of the Magdalena-river district, is called the Vegetable Ivory-Palm, because the hard horny albumen of its seed is used like ivory. Archer says, that 80,000 nuts were imported in 1852. The large round clusters of nuts receive the name of Cabeza del Negro.

Plectocomia elongata produces pinnate leaves, the midribs of which are extended in a naked form beyond the pinnæ, and bear on their under surface remarkable spiny processes like the foot of a mole. These enable it to attach itself to neighbouring plants.

Saguerus saccharifer is a valuable Sago Palm, and yields a large quantity of saccharine juice when its spadix is wounded. From this sugar is prepared. The Palm supplies a kind of fibre called Gommuti or Ejow fibre.

Sagus (Fig. 1744). Several species supply the starchy matter called Sago. Sagus Rumphii is the Sago-Palm of Malacca. The reticulum is black, and resembles pieces of thin whalebone mixed with horse-hair. It can be used for brushes.

1519. Nat. Ord. 252.—ALISMACEÆ, the Water-plantain order.—Floating or marsh plants, with a creeping rhizome, narrow or broad leaves, and flowers in umbels, racemes, or panicles. Perianth of 6 pieces; outer 3 herbaceous; inner 3 petaloid. Ovaries several, 1-celled; ovules solitary, or 2 superposed. Fruit indehiscent. Seeds exalbuminous; embryo like a horse-shoe, undivided. Natives chiefly of northern countries. The fleshy rhizomes of Alisma and Sagittaria are edible. Species 50. *Ill. Gen.*—Alisma, Sagittaria, Actinocarpus.

1520. Nat. Ord. 253.—JUNCAGINACEÆ, the Arrow-grass order.—Marsh plants, with narrow radical leaves, and ☿ flowers in spikes or racemes. Perianth greenish. Stamens 6; anthers extrorse. Carpels 3-6, united or distinct; ovules 1 or 2, erect. Fruit dry, 1-2-seeded. Albumen 0; embryo straight, with a lateral cleft (Fig. 1272, p. 638). A small order of plants found in cold and temperate regions. Species about 20. *Ill. Gen.*—Triglochin, Scheuchzeria, Tetronceum.

1521. Nat. Ord. 254.—BUTOMACEÆ, the Flowering-rush order.—Aquatics, with very cellular leaves, often milky, and umbellate handsome flowers. Perianth of 6 pieces, 3 inner petaloid. Stamens definite or ∞. Ovaries 3-6 or more, distinct or united; ovules ∞. Fruit, follicles, distinct or united. Seeds ∞, attached to a reticulated placenta, spread over the whole inner surface of the fruit; albumen 0. Natives chiefly of northern countries. Butomus umbellatus is an ornamental Enneandrous plant. It has acrid and bitter properties. Limnocharis has a hole in the apex of its leaf. The cellular texture of the leaf is very beautiful. Species 7. *Ill. Gen.*—Butomus, Hydrocleis, Limnocharis.

3. INCOMPLETÆ.

Flowers incomplete, generally Unisexual, without a proper Perianth, or with a few Verticillate Scales.

1522. Nat. Ord. 255.—PANDANACEÆ, the Screw-pine order (Fig. 1752).—Trees or bushes, often branching dichotomously, or in a candelabra-like manner, having adventitious roots (Fig. 167, p. 70), leaves imbricated, linear-lanceolate or pinnate or fan-shaped, and spiny; and flowers unisexual or polygamous, spathaceous, covering a spadix completely. Perianth 0, or a few scales. Stamens numerous; anthers 2-4-celled. Ovaries 1-celled, collected into parcels; stigmas sessile; ovules solitary or numerous. Fruit either 1-seeded fibrous nuts, or many-seeded berries. Albumen fleshy; embryo minute, without a lateral slit. Natives of tropical regions, and abundant in insular situations. The seeds of the Screw-pines are eatable, and their spermoderm contains numerous crystals. The flowers of some species are fragrant, and the juice of Nipa is fermentescible. Nipa fruticans produces the Atap, one of the fruits of tropical India. Species about 80 or 90. *Ill. Gen.*—Pandanus, Freycinetia, Carludovica, Nipa, Cyclanthus.

Fig. 1752.

1523. Nat. Ord. 256. — TYPHACEÆ, the Bulrush order. — Herbs growing in marshes or ditches, having stems without nodes, rigid,

Fig. 1752. Pandanus odoratissimus, the Screw-pine, with adventitious roots, and spiny leaves like those of Pine-apples, arranged in a spiral (screw-like) manner.

ensiform leaves, and monœcious flowers on a spadix, without a spathe. Perianth 3 or more scales, or a bundle of hairs. Stamens 1-6, distinct or monadelphous; anthers innate. Ovary solitary, 1-celled; ovule solitary, pendulous. Fruit dry or spongy, indehiscent, 1-celled, angular by pressure. Seed solitary, pendulous, with a membranous spermoderm adhering to the pericarp. Embryo in the axis of mealy albumen, straight with a lateral cleft; radicle next the hilum. Most abundant in northern countries. Species 13. *Ill. Gen.* — Typha, Sparganium.

1524. Starch is a product of the rhizomes of many of the plants, and the pollen, which is very abundant, is inflammable, and is also used for food.

Typha. The young shoots of T. latifolia and T. angustifolia, the greater and less Reed Mace, are sometimes eaten like Asparagus. Their large amylaceous rhizomes are also used as food. The pollen of T. elephantina or Elephant-grass, is made into a kind of bread in Scinde, called Boor or Booree. The pollen of T. utilis in New Zealand is used in making a kind of bread called Hunga-hunga. The pollen contains both amylaceous and azotized matter. Johnston states, that children carry the flowered plant of T. latifolia in processions, and burn the dried spadix for tapers.

1525. Nat. Ord. 257. — ARACEÆ, the Arum order (Figs. 1753 and 1754).—Herbs or shrubby plants, sometimes climbing, often with corms (Fig. 1753); leaves sheathing at the base, convolute in æstivation, sometimes compound, and usually with branching veins; flowers monœcious, on a spadix (Fig. 1754) mostly with a spathe (Fig. 342, p. 146). Perianth 0. Sta-

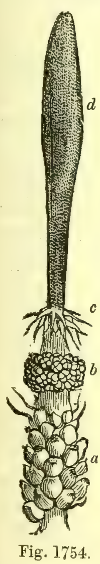


Fig. 1754.


Fig. 1753.

Figures 1753 and 1754 illustrate the natural order Araceæ.

Fig. 1753. Arum maculatum, Cuckow-pint, with its underground amylaceous corm, its sagittate leaves, and young spathe. Fig. 1754. The spadix of Arum maculatum, removed from its spathe; female flowers, *a*, male, *b*, abortive, *c*, fleshy end of spadix, *d*.

mens definite or ∞ ; anthers extrorse, 1 or 2-celled or more. Ovary with 1 or more cells. Fruit succulent; seeds pulpy; embryo in the axis of fleshy and mealy albumen, with a lateral cleft. Abundant in tropical climates; rare in cold or temperate regions. Species 170. *Ill. Gen.*—Cryptocoryne, Lagenandra, Arum, Colocasia, Caladium, Dieffenbachia, Richardia.

1526. Acridity prevails in the order, and many of the plants are irritant poisons. Some, as Lagenandra toxicaria, are very dangerous. The corms sometimes supply starch, which is separated from the acrid matter by washing.

Arum. The species of this genus are remarkable for the production of heat when the pollen is ripe (page 520). Some of them, as A. Dracunculus, have a very fetid odour. A. maculatum, Cuckow-pint, or Wake-Robin (Fig. 1753, and Fig. 342, p. 146), has an amylaceous acrid corm.* The starch used to be separated in large quantities at Weymouth and in the island of Portland, and sold under the name of Portland Sago. A. campanulatum is cultivated in some parts of India on account of its edible corms.

Caladium bicolor, and other species, have corms which, when roasted or boiled, are used as food.

Colocasia. The species of this genus are milky. They develope heat during flowering (page 524). C. esculenta, and other species, have edible corms, which are called Cocoes and Eddoes in the West Indies. The corms of C. macrorhiza constitute the edible Tara of the South Sea Islanders; while those of C. himalensis afford food in the Himalayas.

Dieffenbachia seguina is called Dumb-cane in the West Indies, because when chewed, it causes painful swelling of the tongue.

Richardia africana is commonly cultivated under the name of Æthiopian Lily. It has a white spathe. In its native country it is called Varkensblader or Pig's-leaf.

1527. Nat. Ord. 258.—ORONTIACEÆ or ACORACEÆ, the Orontium or Sweet-flag order.—Herbs with broad, occasionally ensiform leaves, and spadiceous flowers enclosed by a spathe. They are usually associated with Araceæ, from which they differ in their hermaphrodite flowers, and in having frequently a perianth consisting of 4-8 scales. Lindley, on account of their ☿ flowers, places them near Juncaceæ. Natives both of tropical and cold regions. Species 70. *Ill. Gen.* — Calla, Monstera, Pothos, Dracontium, Symplocarpus, Orontium, Acorus.

1528. Acridity is met with in this order, which also contains nutritious, bitter, and aromatic plants.

Acorus Calamus, common Sweet-Sedge, has an agreeable odour, and has been used as a stimulant, tonic, and antispasmodic. Its starchy matter is associated with a fragrant oil, and it is used as hair-powder.

Calla palustris has acrid, amylaceous rhizomes which, after washing, are used as food. The plant extends to Lapland.

Monstera (Dracontium) pertusa has a remarkable perforated leaf. It is an acrid plant, and its leaves are used for blistering.

Symplocarpus fœtidus, Skunk-cabbage, has a very fetid odour. Its rhizome and seeds are used as antispasmodics.

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* The name Lords and Ladies, given to this plant, is said to be in allusion to the fact, that in former days those personages were attired in stiffly starched ruffs, in the preparation of which starch from the root of this plant was employed.

1529. Nat. Ord. 259.—PISTIACEÆ or LEMNACEÆ, the Duckweed order (Figs. 1755 to 1757).—Floating plants with lenticular or

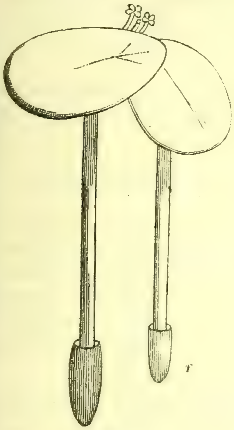

Fig. 1756.

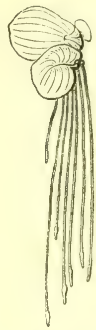

Fig. 1755.

Fig. 1757.

lobed leaves or fronds (Figs. 1755 and 1756), bearing 1 or 2 monœcious flowers enclosed in a spathe, but with no perianth (Fig. 1757). Stamens definite, often monadelphous. Ovary 1-celled; ovules 1 or more, erect or horizontal. Fruit indehiscent or membranous, or bursting transversely, or baccate, 1 or more-seeded. Seeds with a thick ribbed episperm and an indurated micropyle; embryo in the axis of fleshy albumen, with a lateral cleft, or at the apex of the nucleus. Natives both of cool and of warm regions. Lemnas form a green covering of pools in Britain. They have a peculiar root-sheath (Fig. 1756). Pistia Stratiotes, Water-lettuce, floats in the ponds of warm countries (p. 467). Species 20. *Ill. Gen.*—Lemna, Spirodela, Pistia, Ambrosinia.

1530. Nat. Ord. 260.—NAIADACEÆ or POTAMOGETONACEÆ, the Naias or Pondweed order.—Plants of fresh or salt water, with cellular leaves and stems, and inconspicuous spiked flowers, which are sometimes hermaphrodite. Perianth of 1-4 scaly pieces or 0. Stamens definite, hypogynous. Ovary free, of one or more carpels, 1-celled; ovule solitary, erect or pendulous, rarely 3 and erect. Style simple, or 2-3-cleft. Fruit indehiscent, dry, 1-celled, and usually 1-seeded; albumen 0; embryo with a lateral cleft (Fig. 1273, p. 638, and Fig. 1275, p. 639). What is called the perianth in Potamogeton, and a few other allied genera, is considered by some as composed of bracts,

Figures 1755 to 1757 illustrate the natural order Pistiaceæ.

Fig. 1755. Lemna minor, lesser Duck-weed, with its frond and sheathed roots. Fig. 1756. The same magnified, showing the imperfect flowers produced on the frond and the distinct pileorhizæ or sheaths, *r*, at the extremities of the roots. Fig. 1757. The flower of Lemna minor, showing two male flowers with quadrilocular anthers, and a female flower in the centre, all surrounded by an urceolate spathe.

bearing unisexual flowers. If that is the true view, then this order will not include any ☿ plants. Natives of temperate and warm climates. Species about 40. *Ill. Gen.*—Potamogeton, Ruppia, Aponogeton, Ouvirandra, Caulinia, Naias, Zannichellia, Zostera, Thalassia, Amphibolis.

1531. Some species are styptic, others yield edible roots, and a few are used for stuffing cushions and beds. In the cells of many of the plants, rotation is seen (p. 416).

Aponogeton distachyum, a Cape aquatic, thrives well in some ponds in Britain. It flowers nearly during the whole year (p. 682).

Ouvirandra fenestralis, a South African plant, has peculiar skeleton cellular leaves.

Potamogeton, Pondweed, and a few allied hermaphrodite (?) genera, are put by Lindley in Juncaginaceæ. The root of P. natans is used for food in some countries.

Zostera, Sea-wrack, is made the type of an order, Zosteraceæ, by Lindley. It grows in sea-water, has its flowers enclosed in herbaceous spathes, and its pollen has a beautiful filamentous appearance.* The dried plant is sometimes used for stuffing beds, &c.

1532. Nat. Ord. 261.—Triuridaceæ, the Triuris order.—A small tropical order of cellular, unisexual plants, allied to Naiadaceæ, but distinguished in part by their peculiar seed, which consists of a hard striated integument, containing an embryo in the form of a multicellular nucleus. Species 8. *Ill. Gen.*—Triuris, Hexuris, Sciaphila.

1533. Nat. Ord. 262. — Restiaceæ, the Restio order.—Herbs or undershrubs, with narrow leaves or 0, naked or sheathed stalks, and flowers in bracteated heads or spikes, generally ♂ ♀; glumaceous bracts 2-6, sometimes 0. Stamens 2-3; anthers usually 1-celled. Ovary 1 or more-celled; ovules, one in each cell, pendulous. Fruit a capsule or nut. Embryo lenticular, outside the albumen. Natives chiefly of South America, Australia, and South Africa. Their wiry stems are used for baskets and brooms, and for thatching. Species about 170. *Ill. Gen.* — Chætanthus, Willdenovia, Lepidanthus, Thamnochortus, Restio.

1534. Nat. Ord. 263.—Eriocaulonaceæ, the Pipewort order.—Marsh plants, with minute, unisexual flowers, allied to the last order, and differing principally in their capitate inflorescence, 2-celled anthers, ovary surrounded by a 2-3-toothed membranous tube, and seeds with rows of hairs. The species abound in South America, Brazil containing upwards of 100 species of Eriocaulon, some of them branching plants 6 feet high. Other plants of the order are found in Australia and North America. Eriocaulon septangulare, jointed Pipewort, is the only species found in Britain. It is met with in Skye and Galway. Species 200. *Ill. Gen.* — Eriocaulon, Cladocaulon, Paspalanthus.

1535. Nat. Ord. 264.—Desvauxiaceæ, the Bristlewort order.—Small herbs, like species of Scirpus, having setaceous leaves, flowers glumaceous in a spathe, distinguished from Restiaceæ principally in having separate ovaries attached to a common axis, and fruit consisting

* See Hofmeister on Zostera, in Henfrey and Huxley's Scientific Memoirs, i. 239.

of utricles opening longitudinally. They inhabit the South Sea Islands and New Holland. Species 15. *Ill. Gen.*—Centrolepis, (Desvauxia), Aphelia.

SUB-CLASS 3.—GLUMIFERÆ.

1536. Nat. Ord. 265.—CYPERACEÆ, the Sedge order (Figs. 1758

Fig. 1758.

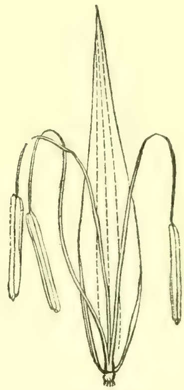

Fig. 1759.

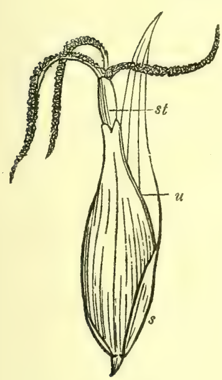

Fig. 1760.

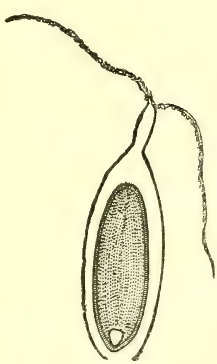

Fig. 1761.

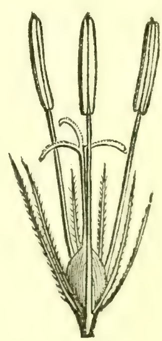

Fig. 1762.

to 1762).—Grass-like, cæspitose plants, have solid, usually un-

Figures 1758 to 1762 illustrate the natural order Cyperaceæ.

Fig. 1758. Cyperus esculentus, with its edible corms or tubers. It is conjectured to be the Hebrew Achu, translated Flag in Job viii. 11, and Meadow in Gen. xli. 2, 18. Fig. 1759. Staminiferous flower of Carex, Sedge, consisting of a scale or glume bearing 3 stamens with long filaments and innate anthers. Fig. 1760. Pistilliferous flower of Carex, consisting of a scale or glume, *s*, bearing a pistil surrounded by an urceolate perigynium, *u*, through which projects the style, *st*, with its three

jointed, and frequently angular stems (Fig. 157, p. 66), leaves with entire sheaths, and ☿ or ♂ ♀ flowers, each with a solitary bract or glume (Fig. 1759), imbricated on a common axis, so as to form a spikelet. The lowermost glumes are often empty. Perianth 0, or existing in the female flowers in the form of a membranaceous covering called perigynium (Fig. 1760). Stamens hypogynous, definite, varying from 1 to 12, most commonly 3; anthers innate, 2-celled. Ovary superior, often surrounded by hypogynous bristles called setæ (Fig. 1762); ovule 1, erect; style single, 2-3-cleft; stigmas 2-3. Fruit a crustaceous or bony achene. Embryo lenticular, in the base of fleshy or mealy albumen (Fig. 1761). Generally distributed all over the world, and growing abundantly in moist situations. Species 2000. *Ill. Gen.*—Carex, Kobresia, Scleria, Rhynchospora, Schœnus, Cladium, Lipocarpha, Fuirena, Fimbristylis, Isolepis, Scirpus, Blysmus, Eleocharis, Eriophorum, Cyperus, Papyrus, Kyllingia, Mariscus, Abilgaardia.

1537. Some of the Sedges are diaphoretic and demulcent, others are bitter, stomachic, and astringent. By means of their creeping underground stems, some of them bind together the loose sands of the sea-shore. Some of the plants, such as Cyperus Hydra, prove troublesome weeds on account of their creeping, subterranean stems. The cellular tissue is occasionally used for paper.

Carex arenaria (Fig. 157, p. 66), C. incurva, and other species, are found on the sandy shores of Britain, and along with Psamma arenaria, and other Grasses, are useful in forming the Bent, which prevents the sand from being blown inland. The creeping stems of C. arenaria are used as a substitute for Sarsaparilla.

Cyperus longus has been used as a tonic and astringent, its roots being the officinal part. The roots of C. rotundus contain an aromatic volatile oil. The corms of C. esculentus (Fig. 1758) have been used as food, and when roasted, they have been recommended as a substitute for Coffee. The corms of C. bulbosus are also eaten.

Eriophorum, Cotton-grass, is so called on account of the long silky hypogynous bristles or hairs which surround the fruit. The leaves are considered to be astringent. The hairs cannot be manufactured, but they are employed for paper, for wicks of candles, and for stuffing cushions.

Papyrus antiquorum (Fig. 25, p. 19, and Fig. 26, p. 20) appears to be the Hebrew Gome, which is translated Rush or Bulrush in Scripture (Exod. ii. 3; Job viii. 11; Is. xviii. 2, and xxxv. 7). It is probably the Bulrush of the Nile which, with its spreading rhizomes, helped to consolidate the mud of the Delta. It was used for making boats, and for ropes. The cellular tissue which fills the interior of its stem has been used for making paper. In Sicily a species is used for this purpose at the present day, which, according to Parlatore, is P. sicula, the plant usually cultivated in European gardens. A specimen of Sicilian Papyrus paper is seen in the Edinburgh Botanical Museum. P. corymbosus supplies Indian-grass matting.

Scirpus lacustris, C. Tabernæmontani, and other species of Clubrush or Bull-rush, are used, like Rushes, for making mats, baskets, and the bottoms of chairs.

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stigmas. Fig. 1761. The ripe pistil of Carex cut vertically, showing the minute embryo in the base of the albumen. Fig. 1762. Hermaphrodite flower of Scirpus, Club-rush. The glume has been removed, and there are seen six hypogynous, retrorsely-toothed bristles, three stamens with innate anthers, and the pistil with a single style and three stigmas.

1538. Nat. Ord. 266.—Gramineæ, the Grass order (Figs. 1763 to 1781).—Herbaceous plants, with round, usually hollow, jointed stems; narrow, alternate leaves, having a split sheath and often a ligule at its summit (Fig. 1772); hermaphrodite or monœcious, or polygamous

Fig. 1763.

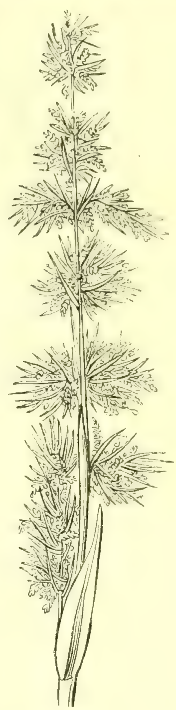

Fig. 1764.

flowers, either solitary or arranged in spiked or panicled locustæ (Fig. 1773). The flowers are considered as composed of a series of bracts; the outer, called glumes (Fig. 1774), alternate, often unequal, usually 2 (Fig. 1778), sometimes 1, rarely 0; the next, called pales or glu-

Figures 1763 to 1781 illustrate the natural order Gramineæ.

Fig. 1763. Arundo Donax, a panicled grass, supposed to be one of the plants implied in the Hebrew Kaneh, and the Greek Kalamos, translated Reed in many parts of Scripture (1 Kings xiv. 15; Job xl. 21; Is. xix. 6; Ezek. xxix. 6; Matt. xii. 20). Fig. 1764. Andropogon Calamus aromaticus, a grass which yields a fragrant oil, and supposed by Royle to be the Hebrew Kaneh Bosem, 'and Kaneh Hattob, translated Sweet Calamus (Exod. xxx. 23), and Sweet Cane (Jer. vi. 20); probably also the Calamus of Cant. iv. 14, and Ezek. xxvii. 19, and the Sweet Cane of Is. xliii. 24. Fig. 1765. Panicum miliaceum, Millet, appears to be the Hebrew Dokham or Docham, translated Millet in Ezek. iv. 9. Fig. 1766. Lolium temulentum, the Darnel-grass, said to be the only poisonous grass; but there are doubts in regard to its narcotic qualities. Some suppose it to be the Zizania or Tares of Scripture (Matt. xiii. 25, &c.), the infelix lolium of Virgil (See also Fig. 385, p. 160). Fig. 1767. Dactylis cæspitosa, the Tussac-grass of the Falkland Islands, a valuable kind of pasture grass. Fig. 1768. Spike of Triticum, Wheat, consisting of numerous spikelets arranged along a common rachis. Fig. 1769. Triticum Spelta, Spelt, a kind of awned or aristate Wheat, supposed to be the Hebrew Kussemeth,

melles (paleæ or glumellæ), usually 2, alternate (Figs. 1775 and

Fig. 1765.

Fig. 1769.

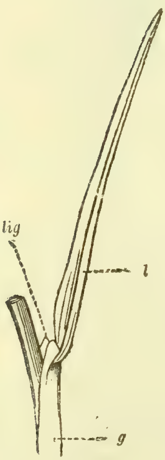

Fig. 1772.

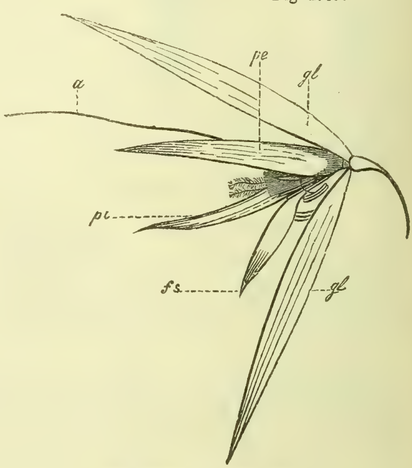

Fig. 1778.

translated Rye (Exod. ix. 32; Is. xxviii. 25), and Fitches (Ezek. iv. 9). Fig. 1770. Triticum compositum, Egyptian Wheat, having numerous spikes (ears) coming from one stalk. It is one of the plants included in the Hebrew Chittah, translated Wheat in various parts of the Old Testament (Gen. xxx. 14; Exod. ix. 32; Deut. viii. 8, &c.) Fig. 1771. Diagram of a spikelet of Avena, Oat, shewing two glumes, *gl gl*, enclosing three flowers, one of which, *a*, is abortive; the two pales or glumelles, *b b b*, the inner apparently formed by the union of two; two scales, lodicules, *p p*, the third being abortive and marked by a dotted curve; three stamens, *e*, ovary, *c*, with two feathery styles.

1776), the lower or outer one being simple, the upper or inner having

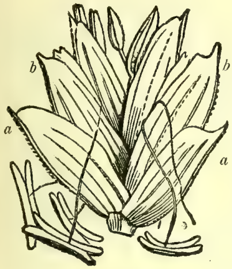

Fig. 1773.


Fig. 1776.

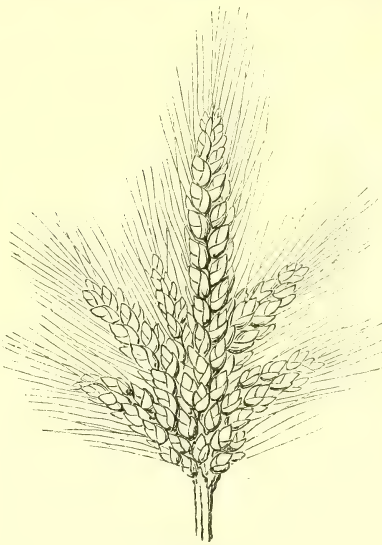
Fig. 1770.

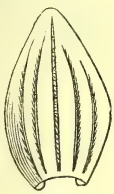
Fig. 1775.

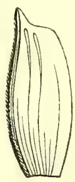
Fig. 1774.

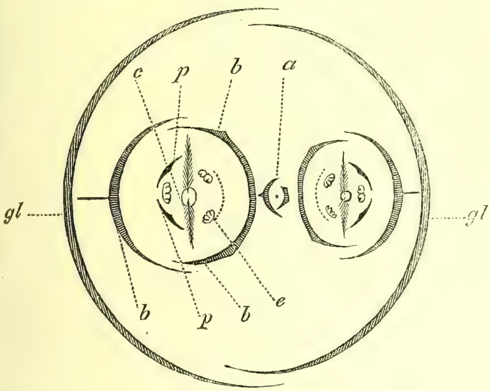

Fig. 1771.

Fig. 1777.

2 dorsal or lateral ribs, and supposed to be formed by 2 pales united; sometimes 1 or both are awanting. The glumes enclose either one

Fig. 1772. Leaf, *l*, of Poa, Meadow-grass, with a split sheath, *g*, and a ligule, *lig*. Fig. 1773. Spikelet of Wheat, composed of numerous flowers, *bb*, enclosed within two glumes, *aa*. The stamens have thread-like filaments and versatile anthers. Fig. 1774. A glume of Wheat seen in profile. Fig. 1775. Outer pale or glumelle of Wheat with one mid-rib and four lateral ribs. Fig. 1776. Inner pale or glumelle of Wheat, with two ribs, indicating its probable formation by the union of two pales. Fig. 1777. Ovary of Wheat with the pales removed, shewing the hypogynous scales, lodicules, *sq*, three stamens with versatile anthers, *a*, and two feathery styles, *st*. Fig. 1778. Spikelet of Avena sativa, Oats, shewing two glumes, *gl gl*, outer pale or glumelle, *pe*, with a dorsal awn (arista), *a*, inner pale, *pi*, the pales enclosing the essential organs; abortive or sterile flower, *fs*. Fig. 1779. Flower of

flower, as in Fox-tail grass, or more flowers, as in Wheat (Fig. 1773), and among the flowers there are frequently abortive florets (Fig. 1771,

Fig. 1768.

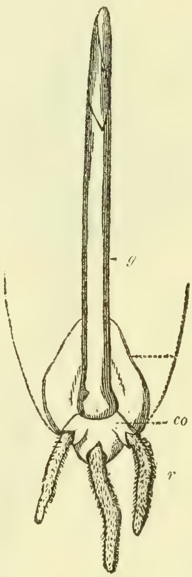

Fig. 1781.

Fig. 1766.

a, and Fig. 1778). Stamens hypogynous, 1-6, usually 3 (Fig. 1777); anthers versatile. Ovary superior, 1-celled, with 2 (rarely 1 or 0) hypogynous scales called lodicules (Figs. 1777 and 1779); ovule 1; styles 2 or 3, rarely united; stigmas often feathery (Fig. 1777). Fruit a caryopsis (p. 282). Embryo lenticular, external, lying on one side, at the base of farinaceous albumen (Fig. 1780). Germination endorhizal (Fig. 1781). Grasses are widely distributed, and are found in all quarters of the globe. Schouw conjectures that they constitute 1-22d of all known plants. They are usually social plants, forming herbage in temperate regions, and sometimes becoming arborescent (50 or 60 feet high) in tropical countries. There appear

Oat cut vertically, shewing inner pale, *pi*, lodicules, *sq*, three stamens, and ovary with two feathery styles. Fig. 1780. Caryopsis, grain of Oat; pericarp, *o*, spermoderm, *t*, farinaceous albumen, *a*. Embryo plant lying at one side at the base, with radicle, *r*, plumule, *g*, and cotyledon, *c*. Fig. 1781. Grain of Oats germinating; radicles, *r*, coleorhizæ or sheaths, *co*, plumule, *g*, and cotyledon, *c*.

to be nearly 4000 known grasses. *Ill. Gen.*—Oryza, Zizania, Zea, Coix, Alopecurus, Phleum, Holcus, Milium, Panicum, Stipa, Agrostis,

Fig. 1767.

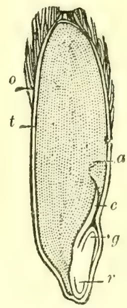

Fig. 1780.

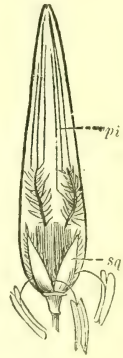

Fig. 1779.

Arundo, Echinaria, Cynodon, Chloris, Spartina, Hierochloe, Anthoxanthum, Aira, Arrhenatherum, Poa, Briza, Dactylis, Cynosurus, Festuca, Bromus, Bambusa, Lolium, Triticum, Elymus, Hordeum, Ægilops, Nardus, Lepturus, Saccharum, Andropogon.

1539. This is perhaps the most important order in the vegetable kingdom, as supplying food for man and animals. To it belong the cultivated grains, Wheat, Oats, Barley, Rye, Rice, Maize, and Millet. Most of these have been so long under constant cultivation that their native state is unknown. Some curious observations, however, have been lately made in regard to the native state of Wheat (p. 709). The properties of the order are nutritive in a marked degree. Some yield fragrant oils, others produce sugar. The fragrant odour given out by Anthoxanthum, and other grasses used for hay, has been attributed to benzoic acid. Some, as Bromus catharticus and B. purgans, were stated to have cathartic qualities, but this seems to be erroneous. Lolium temulentum, Darnel-grass (Fig. 1766), supposed to be the Tares, Zizania, of Scripture, has been said to be narcotic and poisonous, but this has not been fully proved. Some grasses, with creeping subterranean stems, as Triticum repens, Quick-grass, are troublesome weeds; others of a similar nature, as Elymus arenarius and Psamma arenaria, bind the loose sand of the sea-shore together. Spruce says that grasses chiefly belonging to the tribes Oryzeæ, Chlorideæ, and Paniceæ, constitute the mass of the numerous floating islands in the Amazon, called Ilhas de Capim. These islands are sometimes acres in extent, and from 5 to 8 feet of their thickness is under water. The

Additional illustrations of Gramineæ:—Grains of Wheat, Figs. 846 and 847, p. 283. Culm of Wheat, Fig. 291, p. 126. Germination of Wheat, Maize, and Briza, Fig. 1274, p. 638; Fig. 1281, p. 641; and Fig. 1282, p. 642. Consult also Parnell's work on British Grasses, and Lawson's List of cultivated Grasses.

hollow stems of some tropical Grasses contain a cool fluid which supplies a refreshing drink. The cuticle of Grasses is siliceous.

Anatherum muricatum is an Indian grass, having an aromatic rhizome, which is sold as a perfume under the name of Vetivert.

Andropogon Schœnanthus, Lemon-grass or Ginger-grass, and A. Calamus aromaticus (Fig. 1764), yield a fragrant oil. The latter is considered by Royle the Kaneh Bosem, Sweet-cane, or Calamus of the Bible. A. saccharatum, Shaloo, is cultivated in India as a nutritious grain. The grain of A. Sorghum is imported under the name of Durra or Doura. It resembles Millet.

Arundo includes many of the plants commonly called Reeds, some of which, such as Arundo Phragmites (Phragmites communis), are probably implied in the Hebrew word Agmon, which occurs in Job xl. 21, xli. 2; Is. ix. 14, xix. 15, lviii. 5, and has been translated Flag, Hook, Rush, and Bulrush. A. Donax (Fig. 1763) is considered by Royle to be one of the plants included in the Hebrew Kaneh and Greek Kalamos, translated Reed in Scripture.

Avena sativa, the common Oat, is a grain of northern climates.* A. nuda, the naked or Hill Oat, used to be cultivated in Scotland, and A. orientalis, Tartarian Oat, with its unilateral panicle, is still occasionally grown in fields. A. fatua, the Wild Oat, has a very hygrometric awn.

Bambusa arundinacea, the Bamboo, attains a great height, and in hothouses in Britain it has sometimes grown at the rate of a foot or more per day. Wallich mentions, that in the Calcutta Garden the shoots of Bambusa gigantea grew not less than 25 feet 9 inches in length during July 1833 (Kew Miscel. i. 213). Occasionally the Bamboo has a diameter of 9 or 10 inches. The young shoots are used for pickles, and the hollow stem is employed for a variety of purposes. Paper is prepared from it, and a siliceous matter called Tabasheer is procured from its joints (p. 389). Dr. Hooker, in speaking of the Bamboos near Darjeeling, says—"There are so many kinds, they so seldom flower, require so much experience in their native states, and so cautious an examination from the botanist, that it is next to impossible to define the limits of ten or twelve species easily distinguished by the Lepchas who inhabit the district. A very large kind of Bamboo is used by the Lepchas for *choongis* or 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. In an economical point of view, they are classed into those which split readily and those which do not. 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 young shoots are boiled and eaten, and sweetmeats are also made of them.†

Coix Lachryma has hard grains, which are commonly called Job's-tears, and are used as beads.

Dactylis cæspitosa, the Tussac-grass of the Falkland Islands (Fig. 1767), has been cultivated with some success in Shetland and in the island of Lewis. It yields valuable fodder. D. glomerata is the common Cock's-foot grass.

Gynerium argenteum, the Pampas-grass of the Cordillera, thrives well in some places in Britain, and is a graceful grass. The flowers are in panicles $1\frac{1}{2}$ to $2\frac{1}{2}$ feet long, and of a silvery whiteness. G. saccharoides yields sugar in Brazil.

Hordeum includes the species of Barley which, along with Oats, is a grain of temperate and cold climates. H. distichum, two-rowed Barley, is the common cul-

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* The chief varieties of Oat in cultivation in Scotland are the Potato, Sandy, Hopetoun, Early Angus, Poland, and Common Oat.

† A Chinese cloak, made from Bamboo leaves, and wove paper, made from strips of Bamboo, have been presented by A. H. Balfour, Esq., Hong Kong, to the Edinburgh Botanical Museum.

tivated species. H. vulgare, Bere, Bigg, or four-rowed barley, and H. hexastichum, six-rowed Barley, are confined to higher districts, and are rarely cultivated in Britain. The Hebrew word Seorah or Shoreh, translated Barley, occurs in many parts of Scripture (Exod. ix. 31; Lev. xxvii. 16; Is. xxviii. 25; Joel i. 11, &c.); and Barley-bread is referred to as being used by the common people (Judges vii. 13; 2 Kings iv. 42; John vi. 9, 13).

Oryza sativa, Rice, is the grain which is said to support the majority of the human race. Rice Starch is manufactured and sold under the name of Patent Starch. Rice, along with Maize and Millet, is the chief grain of warm countries.

Panicum miliaceum, a kind of Millet (Fig. 1765), is cultivated for its grain in warm countries. It is the Hebrew Dokham. The grain is called Warree in the East Indies. P. jumentorum is the Guinea-grass; P. spectabile the Angola-grass.

Paspalus virgatus, Lamaha-grass, is excellent fodder in Demerara.

Phalaris canariensis produces the grain called Canary-seed, used for birds.

Saccharum officinarum, the Sugar-cane (Fig. 78, p. 33), is an important Grass. The import of Cane-sugar into Britain in 1852, was 7,214,635 cwts., besides 543,628 cwts. of Molasses.

Secale cereale, Rye, is subject to a disease called Ergot, which renders it unfit for use (page 689). The Hebrew word Kussemeth, translated Rye, appears to mean Triticum Spelta, Spelt Wheat (Fig. 1769).

Sorghum. This genus yields the grain called Guinea-corn. Sugar is procured from S. saccharatum, Sweet Sorgho. S. vulgare is called great Millet or Sowaree.

Triticum vulgare is the common Wheat; the variety called T. æstivum, or Spring Wheat, being sown in spring, and that called T. hybernum, Winter Wheat, being sown in autumn.* Some varieties of Wheat are destitute of awns, others are awned like barley, as is seen in T. Spelta, Spelt (Fig. 1769), the Hebrew Kussemeth. T. compositum is the Egyptian or many-eared Wheat (Fig. 1770), and is included in the Hebrew word Chittah. M. Esprit Fabre has recently maintained, that all the varieties of cultivated Wheat are derived from a grass called Ægilops ovata (p. 709).

Zizania aquatica supplies the Swamp-rice of Canada.

1540. Analysis of the Monocotyledonous natural orders, with references to the numbers of the orders in the preceding pages.

I. Endogens with netted leaves.

1. *Perianth adherent, ovary inferior.*
    Unisexual, fruit capsular, a cavity in the albumen ...... Dioscoreaceæ, 224.

2. *Perianth free, ovary superior.*
    Ovary 1-celled.
        Placentas basal, flowers tetramerous .... Roxburghiaceæ, 227.
        Placentas parietal, flowers trimerous .... Philesiaceæ, 228.
    Ovary 3-5 celled.
        Flowers ♂ ♀; perianth with 6 divisions, all petaloid, leaves articulated with the stem............... Smilaceæ, 225.
        Flowers ☿; perianth with 6 or 8 divisions, all herherbaceous or 3 petaloid, leaves not articulated Trilliaceæ, 226.

II. Endogens with parallel-veined leaves.

1. Flowers with a verticillate perianth, and usually hermaphrodite.
    a. *Perianth adherent, ovary inferior.*
        Flowers gynandrous.

* The varieties of Wheat recommended for cultivation in Scotland are Fenton, Hunter's, and Hopetoun.

Ovary 1-celled, placentas parietal .... Orchidaceæ, 230.
Ovary 3-celled, placentas axile .... Apostasiaceæ, 231.
Flowers not gynandrous.
Veins of the leaves running from the midrib to the margin.
Stamens, one only fertile.
Anther 1-celled, filament petaloid .... Marantaceæ, 234.
Anther 2-celled, filament not petaloid .... Zingiberaceæ, 233.
Stamens, 5 or 6 fertile .... Musaceæ, 235.
Veins of the leaves running parallel to the midrib.
Stamens 3.
Anthers extrorse, distinct embryo in dense albumen .... Iridaceæ, 236.
Anthers introrse, embryo a loose cellular nucleus Burmanniaceæ, 232.
Stamens 6.
Anthers turned outwards .... Burmanniaceæ, 232.
Anthers turned inwards.
Leaves equitant.. Hæmodoraceæ, 239.
Leaves flat, not equitant.
Fruit 3-celled.
Outer perianth coloured, albumen fleshy or hard.
Seed with a beaked strophiole, radicle remote from the hilum, leaves dry Hypoxidaceæ, 238.
Seed not strophiolate, embryo next the hilum, leaves not dry .... Amaryllidaceæ, 237.
Outer perianth herbaceous, albumen mealy.
Leaves rigid, channelled, often scurfy Bromeliaceæ, 241.
Fruit 1-celled.. Taccaceæ, 240.
Stamens more than 6. Aquatic plants............ Hydrocharidaceæ, 229.

b. Perianth free, ovary superior.

Outer perianth herbaceous or glumaceous.
Carpels more or less separate.
Placentas parietal, forming a network on the inner surface of the ovary, fruit many-seeded ...... Butomaceæ, 254.
Placentas axile or basal, fruit 1-2-seeded.
Anthers extrorse, embryo straight, with a lateral slit .... Juncaginaceæ, 253.
Anthers introrse, embryo like a horse-shoe, no slit .... Alismaceæ, 252.
Carpels combined into a solid pistil.
Verticils of the perianth visibly different.
Placentas axile, anthers 2-celled .... Commelynaceæ, 248.
Placentas parietal, anthers 1-celled .... Mayacaceæ, 249.
Verticils of the perianth not different, usually dry and glumaceous... Juncaceæ, 250.
Outer perianth petaloid.
Carpels more or less separate.
Seed solitary, flowers on a scaly spadix .... Palmæ, 251.
Seeds numerous, flowers not spadiceous.
Anthers extrorse .... Melanthaceæ, 243.
Anthers introrse.
Perianth of 6 parts .... Butomaceæ, 254.
Perianth of 2 parts .... Philydraceæ, 247.
Carpels combined into a solid pistil.
Anthers extrorse.
Outer perianth glumaceous............................ Xyridaceæ, 246.
Anthers introrse.

Flowers more or less irregular, perianth rolling inwards after expansion, aquatics ... . Pontederiaceæ, 245.
Flowers regular, no rolling inwards of the perianth.
Inner perianth minute, of a single lobe, or urceolate or 5-toothed .... Gilliesiaceæ, 244.
Inner and outer perianth alike .... Liliaceæ, 242.

2. Flowers without a true perianth, either achlamydeous or with a few verticillate scales, often unisexual.

a. Flowers on a spadix.

Flowers hermaphrodite .... Orontiaceæ, 258.
Flowers unisexual.
Embryo with a cleft at one side in which the plumule lies.
Fruit succulent, stamens very short, perianth 0 Araceæ, 257.
Fruit dry, filaments long, with cuneate anthers, perianth being scales or hairs .... Typhaceæ, 256.
Embryo without a cleft.
Fruit, 1-seeded fibrous nuts, or many-celled berries Pandanaceæ, 255.

b. Flowers not on a spadix.

Ovules pendulous.
Carpel solitary.
Anthers 1-celled .... Restiaceæ, 262.
Anthers 2-celled .... Naiadaceæ, 260.
Carpels several.
Carpels separate.
Anthers 1-celled .... Desvauxiaceæ, 264.
Anthers 2-celled.
Ovary surrounded by a membranous tube Eriocaulonaceæ,263.
Ovary without a surrounding tube .... Naiadaceæ, 260.
Carpels combined into a solid pistil .... Restiaceæ, 262.
Ovules erect.
Embryo with radicle and cotyledon conspicuous.
Seeds with a thick coriaceous ribbed spermoderm, and an indurated foramen, flowers spathaceous .... Pistiaceæ, 259.
Seeds without a thickened covering, foramen not indurated, flowers naked or with scales.... Naiadaceæ, 260.
Embryo consisting of a cellular nucleus, with no division of parts .... Triuridaceæ, 261.

3. Flowers consisting of imbricated bracts, called glumes.

Stem hollow, leaf-sheath split, embryo outside the albumen at its base .... Gramineæ, 266.
Stem solid, leaf-sheath not split, embryo within the base of the albumen .... Cyperaceæ, 265.

II.—CRYPTOGAMEÆ, ACOTYLEDONEÆ, OR FLOWERLESS PLANTS.

CLASS III.—ACOTYLEDONES OR ACRO-THALLOGENÆ.

SUB-CLASS 1.—ACROGENÆ, ACROBRYA, OR CORMOGENÆ.

1541. Nat. Ord. 267. — Filices, the Fern order (Figs. 1782 to 1784).—Leafy plants, the leaves, or more properly fronds, being cir-

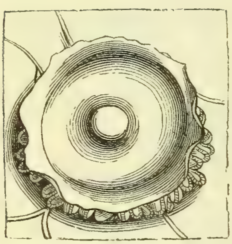

Fig. 1783.

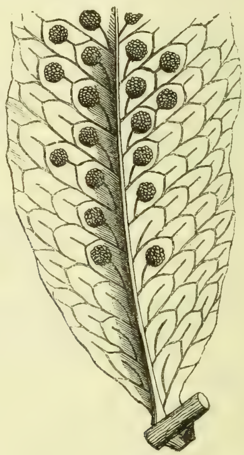

Fig. 1782.

Fig. 1784.

cinate in vernation (Fig. 974, p. 324), and arising from a rhizome (Fig. 69, p. 29), or from a hollow arborescent trunk (Fig. 973, p. 324), having the acrogenous structure (p. 92). The fronds bear

Figures 1782 to 1784 illustrate the natural order Filices.

Fig. 1782. Frond of Niphobolus, showing clusters of sporangia, called sori, at the extremities of the veins. The Fern is dorsiferous, inasmuch as the sori are on the back of the fructiferous leaf or frond. Fig. 1783. Sorus of Aspidium trifoliatum. The cluster of sporangia is covered by an indusium, or as it is sometimes called an involucre, derived from the epidermis of the frond. The indusium is orbicular and attached by its centre. The sporangia are annulate. Fig. 1784. Sporangium of Lastrea Filix-mas, supported on a cellular stalk, *p*, which is prolonged round the spore-case in the form of an elastic ring, *a*, which by straightening opens the sporangium transversely, so as to scatter the spores.

Further illustrations of Filices:—Stems of Ferns, Figs. 203 and 204, p. 93; Fig. 972, p. 324. Scalariform vessels of Ferns, Fig. 970, p. 324. Venation of Ferns, Figs. 975 to 982, pp. 325 and 326. Indusium, Fig. 984, p. 327. Spores, Figs. 938 and 939, p. 313, and Fig. 988, p. 328. Prothallus, Figs. 1270 and 1271, p. 637.

on the veins of their lower surface (Fig. 1782), or along their margins, sporangia, which open in various ways in order to discharge minute spores. The supposed organs of reproduction, called antheridia and archegonia (Figs. 1226 to 1232, p. 574), are seen on the young frond, when first developed from the spore in the form of a prothallus.—(For full details of structure and reproduction see pages 321 and 575). A moist, insular climate is that best adapted for Ferns in general. They abound in tropical islands, where they sometimes have trunks 50 or 60 feet high (Fig. 165, p. 70, and Fig. 967, p. 322). Ferns form the characteristic Flora of New Zealand. Species between 2000 and 3000.

1542. The following divisions have been adopted:—Sub-order 1. Polypodiaceæ, the Polypody tribe (Fig. 205, p. 94); Sporangia, in variously-shaped clusters, called sori, on the back or margins of the fronds, each sporangium having a vertical, incomplete ring (annulus), or a horizontal complete one, which, when mature, straightens so as to open the spore-case transversely, or irregularly, and thus discharge the spores (Fig. 1784). The sori are covered by an indusium or involucre (Fig. 1783), or by the reflexed margins of the frond. *Ill. Gen.* — Gymnogramma, Ceterach, Polypodium, Adiantum, Pteris, Allosorus, Blechnum, Asplenium, Nephrodium, Polystichum, Cystopteris, Davallia, Cibotium, Hemitelia, Alsophila, Cyathea, Ceratopteris, Parkeria, Hymenophyllum, Trichomanes, Gleichenia. Sub-order 2. Osmundaceæ, the Flowering-fern tribe (Fig. 985, p. 327); Sporangia dorsal, or clustered on the margin of a transformed frond, with a terminal or dorsal ring, more or less complete, reticulated, and opening vertically (Fig. 986, p. 328). *Ill. Gen.*—Osmunda, Todea, Aneimia, Schizæa, Lygodium, Mohria. Sub-order 3. Ophioglossaceæ, the Adder's-tongue tribe; Sporangia in a spike-like form, sessile on the margin of a contracted frond, without reticulation or a ring (exannulate), 2-valved; fronds with straight vernation. *Ill. Gen.*—Ophioglossum, Botrychium. Sub-order 4. Danæaceæ, the Danæa tribe; Sporangia dorsal, combined in masses, exannulate, splitting irregularly by a central cleft. *Ill. Gen.*—Kaulfussia, Angiopteris, Danæa, Marattia.

1543. Some Ferns are used medicinally as anthelmintics, while others are demulcent and astringent. The rhizomes of several species, such as Diplazium esculentum, Pteris esculenta, Marattia alata, Nephrodium esculentum, are used as food in Australia, the Sandwich Islands, and India. Some species are fragrant, as Aspidium fragrans, Polypodium phymatodes, and Angiopteris erecta.

Adiantum Capillus Veneris, true Maiden-hair, has been used in the preparation of Syrup of Capillaire. A. pedatum is also employed for a similar purpose, as well as for pectoral mixtures.

Aspidium Baromez, the Barometz, has received the name of Scythian-lamb, from the appearance presented by its woolly rhizome when the leaves are cut off in a particular way, and it is turned upside down.

Davallia canariensis, found in the Canary Islands, is called Hare's-foot Fern, on account of the form of its hairy rhizome.

Lastrea Filix-mas is an effectual vermifuge in cases of Tape-worm. The powdered rhizome, and an oleo-resin extracted from it by ether, are the forms employed.

1544. Nat. Ord. 268.—MARSILEACEÆ or RHIZOCARPEÆ, the Pepperwort or Rhizocarp order. — Aquatic plants, with creeping stems, bearing leaves, which are usually divided into 3 or more cuneate portions (Fig. 996, p. 332), and have a circinate vernation. The fructification is produced at the base of the leafstalks, and consists of sporocarps or involucres enclosing clustered organs (Fig. 995, p. 333), which consist of antheridian (Fig. 1239, p. 576) and pistillidian cells (Fig. 1241, p. 577). The germinating body has an oval form, and occasionally a mammilla on one side (Fig. 1240, p. 577), whence roots and leaves proceed.— (See full description, pages 333 and 577). Found in ditches in various parts of the world, chiefly in temperate regions. Species about 20. *Ill. Gen.*—Pilularia, Marsilea, Azolla, Salvinia.

Fig. 1785.

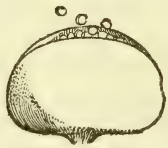
Fig. 1786.

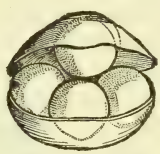
Fig. 1787.

1545. Nat. Ord. 269. — LYCOPODIACEÆ, the Club-moss order (Figs. 1785 to 1787).—Plants with creeping stems or corms, which produce leafy branches, somewhat resembling Mosses. The leaves are small, sessile, and imbricated or verticillate. The fructification occurs in the axil of leaves (Fig. 994, p. 329), and often in a spike-like form (Fig. 1785), and consists of kidney-shaped, 2-valved cases, which contain antheridian or spermatozoidal cells (Fig. 1786), and roundish or four-sided bodies, called oophoridia, opening by 2 valves, and containing 4 large spores (Fig. 1787). In the interior of the latter a pro-embryo is developed (Fig. 1236, p. 576), in which archegonia are produced (Figs. 1237 and 1238, p. 576), and thereafter impregnation gives rise to the germinating body.—(Full details are given at pages 331 and 576). Natives both of cold and warm climates, but abounding in the tropics, and especially in insular situations. Species about 200. *Ill. Gen.*—Psilotum, Lycopodium, Selaginella, Isoetes, Phylloglossum.

1546. Some of the plants have emetic and purgative properties. The powdery matter contained in their fructification is inflammable.

Figures 1785 to 1787 illustrate the natural order Lycopodiaceæ.

Fig. 1785. End of fructiferous branch of Lycopodium clavatum, common Club-moss. The leafy branch, *l*, ends in stalk bearing two spikes of fructification, *f*. Fig. 1786. A kidney-shaped 2-valved

Lycopodium clavatum furnishes the yellow Lycopode powder, which is often called vegetable brimstone, and used for fire-works, as well as for covering pills. A similar powder is furnished by L. Selago and other species. L. catharticum is said to be a powerful cathartic. L. squamatum (Selaginella convoluta), is hygrometric, coiling up like a ball when dry, and expanding when moisture is applied.

1547. Nat. Ord. 270.—Equisetaceæ, the Horsetail order (Fig. 1788).—Cryptogams having rhizomes or underground stems, bearing hollow, striated, siliceous branches, which are jointed and have membranous sheaths at the articulations. The place of leaves is supplied by green-coloured branchlets, which are sometimes verticillate. The fructification consists of cone-like bodies (Fig. 1788, *f*) bearing peltate polygonal scales (Fig. 989, p. 328), under which are spore-cases opening inwards by a longitudinal fissure, and enclosing spores with 2 hygrometric club-shaped elaters (Figs. 990 and 991, p. 328). The plants have a confervoid prothallus, and on it antheridian and archegonial cells are developed.—(Full details are given at pages 330 and 575). Found in ditches and rivers in all parts of the world, both warm and cold. In tropical regions some attain a height of 15 or 16 feet. Species about 12. *Ill. Gen.*—Equisetum.

1548. A large amount of silica is found in the cuticle of the Horsetails, associated also with fluorine (p. 388). The rhizomes contain starch.

Equisetum hyemale, rough Horsetail, is used for polishing furniture, as well as ivory and brass. It is imported from Holland under the name of Dutch Rushes.

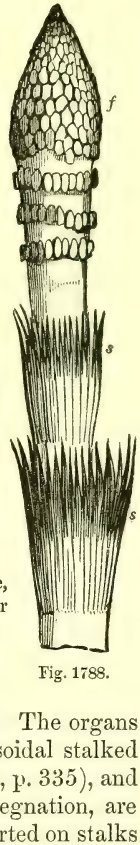

Fig. 1788.

1549. Nat. Ord. 271.—Musci, the Moss order (Figs. 1789 and 1790.)—Erect or creeping, terrestrial or aquatic plants, with cellular stems, bearing minute cellular leaves. The organs of fructification consist of cylindrical, pear-shaped, or ellipsoidal stalked sacs, containing antheridian cells with phytozoa (Fig. 1000, p. 335), and of spherical or obovate archegonia, from which, after impregnation, are developed urn-shaped sporangia (Fig. 1001, p. 335), supported on stalks called setæ (Fig. 1789, *p*), and containing germinating spores. The sporangia have a calyptra (Fig. 1002, p. 335), an operculum, and frequently a peristome, consisting of processes called teeth (Fig. 1790, *p*), which are either 4 or some multiple of that number.—(Full details are given at pages 334 and 572). They are found in all parts of the world, and abound

case, containing antheridian cells with phytozoa; these cells are sometimes called small spores. Fig. 1787. Oophoridium, with four large spores, each containing a prothallus on which archegonia are formed.

Fig. 1788. Fructification of Equisetum Telmateia, Great Water Horse-tail, showing the stalk surrounded by membranous sheaths, *s s*, which are fringed by numerous processes or teeth. The fructification, *f*, at the extremity, is in the form of a cone bearing polygonal scales, under which are spore-cases containing spores with clavate filaments (p. 328).

in moist temperate regions. Species between 1100 and 1200. There

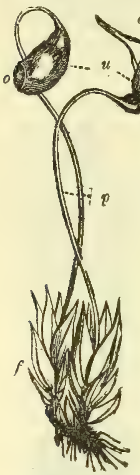

Fig. 1789.

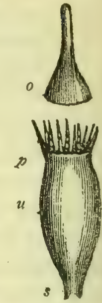

Fig. 1790.

are two divisions of the order. Sub-order 1. Andræaceæ, Split-mosses; Sporangia calyptrate, splitting longitudinally into 4 equal valves, which are kept together at the summit by a persistent operculum. *Ill. Gen.*—Andræa. Sub-order 2. Bryaceæ, true Urn-mosses; Sporangia calyptrate, opening at the summit, and not by valves. *Ill. Gen.*—Phascum, Gymnostomum, Splachnum, Orthotrichum, Weissia, Dicranum, Didymodon, Bryum, Bartramia, Funaria, Polytrichum, Buxbaumia, Hypnum, Neckera, Hookeria, Fontinalis, Sphagnum.

1550. Nat. Ord. 272.—HEPATICÆ, the Liverwort order (Fig. 1791).—Plants having a cellular axis of growth which bears leaves or a thallus (Fig. 1791). Antheridia (Fig. 1008, p. 340) and archegonia (Fig. 1222, p. 573) are placed either in the substance of the thallus, or on sessile or stalked processes. The stalks support sporangia or peltate sporangiferous receptacles. Sporangia sometimes open by valves, and bear elaters.—(Full details are given at pages 338 and 571). The plants are generally distributed both in cold and warm climates, and more especially inhabit damp places. Some of the species of Marchantia, especially M. hemisphærica, have been recommended as poultices in cases of Anasarca. Species about 700. The following are the divisions of the order. Sub-order 1. Jungermanniaceæ, the Scale-moss tribe; Sporangia opening by 4 valves, the spores mixed with elaters. *Ill. Gen.*—Blasia, Pellia, Radula, Jungermannia, Plagiochila, Gymnomitrium, Anthoceros, Monoclea. Sub-order 2. Marchantiaceæ, the true Liverwort tribe (Fig. 949, p. 316); Sporangia not opening by valves, bursting irregularly, spores mixed with elaters (Fig. 1012, p. 340). *Ill. Gen.*—

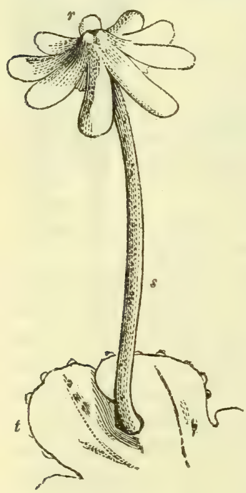

Fig. 1791.

Figures 1789 and 1790 illustrate the natural order Musci.

Fig. 1789. Funaria hygrometrica, hygrometric Cord-moss. Perichætial cellular leaves, *f*, from which arise stalks or setæ, *p*, bearing sporangia, *u*, with a split calyptra, *c*, and an operculum, *o*. Fig. 1790. Sporangium, *u*, of Encalypta, Extinguisher-moss, with its stalk, *s*, and operculum, *o*, removed to show 16 processes, *p*, called teeth, of the peristome.

Additional illustrations of Mosses:—Polytrichum, Fig. 947, p. 316, and Fig. 954, p. 317. Sporangia, Figs. 1004 and 1006, p. 337. Germinating spores and prothallus, Figs. 1268 and 1269, p. 636.

Fig. 1791. Portion of the thallus, *t*, of Marchantia polymorpha, Liverwort, bearing the fructification on a peltate receptacle, *r*, supported on a stalk, *s*.

Fegatella, Lunularia, Marchantia, Targionia. Sub-order 3. Ricciaceæ, the Crystalwort tribe; Sporangia not opening by valves, and having no elaters. *Ill. Gen.*—Riccia.

SUB-CLASS 2.—THALLOGENÆ, THALLOPHYTA, OR CELLULARES.

1551. Nat. Ord. 273.—Lichenes, the Lichen order (Figs. 1792 to 1794).—Cellular plants growing on stones, on the surface of the

Fig. 1793.

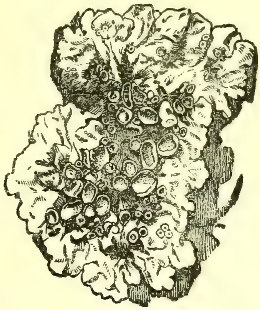

Fig. 1792.

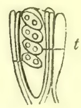

Fig. 1794.

earth, or on trees, and taking up nourishment by all points of their surface, having a foliaceous, crustaceous, or leprous thallus (Fig. 1792). Their fructification consists of thecæ or asci, containing 4, 8, 12, or 16 sporidia (Fig. 1794). The thecæ are often mixed with paraphyses, and by their union form circular, cup-shaped, or linear masses, which are called shields (Fig. 1793). There are also spermogones or conceptacles, containing cells with antherozoa, which are motionless, and have received the name of spermatia. The spermogones are either in the substance of the thallus, or superficial, and the spermatia are discharged through a pore. Between the upper and lower thalloid layers, green cells, called gonidia (Fig. 1020, p. 343) are found.—(Full details are given at page 341). Lichens, although growing on the bark of trees, do not destroy plants like Fungi. Thus, in the case of the officinal barks, those specimens which are covered with healthy Lichens, abound in the peculiar principles which make them valuable as medicines, while those portions which are covered by the beautiful Hypochnus rubro-cinctus, and other Fungi, are totally worthless, because their tissue has been penetrated and preyed upon by the mycelium. Lichens and Mosses, however,

Additional illustrations of Hepaticæ:—Antheridia and pistillidia, Figs. 1009 and 1011, p. 340. Germinating spores, Fig. 1266, p. 634.

Figures 1792 to 1794 illustrate the natural order Lichenes.

Fig. 1792. Parmelia, with fructification in the form of round apothecia. Fig. 1793. Portion of the thallus of a Lichen, showing a round apothecium. Fig. 1794. Theca or ascus, *t*, of a Lichen, containing four sporidia; paraphyses in the form of filaments surround the theca.

may injure the growth of trees by closing up the stomata. Lichens are found in various parts of the world. The pulverulent species are the first plants which cover the bare rocks of newly-formed islands. Species 2400. *Ill. Gen.*—Pulveraria, Calycium, Opegrapha, Urceolaria, Umbilicaria, Verrucaria, Endocarpon, Sphærophoron, Lecidea, Patellaria, Cladonia, Stereocaulon, Parmelia, Sticta, Cetraria, Roccella, Ramalina, Evernia, Usnea.

1552. Many of the Lichens are used for dyeing, others are employed as articles of food and medicine. The nature of the dyes produced by Lichens has been lately investigated by Dr. Lauder Lindsay.* Some Lichens are aromatic, and a fragrant powder called Cyprio at Rome is in part made from them. Oxalate of lime exists largely in some species, more especially in Variolarias.

Cetraria islandica, Iceland-moss (Fig. 75, p. 32), contains starch, along with a bitter principle; it has been used as a tonic and demulcent. C. nivalis is also nutritious.

Cladonia rangiferina (Fig. 1016, p. 343) is called Reindeer-moss, on account of supplying food for that useful animal.

Gyrophora embraces many dark-coloured Rock-lichens, which have a certain amount of nutritious qualities. Franklin and his companions lived on some of the species for many weeks in the arctic regions. The plants were denominated Tripe de Roche.

Lecanora tartarea, called in commerce Rock-moss, supplies the dye denominated Cudbear. It is used in the form of liquid and of paste. L. Perella has also dyeing properties. L. esculenta and L. affinis are used as food; the former is eaten in Tartary and in other countries.

Lecidea geographica is a green-coloured Lichen which covers mountain rocks, and often assumes map-like appearances. L. aromatica is sweet-scented when bruised.

Parmelia parietina yields a crystalline yellow colouring matter, Chrysophanic acid, identical with the yellow colouring matter of Rhubarb root. P. fragrans gives out a fine odour when moistened.

Roccella tinctoria (Fig. 1015, p. 342) is one of the Lichens imported under the name of Orchella-weed, from the Canary and Cape de Verd islands, the Azores, Madeira, South America, Barbary, Corsica, and Sardinia. The colouring matter is called Archil or Orchil; it is used for dyeing purple and red. Some have supposed that it supplied the purple of ancient Tyre, referred to in Ezek. xxvii. 7. R. fuciformis is another Orchella-weed imported from Angola, Madagascar, Madeira, and South America. R. hypomecha is another dyeing Lichen imported from the Cape of Good Hope. Litmus is a dye procured from several species of Roccella.

Sticta pulmonaria is nutritious, and has been used as an article of diet.

1553. Nat. Ord. 274.—Fungi, the Mushroom order (Figs. 1795 to 1797).—Cellular plants, with a spawn, mycelium (Fig. 1795, *m*), by which they are nourished, and which bears organs of fructification of various kinds. Spores are produced, which are either naked (Fig. 1795), or enclosed in thecæ (Fig. 1796). There appear to be an-

* Dr. Lindsay's papers were read to the Edinburgh Botanical Society, and his observations are partly recorded in the Transactions of the Society, as given in the Annals of Natural History, and in the Phytologist. Specimens of the Lichens used for dyeing, and of the dyes which they yield, have been presented by Dr. Lindsay to the Edinburgh Museum of Economic Botany.

theridian cells, containing spermatozoids, by the action of which on archegonial cells germinating spores are developed. In Agarics (Fig. 1797), the mycelium bears tubercles enclosed in a volva, which rup-

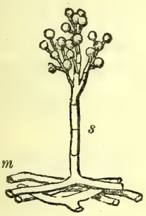

Fig. 1795.

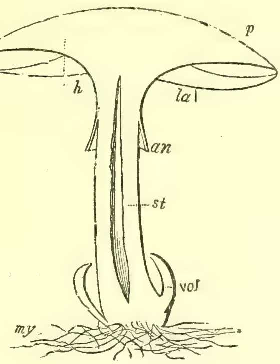

Fig. 1797.

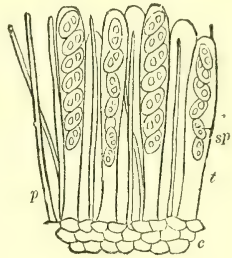

Fig. 1796.

tures so as to allow of the development of the stalked pileus, with its lamellæ and hymenium.—(Full details are given at page 344). Species between 4000 and 5000. *Ill. Gen.*—Agaricus, Boletus, Polyporus, Merulius, Hydnum, Clavaria, Exidia, Tremella, Phallus, Clathrus, Lycoperdon, Geaster, Reticularia, Craterium, Nidularia, Stilbospora, Torula, Puccinia, Uredo, Ustilago, Æcidium, Ceratium, Aspergillus, Botrytis, Morchella, Helvella, Peziza, Cyttaria, Tuber, Sphæria, Onygena, Mucor.

1554. This order contains esculent and poisonous plants ; the genus Agaricus, to which the true Mushroom belongs, contains both, and it is not easy to give rules for distinguishing the two kinds. In general terms it may be said that poisonous Fungi are often highly coloured, are scaly or spotted on their surface, have tough or watery flesh, and grow in clusters in wet or shady ground ; whereas edible species are rarely highly coloured, being commonly white or brownish, are seldom scaly or spotted, have brittle, not tough or watery flesh, and grow solitary in dry pastures. Fungi that are bitter or styptic, and that burn the fauces, or those that yield pungent milk, are unsafe. Those whose flesh is livid, and those which assume various hues when broken or bruised, are to be avoided. Badham says that the immense majority of Fungi are harmless, and that innoxious and esculent kinds are the rule, while poisonous are the exception. Their qualities seem to depend in part on the mode in which they

Figures 1795 to 1797 illustrate the natural order Fungi.

Fig. 1795. Botrytis, a kind of Mould-Fungus, consisting of a mycelium, *m*, a septate cellular stalk, *s*, which branches at the apex and bears naked spores. Fig. 1796. Vertical section of the fructification of Peziza, showing a cellular stratum, *c*, bearing clavate asci or thecæ, *t*, which contain sporidia, *sp* ; paraphyses or abortive filaments, *p*. Fig. 1797. Agaricus campestris, common Mushroom, cut vertically. Mycelium or spawn, *my*, volva or wrapper, *vol*, which is burst, stipe or stalk, *stip*, pileus or cap, *p*, bearing lamellæ or gills, *la*, with the hymenium, *h*, the annulus or ring, *an*, which is the remains of the ruptured velum or veil.

Additional illustrations of Fungi:—Species of Uredo, Puccinia, Ustilago, and Botrytis, causing diseases, Figs. 1301 to 1305, pp. 687, 688, and 690. Naked spores of Mushroom, Fig. 1028, p. 346.

are prepared for food, and this may account for species which are eaten in some countries having proved poisonous in others. Badham states that the yearly average of taxed Mushrooms in Rome during 10 years (1837 to 1847) was between 60,000 and 80,000 pounds weight. He says there are 30 esculent species in Britain.* Drummond remarks, that few orders of plants appear to contribute more to the support of animal life than the Fungi in Western Australia. Many species, particularly of the genus Boletus, are used as food by the natives, and directly supply no inconsiderable portion of their support for several months in the year. He was surprised at the large number of Fungi that were eaten by marsupial animals. They often dig up species, being guided to them by smell, and the cracking of the ground over them.

1555. Fungi contain much nitrogen in their composition, and they do not appear to give out oxygen gas. They are often developed with great rapidity. The spawn spreads under ground, or in the interior of living or dead organisms, and when favourable circumstances occur, the fructification bursts forth with astonishing quickness. Phallus impudicus and Bovista giganteum have grown to a great size in a single night (p. 410). The spores of Fungi seem to resist well the action of cold and heat, and to retain their vitality frequently for a great length of time (p. 628). Many of them are developed on living plants, and cause disease and death by their parasitic growth. Some of the species are limited to certain kinds of decaying matter. This has been remarked in species of Onygena, which have been on that account denominated O. equina, O. felina, and O. corvina. Moulds are formed by different species of Aspergillus (Fig. 1026, p. 346), Penicillium (Fig. 1021, p. 345), Botrytis (Fig. 1795), Mucor (Fig. 1029, p. 347), Myxotrichum, Chætomium, Oidium, Sporocybe, and Cladosporium. Some of them are developed in syrup and vinegar. The mycelium of Fungi, in certain conditions, seems to form the Vinegar-plant (p. 636), the Yeast-plant† (Fig. 1061, p. 360, and Fig. 1080, p. 410), and many of the so-called genera Ozonium, Himantia, Fibrillaria, Acrothamnium, and Byssocladium. These assume a leathery, gelatinous, fibrous, or byssoid appearance. The parasitic Fungi causing smut, mildew, ergot, and dry-rot, and those connected with diseases in the Potato and Vine,

* Dr. Badham was shocked to see numerous edible Funguses or Toadstools rotting uncared for at the time when famine prevailed:—"To see unused, pounds innumerable of extempore beefsteaks growing on our oaks in the shape of Fistulina hepatica; Agaricus fusipes to pickle, in clusters under them; Puffballs, which some have compared to Sweet-bread; Hydna as good as oysters; Agaricus deliciosus, like tender lamb-kidneys; excellent yellow Chantarelle; the sweet nutty-flavoured Boletus in vain calling himself edulis when there was none to believe him; the dainty Orcella, and the Agaricus heterophyllus which taste like the Craw-fish when grilled; the Agaricus ruber and virescens to cook in any way, and equally good in all." The following are the species eaten by Badham and his friends in England:—A. rubescens, procerus, prunulus, ruber, heterophyllus, virescens, deliciosus, nebularis, personatus, virgineus, fusipes, oreades, ostreatus, Orcella, campestris (and var. edulis and pratensis) exquisitus, comatus, and ulmarius; Amanita vaginata; Cantharellus cibarius; Polyporus frondosus; Boletus edulis and scaber; Fistulina hepatica; Hydnum repandum; Helvella lacunosa; Peziza Acetabulum and Bovista plumbea; Lycoperdon gemmatum; Clavaria strigosa.

† The Yeast-plant is probably a masked form of an Oidium or Penicillium.

have been noticed at page 685, *et seq.** During the progress of diseases in man and animals, especially those of the skin and mucous membrane, cellular plants like Fungi † are produced (p. 635). Animals are also infested with species of Sphæria and Botrytis which cause their death (p. 635). Leidy describes species of Enterobryus, Eccrina, Arthromitus, Cladophytum, and Corynocladus, as growing on the mucous membranes of living animals.‡

Agaricus campestris (Fig. 1797) is the common Mushroom of Britain; it is distinguished in part by its pink gills. A. Georgii is another edible British species, which sometimes attains a large size; Withering mentions a specimen weighing 14 pounds. A. prunulus is said to be the most delicious Mushroom. It is much prized on the Continent, but it is totally neglected in Britain. Many species of Agaric, as A. piperatus, A. rhacodes, and others, are poisonous. Fairy rings (p. 429) are formed by A. oreades (the English champignon), Orcella, Georgii, prunulus, personatus, and campestris. Some of the Agarics are luminous (p. 675).

Amanita muscaria is a poisonous species, which produces giddiness and narcotic symptoms. When eaten it communicates intoxicating qualities to the urine.

Boletus edulis, as its name implies, is an edible species.

Cyttaria Darwinii is a globular bright-yellow Fungus, which grows on a species of Beech, and is used as food in Tierra del Fuego. C. Berteroi is a Chilian species, which grows on Fagus obliqua, and is also edible.

Exidia Auricula Judæ, Jew's-ear, has been used for arresting hemorrhage. E. hispidula grows in China on the decaying stems of the Castor-oil plant. It is used as an article of food, in soups and stews, and is employed as a styptic, under the name of Mó-ghí, or ears of trees.

Morchella esculenta, Morel, an edible Fungus, is imported from Italy in a dry state.

Penicillium glaucum is the common Mould developed wherever organic substances are in fitting conditions of moisture and temperature. Books are constantly injured by its growth, on which it produces spots and continuous patches. Various species of Mould-Fungi are produced on paper, linen, and parchment, in different circumstances. The Vinegar-plant (p. 636) seems to be the abnormally developed mycelium of P. glaucum, or perhaps P. crustaceum.

Phallus impudicus has a most penetrating disagreeable odour. Such is also the case with Clathrus cancellatus.

Polyporus squamosus is stated by Berkeley to have grown in three weeks to 7 feet 5 inches in periphery, and to have weighed 34 lbs. It is cut from the Ash in autumn in a consolidated state to make razor strops. After being pressed, rubbed with pumice, and sliced longitudinally, the strops are glued on a wooden stretcher. P. betulinus is also used in a similar way. P. fomentarius is the source of the tinder called Amadou, which is used as a styptic and as a moxa.

Sphæria sinensis, the Hia-tsao-tom-chom of the Chinese, is a Fungus parasitic on a caterpillar. It is a celebrated drug in China. Its properties are considered tonic, like the Ginseng. S. Robertsii (Figs. 1023 and 1024, p. 345), S. militaris, S. entomorhiza, and S. sphærocephala, are also found on caterpillars.

Tuber is the genus which embraces the various kinds of Truffle, an underground Fungus, which is scented out by dogs and pigs. Limestone districts are said to

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* In addition to the remedies mentioned at this place, it may be noticed, that Dr. Price recommends for the Vine disease the use of Pentasulphide of Calcium applied in a diluted state. This is decomposed by the carbonic acid of the atmosphere, and thus the sulphur is deposited so as to form a uniform coating on the Vine twig. In the Potato disease Herapath recommends the putting of the dried tubers into a dilute solution of sulphate of copper; while Claussen advocates the putting of them into a weak solution of sulphuric acid and then into lime water; the sulphate of lime thus produced being considered by him a preservative.

† Achorion Schoenleinii is one of these parasitic fungus-like forms described by Dr. Bennet.

‡ Leidy, A Flora and Fauna within Living Animals. See also Robin, Des Végétaux qui croissent sur l'Homme et sur les Animaux.

be most favourable for its growth. T. æstivum is consumed in France, and to this species belong by far the greater quantity of Truffles, under whatsoever name, which are sold in the English markets. T. melanosporum is a richly scented Truffle, common in the Paris market. T. cibarium (Fig. 1022, p. 345), brumale, griseum, moschatum, and rufum, are also used. Truffles are imported from France and Italy preserved in oil. The black esculent Truffles are gregarious; they are found every year in the same spots, which are hence called Truffle-grounds. Their layers are mostly circular. In Britain they are generally only a few ounces in weight. In Van Diemen's Land there is a species called Native Bread, which sometimes weighs lbi. or lbii. It has been called Mylitta australis, but is probably a Tuber. Few Truffles have been found in America. The soil for Truffles is composed of decayed Beech and Oak leaves, materials of old ant hills, loamy pasture, chalk, road-sand, and a small proportion of iron. They may be propagated by taking the plants in their mature state and when undergoing decomposition, breaking them down, and placing them in proper soil.

1556. Nat. Ord. 275.—CHARACEÆ, the Chara order (Fig. 1798). —Aquatic plants composed of parallel cellular tubes, which give off whorled branches (Figs. 1054 and 1055, p. 354), and which are often encrusted with carbonate of lime. In their tubes, rotation is observed (p. 414). Their reproductive organs consist of globules containing antheridian cells with spirilla, and spiral nucules (Fig. 1798) containing germinating cells or spores.—(Full details are given at page 354). Charas are found submersed in stagnant fresh or salt water in various parts of the world. They have a fetid odour. In the case of reservoirs of water for the supply of towns, it has been found that the presence of Chara flexilis has been the means of communicating a peculiar fugitive and intermittent odour. Species 35. *Ill. Gen.* —Chara, Nitella.

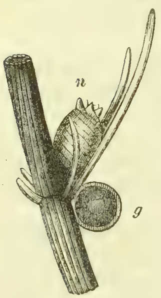

Fig. 1798.

1557. Nat. Ord. 276.—ALGÆ, the Sea-weed order (Figs. 1799 to 1805).—Cellular plants found in the sea, in rivers, lakes, marshes, and hot-springs, all over the world, consisting of a brown, red, or green thallus, sometimes stalked, which bears the organs of fructification (Fig. 1799). These consist of antheridian cells containing phytozoa (Figs. 1033 and 1034, p. 349), and of others containing germinating spores of different kinds (Fig. 1801). These organs of reproduction are often united in the same conceptacle (Fig. 1800). In other cases, they are on different parts of the same plant, or even on different plants. Thuret has proved, that in diœcious Fuci the antheridia are necessary for the impregnation of the archegonia. The spores sometimes have moving cilia, and are called zoospores (Fig. 1804), at other times four are united so as to constitute tetraspores (Fig. 1802). In some of the filamentous Algæ there is a conjugation of 2 cells, so as to produce a spore (Fig. 1803), in others there is a fissiparous

Fig. 1798. Cellular tubes of Chara, with verticillate branches, from the axil of which proceeds the nucule, *n*, containing a germinating spore, while below the branches is placed the globule, *g*, containing antheridian cells and spermatozoids.

Additional illustrations of Characeæ:—Reproductive organs, Figs. 1051 to 1053, p. 353; and Figs. 1056 to 1060, p. 355.

division of cells. (Fig. 1805).—(Full details are given at page 348).

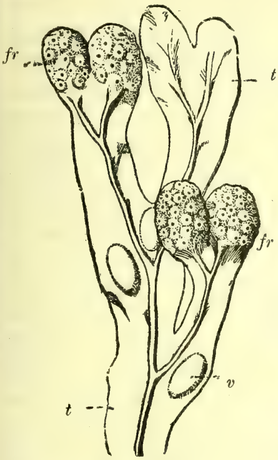

Fig. 1799.

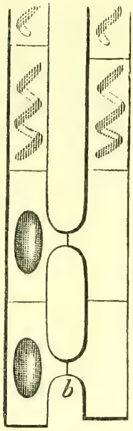

Fig. 1803.

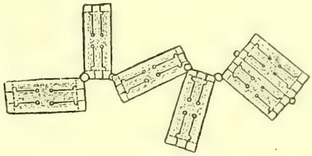

Fig. 1805.

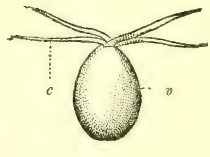

Fig. 1804.

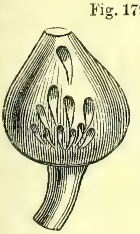

Fig. 1801.

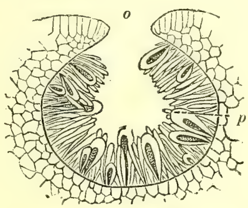

Fig. 1800.

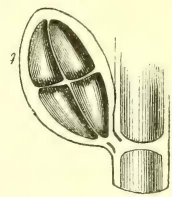

Fig. 1802.

1558. Species of Algæ abound both in salt and fresh water, whether running or stagnant, and in mineral springs. Harvey states that the strongly impregnated sulphureous streams of Italy,* the eternal snows of the Alps and Arctic regions, and the boiling springs of Iceland, have each their peculiar species. Even chemical solutions, if long kept, produce Algæ. Very few comparatively inhabit stations which are not submerged or exposed to the constant dripping of water; and in all situations where they are found, great dampness at least is

Figures 1799 to 1805 illustrate the natural order Algæ, with its four divisions.

Fig. 1799. Thallus, *t t*, of Fucus vesiculosus, the common Bladder Sea-weed, with air cavities, *v* and masses of conceptacles constituting the fructification, *fr fr*, which is sometimes called gleba. Fig. 1800. Transverse section of one of the conceptacles containing spores in their coverings, *p*, along with paraphyses. The spores escape by an opening, *o*. Fig. 1801. Ceramidium or fructification of Bonnemaisonia asparagoides, containing pear-shaped germinating spores, which are discharged by an opening at the apex of the sac. Fig. 1802. Tetraspore, *t*, of Callithamnion cruciatum. Fig. 1803. Conjugating filaments of Zygnema, with their uniting tubes, *b*, endochrome in a spiral form, and oval spores. Fig. 1804. Zoospore of Chætophora, with vibratile filaments called cilia. Fig. 1805. Diatoma with its frustules separating by fissiparous division.

Additional illustrations of Algæ:—Unicellular Algæ, Fig. 1039, p. 350; Fig. 1040, p. 351. Antheridia and filaments, Figs. 1048 and 1049, p. 353. Germinating spores, Figs. 1264 and 1265, p. 634.

* Harvey, Brit. Algæ, Introd. ix.

necessary to their production. There are three colours in Algæ, grass-green, olivaceous, and red. Grass-green is characteristic chiefly of fresh water Algæ, and of those in shallow parts of the sea; olivaceous-brown or olive-green is almost entirely confined to marine species; red is almost exclusively marine, its maximum being in deep water. The green species have the simplest structure, and have ciliated spores; the olivaceous are most perfect and compound in the organs of vegetation, and attain the largest size; while the red are the most beautiful, and have two kinds of spores. When decaying they undergo various changes of colour. Some Sea-weeds are microscopic, others growing in the depths of the Pacific have trunks exceeding in length those of the tallest forest trees, and fronds rivalling the leaves of the Palm. Some have fronds formed of delicate perforated net-work, resembling fine lace or the skeletons of leaves. D'Urvillæa utilis and Lessonia fuscescens are thick-stemmed species, in which the cellular tissue is arranged in the form of concentric circles. Many of the lower Algæ approach nearly to some of the lowest animal forms, and it is difficult to form a line of demarcation. Species of Navicula, Pleurosigma, and other allied forms, are placed by some among Diatoms, by others among animals. Williamson, Cohn, Busk, and others, have examined the structure and development of Volvox globator, V. aureus, V. stellatus, and Sphærosira Volvox of Ehrenberg, and they look upon them as truly vegetable. They are plants in the homologies of their structure, in their chemical composition, and apparently in their cellular tissue. On testing them with iodine and sulphuric acid, cellulose and starch are detected. The analogies of their development with that of Protococcus nivalis and P. viridis (Figs. 1062 and 1063, p. 360) are very strong, as also with the supposed animalcules called Euglena viridis. It seems probable that the whole of the Monadinæ, the Cryptomonadinæ, and the Volvocinæ of Ehrenberg, belong to the vegetable rather than to the animal kingdom. Peculiar forms are met with in diseased states of the stomach and bladder, which are referred to Diatoms; one of them is called Sarcinula ventriculi. Achlya prolifera is sometimes produced on the gills of gold fishes, and other animals in a state of disease.

1559. The order has been divided in the following manner:—Sub-order 1. Melanospermeæ or Fucaceæ, brown-coloured Sea-weeds (Fig. 1799); Marine plants of an olive-green or olive-brown colour, consisting of multicellular fronds, which assume a thalloid or a filamentous form; fructification consisting of conceptacles (Fig. 1800, and Fig. 1047, p. 352), containing archegonial and antheridian cells, the latter containing phytozoa (Fig. 1050, p. 353), the former being developed as germinating spores (Fig. 1267, p. 636). *Ill. Gen.*—Fucus, Himanthalia, D'Urvillæa, Halidrys, Cystoseira, Sargassum, Desmarestia, Alaria, Laminaria, Lessonia, Padina, Dictyosiphon, Cladostephus, Chordaria. Sub-order 2. Rhodospermeæ or Ceramiaceæ, rose-coloured Sea-weeds; Marine plants of a rose-red, purple, or red-brown colour, leafy, cylindrical or filamentous; fructification consisting of conceptacles containing spores (Fig. 1801, and Fig. 1044, p. 352), and clavate filaments considered as antheridia. The spores are arranged often in fours, and are called tetraspores (Fig. 1802). *Ill. Gen.*—Callithamnion, Griffithsia, Ceramium, Ptilota, Iridæa, Phyllophora, Chondrus, Laurencia, Dasya, Polysiphonia, Rhodomela, Corallina, Rhodymenia, Plocamium, Delesseria. Sub-order 3. Chlorospermeæ, or Confervaceæ, green-coloured Sea-weeds (Fig. 1037, p. 350); unicellular (Fig. 1062, p. 360), or multicellular (Fig. 1042, p. 351), marine or fresh-water plants; the cells contain a green (rarely purple or red) endochrome; reproduction effected by conjugation of cells (Fig. 1803, and Fig. 1043, p. 352); zoospores (Fig. 1804, and Fig. 1038, p. 350), often produced. *Ill. Gen.*—Ulva, Caulerpa, Porphyra, Chætophora, Achlya, Conferva, Zygnema, Vaucheria, Oscillatoria, Rivularia, Nostoc, Palmella, Protococcus. Sub-order 4. Diatomaceæ, Brittleworts (Fig. 1805); plant a frustule, consisting of a unilocular or a septate cell; cells composed of 2 symmetrical valves; gemmiparous increase by self-division (Fig. 1805); reproduction by conjugation and the formation of sporangia. There are 2 distinct sections: *a.* Diatomeæ; invested with a siliceous epidermal covering, and found both in salt and fresh water.* *Ill. Gen.*—Eunotia, Cymbella, Cocconeis, Coscinodiscus, Actinocyclus, Arachnoidiscus, Campylodiscus, Nitzschia, Navicula, Pleurosigma, Cocconema, Gomphonema, Licmophora, Meridion, Fragilaria, Achnanthes, Diatoma, Isthmia, Melosira, Mastogloia, Dickieia, Schizonema, Homœocladia. *b.* Desmidieæ; minute fresh-water plants of a green colour, without a siliceous epidermis.† *Ill. Gen.*—Desmidium, Micrasterias, Euastrum, Cosmarium, Xanthidium, Staurastrum, Tetmemorus, Closterium, Pediastrum. Agardh divides Algæ into Fucoideæ, corresponding to Melanospermeæ of Harvey, Florideæ equivalent to Rhodospermeæ, and Zoospermeæ corresponding to Chlorospermeæ. The primary divisions into orders he bases on the structure and development of the sporiferous nucleus.‡

1560. Many of the Algæ supply nutritious matter, and are used as food. Among them may be noticed species of Rhodymenia (Dulse), Sphærococcus, Alaria, Iridæa, Laminaria, Porphyra, Ulva (Laver), and Gelidium. The edible nests formed by swallows in China have been supposed to be made of portions of gelatinous Sea-weeds.

Anabaina Flos aquæ (Dolichospermum Thompsoni) gives a green colour to some lakes in Ireland, also to the Serpentine and to Lochmaben Loch.

Chondrus (Sphærococcus) crispus, and C. mammillosus, receive the name of Carrageen or Irish Moss. Their fronds consist in great part of a substance somewhat allied to starch, which is extracted by boiling in water. On cooling it forms a jelly.

Diatomaceæ. The indestructible nature of their siliceous covering has served to perpetuate Diatoms in numerous localities. Myriads of the exuviæ of these plants

* Smith, British Diatomaceæ. † Ralfs, British Desmidieæ.

‡ Agardh, Species, Genera et Ordines Algarum.

occur in the form of extensive deposits in various parts of the world. It is said that the city of Richmond, in Virginia, is built on a stratum of Diatomaceous remains 18 feet in thickness. Extensive tracts in arctic and antarctic regions are covered with similar relics of a former vegetation. Diatomaceous deposits have been found in Britain at Peterhead, Premnay, Dolgelly, Lough Mourne, Lough Island-Reavey, Marl, Raasay, Cantyre, and the island of Mull; in the last-mentioned deposit Dr. Gregory has detected 150 species. Diatoms are also met with in Guano. The whitish powdery substance known by the name of Mountain Meal or Berg-mehl in Sweden, is composed of fossil Diatomaceæ. Dr. Hooker found Diatomaceæ discolouring the seas of the South Pole, and he also detected them in the lava of the volcanic mountain Victoria. They are sometimes carried in the form of small dust into the atmosphere. Campylodiscus Clypeus was found at Grahams-land in mud from 270 fathoms. Beds of peat often contain myriads of Diatoms. The mud at the mouths of many rivers is made up in a great measure of these organisms. The same species are found in very widely separated localities. The beautiful marking on some Diatoms render them excellent test objects for microscopes. On species of Nitzschia, Navicula and Pleurosigma, there are both longitudinal and transverse markings—the latter being the finer. The distance between them is often 1-30,000th or 1-40,000th of an inch, and some are even said to be 1-100,000th and 1-130,000th of an inch separate; and it is said that the latter markings have only been seen with a 1-12th objective, and by means of oblique light.

D'Urvillæa utilis is used for food on the coast of Chili.

Fucus nodosus and F. vesiculosus (Fig. 1799), when fermenting at a temperature of 90°-96° F., yield acetic acid. The air bladders of the latter plant vary in form and appearance according as it grows in the sea or in brackish water.

Gigartina speciosa is used for jelly by the colonists of Swan River.

Gracilaria lichenoides is the Ceylon-moss of the East, and is used in soups and jellies. G. spinosa is the Agar-Agar or Agal-Agal of the Chinese, which is also an article of diet. G. Helminthocorton is the Corsican-moss, used as a vermifuge. It is often mixed with other Sea-weeds, such as Laurencia obtusa. G. tenax is used in China for glue and varnish.

Laminaria saccharina yields upwards of 12 per cent. of Mannite. This substance is also procured from L. digitata, Alaria esculenta, and other Sea-weeds, which furnish five to six per cent. L. potatorum is used as food in Australia.

Nostoc edule is employed in China as an article of diet. An edible Nostoc, perhaps a variety of N. commune, is used in arctic regions as food. A similar Nostoc is found on the mountains of central Asia.

Porphyra vulgaris and P. laciniata are collected on the rocky shores of Europe, and by boiling are reduced to a dark-brown semifluid mass, which is eaten with lemon-juice or vinegar, under the name of marine sauce or Slouk or Slowcan.

Protococcus nivalis (Fig. 1062, p. 360) helps to give a red colour to snow, and P. viridis (Fig. 1063, p. 360) a green colour. P. atlanticus imparts a red colour to the waters of the Atlantic in some places.

Rhodymenia palmata is the Dulse of the Scotch, the Dillesk of the Irish, which is used occasionally as food by poor people.

Sargassum bacciferum constitutes the Gulf-weed, which has been noticed by all who have crossed the Atlantic. The Gulf-weed has never been found attached, but always floating. In that state it is healthy, putting out new fronds, but never showing fructification. Harvey conjectures, that it may be a pelagic variety of Sargassum vulgare, in the same way as the variety subecostatus of Fucus vesiculosus has never been found attached, but growing in salt marshes; so also Fucus Mackaii, which has never been found attached, and which may be a form of Fucus nodosus, growing on muddy shores.

Trichodesmium erythræum is said to help in giving a red colour to the waters of the Red Sea.

1561. Analysis of the Acotyledonous natural orders, with references to the number of the orders in the preceding pages.

I. ACROGENS.

1. Axis of growth elongated, bearing leaves or green branches.

Spores provided with elaters, or with clavate filaments.
  Sporangia opening by four valves .... Hepaticæ, 272.
  Sporangia collected in cone-like heads, and opening by a longitudinal fissure.. Equisetaceæ, 270.
Spores without elaters or clavate filaments.
  Sporangia enclosed in a 2 or 4-valved involucre or sporocarp.
    Sporocarps at the base of the leaves or leafstalks .... Marsileaceæ, 268.
  Sporangia not enclosed in sporocarps.
    Sporangia on the back or margin of the fronds............ Filices, 267.
    Sporangia distinct from the fronds or leaves.
      Sessile in the axil of leaves .... Lycopodiaceæ, 269.
      Stalked .... Musci, 271.

2. Axis of growth not distinct, no true leaves.

Spores with or without elaters .... Hepaticæ, 272.

II. THALLOGENS.

Plants with a mycelium or spawn .... Fungi, 274.
Plants without a mycelium.
  Terrestrial... Lichenes, 273.
  Aquatic.
    Germinating bodies in spiral nucules .... Characeæ, 275.
    Germinating bodies in non-spiral cells .... Algæ, 276.

The Monochlamydeous orders Rafflesiaceæ, Cytinaceæ, and Balanophoraceæ, included by Lindley in his class of Rhizogens or Rhizanths, have an acotyledonous embryo. Triuridaceæ among Endogens appear to have a similar embryo. Some leafless Exogens, such as Cuscuta, have no cotyledons in the embryo.*

* For full details in regard to the classification, the characters, affinities, and properties of the natural orders, the student should consult Lindley's Vegetable Kingdom, 3d Edition. For the characters of Genera, Endlicher's Genera Plantarum may be consulted ; and for the characters of species, DeCandolle's Prodromus, and Kunth's Enumeratio Plantarum. The natural orders, genera, and species of British plants, are given in Hooker and Arnott's British Flora, and in Babington's Manual of British Botany.

PART IV.

GEOGRAPHICAL BOTANY,

OR THE GEOGRAPHICAL DISTRIBUTION OF PLANTS.

1562. This department of Botany is one of vast extent and importance, and the consideration of it would require much more space than can be allotted to it in the present work. All that we can attempt to do is to give some general facts regarding the distribution of plants over the globe, and to point out some of the causes which regulate this distribution.

1563. The nature of the vegetation covering the earth varies according to climate and locality. Plants are fitted for different kinds of soil, as well as for different amounts of temperature, light, and moisture. From the Poles to the Equator there is a constant variation in the nature of the Flora. Between the Lichens and Mosses of the Arctic and Antarctic regions, and the Palms, Bananas, and Orchids of the Tropics, there is a series of regulated changes in the number and forms of the members of the vegetable kingdom. The same thing is observed in the vegetation of lofty mountains at the Equator, in descending from their summit to their base. There are a few spots in which no vegetation whatever can be detected. Among such barren districts may be mentioned the hot, sandy deserts of Africa, and some of the Antarctic Islands. Dr. Hooker states, that in Franklin Island, lat. 76°.8 S., long. 168°.12 E., he could not perceive the smallest trace of vegetation, not even a Lichen or piece of Sea-weed growing on the rocks. In some inhospitable cold regions the vegetation is very scanty, and consists chiefly of Cryptogamics. On Deception Island Hooker found only Lichens, and no grass; on Cockburn Island, he saw Lecanoras, Lecideas, and five Mosses. This seems to be the limit of land vegetation in the south. In northern regions vegetation approaches nearer the pole than in southern ones. In Walden Island, in lat. $80\frac{1}{2}$° N., ten species of flowering plants have been enumerated; while in the southernmost isles of the South

Shetlands, in lat. 63° S., only a solitary grass has been found. A few species of Ranunculus and Saxifrage, along with a small number of Cruciferæ, Compositæ, and Grasses, constitute the chief Phanerogamous Flora of Melville Island. The only woody species in Spitzbergen and its vicinity are Salix arctica and S. polaris. As we proceed from the Poles to the Equator, vegetation increases in amount and in variety. From a region characterized by the presence of Lichens, Mosses, Saxifrages, and Gentians, we come to that of Cruciferæ and Umbelliferæ; we then reach the grassy pasture, and the Coniferous and Amentiferous trees of temperate regions; and passing through the districts of the Vine, the Orange, and the dwarf Palm, to those of the Date, Coffee, Cotton, Sugar-cane, and Pine-apple, we arrive at the luxuriant vegetation of Equatorial regions. In this progress, as Humboldt remarks, we find organic life and vigour gradually augmenting with the increase of temperature. The number of species increases as we approach the Equator, and decreases as we retire from it. Each zone, however, has its own peculiar features. The Tropics have their variety and grandeur of vegetable forms, while the North has its meadows and green pastures, and the periodical awaking of nature in Spring.

I.—INFLUENCE OF CLIMATE, MORE ESPECIALLY OF TEMPERATURE AND MOISTURE, ON THE DISTRIBUTION OF PLANTS.

1564. In determining the effects of climate on vegetation, our attention is chiefly directed to temperature and moisture,—to the daily, monthly, and annual distribution of heat, and to the amount of rain. We must also take into account light, the nature of the plant, its exposure, and many other causes, the effects of which are by no means easily estimated. They operate, however, usually within narrow limits, heat and moisture being the general agents. While in a given place the quantity of heat received varies according to different circumstances, it is found that the mean is pretty uniform. The quantity of heat is modified by winds and moisture. In China, for instance, the north-east monsoon causes a great depression of temperature. The general preponderance of moist warm winds over dry cold ones is the reason why mild winters are more frequent in Europe than severe ones. Mountain chains, by intercepting winds, often produce a marked effect on climate. The effect of the sea in modifying the temperature is seen in insular climates, which are more equable than those of vast continents. Marine currents have also a decided influence on temperature. Thus the gulf-stream in the Northern Atlantic Ocean carries warm water towards the Arctic regions, and materially affects the temperature of the coasts around which it flows; while the

Peruvian coast current, by bringing cold water from the antarctic regions towards the Equator, also modifies temperature.

1565. The temperature of the globe varies both as regards latitude and altitude, and vegetation at the same time undergoes changes. Latitudinally the globe, as regards temperature, may in a general way be divided into a tropical region, extending from the Equator to 23° 28′; a sub-tropical, as far as 40°; a temperate from 40° to 60°; and a cold region beyond 60°. Dove, in his account of the distribution of heat over the globe, arrives at the following conclusions.* The decrease of temperature in advancing from the Equator towards the Pole is least near the Equator, and becomes progressively greater to about 45° of latitude. The temperature of the Equator is 79°.8, that of the Pole 2°.2, the difference on the mean of the year being, therefore, 77°.6. The difference of temperature between the Equator and the Pole is 48° in July, and 106° in January. The temperature of the Pole rises in July to 30°.6 F., and in January sinks to 26°.6. From the Pole to the latitude of 40°, July is the warmest month. In lat. 30°, August is the warmest; and in lat. 20°, July and August are alike. In lat. 10°, May is the warmest month. At the Equator, the maxima are in April and November, and the minima in July and at the end of December. From 60° to 80°, the decrease of temperature is found by the following formula (in which t_x denotes the mean temp. of the year according to Fahrenheit in the latitude x), $t_x = + 3°.65 + 105°.75 \cos.^2 x$. The warmest parallel is not exactly at the Equator; in the northern hemisphere, the parallel of 10° is slightly warmer than the Equator. Up to 40° south latitude, the temperature of the southern hemisphere is lower than that of the northern.

1566. In a hypsometrical or altitudinal point of view, different zones of temperature are recognised, corresponding more or less with those of latitude. On an average, it may be said, that there is a difference of 1° of Fahrenheit for every 300 or 400 feet of ascent, and a difference of 1° of the thermometer in the boiling point of water for every 550 feet of ascent. The following is a general view of the hypsometrical decrease in temperature.

Height above the Level of Sea.	Cordilleras of the Andes, 10° N. to 10° S.	Mountains of Mexico, 17° to 21° N.L.	Mountains of Europe, 45° to 47° N.L.
	Mean Ann. Temp.	Mean Ann. Temp.	Mean Ann. Temp.
0	81°.5 F.	78°.80 F.	53°.6 F.
3,197 feet	71°.24	67°.64	41°.
6,394 feet	64°.4	64°.4	31°.64
9,591 feet	57°.74	57°.2	23°.36
12,789 feet	44°.6	45.°5	
15,985 feet	37°.7	33°.8	

* Dove, on Distribution of Heat on the Surface of the Globe, printed by the British Association, 1853.

The height of the snow line at the Equator is upwards of 15,000 feet above the level of the sea. At lat. 40°, it is about 9000 feet; at lat. 55°, about 5000 feet; in lat. 80°, about 450. The snow line, or the edge of the belt of perpetual snow, on the southern face of Himalaya, is at 15,500 feet; while on the northern face it reaches 18,500 feet. On Cotopaxi the limit of the snow line is about 15,735 feet; on Chimborazo, 15,320; on Ararat, 13,441; on the Caucasus, 10,602; on the Pyrenees, about 8,680; on the Appenines, about 9,231; on the Alps, about 8,600; on Norway, lat. 62°, 5,120; in Iceland, lat. 63½°, 2,642; at Hammerfest, lat. 70°, 2,585; and at the North Cape, 2,275.

1567. Each species of plants can bear a definite range of temperature. A certain amount of heat is also required during a given period of time, in order that a plant may be enabled to perform all its functions properly. Although a plant may continue to live in a certain climate, it may not thrive. The only true indication of climatal adaptation is, that the plant can perfect its seed and produce its various secretions (page 683). The latitude of a place does not at once tell the range of temperature. Many places in the same parallel of latitude differ widely in this respect. Lines, called Isothermal, have been drawn through places in which the mean annual temperature is the same, and it is found that while at the Equator these correspond nearly with the lines of latitude, as we recede from the Equator the two are widely separated. Yearly isotherms run in curves, rising in their course from the east of America towards the west of Europe, and sinking towards the south in the interior of the continent. The yearly isotherm of 50° passes through latitude 42°.30 in the east of America, 51°.30 in England, 47°.30 in Hungary, and 40° in eastern Asia. The want of conformity between the isothermal and latitudinal lines will be easily understood, when we consider that a place having a moderate summer and winter temperature may have the same annual mean as one having a very cold winter and a very warm summer. The vegetation in such districts would, however, be very different, and thus the annual isotherms are not sufficient for the purposes of botanical geography. Plants which stand the winter of London will not withstand the cold of places in Hungary in the same annual isotherm. In estimating, therefore, the effect of different climates on vegetation, attention must be paid also to the summer and winter heat. Lines passing through places with an equal mean summer heat are called Isotheral, while those indicating an equal mean winter temperature are called Isocheimal or Isocheiminal. The latter in continents bend considerably towards the south, while the former bend towards the north, but approach nearer the parallels of latitude in the interior of continents. Some plants require a long period of winter repose and a few weeks only of warm and continued summer; others demand a dry season succeeded by a moist one. Some require a hot summer after an extremely cold winter of moderate duration; others succeed in a climate where the temperature of both seasons is moderate.

1568. In determining the limits of distribution in the vegetable kingdom, we must know the mean monthly and the mean daily temperature during those periods when vegetation is active. We must ascertain the number of days which a plant requires to produce successively its leaves, flowers, and fruit, and we must estimate the mean temperature during that period. The conditions which define the limits of a plant require that we should know at what degree of temperature its vegetation begins and ends, and further, the sum of the mean temperatures during that time. Adanson first stated, that by adding the mean temperature of each day from the commencement of the year, it was found that when the sum reached a certain figure the same phenomena of vegetation were exhibited, such as leafing and flowering. Boussingault afterwards promulgated the statement, that if we multiply the number of days (the length of time the culture of a summer plant endures) by the mean temperature of this time, the product will be the same in all countries and in all years. Thus if a plant, he says, has taken 20 days to ripen its seeds from the period of flowering, and the mean temperature during these 20 days has been 50°, it will be found that the heat received by the plant has been 1000°. The same sum may be given by a greater amount of heat during a smaller number of days. Lucas says that at Arnstadt, which is 897.4 French feet above the level of the sea, and has a mean temperature of 46°.6 F., winter Rye requires an average temperature of 48°.1 F. during 105 days, in all 5048°, to bring it into flower; from the flowering to the ripening 53 days, with a mean temperature of 63°.4, in all 3360°.2; altogether the duration of the vegetation of Rye amounts to 158 days, with a mean temperature of 53°, the sum of this being 8466°.9. Again, winter Wheat requires for flowering 129 days, with a mean temperature of 50°.6, in all 6527°.4; from flowering to ripening 53 days, with a mean temperature of 63°, in all 3339°. The total duration of the vegetation of Wheat is thus 182 days at Arnstadt, with a mean temperature of 54°, which makes a total of 9828°. Wheat requires a higher mean temperature than Rye to bring it into flower; it therefore blossoms on an average 24 days later, and consumes 6527°.4 of heat, while Rye only requires 5048°. From the flowering to the maturation, Wheat and Rye require nearly the same length of time and the same amount of heat.* Boussingault's law has been somewhat modified by Alphonse De Candolle, who has pointed out many sources of error to be avoided. It is difficult to fix the time which is to be taken into account; the temperature of the soil requires to be attended to; low temperatures, and especially all below 32°, which do not excite the phenomena of vegetable life, should be left out of the calculation; and the thermometric measurements should be made by observations

* Botanische Zeitung, 1849. Bot. Gazette, i. 172.

on the plants themselves, and not merely on the air. By attention to these points, he thinks that useful and accurate conclusions may ultimately be arrived at relative to the temperature required for the performance of vegetable functions.

1569. Light and heat are so intimately connected, and so generally accompany each other, that the laws of the one are very nearly those of the other. Both of them are of the utmost importance in vegetation. Light is concerned in the various functions of plants. The physiological action of the leaves cannot go on without it, and the activity of vegetable life is in no small degree dependent on it. Some plants require full exposure to light, others luxuriate in the shade. The difference of the intensity of light in different countries influences the secretions of plants, and has a certain effect on the nature of the vegetation. While the chemical constitution of the atmosphere is nearly the same every where, its density varies much. This depends both on elevation and on the matters which may be suspended in it. It is probable that the varying density of the atmosphere at different elevations produces little or no effects in comparison with those which result from the modifications which the temperature, light, and humidity of the air undergo. Humboldt is disposed to think that diminished atmospheric pressure has an influence on vegetation. Dr. Hooker, however, has not been able to verify this on the Himalaya. A comparison of arctic vegetation with that of elevations of 17,000 feet, where 15 inches of pressure were removed, showed no difference in the habits and characters of such plants as were common to both regions. It does not induce any peculiarity of vegetation, for the alpine floras, both of India and America, are truly arctic ones. Cardamine hirsuta, Capsella Bursa-pastoris, and other Plain-plants of the cold weather in India, Hooker remarks, are identical with the same species of the alpine summer. The variation, therefore, due to elevation would not appear to depend on laws of diminished pressure. The presence of saline or extraneous gaseous matters in the atmosphere, in certain localities, will affect vegetation.

1570. Moisture is an agent which exerts a powerful influence on the distribution of plants. Vegetation developes itself only when moisture is present. Very dry regions are deficient in vegetable productions, while the luxuriance of tropical vegetation is connected with great heat and moisture. Plants differ in regard to the quantity of moisture they require. Some are of a loose, spongy texture, with large, soft leaves, little or no pubescence, and many stomata, and demand a great deal of water. Others, growing in sandy, dry situations, where little rain falls, are firm and succulent, and often have long hairs and few stomata. The hard dry texture of the leaves of Banksias and other Australian plants, seems to be connected with the small amount of moisture in the atmosphere. Forests have a marked effect on the humidity of climates, and the felling of them has often been productive of very injurious consequences, by diminishing the quantity of water (page 462). In warm climates, the dry season may be said to correspond to our winter in its effects on vegetation. In some parts of South America, where no rain falls for many months of the year, the leaves during the dry season fall, buds are developed in their axils, and it is only when the wet season arrives that the trees become clothed with verdure, and the herbage appears. As regards rains, Schouw divides Africa and Europe, from the Equator to 60°, into—1. The zone of summer rains, extending from the Equator to 15° N. lat. 2. The rainless or desert zone, from 15° to 30° N. lat. 3. The zone of winter rains, including the north of Africa and the south of Europe, between 30° and 45° N. lat. 4. The zone of constant rains—that is, rains (including snow) in all seasons. The absence of rain seems occasionally to retard the period of flowering. Thus Ball states, that on the borders of the Tagus, in a dry season, he found the Calluna vulgaris growing on bare granite, and just coming into full flower, about two months later than it did in Scotland, which was 18° farther north.

II.—INFLUENCE OF SOILS ON THE DISTRIBUTION OF PLANTS.

1571. Soils, or the media in which the roots of plants grow, regulate to a certain degree their distribution. In estimating this influence we must take into account the geognostic nature of the soil, its state of aggregation, its temperature, moisture, and exposure. Some plants are terrestrial, others aquatic ; some grow suspended in the air, others are parasitic. The effects produced by ordinary soils depend perhaps more on their mechanical nature than on their chemical composition. Hard, undecomposed felspar will bear a scanty vegetation, but when disintegrated and loose it affords abundant nourishment. The vegetation of limestone and trap rocks is more luxuriant than that of sandy soils. The moisture retained by aluminous soils is much greater than that by siliceous soils. The latter support plants with long branching roots, while the former are adapted for plants whose roots do not penetrate deeply. Thurmann endeavours to show, that there exist appreciable relations between the distribution of species and the subjacent rocks ; and that these relations are owing more to the physical properties of the rocks, than to their composition. He divides rocks, as regards vegetation, into eugeogenous, which are easily disintegrated, and furnish an abundant detritus ; and dysgeogenous, which are not easily disintegrated, and yield only a scanty detritus.

1572. In speaking of the Lycian Flora, Forbes remarks :—" At almost any distance we could distinguish the serpentine from the limestone country, not merely from the peculiar bossy character, and the pink colour of the tints of the former, contrasting strongly with the abrupt and broken escarpments, and grey and yellow rocks of the latter, but also from the disposition of the arborescent vegetation. On the serpentine, usually Pines only grew, and never in thick forest masses, but scattered as it were individually, and as if they had been planted in a quincunx arrangement; while the limestone was wooded, and in many parts it bore great forests; thick clustered oaks covered a luxuriant underwood, interrupted by groves of Strawberry-trees, and by clumps of lofty Pines. High in the mountains the Pines prevailed over the Oaks, and higher still the Cedar-junipers (J. excelsa) replaced them. This difference between limestone and serpentine was seen equally in the yailahs (high-grounds) and among the high mountains. and in the low country near the sea. In the latter we found serpentine marked by Senecio squalidus, a little Erophila, and Cheilanthes odora; on limestone, Acrostichum lanuginosum was the conspicuous Fern." * He also remarked that the Anemones on the tertiary rocks were mostly red, those on the Scaglia or the secondary cretaceous limestone, were oftener blue and purple. Many plants seem to thrive best on chalky soils, others on siliceous, argillaceous, or peaty soils. Certain species grow only on soils impregnated with saline matters; others require to be within the influence of the sea. Parasitic plants are often confined to peculiar species of plants.

1573. Plants, in reference to the physical localities or stations in which they grow, have been divided into terrestrial, aquatic, marshy, epiphytic, and parasitic. Among terrestrial plants, the nature of the soil in which they grow gives rise to various groups. Arenaceous or sand plants have a peculiar character in all parts of the world, and the greater number are probably grasses. On our shores, Carex arenaria (Fig. 157, p. 66), Psamma arenaria, Elymus arenarius, and Triticum junceum, bind the loose sand by their creeping stems. Sedum acre, Plantago arenaria, and many species of Cerastium, Tussilago, and Potentilla, grow in similar localities. Calcareous or chalk plants are found on limestone rocks. Many Orchids belong to this division, especially species of Ophrys (Fig. 136, p. 56), and Cypripedium. Teucrium montanum, Clematis Vitalba, and Onobrychis sativa, are also recorded as calcareous plants. Saline plants are those found in maritime situations, or near salt lakes, and which seem to require much soda in their composition, and which have been called Halophytes. Among them are species of Salsola, Salicornia, Armeria, Statice, Samolus, and Glaux. Rupestral and mural plants are those found on rocks and walls, such as species of Saxifrage, Sedum, Draba, Sisymbrium, Parietaria, Linaria Cymbalaria, Asplenium Ruta-muraria, A. Trichomanes, Lichens, and Mosses. Some also grow on the ruins of

* Forbes's Travels in Lycia, ii. p. 160.

old buildings, and on rubbish-heaps, &c., near the habitations of man and animals. Among these are included Nettles, Docks, Hyoscyamus, Xanthium, and Sempervivum tectorum. Plants which grow in cultivated grounds, as in fields and gardens, may be said to form a special division. Among them may be noticed Centaurea Cyanus (Fig. 392, p. 163), Lychnis Githago, Spergula arvensis, Sinapis arvensis, Lolium temulentum, Stellaria media, Lamium amplexicaule, L. intermedium, Chenopodium album, species of Veronica and Euphorbia.

1574. Plants of uncultivated ground are :—Meadow and Pasture plants, such as Grasses, Trefoils, Clovers, species of Ranunculus, Veronica, Campanula, Galium, and Myosotis, Bellis perennis, Lotus corniculatus, Pimpinella Saxifraga, Gentiana campestris: Heath plants, such as Calluna vulgaris, the species of Erica, Juniperus communis, species of Ledum, Andromeda, and Polytrichum: Forest-plants, growing in woods, such as the different kinds of trees forming Pineta, Fageta, Querceta, Palmeta, Oliveta, according as these are composed of species of Pinus, Fagus, Quercus, Palms or Olives; and the plants which grow under their shade, as Oxalis Acetosella, Trientalis europæa, Linnæa borealis, Geum rivale, Hepatica triloba, Vaccinium Myrtillus, and species of Orchis: Bush-plants, or those growing in bushy places, as Origanum vulgare, Corydalis bulbosa, Vincetoxicum officinale: Mountain-plants, which vary much according to elevation, and which include species of Saxifraga, Gentiana, Primula, Rhododendron, Salix, Cyperaceæ, Juncaceæ, Labiatæ, &c. : Hedge plants, such as Hawthorn and Sweet-briar, and the plants which twine among their branches, as Lonicera, Humulus, Bryonia, Tamus, Clematis, Lathyrus, as well the species of Viola, Adoxa, and Oxalis, which grow at their roots.

1575. Aquatic plants may either grow in salt or in fresh water. Among the former are marine species, such as the common species of Fucus, and other Sea-weeds which grow buried in the ocean, and the Sargassum, or Gulf-weed, which floats on its surface; with them may be included such Phanerogamous plants as Zostera. Among the latter are some which root in the mud, and flower above the water, as species of Nymphæa (Fig. 1363, p. 754), Nuphar, Potamogeton, Ranunculus, Utricularia, Sagittaria; others flower under water, as Subularia aquatica; while others float in the water, as species of Lemna (Fig. 117, p. 51), Pistia, Stratiotes, and various green fresh-water Algæ. Some aquatics are fluviatile, as Ranunculus fluviatilis and Œnanthe fluviatilis; others grow in fresh clear water springs, or near them, as Montia fontana.

1576. Marshy plants are those which grow in different kinds of wet soil. Some of them, as Comarum, Menyanthes, species of Bidens, Œnanthe, Cicuta, and Carex, grow in very wet places, which are not always easily accessible; others, as Primula farinosa, and Pinguicula alpina, grow in firmer, peaty soil. To this class may be referred certain amphibious plants, which generally grow submerged, but which can live in dry soil. Among them are included various forms of Ranunculus, Polygonum amphibium, Nasturtium amphibium, Limosella aquatica, as well as species of Rhizophora and Avicennia, which are found in warm countries at the muddy mouths of rivers.

1577. Epiphytic plants are those which send their roots into the air, and grow attached to other plants. Among them are enumerated numerous species of tropical orchids (Fig. 143, p. 60), and other air-plants, such as species of Tillandsia and Pothos. Parasitic plants are those which derive nourishment from other plants. Among them are included those growing on living vegetables, such as species of Loranthus, Viscum (Fig. 125, p. 53), Lathræa, Orobanche (Fig. 126, p. 54), Cuscuta (Fig. 128, p. 54), Rafflesia (Fig. 127, p. 54), and many Fungi; those growing on dead vegetable or animal tissues, as the various Mould-plants (Fig. 1021, p. 345), also species of Onygena and Splachnum. Among peculiar epiphytes and parasites may be mentioned Racodium cellare, a fungus found on wine casks; Byssocladium fenestrale, a filamentous cellular plant (mycelium ?) growing on window panes; Conferva dendrita, developed on paper; species of Sphæria, growing on living animals (Figs. 1023 and 1024, p. 345), and Sarcinula ventriculi, found in animal fluids.

III.—EFFECTS OF CLIMATE ON THE PERIODS OF LEAFING, FLOWERING, AND FRUITING.

1578. Epirrheology or the influence of various physical agents on plants, is well illustrated by the variations in the epochs of foliation, defoliation, flowering, and fruiting, which have already been partially alluded to at pages 500 and 527. Berghaus has paid particular attention to this subject, and has given tabular views of these epochs in different countries. We have already seen that germination, or the first budding of plants, is materially influenced by temperature (p. 629, 630). The unfolding of the leaves takes place at different periods of the year in different countries (p. 500). Thus the Elm (Ulmus campestris) unfolds its leaves at Naples at the beginning of February, at Paris in the month of March, in England 15th April, and at Upsal about the middle of March. Schubler found in general that in the middle latitudes of Europe and North America, the flowering of plants is delayed four days for each degree of latitude towards the north. Berghaus* remarks that in higher latitudes, in districts situated in the north of Germany, the development of vegetation is less retarded than in more southern positions. The delay in the period of flowering, between Hamburgh and Christiania, amounts to only 3.4

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* Berghaus on the Epochs of Vegetation. Edinburgh New Philosophical Journal, xxx. 182.

days for one degree of approach towards the north, while that between southern Germany and Smyrna, in Asia Minor, which is in the same parallel as the most southern portions of Europe, amounts for the same space to 7.4 days. The cause of this difference arises from the different lengths of the days, which in higher latitudes, during the warm period of the year, increase in a much greater degree than they do in southern parallels, by which the vegetation is hastened into development more speedily; and it is only in this way that it is possible, in higher latitudes, for various summer plants to reach their requisite maturity. The activity of vegetation is not increased in equal proportions in different plants by the same elevation of temperature. Plants of northern climates are less retarded in their development at the same low temperature than are plants of more southern regions.

1579. When we compare the epochs of flowering in Europe and America, we find that—

NAMES OF PLANTS.	NEW WORLD.	OLD WORLD.	
	Lat. 40 deg. 20 min. Perth-Amboy, Jersey.	Naples, 40 deg. 51 min.	Tubingen, 48 deg. 32 min.
The Peach-tree blossoms	21st April . .	8th February	6th April.
The Pear-tree ,,	27th ,, . .	8th March . .	4th May.
The Apple-tree ,,	2d May	8th ,, . . .	8th ,,

Between Perth-Amboy, on the east coast of North America, and Naples, there is therefore a difference in the flowering period of the Peach-tree of 10 weeks, although the two places are nearly under the same parallel; and there is a difference of 6 weeks in the case of the Pear-tree and 8 in the Apple. Perth-Amboy, however, lies in the isothermal parallel of 54½°, while Naples is nearly in that of 63½°. At the former place the winter has a temperature of only 32°54 F., and at the latter of 50° F. The mean temperature of April at New York, Lat. 40°40′, is 49°.1 F., and at Tubingen 48°.2 F. The Peach, therefore, requires for the development of its blossoms at least 48°.2 F., and Naples has that temperature in the month of February.

1580. As regards the ripening of the Peach, the same variations occur. Wheat harvest begins at Naples in June, in central Germany in July, in the south of England and the middle districts of Sweden about the 4th of August. Barley harvest commences at Naples in June, in central Germany about the end of July or beginning of August, in the south of England about the 14th of August, and in the middle districts of Sweden about the 4th of August. Ripe Cherries may be had at Naples during the first days of May, at Paris and in central Germany about the end of June, and in the south of England about the 22d of July. Owing to the comparatively higher summer heat in Sweden, and to the more rapid vegetation than in England, the Wheat harvest does not take place sooner in the south of England than at Upsala; and Barley is 10 days later of ripening in England than in Sweden. From observations made during two years in Saxony, we find, as a mean result, that from the flowering to the ripening of the fruit, 56 days are required for Wheat, 59 for Rye, 31 for Barley, 45 for Oats. From observations at Wurtemberg, the same period of vegetation required 56.4 days for Rye, $42\frac{1}{2}$ for Triticum Spelta, $51\frac{1}{2}$ for winter Barley, 25 for summer Barley, and $25\frac{1}{2}$ for Oats. The following are given as the periods of vegetation of winter Wheat:—

LOCALITIES.	Mean period of Sowing.	Mean time of Harvest.	Difference in Days.
Malta	December 1.	May 13.	163
Sicily (Palermo)	December 1.	May 20.	170
Naples	November 16.	June 2.	195
Rome	November 1.	July 2.	242
Berlin	. . . .	. . . .	299
Alps at 3000 feet	September 12.	August 7.	329

For Winter Rye the following periods are given:—

LOCALITIES.	Mean period of Sowing.	Mean time of Harvest.	Difference in Days.
Alps at 3000 feet	September 20.	July 30.	313
Alps at 4000 feet	September 8.	August 14.	340

The progression from southern Italy to the north of Germany produces the same effect as a considerable increase in elevation. In both cases there is a great prolongation of the period of vegetation in Cereals. At 5000 to 5200 feet, the extreme limit of Rye, it often remains a whole year in the ground.

1581. Thurmann states that in the Jura, generally speaking, a delay of 17 days in the harvest corresponds to a difference of altitude of 1000 feet. On the Alps, according to Schlagintweit, there is a delay of 11 days in the development of vegetation for every 1000 feet. Quetelet finds that in the climate of Europe every 600 or 700 feet produces a delay of about 4 days, which is equal to about 1° of latitude. Schlagintweit,* who has examined particularly the vegetation of the Alps, gives the following tabular view of the effect of elevation on the epochs of vegetation:—

* Pflanzengeographie Untersuchungen, von Adolphe Schlagintweit.

MEAN COMMENCEMENT OF PERIODS OF VEGETATION, AT DIFFERENT ALTITUDES IN THE ALPS.

Indication of Periods.	From 1500 to 2000 feet.	From 2000 to 3000 feet.	From 3000 to 4000 feet.	From 4000 to 5000 feet.	From 5000 to 6000 feet.	From 6000 to 7000 feet.	From 7000 to 8000 feet.
Melting of the snow, and re-appearance of vegetation	17 March	30 March	10 April	21 April	12 May	2 June	28 July
Culture of summer Cereals	25 „	8 April	15 „	24 „	13 „		
Last Falls of Snow:—							
Mean	20 April	30 „	15 May	28 May	15 June		
Extreme	15—25 May	15 June	30 June	15 July			
Foliation:—							
Fagus sylvatica	2 May	11 May					
Fraxinus excelsior	3 „	11 „	22 May	31 May	17 May Growth of meadows.	7 „ Growth of meadows.	1 „ Growth of meadows.
Juglans regia	10 „	19 „	26 „ In very favourable situations.				
Flowering:—							
Viola odorata	4 April	12 April	21 April	4 „	12—15 May First spring flowers. Anemones, Gentianellas, Primroses, &c.	2—5 June First spring flowers.	28—30 June First spring flowers.
Prunus Cerasus	5 May	10 May	16 May	28 „	22 June Rhododendron.	11 July Rhododendron.	29 July Rhododendron.
Fragaria vesca	4 „	10 „	16 „				
Syringa vulgaris	9 „	21 „	2 June				
Secale cereale hibernum	4 June	14 June	21 „	28 June	8 July (5200)		
Sambucus nigra	8 „	19 „	29 „				
Hordeum distichum, and hexastichum	11 „	20 „	30 „	11 July	21 July (5200)		
Hay harvest	15—20 June	24 „	25 „	27 June	1 July	3 August	
Ripening of Fruits:—							
Prunus Cerasus	25 June	18 July	3 August	20 August			
Secale cereale hibernum	18 July	31 „	8 „	18 „	3 September (5200)		
Hordeum distichum, and hexastichum	25 „	7 August	17 „	29 „	11 September (2500)		
Triticum vulgare æstivum	9 August	21 „	31 „	13 September			
Avena sativa	14 „	27 „	5 September	16 „	29 September (5200)		
Sambucus nigra	9 September	21 September	3 October				
Snow covering the ground almost continuously, commencement of winter	10 December	30 November	20 November	10 November	28 October	15 October	1 October
	These periods are not yet well determined.						

1582. As regards the fall of the leaf, or defoliation, Berghaus remarks, that the Hazel-nut tree, the Ash, Lime, Poplar, and Maple, lose their leaves at Upsala at the very beginning of autumn; while in the neighbourhood of Naples they remain in full foliage during the whole month of November. The Apple-tree, the Fig-tree, the Elm, Birch, and different kinds of Oak, which in Paris are deprived of their leaves at the beginning of November, retain them at Naples till the end of December. In England, the Walnut is one of the first trees that loses its leaves; and after it the Mulberry, the Ash (especially when it has had much blossom), and then the Horse-chestnut.*

IV. — DISTRIBUTION OF CLASSES, ORDERS, GENERA, AND SPECIES OF PLANTS OVER THE GLOBE.

1583. Some plants are generally distributed over the globe, occurring in both hemispheres, and having an extensive latitudinal range; others are restricted and endemic in their distribution. There are numerous interesting facts in regard to geographical distribution in Hooker's Antarctic Flora, a work from which many of the following examples are taken. Trisetum subspicatum is a Grass having a very wide range. It extends from Tierra del Fuego over the whole of the Peruvian Cordilleras, and over the Rocky Mountains to Melville Island, Greenland, and Iceland; it is found in the Swiss and Tyrolese Alps, on the Altai, in Kamtschatka, and in Campbell's Island. The range is from 54° S. lat. to 74½° N. lat., through 128½° of latitude. Drimys Winteri (Fig. 1358, p. 750) extends over no less than 86° of latitude, or 5160 geographical miles, forming at the southern limit of its growth one of the trees which advance nearest to the antarctic circle, and reaching as high a latitude as any flowering plant, save the solitary Grass of the South Shetland Islands. "No vegetable production of its size affords a parallel case to this, either in America or in any other country. Such an extraordinarily extended range is in part obviously due to some peculiarities in the form and surface of South America, where under every degree of latitude there are large areas either at the level of the ocean, or at an elevation where such a tree can enjoy a climate that is equable." Gentiana prostrata has a great range, both in longitude and latitude. In southern Europe it inhabits the Carinthian Alps between 6000 and 9000 feet high; in Asia, it occurs on the Altai mountains about N. lat. 52°; in America, on the tops of the Rocky Mountains, in lat. 52° N.,

* See tabular view of foliation and defoliation, p. 501.

at an elevation of 15,000 to 16,000 feet; and on the east side of the Andes of South America, in 35° S. It descends to the level of the sea at Cape Negro, in the Straits of Magalhaens, in lat. 53° S.; and at Cape Good Hope, in Behrings Straits, lat. 68½° N. Potentilla anserina is widely distributed both in the northern and southern hemispheres. It grows throughout Europe, from the shores of the Mediterranean to the Arctic Sea; over all Asia to the north of the Altai range; in North America, from lat. 40° to Whale-fish Island in 70° N. lat.; and from the Oregon River to Kotzebue's Sound on the west coast. It is frequent in Tasmania, but is not indigenous there. Pinus sylvestris extends from the north of Persia, lat. 36°, to the north of Lapland, lat. 70°; and from Eastern Siberia, 65° 15′, to the mouth of the Ob in the Frozen Sea. It thus ranges over a space of 34 degrees of latitude, and 74 degrees of longitude. Epilobium tetragonum, a British plant, extends from Canada to Fuegia. Callitriche verna is universally diffused through the temperate regions of both hemispheres. Oxalis corniculata, Calystegia Soldanella and Senebiera didyma, natives of Britain, are found in the Galapagos Islands. Carex festiva ranges in the northern hemisphere, from Greenland on the east, to Unalaschka on the west, crossing by Cumberland House on Bear Lake, and thence runs south along the Rocky Mountains. In Europe, it has only been found in Lapland. Hymenophyllum Wilsoni is found in all the four quarters of the globe, also in Australia, New Zealand, Tierra del Fuego, and the Falkland Islands. Cistopteris fragilis is very extensively diffused. It avoids such hot and equable climates as the low lands of the tropics. In America, it ranges along the Cordilleras, from the Arctic Sea and Greenland to the Straits of Magalhaens; in Europe, from Iceland and Lapland to the Mediterranean; in Asia, between Kamtschatka and the Himalaya; but in Africa, it is confined to the Canary Islands and the Cape of Good Hope.

1584. The British and European grass, called Phleum alpinum, is found at the Straits of Magalhaens, on the east side of the Andes at an elevation of 6000 to 7000 feet, on the Cordilleras of Mexico, and on the Peak of Orizaba, 10,000 to 12,000 feet above the level of the sea. Many species in the Falkland Islands are identical with those found in Iceland. The following British plants, along with many others, are found at Chamisso Sound (Behrings Straits), Vaccinium uliginosum, V. Vitis-Idæa, V. Oxycoccus, Rubus Chamæmorus, Arctostaphylus alpina, Cornus suecica and Empetrum nigrum. Funaria hygrometrica, a well-known British Moss, is found all over the world. On turning the surface of the ground, in all quarters of the globe, this Moss springs up. Galium Aparine is a British plant, found at the Cape of Good Hope, at the Straits of Magalhaens, in the island of Chiloe; and in North America it ranges between the latitude of Fort Vancouver and the Mississippi River. Plantago maritima occurs in Britain, at the Cape, and at the southern point of America. Montia fontana is found in Iceland, Britain, and Kerguelen's Land, S. lat. 52°. Chara flexilis also occurs in the last two places. Cryptogamic cellular plants have generally a very wide range; many of them are universally distributed.

1585. Hooker has recognised more than 30 antarctic forms as identical with European ones. Among them may be enumerated—

Lycopodium Selago.
———— clavatum.
Poa nemoralis.
— pratensis.
— annua.
Aira flexuosa.
Festuca duriuscula.
——— bromoides.
Agrostis alba.
Lolium perenne.
Alopecurus alpinus.
Phleum alpinum.
Carex curta.
Eleocharis palustris.
Armeria maritima.
Plantago maritima.
Chenopodium glaucum.
Limosella aquatica.
Convolvulus sepium.
Galium Aparine.
Leontodon Taraxacum *var.* lævigatum.
Erigeron alpinus.
Senecio vulgaris.
Hippuris vulgaris.
Epilobium tetragonum.
Lathyrus maritimus.
Montia fontana.
Stellaria media.
Sagina procumbens.
Cerastium arvense.
Sisymbrium Sophia.
Capsella Bursa-pastoris.
Cardamine hirsuta.
Apium graveolens.
The last two are found in Fuegia, in the Falkland Islands, and in Tristan d' Acunha.

1586. Some plants which have a great latitudinal range are restricted to a narrow space as regards longitude. This is the case with the species of Erica, which extend from the Cape of Good Hope to northern regions. Certain species of Rhododendron, Magnolia, Azalea, Actæa, and Andromeda, occur on the east of the Rocky Mountains, and are not found on the western side. In the western part of Ireland we meet with Daboecia polifolia, Erica mediterranea, and Arbutus Unedo, which are not met with in other parts of Britain, and which again appear on the mountains of Asturias. On the western side of the Cordilleras of Chili, Calceolarias grow, which are not found on the eastern side. Lobelia Dortmanna seems to be confined to the western European countries. Tamus communis, Briza minor, Gastridium lendigerum, and Calamintha officinalis, are said to have a tendency to migrate in a north-westerly direction towards their vanishing point.

1587. While some plants are generally and widely distributed, others are limited to particular countries, and sometimes confined within very narrow limits. The floras of the different quarters of the world contain certain plants, which are restricted to them, and some which are only found in a few localities. One region in the Andes is marked by the occurrence of species of Bejaria, and others by Cinchonas. Certain plants belonging to the natural order Polemoniaceæ are peculiar to California; an Orchid, called Disa grandiflora, is confined to Table Mountain; Codon Royeni and Protea acaulis are restricted to a few localities at the Cape of Good Hope. Numerous instances of a similar kind may be given, more particularly in the case of islands. The flora of islands near continents partakes of the character of that of the mainland. Those remote from continents, however, have often a more or less endemic flora. St. Helena had a peculiar flora, which has been strangely altered by foreign introductions. The flora of Madeira consists of 672 Phanerogamous plants and Ferns, of which 85 are absolutely peculiar to it, while 480 are common to Europe. The flora of the Azores is estimated at 425 species, of which 280 are common to them and Madeira. The Canaries and Madeira have 312 in common, and 170 are common to Madeira and Gibraltar, where 456 species have been collected. Vaccinium maderense, Matthiola maderensis, Sideroxylon Marmulana, and Erica arborea, are characteristic Madeira plants. Aira antarctica, the most southern flowering plant known, is restricted to the antarctic islands. Origanum Tournefortii is said to be found only on one of the islands of the Ægean Sea. Pringlea antiscorbutica, Kerguelen's Land Cabbage, is an interesting plant growing on an island, the remotest of any from a continent, and which, according to Hooker, yields, besides this esculent, only 17 other flowering plants.

1588. We sometimes meet with marked centres, where the maxima of the genus of an order, or of the species of a genus, occur, the number of the genera or species diminishing as we recede from these centres, and ending perhaps in a solitary representative in some distant country. Gentians and Saxifrages have their maxima in the European Alps; Eriocaulons have their great centre in Brazil, but a few species are found in other countries. Thus, E. decamgulare is found in North America, E. septangulare in Galway and the Isle of Skye, and a few other species in New Holland and India. Epacridaceæ are restricted to Australia. The genus Viola has two marked centres, one in Europe and another in America. The form of the European and American species are quite distinct. The maximum of the genus Erica is at the Cape of Good Hope; but members of the Heath family extend to northern regions in the form of Erica Tetralix, E. cinerea, and Calluna vulgaris. The maximum of the orders Palmæ, Musaceæ, Piperaceæ, Zingiberaceæ, and Marantaceæ, is in equatorial regions, but certain species are found in high latitudes. Thus the Palm, denominated Chamærops humilis, is found in Europe as high as latitude 43° to 44° N.; C. Palmetto, in North America, in lat. 34° to 36° N.; while some species occur in New Zealand, in lat. 38° S. Acacias have their maximum in Australia, but Acacia heterophylla is found in the Sandwich Islands. The Laurel order is tropical, but Laurus nobilis grows in Europe. The tropical Myrtaceæ have Myrtus communis to represent them in Europe, Leptospermeæ in Australia, and Metrosideros lucida in Lord Auckland's group, lat. 50½° S.

1589. An order, or a genus, or a species, in one country is occasionally represented in another by forms which are either allied, or have a physiognomic resemblance. There is thus sometimes a repetition of resembling or almost similar forms in countries separated by seas or extensive tracts of land. The Ericaceæ of the Cape have in Australia a representative in the nearly allied Epacridaceæ; the Cactaceæ of America are represented by certain succulent forms of Mesembryanthemaceæ and Euphorbiaceæ in Africa; and by some Crassulaceæ in Europe. The species of Cistus, found in Spain and Portugal, have their representatives in the north of Europe in the species of Helianthemum. The Pines and Firs of the northern hemisphere have representatives in the southern hemisphere in the genera Araucaria, Dammara, and Dacrydium.* Trientalis europæa has a representative form in America, T. americana; Cornus suecica occurs in Europe, C. canadensis in Canada. Empetrum nigrum, in arctic regions, has E. rubrum to take its place in the antarctic; Pinguicula lusitanica, in the northern hemisphere, has P. antarctica closely resembling it in the southern; Hydnora africana and H. triceps in South Africa are represented in South America by H. americana. The Culcitiums of the Andes have their counterpart in the woolly Espeletias of the mountains of New Granada. Drapetes muscosa, a Thymelaceous plant, confined in its geographical range to the mountains of antarctic America, is represented in New Zealand by a very similar one, forming its only congener, D. Dieffenbachii.

1590. The mode in which the globe has been clothed with vegetation, has given rise to much discussion. We know from the Sacred Record, that on the third day of the Creation of the present state of the globe, the earth brought forth grass, and herb yielding seed after his kind, and the tree yielding fruit after his kind; but whether the whole earth was at once clothed with vegetation, or certain great centres were formed, whence plants were gradually to spread, we have no means of knowing. The endemic limitation of certain orders, genera, and species, would certainly lead to the opinion, that, in many instances, there have been definite centres, whence the plants have spread only to a certain extent. But the general distribution of other tribes of plants, and the occurrence of identical species in distant parts of the world, would favour the view, that countries with similar climates had originally many species of plants in common. In the case of Grasses, we would naturally suppose that they must have been produced in their social state, forming pasture for the nourishment of animals; and such we might conjecture to be the case with social plants in general.

1591. Edward Forbes advocates strongly the view of specific

* In speaking of southern Coniferæ, Hooker states that four genera are peculiar to the southern hemisphere—Araucaria, Phyllocladus, Microcachrys, and Arthrotaxis; three others have their maximum to the south of the tropics—Callitris, Podocapus, and Dacrydium. Dammara has one species in each hemisphere. Thuja is equally divided between the two; whilst Juniperus and Cupressus are barely, if at all, represented, except perhaps the latter by Arthrotaxis.—Hooker, Journal of Botany, iv. 143.

centres, and endeavours to account for the isolation of certain species or assemblages of plants from their centres, by supposing that these outposts were formerly connected, and have been separated, by geological changes, accompanied with the elevation and depression of land. Schouw opposes the view of specific centres. He thinks that the existence of the same species in far distant countries is not to be accounted for on the supposition of a single centre for each species. The usual means of transport, and even the changes which have taken place by volcanic and other causes, are inadequate to explain why many species are common to the Alps and the Pyrenees on the one hand, and to the Scandinavian and Scotch mountains on the other, without being found on the intermediate plains and hills; why the flora of Iceland is nearly identical with that of the Scandinavian mountains; why Europe and North America, especially the northern parts, have various plants in common, which have not been communicated by human aids. Still greater objections to this mode of explanation, he thinks, are founded on the fact that there are plants on the Straits of Magalhaens, and in the Falkland and other antarctic islands, which belong to the flora of the arctic pole; and that several European plants, as Phragmites communis, Alisma Plantago, Aira flexuosa, species of Typha, Lemna, Scirpus, &c., appear in New Holland, Van Diemen's Land, and New Zealand, and which are not found in intermediate countries. In the case of Cryptogamic plants, the number of such recurring species is much increased. It is also difficult to conceive that large tracts continued quite barren until migration caused them to be covered with vegetation. Schouw, therefore, supposes that there were originally not one, but many primary individuals of a species.

1592. From all that has been said on this interesting subject, we are led to the conclusion that many plants must have originated primitively over the whole extent of their natural distribution; that certain species have been confined to definite localities, and have not spread to any great distance from a common centre; while others have been generally diffused, and appear to have been created at the same time in different and often far distant localities; that migration has taken place, to a certain extent, under the agency of various natural causes; that geological changes may, in some instances, have caused interruptions in the continuity of floras, and may have left isolated outposts in various parts of the globe; and finally, that social plants were probably created in masses, that being the natural arrangement suited to their habits.

V.—MODES IN WHICH PLANTS HAVE BEEN DISSEMINATED.

1593. Provision has been made for the extension of plants over the globe. The usual modes of transport are man, tides of the sea, rivers, winds, and birds. The Coco-nut wafted on the ocean is able to resist the action of the salt water by means of its fibrous covering, and lands on islands and shores in a state fit for germination. In this way recently produced coral islands are covered with vegetation. The hairy fruits and seeds of many plants are wafted to a distance by the winds, and rivers carry down the seeds of plants which have grown at their source. Birds which feed on pulpy fruits, often deposit the hard seeds at distant parts. Man, in his migrations, has distributed many plants, including common weeds, as well as plants useful for food or clothing. Rumex crispus, R. Acetosa, and R. Acetosella, Senecio vulgaris, Agrostis alba, Poa annua, Cerastium triviale, Stellaria media, and Veronica serpyllifolia, have been introduced by man into the Falkland Islands. The last-mentioned weed has also been introduced near Quito. Capsella Bursa-pastoris, Centaurea Cyanus, and Lolium temulentum have been carried to South Australia. Fennel, Trifolium repens, Echium violaceum, Sonchus oleraceus, Medicago denticulata, Lolium perenne, Hordeum murinum, and H. pratense, are recorded by Bunbury as growing abundantly near Buenos Ayres; all of them being British species which have followed man in his migration. The Thistle and the Artichoke, coming with Europeans, have quickly spread themselves over the Pampas of Buenos Ayres.

1594. Certain useful plants are considered by Schouw * as originally characteristic of nations, although at the present day they have become much more widely diffused. In the South Sea Islands, the Bread-fruit tree (Fig. 783, p. 268) and Coco-nut palm (Fig. 166, p. 70), supply important articles of food and clothing. New Zealand flax (Fig. 48, p. 24) is characteristic of the island whence it derives its name. Among the Malays of the Indian Islands, the Clove-tree, Nutmeg, Pepper (Fig. 1660, p. 895), and Ginger (Fig. 1713, p. 921), are the principal characteristic plants, and these are also common in India. Maize, which gives the most abundant, and also the most uncertain of all crops, was originally confined to America; such was also the case with the Potato. The Maguey plant (Agave potatorum) is a valuable product of Mexico, and may be called the Vine of the Mexicans; while Agave americana is useful for clothing. Chenopodium Quinoa is a plant used for food in the high districts of Mexico, Peru, and Chili; the Mauritia Palm is an important means of subsistence to the tribes of the Orinoco; the Date-Palm (Fig. 1743,

* Schouw's Earth and Man, translated by Henfrey, p. 221.

p. 934) is equally useful in the north of Africa, and in the Arabian deserts. The Coffee-tree (Fig. 1526, p. 830) characterizes the south of Arabia, and Abyssinia. Rice and Cotton were two important plants for the Hindoos; the Tea-plant (Fig. 1421, p. 773) for the Chinese; Wheat, Barley, Rye, and Oats, for the Indo-Caucasian races of Western Asia and Europe; the Olive (Fig. 1562, p. 851) and the Vine (Fig. 152, p. 64) for the inhabitants of Mediterranean districts; and the Rein-deer Moss (Fig. 1016, p. 343) for the Laplanders.

1595. While such was the original distribution of these plants, great changes have taken place chiefly by the agency of the Caucasian races, who have transplanted to their own countries the characteristic plants of other nations. Thus Schouw goes on to remark,—they have brought the Apricot, the Peach, and the Almond, from Asia Minor and Persia, and the Orange from China; they have transplanted Rice and Cotton to the Mediterranean coasts; they have brought the Maize and Potato from America to Europe. They have also carried their own characteristic plants to their colonies, and have transported into various climates useful and ornamental vegetable productions. European Corn plants have been widely spread through North America, in Mexico, the elevated countries of South America, Chili, Buenos Ayres, in South Africa, in the temperate parts of Australia and Van Diemen's Land. The Vine has been spread to Madeira, the Canary Islands, South Africa, and the high lands of South America. The Coffee-tree and Sugar-cane (Fig. 78, p. 33) have been transplanted by man into the West Indies and Brazil; the Nutmeg and Clove into the Mauritius and Bourbon, and various West India islands; plantations of Tea have been formed in Brazil, Java, and India; Rice and Cotton have been cultivated in the warmer parts of North America and Brazil, and New Zealand Flax in New Holland.

1596. Man has diffused widely plants which are useful for food, or for the purposes of manufacture. The consideration of the distribution of the Cereal grains and of the Potato is a subject of much interest. The former have been so long cultivated, and so extensively spread, that it is difficult to discover their native country. They are not seen in a wild state, unless it be true, as Esprit Fabre says, that Ægilops ovata is the wild condition of Wheat, and they have a wide geographical range, so as to be fitted for various climates. Rice is the grain which furnishes food to the greatest number of the human race; it is extensively used in the warm countries, and more especially in China. Maize bears the greatest range of temperature, and succeeds in the hottest climates. Millet also is associated with it in hot countries. Wheat succeeds best on the limits of the sub-tropical region, and, as we proceed north, is succeeded by Rye, and then by Barley and Oats, which extend farthest north in Europe.

1597. The Old World has been divided into the following agricultural zones: — 1. The zone of Barley, Oats, and the Potato, including Finmark and the higher districts of Scandinavia, the Faroe

Islands, Shetland, and the most northern part of Scotland and Ireland—the north boundary being 62°, 70°, 67°, and the south boundary 57° in Scotland, 52° in Ireland, 65° and 60°. 2. The zone of Rye and Wheat occupying the greater part of Europe north of the Alps, and extending to about 50° latitude, or as far as the polar limit of the cultivation of the Vine; in this zone, Buck-wheat, Peas, and Beans, are also important articles of food. 3. The zone of Wheat, including those parts of Europe and Western Asia which lie south of the 50th degree; in several districts Maize is cultivated as well as Wheat. 4. The zone of Rice and Wheat in those provinces which are subject to the influence of tropical seasons; in tropical Western Africa, Rice and Maize are the chief grains. The zone extends from about 15° N. lat. to 23° S. lat. In America, Berghaus distinguishes the following zones:—1. Rye, Wheat, and Barley (summer Cerealia). 2. Rye and Maize. 3. Wheat and Maize. 4. Wheat. In the tropical zone, Maize is the principal Cereal grain.

VI.—PHYSIOGNOMY OF VEGETATION IN DIFFERENT QUARTERS OF THE GLOBE.

1598. In this department of botanical geography we consider plants according to the distribution of forms, marking the predominance of this or that form of plants by the absolute mass of its individuals or by the impression it makes from the character given to the flora. The prevalence of a single form will often produce a much greater physiognomic effect than the number and variety of the floral productions. Hinds says that a general physiognomic impression is sometimes conveyed by the prevalence of colour. Yellow colours, according to him, abound on the tropical mountain plains in autumn, while blue colours prevail in sub-tropical regions. In northern latitudes and in alpine districts white flowers are more common than on the plains. He makes the following statements as to the proportion of colours in the flowers of different countries:—

	Cyanic.	Xanthic.	White.
Central America . . .	12	30	8
Sandwich Islands . .	12	31	7
Alashka	26	13	11
California	25	19	6
New Guinea	12	23	15
Hong-Kong	13	27	10

1599. Social plants, in an especial manner, affect the landscape from growing in masses. Among social plants may be noticed the Reindeer-moss of arctic regions, the Cladonias and Mosses of the waste levels of northern Asia; Grasses forming pastures, or arborescent forms, as Bamboos; Phragmites communis, and Scirpus lacustris of marshy grounds; Willows, Epilobium angustifolium, and Heaths; Cactuses in South America; Avicennias and Mangroves at the muddy estuaries of tropical rivers; Ferns in the South Sea islands and in New Zealand; Banksias in New Holland; Coniferous trees and Birches in the Baltic and Siberian plains; Cinchona-bark trees on the Andes. Aquatic plants, both of fresh and salt water, grow socially more frequently than land plants. Thus Sea-weeds, such as Sargassum bacciferum, Macrocystis pyrifera and Fucus antarcticus are found in masses in the ocean. Agricultural nations increase the domain of various social plants in temperate and northern zones, while they root out and destroy many wild species.

1600. There are certain marked vegetable forms which are concerned in determining the aspect or physiognomy of nature in different countries. Some of these leading forms coincide with natural orders; at other times, several distinct botanical groups require to be united.

The Palm Form (Figs. 187-190, pp. 87 and 88)—gives a marked character to the warmest regions of the globe, between 10 deg. north and 10 deg. south lat. The true Palm climate has a mean annual temperature of 78.2 deg. to 81.5 deg. F. South America is conspicuous for the beauty and number of its Palms. Certain Palms are associated in large groups, as the Coco-nut, Mauritia flexuosa, and some species of Chamærops. The indigenous vegetation of Europe comprises a single Palm-form, Chamærops humilis, or sea-coast Dwarf Palm, which in Spain and Italy extends as far north as the 44th parallel of latitude. In Asia and America Palms extend to 34 deg. north lat.; the southern limit of Palms in Africa is 34 deg., in New Zealand 38 deg., and in South America 36 deg. In the Old World the Eastern Archipelago produces the greatest number of Palms, in the New World the great valleys of the Amazon and the Orinoco. The Coco-nut is a littoral Palm. The Date, another social Palm, has been brought from Africa to the south of Europe, where it grows, but not in a vigorous manner, with a mean temperature of 59 deg. to 62.4 deg. F. Some alpine Palms, as Kunthia montana and Ceroxylon Andicola (Fig. 188, p. 87), attain an elevation of 6400 to 9600 feet on the Andes. With the Palm form has been associated the Cycadaceous order (p. 911), which resembles it somewhat in the appearance of its naked stems and tufts of pinnated leaves.

The Banana and Plantain Form (Fig. 245, p. 110)—is usually associated with the Palms in the torrid zone. In this form the physiognomist includes the natural orders Musaceæ (p. 922), Zingiberaceæ, and Marantaceæ (p. 921). The plants representing this form have succulent herbaceous stems and long delicately-veined verdant leaves. Groves of Bananas and Plantains are ornaments of equatorial regions, and supply important food for the inhabitants.

The Malvaceous Form (Fig. 1414, p. 769)—represented in warm climates by trees with thick trunks, large soft cordate or lobed leaves, and gorgeous flowers. It includes the orders Malvaceæ (p. 768), Byttneriaceæ, Sterculiaceæ (p. 771), and Tiliaceæ (p. 772), the Silk Cotton-tree, the Chocolate-tree, the Hand-tree of Mexico, the Baobab of Senegal (Fig. 176, p. 73). Cavanillesia platanifolia, and Sparmannia africana, are examples. The larger Malvaceous forms appear as soon as the Alps are crossed.

The Mimosa Form (Fig. 1159, p. 494)—is represented by Leguminosæ, with delicately pinnate leaves (Fig. 1157, p. 492), and is met with both in warm and in temperate regions. It is not seen in the temperate zone of Europe, though found in the United States.

The Heath Form (Fig. 1557, p. 846)—belongs especially to the African continent and islands, as well as to Australia. Under it are included the species of Erica and Calluna, the Epacridaceæ of Australia, the sub-order Diosmeæ of the order Rutaceæ, and some Proteaceæ. Humboldt associates with it the leafless or phyllodiferous Acacias of New Holland. In some respects it approaches the Coniferous form. While in the colder temperate zone this form is diminutive, it assumes an arborescent aspect in Africa, and even as far as the northern shore of the Mediterranean. Erica cinerea, E. Tetralix, E. carnea, and Calluna vulgaris, cover large tracts in Germany, France, Britain, and Norway. In southern Africa the species of Erica abound.

The Cactus Form (Figs. 1503 and 1504, p. 820)—with its peculiar jointed or spherical or polygonal stems without true leaves, is exclusively American. Humboldt says :—“ There is hardly anything in vegetable physiognomy which makes so singular and ineffaceable an impression on a newly arrived person, as the sight of an arid plain thickly covered, like those of Cumana, New Barcelona, and Coro, in the province of Jaen de Bracamosos, with columnar and candelabra like divided Cactus stems.” Some of the stems become hard and ligneous, and are very indestructible. Certain Euphorbias may be said to represent this form in Africa.

The Orchideous Form (Fig. 1705, p. 918)—is represented by the epiphytes which enliven the rocks and the trunks of trees in tropical climates, and which are distinguished by the animal shapes and colouring of their flowers. In temperate climes this form does not display the same magnificence ; in them the plants are not epiphytic.

The Casuarina Form (p. 901)—consists of leafless trees, with branches resembling those of Equisetums, found chiefly in the islands of the Pacific ocean and in India. Along with phyllodiferous Acacias and some Myrtaceæ, Casuarinas give a uniform character to the Tasmanian flora.

The Coniferous Form (Figs. 1121-1125, p. 436)—is represented by the needle-leaved trees of northern regions, the Pines, Cypresses, and Thujas ; and by the broader-leaved Dammara and Salisburia of more southern regions. In the Himalaya and the Mexican mountains Coniferous and Palm forms are associated.

The Pothos Form (p. 939)—prevails chiefly in the tropics, and is represented by Pothos, Dracontium, Caladium, and Arum. They have succulent stalks, large thick-veined leaves, and flowers more or less spathaceous.

The Liane Form (Figs. 197 and 198, p. 90)—is represented by the twining rope-plants, the Paullinias, Banisterias, Bauhinias, Bignonias, Passifloras, and Aristolochias, of the hottest parts of South America, and the Hop and Vine of temperate climes.

The Aloe Form (Fig. 1731, p. 929)—consists of plants with succulent tufted leaves, found in arid regions, often growing singly, and imparting, according to Humboldt, a peculiar melancholy character to the tropical regions in which they are found. With the Aloe are associated some Bromeliaceæ, as Pitcairnias, the American Aloe, some thick short-stemmed Euphorbias, the Dragon-trees, the Yuccas, and the Screw-pines.

The Gramineous or Grassy Form (p. 945)—illustrated in tropical regions by arborescent Bamboos, and in temperate regions by meadows and pastures. In the southern part of Europe Arundo Donax (Fig. 1763, p. 945), represents the arborescent form. Sugar-cane, Rice, and Millets, are grassy forms of warm regions, while Barley and Oats are extratropical. Along with true Grasses are associated Cyperaceæ (p. 943), Juncaceæ (p. 933), Restiaceæ, and Eriocaulonaceæ (p. 942). The genus Carex (Fig. 157, p. 66), is one of the Grassy forms of cold regions. The Tussac-grass (Fig. 1767, p. 949) gives a feature to the flora of the Falkland Islands. Aira antarctica is the most antarctic flowering plant hitherto discovered.

The Fern Form (Figs. 967 and 969, pp. 322 and 324)—gives a character to the landscape of warm and tropical regions. Like Grasses, Ferns have a gigantic appearance in the hotter parts of the globe. Tree-ferns, with their elegantly cut foliage, belong chiefly to the tropical zone, growing at an elevation of 2000 or 3000 feet above the level of the sea. Some extend to New Zealand and Tasmania. On the Andes they are associated with the Cinchona trees. In temperate insular climates, such as that of New Zealand, Ferns predominate. Tree-ferns were found by Hooker in Enderby and Campbell's Islands, which are the highest south latitudes in which they occur.

The Liliaceous Form (Figs. 1723 and 1724, p. 925)—includes the orders Liliaceæ (p. 927), Amaryllidaceæ (p. 924), and Iridaceæ (p. 922). In southern Africa the species of Amaryllis, Ixia, and Gladiolus, with their ensiform leaves and gorgeous blossoms, represent this form. In America the Liliaceous form is represented by Alstrœmerias and species of Pancratium, Hæmanthus, and Crinum, which, however, are less social than the European Iridaceæ.

The Willow Form (p. 896)—is represented by the species of Salix which spread over the northern hemisphere from the equator to Lapland. They increase in northern countries. In the Swiss and Scandinavian mountains, as well as in Scotland, we meet with small creeping Willows, such as Salix herbacea, S. reticulata, and S. lanata. In Spitzbergen very dwarf forms occur. There are no Willows in Australia.

The Myrtle Form (Figs. 1482, p. 810)—gives a peculiar character to the south of Europe, especially the Mediterranean islands ; to New Holland, in species of Eucalyptus, Melaleuca, Metrosideros, and Leptospermum ; and to the district of the Paramos in the Andes, where certain species of Escallonia, Symplocos, Myrica, and Myrtus, are found. The form consists of plants with stiff, shining, small, generally entire and dotted leaves, and includes plants belonging to the orders Myrtaceæ (p. 809), Escalloniaceæ (p. 822), Styracaceæ (p. 841), and Myricaceæ (p. 895). One species of Myrtus is found in Fuegia in lat. 56½ deg. S. Metrosideros lucida is found in Lord Auckland's group, lat. 50½ deg. S.

The Melastoma Form (p. 808)—is represented by the species of Melastoma and Rhexia, with their ribbed and beautifully veined leaves, which abound in tropical America, and some of which ascend to 10,000 and 11,000 feet on the Andes.

The Laurel Form (Figs. 242 and 246, pp. 109 and 111)—is represented in South America by species of Laurus and Persea, as well as by some of the Guttiferæ (p. 777), such as Calophyllum and Mammea.

The Form of Dicotyledonous Trees (Figs. 172 and 173, p. 72)—is represented in northern climates by the Oak, Beech, Elm, Horse-chestnut, Poplar, Alder, and Birch ; in warmer climates by the Olive, and in the hottest regions by the large-leaved Bread-fruit trees and Cecropias.

The Moss Form (Fig. 1003, p. 335)—is characteristic of cold regions. Hooker mentions, that in New South Shetland there are specks of Mosses struggling for existence. In Cockburn Island five Mosses are found.

The Lichen Form (Figs. 1013-1015, p. 342)—is associated with Mosses, and may be said to extend still farther. It forms the limit of terrestrial vegetation. On Deception Island Lichens only exist.

VII.—THE STATISTICS OF VEGETATION OVER THE GLOBE.

1601. This subject involves the consideration of the number of known vegetable species in the world, their numerical distribution, and the relative proportion of classes, orders, genera, and species in different countries. In the present imperfect state of our knowledge of the floras of different countries, it is impossible to tell the exact number of species of plants in the globe. Those known at the present day, described and undescribed, amount probably to nearly 120,000, and from this estimates have been made of the total vegetation, the numbers varying from 150,000 to 200,000. Hinds, reckoning the species at 134,000, gives the following conjectural distribution as compared with surface :—

	Species.	Extent of Surface.
Europe	11,200	2,793,000 geog. sq. miles.
Asia	36,000	12,118,000 ,,
Africa	25,200	8,500,000 ,,
North America	14,400	7,400,000 ,,
South America	40,000	6,500,000 ,,
Australasia	7,200	3,100,000 ,,
	134,000	40,411,000 ,,

The following is the estimated number of known and described plants:—

	Genera.		Species.
Acotyledonous plants* .	1,400	.	15,000
Monocotyledonous plants .	1,450	.	14,000
Dicotyledonous plants .	6,300	.	67,000
	9,150	.	96,000

1602. The relative numerical proportion of these great classes of plants varies in different quarters of the world. It is estimated that Cryptogamic plants are to Phanerogamous plants as 1 to 7. In northern and alpine regions the proportion of the former increases. In equatorial regions, Monocotyledons are to Dicotyledons in the proportion of 1 to 5 or 6; in temperate regions as 1 to 4; and arctic regions as 1 to 3. In temperate and cool climates there is an increase of Monocotyledonous plants, particularly of Gramineous forms. Tropical islands in general possess proportionally more Monocotyledons than do the continents; the usual proportion in these islands is said to be 1 to 4. An equable temperature, and a rather humid climate, are favourable to Monocotyledons. They diminish both under the extreme cold of the arctic zone and the great heat of the tropics. They increase towards the southern temperate and antarctic zones. Hooker remarks, that the Galapagos Islands differ from other tropical islands in having a small proportion of Monocotyledons, which in them are only $\frac{1}{9}$ of the Dicotyledons.† He also states, that in St. Helena Monocotyledons are to Dicotyledons nearly as 1 to 5, in the Society Islands as 1 to 4.2, in the Sandwich Islands 1 to 4, in the Cape de Verd Islands 1 to 5, in the Canaries 1 to 6, in Madeira 1 to 5.4, in the Azores 1 to 4.1, in Great Britain 1 to 4, in Shetland 1 to 3.3, in the Faroe Islands 1 to $2\frac{1}{4}$. There is thus an increase in the proportion of Monocotyledons in passing from the Canaries, lat. 28°, to Madeira, lat. 32°, the Azores, lat. 38°, Great Britain, lat. 50°.57, Shetland, lat. 60°, and Faroe, lat. 62°. In the arctic regions, on the other hand, Hooker remarks, the proportion seems to be inverted. In Iceland, lat. 65°, the proportion is 1 to 4.8; in Spitzbergen, lat. 78°.80, it is 1 to 4.9; on the east coast of Greenland it is 1 to 5; in the arctic American islets, lat. 68°, it is 1 to 5.3; at Baffin's Bay, lat. 70°.76, it is 1 to 5.7; at Port Bowen and Prince Regent's inlet, lat. 74°, it is 1 to 7. Melville Island presents an exception, the proportion being 1 to $2\frac{1}{2}$ or 3. On the antarctic islands, Monocotyledons bear a great proportion to Dicotyledons; thus, in Kerguelen's land, the proportion is 1 to 2. On this island there are 150 species

* Klotzsch estimates Acotyledons at 19,030, viz., Fungi 8000 (species of Agaricus forming $\frac{1}{8}$), Algæ 2580, Lichenes 1400, Musci and Hepaticæ 3800, and Ferns 3250 (Polypodiaceæ being 2165).

† Hooker on the Vegetation of the Galapagos Islands. Linn. Trans. xx. 239.

of plants, of which 18 are flowering plants, 3 Ferns, 25 Mosses, 10 Jungermanniæ, and the rest are Lichens and Sea-weeds. In Campbell's Island, where Hooker collected from 200 to 300 species, the proportion is 1 to 4, and in Lord Auckland's group 1 to 2.2.

1603. In central and southern Europe, the proportion of Monocotyledons to Dicotyledons, which is 1 to 4 in the plains, decreases with the elevation on dry mountain slopes, till, at the height of 8526 feet, it is 1 to 7. Moist mountain slopes favour Monocotyledons, the proportion on them being as 1 to 3. In South Australia, Monocotyledons are to Dicotyledons as 1 to 4, varying, however, according to latitude, the mean being between the vegetation of New South Wales and Van Diemen's Land. In Western Australia, the proportion is 2 to 9, while the Acotyledons are to Dicotyledons as 1 to 6. In Western Eskimaux land, Seemann enumerates 315 species, of which 73 are Cryptogamic and 242 Phanerogamous, the latter being made up of 45 Monocotyledons and 197 Dicotyledons. The proportion of species in some of the orders is given by him as follows:—Mosses 30 species, Lichens 21, Grasses 20, Compositæ 30, Saxifragaceæ 19, Rosaceæ 18, Caryophyllaceæ 15, Cruciferæ 17, and Ranunculaceæ 15; the genus Saxifraga has 18 species, Potentilla 9, Salix, Ranunculus, and Polytrichum 8, Pedicularis and Hypnum 7, Senecio 6, the rest of the genera having fewer species.

1604. In the low plains of the great continents within the tropics, Ferns are to Phanerogamous plants as 1 to 20; on the mountainous parts of the great continents, in the same latitudes, as 1 to 8 or 1 to 6; in Congo as 1 to 27; in New Holland as 1 to 26. In small islands, dispersed over a wide ocean, the proportion of Ferns increases; thus, while in Jamaica the proportion is 1 to 8, in Otaheite it is 1 to 4, and in St. Helena and Ascension nearly 1 to 2. In the temperate zone, Humboldt gives the proportion of Ferns to Phanerogamous plants as 1 to 70. In North America the proportion is 1 to 35, in France 1 to 58, in Germany 1 to 52, in the dry parts of south Italy as 1 to 74, and in Greece 1 to 84. In colder regions the proportion increases, that is to say, Ferns decrease more slowly in number than Phanerogamous plants. Thus in Lapland the proportion is 1 to 25; in Iceland 1 to 18, and in Greenland 1 to 12. The proportion is least in the middle temperate zone, and it increases both towards the equator and towards the poles; at the same time, it must be remarked, that Ferns reach their absolute maximum in the torrid zone, and their absolute minimum in the arctic zone.

1605. Taking other natural orders, we find that Juncaceæ, Cyperaceæ, and Gramineæ increase in proportion to all the Phanerogamous species as the latitude becomes higher; thus, in the torrid zone, the proportion is 1 to 11, in the temperate zone 1 to 8, and in the arctic zone 1 to 4. Cinchonaceæ, Leguminosæ, Euphorbiaceæ, and Malvaceæ, increase in their proportion to Phanerogamæ as we approach the equator.

	Torrid Zone.	Temp. Zone.	Arctic Zone.
Rubiaceæ, including Cinchonaceæ and Galiaceæ . .	1 to 14 (1 to 25 in America.)	1 to 60	1 to 80
Leguminosæ . .	1 to 10	1 to 18	1 to 35
Euphorbiaceæ .	1 to 32	1 to 80	1 to 500
Malvaceæ . .	1 to 35	1 to 200	wanting.

The natural orders Cruciferæ, Umbelliferæ, and Compositæ, have their highest quotients in the temperate zone.

	Torrid Zone.	Temp. Zone.	Arctic Zone.
Cruciferæ . .	1 to 800	1 to 18 (1 to 60 in America.)	1 to 24
Umbelliferæ . .	1 to 500	1 to 40	1 to 60
Compositæ . .	1 to 18 (1 to 12 in America.)	1 to 8 (1 to 6 in America.)	1 to 13

Piperaceæ are plants of the hottest regions; Papaveraceæ are chiefly European; Cinchonaceæ, within the tropics, form 1-29th of the flowering plants; Scrophulariaceæ, in the middle of Europe, are to Phanerogams as 1 to 26, in North America as 1 to 36. Labiatæ have their maximum between 40° and 50° N. lat.; their relation to flowering plants in France is 1 to 24, in Germany 1 to 26; in Sicily 1 to 21, in the Balearic Islands 1 to 19, in Lapland 1 to 40, and they do not occur in Melville Island. Boraginaceæ are chiefly confined to the temperate regions, while Primulaceæ and Gentianaceæ abound in colder zones. Caryophyllaceæ are 1 to 22 of the Phanerogamous plants in France, 1 to 27 in Germany, 1 to 17 in Lapland, and 1 to 72 in America; Malvaceæ 1 to 86 in Sicily, 1 to 145 in France, 1 to 233 in Sweden, 1 to 125 in temperate North America, and 1 to 47 in equinoctial America. Compositæ, in relation to Phanerogamous plants, are 1 to 7 in France, 1 to 8 in Germany, 1 to 15 in Lapland, 1 to 6 in North America, 1 to 2 in tropical America, 1 to 16 in New Holland, and 1 to 13 in Melville Island.

1606. The proportion of species as well as of genera, belonging to the same natural order, varies in different countries. Of Ranunculaceæ 1-5th of the species are European, 1-7th North American, 1-17th

South American, and 1-25th Indian; of Papaveraceæ nearly 2-3ds are European; of Cruciferæ 205 species, according to De Candolle, are found in the frigid zone of the northern hemisphere, 30 in the tropics (chiefly on mountains), 548 in the northern temperate zone, and 86 in the southern temperate zone; of known Malpighiaceæ South America possesses 408 species, Mexico 61, West Indies 56, Africa and its islands 25, Asia, Arabia, India, and Ceylon 16, Indian Archipelago, China, and Polynesia 14; of Hypericaceæ 41 are North American, 24 Asiatic, 21 South American, 19 European, 7 African, 5 Australian, 5 in the Azores and Canaries, 4 common to Europe and Asia, 1 West Indian, and 1 common to Europe, Asia, and Africa; De Candolle states that about 1600 species of Leguminosæ are found in the equinoctial zone, about 1300 to the north of the tropics, and about 500 to the south. Out of 272 species of Crassulaceæ, De Candolle states 133 are found at the Cape of Good Hope, 52 in Europe, 18 in the Levant, 18 in the Canaries, 12 in Siberia, 9 in Barbary, 8 in Mexico, 7 in the United States, 4 in South America, 4 in China and Japan, 3 in the East Indies, 2 in New Holland, 1 in South Africa. Of 9030 Compositæ mentioned by authors, 3590 are found in America, 2224 in Africa, 1827 in Asia, 1042 in Europe, and 347 in the South Sea Islands. Of 2500 species of Euphorbiaceæ 3-8ths are found in equinoctial America, 1-8th in tropical Africa, 1-6th in India, 50 species in America, and 120 in Europe. Lomler calculates that 165 Coniferæ exist in the northern and 51 in the southern hemispheres. There are, according to him, 22 in Europe, 87 in Asia, 16 in Africa, 83 in America, and 35 in Australia. In the tropical zone 24, in the north temp. 159, and in the south temp. 33. The number of Coniferæ in the southern hemisphere is as follows:—16 species in New Holland, 10 in Tasmania, 13 in New Zealand and the South Sea Islands, 8 in South America, 6 in South Africa and Mauritius.

1607. The following are some of the orders which prevail in cold regions, with their relative proportion to Phanerogamous plants:—

	Region of Alpine Plants in France.	Summit of Pic du Midi.	Melville Island.
Gramineæ . . .	1 to 15	1 to 10.1	1 to 4.7
Cyperaceæ . . .	1 to 26	1 to 25.3	1 to 16.7
Compositæ . . .	1 to 11.2	1 to 5.4	1 to 13.4
Campanulaceæ . .	———	1 to 71	1 to 6.7
Saxifragaceæ . . .	1 to 7.9	1 to 17.7	1 to 6.7
Rosaceæ . . .	1 to 19.7	1 to 17.7	1 to 16.7
Leguminosæ . . .	1 to 39.5	1 to 17.7	1 to 32.5
Caryophyllaceæ . .	1 to 11.2	1 to 11.9	1 to 13.4
Cruciferæ . . .	1 to 13	1 to 11.9	1 to 4.9
Ranunculaceæ . .	1 to 39.5	wanting.	1 to 13.4

VIII.—ZONES OF VEGETATION AS REGARDS LATITUDE.

1608. We have already seen that the vegetation varies according to latitude, and that we may trace a series of changes in the flora from the equator to the poles. Meyen proposes to mark out round the world a number of climacteric zones or belts, and to connect with the fact of these zones of climate the peculiarities of the vegetation of the belts. Meyen's plan is not quite correct, because he has made his belts to correspond with the parallels of latitude, and has asserted that between such and such parallels a certain form of vegetation would be found all over the world. The boundary lines of the zones, in order to be accurate, should be undulatory; they should correspond with the isotherm of the particular month in which there is the greatest development of vegetable life. Such undulatory zones, in which the plants present a certain resemblance to each other by sea and land, are denominated by Forbes Homoizoic.

1609. As regards vegetation, Meyen divides the Torrid zone into —1. The equatorial, extending 15° on both sides of the equator, having a mean annual temperature of 78°.8 to 82°.4 F. 2. The tropical, reaching from the 15th degree on each side of the equator to lat. 23°, having a mean annual temperature of 73°.4 to 78°.8, a summer heat of 80°.6 to 86°, and a winter temperature in the eastern coast countries of 59°. The Temperate zone is divided by Meyen into —1. The sub-tropical, from the tropics to 34° lat., with a mean annual temperature of 62°.6 to 71°.6, and a summer temperature of 73°.4 to 82°.4. 2. The warmer temperate zone, from lat 34° to 45°, having a mean annual temperature of 53°.6 to 62°.6, the summer temperature, in North America 77°, in Europe 68° to 75°.2, and in eastern Asia 82°.4 ; the winter temperature in America being 32°.54 to 44°.6, in Europe 34°.7 to 50°, and in eastern Asia 26°.6. 3. The colder temperate zone, between the parallels of 45° and 58°, the temperature of the year 42°.8 to 53°.6 ; the minimum summer temperature on the west coast 56°.31, in the interior of the continent 68° ; the minimum winter temperature in the interior of Europe 14°. 4. The sub-arctic zone, from lat. 58° to the polar circle in lat. 66°.32, mean annual temperature 39°.2 to 42°.8 ; temperature of summer in America 66°.2, in the Old World 60°.8 to 68° ; winter temperature of America 14°, of western Europe 24°.8, and of the interior of Russia 10°.4 to 14°. The Frigid zone is divided into—1. The arctic, from the polar circle to lat. 72°, mean annual temperature being 28°.4 to 32°, and towards the eastern continental regions much lower. 2. The polar, beyond 72° of latitude; mean annual temperature in the Old World 16°.7, in the New World 1°.4 ; the summer of the former 38°.3, of the latter 37°.4 ; winter of the former—2°.2, of the latter—28°.

1610. Equatorial Zone.—This embraces central Africa, including the Guinea coast and Abyssinia, &c., Ceylon, the southernmost part of Hindostan, Malaya, Cochin China, Sumatra, Borneo, Java, New Guinea, islands in the eastern seas, the northernmost part of Australia, the northern part of South America, including Columbia, Peru, the Guianas, and part of Brazil. The vegetable forms characteristic of this zone are Palmæ, Musaceæ, arborescent Grasses, Zingiberaceæ, Marantaceæ, Orchidaceæ, and Lianas. Species of Bombax and Ficus occur here, with gigantic trees such as the Baobab, species of Swietenia, Hymenæa, and Cæsalpinia. The orders Malpighiaceæ, Anonaceæ, Anacardiaceæ, Lecythidaceæ, Sapindaceæ, Artocarpaceæ, Sterculiaceæ, Ebenaceæ, Meliaceæ, Lauraceæ, and Rafflesiaceæ, are also well represented in this zone.

1611. Tropical Zone.—This includes parts of Bolivia, Brazil, and Paraguay in South America, the majority of the West India Islands, Yucatan, Guatemala, and part of Mexico, Nubia and Senegambia in Africa, Madagascar, Mauritius, and North Australia, part of China and India, Burmah, and the south of Arabia. As Palms and Bananas may be said to characterise the equatorial zone, so may arborescent Ferns and species of Ficus be said to predominate in the tropical zone. Besides many equatorial forms, we meet here with plants belonging to the orders Piperaceæ, Melastomaceæ, and Convolvulaceæ.

1612. Sub-tropical Zone.—This embraces the north of Africa, including the Great Desert, Morocco, Barbary, Algiers, Tunis, Tripoli, and Egypt; in Asia, Palestine, Syria, north of Arabia, Persia, Cabul, Beloochistan, Thibet, the north of India, and China; the southern part of Australia; south Africa; Paraguay, La Plata, Chili, and Banda, in South America; the Bahamas, Bermuda, Mexico, Texas, the Southern States and California, in North America. In this zone vegetation is green throughout all the year, like the forests of the damp regions of the torrid zone. It is called the region of Myrtaceæ and Lauraceæ. Certain Palm forms are seen, such as Phœnix dactylifera in Egypt (represented in India by Phœnix sylvestris and P. humilis), Hyphæne thebaica, Chamærops Palmetto. In this zone we meet with succulent Crassulaceæ, Mesembryanthemaceæ, Cactaceæ, and arborescent Euphorbiaceæ, plants belonging to the orders Ternstrœmiaceæ and Magnoliaceæ; and in the southern hemisphere especially Proteaceæ, Epacridaceæ, and Ericaceæ, along with species of Zamia and Diosma.

1613. Warmer Temperate Zone.—In Europe this includes the southern flora as far as the Pyrenees, the mountains in the south of France, and those in the north of Greece. Asia Minor, the country between the Black Sea and the Caspian, the north of China, and Japan lie in this zone. It has been called the region of evergreen trees. Chamærops humilis represents the Palms, Erica arborea the Heaths, Laurus nobilis the Laurels, and Myrtus communis the Myrtles, in this zone, in which there are many sub-tropical forms. Species of Cistus, Vaccinium, Smilax, Eucalyptus, and Melaleuca are met with, as well as many forms of Compositæ, also Figs, Oranges, Pomegranates, and the Vine.

1614. Colder Temperate Zone.—In the northern hemisphere the characteristic forms of the vegetation of this zone are seen in England, the north of France, and Germany. The forests consist of Dicotyledonous trees and especially Coniferæ; the successful cultivation of Wheat scarcely extends beyond the limits of this zone. Heaths, covered with Calluna vulgaris, add a feature in the physiognomy of this zone. The floras of Tierra del Fuego, the Straits of Magalhaens, the Falkland Islands, and Kerguelen's Land, are also included in this zone. We meet with Drymis Winteri, Fagus antarctica, and F. Forsteri, Dactylis cæspitosa, Pringlea antiscorbutica, and many other interesting forms described by Dr. Hooker in his Flora Antarctica.

1615. Sub-arctic Zone.—This zone is of less extent than the preceding, and in the interior of Asia it is perhaps not so easily distinguishable from it as it is in Europe. In the northern hemisphere it is the zone of Firs and Willows. In the southern hemisphere it embraces a few barren islands. The northern parts of Siberia and Norway, the Faroe Islands, and Iceland, belong to this zone. In the Faroe Islands Barley does not always ripen, but the Turnip and Potato succeed. The Amentiferæ in them, as well as in Iceland, do not become trees. Grasses, Calluna vulgaris, Juniperus communis, form features in the physiognomy of Iceland, and Alpine species come down nearly to the sea level. In Siberia, forests of Pinus Cembra, Larch, Spruce, Poplar, and Birch occur.

1616. Arctic Zone.—In this zone the Birch predominates, and along with it are seen Pinus sylvestris and Abies excelsa. The Birch reaches nearly the North Cape, and Firs extend to 69° or 70°. Grasses are also found, and numerous Lichens and Mosses. At Hammerfest, in lat. 71°, Potatoes, Turnips, Carrots, and Cabbage succeed. Species of Rhododendron, Andromeda, and Azalea occur in the American arctic zone.

1617. Polar Zone.—In this zone there are no trees nor bushes, and no cultivation of plants for food. Species of Saxifrage, Dryas, Papaver, Ranunculus, Cardamine, Cochlearia, Pedicularis, Silene, Potentilla, Salix, Juncus, Eriophorum, Parrya, Platypetalum, Phippsia, Dupontia, and a few others, are found in this inhospitable belt. In Melville Island there are 67 species of flowering plants, in Spitzbergen 45. In cold zones we find more genera and fewer species than in warmer regions.

IX.—ZONES OF VEGETATION AS REGARDS ALTITUDE.

1618. The vertical range of vegetation has been divided into zones similar to those of the horizontal range. The relation of plants to such zones of elevation is called Hypsometrical. As we ascend from the plain to the top of a mountain we pass through different belts of vegetation, the extent and variety of which differ in different countries. When Tournefort ascended Mount Ararat he was struck with the circumstance, that, as he left the low ground at the base of the mountain, he passed through a series of belts, which reminded him of the countries he had passed through in travelling from the south to the north of Europe. At the base the flora was that of the west of Asia; as he ascended higher he reached the flora of the countries on the north of the Mediterranean, then that of northern Europe, and when he reached the summit he found the Lapland plants. Humboldt found that on all mountains there occurs such a representation of different floras, and that particular alpine forms are found almost over the whole world at a particular elevation.

1619. The relation between latitude and altitude is seen in the following table, which gives the limits of certain trees in both points of view:—

	Latitude.	Elevation on the Grimsel.
Fagus sylvatica, Beech .	60° N.	3232 feet.
Quercus Robur, Oak . .	61°	2624 „
Corylus Avellana, Hazel .	63°	3478 „
Prunus Cerasus, Cherry .	—	3478 „
Abies excelsa, Spruce .	67° 40′	5068 „
Pinus sylvestris, Scotch Fir	70°	5927 „
Betula alba, Birch . .	70° 40′	6479 „

1620. On the lofty mountains of South America and Asia we are enabled to trace the various forms of vegetation very distinctly. The following are the elevations of some of these mountains:—

Peaks on the Andes.		Peaks on the Himalaya.	
Desyacassada .	19,570 feet.	Gossain Than .	24,700 feet.
Descabesado .	21,100 „	Nanda Devi .	25,749 „
Chimborazo .	21,441 „	Cholo . .	26,000 „
Illimani . .	24,350 „	Dhavala Giri .	27,060 „
Sorato . .	25,400 „	Kinchin-junga .	28,172 „

Kinchin-junga, in the snowy ranges of the Sikkim Himalaya, is, according to Hooker, the highest mountain in the world.

1621. Humboldt, in describing the South American alpine flora, says—"In the burning plains scarce raised above the level of the Southern Ocean, we find Musaceæ, Cycadaceæ, and Palmæ, in the greatest luxuriance; after them, shaded by the lofty sides of the valleys in the Andes, arborescent Ferns; next in succession, bedewed by cool misty clouds, Cinchonas appear. When lofty trees cease, we come to Aralias, Thibaudias, and Myrtle-leaved Andromedas; these are succeeded by Bejarias abounding in resin, and forming a purple belt around the mountains. In the stormy region of the Paramos, the more lofty plants and showy flowering herbs disappear, and are succeeded by large meadows covered with Grasses on which the Llama feeds. We now reach the bare trachytic rocks, on which the lowest tribes of plants flourish. Parmelias, Lecideas, and Leprarias, with their many-coloured thalli and fructification, form the flora of this inhospitable zone. Patches of recently fallen snow now begin to cover the last efforts of vegetable life, and then the line of eternal snow begins."

1622. This vegetation is illustrated in the map (accompanying this volume), which shows the distribution of plants in equinoctial America, according to elevation above the level of the sea. Beginning with subterranean plants, such as species of Tuber and Byssus, we then have the region of Palms and Bananas extending from the level of the sea to 2952 feet, which is above the level of the inferior limit of Cinchona-bark trees. We next come to the region of arborescent Ferns, extending from 1322 to 4920 feet. The region of the Cinchona-bark extends from 2296 to 9512 feet. The region of the Wax Palm reaches from 5904 to 9184. Near the upper limit of Cinchona we meet with the regions of Wintera, Escallonia, Barnadesia, and Duranta ; we are here above the limit of great trees. The Gentian, Chuquiraga, and Espeletia region extends from 6560 to 13,448 feet; the region of Grasses from the latter height as far as 15,088 feet ; and this is immediately succeeded by the region of Lichens, which reaches to 16,072 feet. The upper limit of the Mimosa sensitiva is marked at about 7000 feet, and that of shrubby plants at about 11,000 feet. By consulting the map, as given by Humboldt, the genera characterising the different regions will be seen.

1623. On the Mexican volcano of Orizaba the following regions have been observed:—1. Hot region, 0-3000 feet, characterised by trees of Mimosa, Bombax, Citrus, and Combretum. 2. Warm moist region, 3000 to 6000 feet, a rich botanical region exhibiting forests of Lauraceæ, Myrtaceæ, Anacardiaceæ, Malpighiaceæ, and Anonaceæ, with numerous woody and herbaceous Lianas ; Coffee and Cotton are cultivated up to 4000 or 5000 feet, Sugar and Bananas up to 5500. 3. Region of Oak forests 6000 to 7800 feet, exhibiting species of Quercus, Alnus, Ulmus, Clethra, also Ferns, Orchids, and, at the upper limit, Vaccinium and Andromeda. 4. Coniferous region, 7800 to 11,000 feet, in which occur Pinus leiophylla, P. Montezumæ, Abies religiosa. 5. Region of the Steviæ, 11,000 to 13,600 feet, species of Compositæ, Cruciferæ, Caryophyllaceæ, Umbelliferæ, and Rosaceæ. 6. Alpine mountain plains, 13,600 to 14,800 feet, in which Grasses, Mosses, and Lichens abound ; among the last Phanerogamous plants are Phacelia lactea, Cnicus nivalis, Draba vulcanica, and species of Castilleia, Saussurea, and Arenaria.*

1624. Madden and Strachey give the following account of the Himalayan vegetation, proceeding from the plains of India through Kemaon to Thibet:†—"Ascending, we find forms of temperate climates gradually

* Liebmann in Botanische Zeitung, 1844.

† Notes on the Botanical Geography of part of the Himalaya and Thibet. Trans. Brit. Assoc. for 1851, p. 72.

introduced above 3000 feet, as seen in species of Pinus, Rosa, Rubus, Quercus, Berberis, Primula, &c. At 5000 feet the arboreous vegetation of the plains is altogether superseded by such trees as Oaks, Rhododendron, Andromeda, Cypress, and Pine. The first ridge crossed ascends to a height of 8700 feet in a distance of not more than 10 or 12 miles from the termination of the plains. The European character of the vegetation is here thoroughly established, and although specific identities are comparatively rare, the representative forms are most abundant. From 7000 to 11,000 feet, the region of the alpine forest, the trees most common are Oak, Horse-chestnut, Elm, Maple, Pine, Yew, Hazel growing to a large tree, and many others. At about 11,500 feet the forest ends, Picea Webbiana and Betula Bhojpatra being usually the last trees. Shrubs continue in abundance for about 1000 feet more; and about 12,000 feet the vegetation becomes almost entirely herbaceous. On this southern face of the mountains the snow-line is probably at about an elevation of 15,500 feet. The highest dicotyledonous plant noticed was at about 17,500 feet, probably a species of Echinospermum. An Urtica also is common at these heights. The snow-line here recedes to 18,500 or 19,000 feet. In Thibet itself the vegetation is scanty in the extreme, consisting chiefly of Caragana, species of Artemisia, Astragalus, Potentilla, a few Gramineæ, &c. The cultivation of Barley extends to 14,000 feet. Turnips and radishes on rare occasions are cultivated at nearly 16,000 feet. Vegetation ends at about 17,500 feet, scanty pasturage being found in favoured localities at this elevation; and the highest flowering plants are Corydalis, Cruciferæ, Nepeta, Sedum, and a few others."

1625. Madden observed on the Himalaya, at Kemaon, such northern forms as Pines, Firs, Cypresses, Yews, Oaks, Maples, Hazels, Ash, and many deciduous trees of cold climates, associated with Palms, Bamboos, and Bananas. Among the Palms may be noticed Phœnix humilis, which extends to 5500 feet of elevation, and P. Khasyana, from 6-8000 feet. Among the Bamboo forms are mentioned Arundinaria falcata from 3500 to 8500 feet, A. utilis from 7-9000 feet, and other species, which extend to 11,500, and are thus associated with all the Himalayan Coniferæ, except Pinus longifolia, which does not reach such an elevation, its limit being about 7000 feet. A species of Musa ascends on the eastern Himalaya, north of Assam, to 7000 feet.* On the mountains of Mexico we meet with a Palm, Corypha dulcis, mixed up with the forests of Pinus occidentalis. On the Andes, the Wax Palm, Ceroxylon Andicola, reaches the elevation of 9500, and along with Chusquea (a Bamboo form) is associated with representatives of northern plants. On the Himalaya, at Kemaon, an erect tree Juniper, fruticose Rhododendrons 8 feet high, Betula, Salix, and Pyrus, ascend to 15,000 feet in favourable situations, but all are stunted. Loniceræ are the commonest shrubs at 14,000 feet, along with species of Rosa and Berberis.

* Major Madden on the occurrence of Palms and Bamboos, with Pines, &c., in the Himalaya. Trans. Bot. Soc. Edin. 1853; and Ann. Nat. Hist. 2d ser. xi. 345.

1626. Thomson, in his Thibetan travels, gives a full account of the vegetation of the mountains in that quarter. In speaking of Western Thibet,* he remarks, that "the chain to the south of the Chenab river, rising to an elevation of 15,000 feet, excludes a considerable quantity of humidity from the valley of that river, and the vegetation, although not altogether losing its truly Himalayan character, becomes much modified. Thus the Oaks, Rhododendrons, and Andromedas, so common on the southern mountains, are not found; while fruit-trees become more abundant, and the Grape Vine ripens its fruit admirably. Passing to the north, the next ridge that is crossed reaches a height of 20,000 to 22,000 feet, the passes being usually upwards of 18,000 feet in elevation. To the north of this range the climate and vegetation suddenly changes, and the Thibetan types are at once established. The general character of the flora is Europeo-Siberian, but much modified by the extreme aridity which almost excludes trees and shrubs; it hardly exceeds 500 or 600 species in all. The chief groups are Boraginaceæ, Chenopodiaceæ, Cruciferæ, Leguminosæ section Astragalineæ, and Artemisioid Compositæ. The few trees consist of a Poplar and an occasional Juniper. The more common shrubs are Lonicera, Tamarix, Myricaria, and Hippophäe. The high alpine herbaceous flora is almost strictly Siberian, and is a little more varied and inferior than in other parts of this region, from the additional moisture derived from the melting of the snow. It extends sometimes even to a height of 18,500 feet." Thomson noticed Biebersteinia odora on the Roonung Pass in Kunawar, at 14,200 feet. Just below where the glacier terminated, a minute Astragalus was seen, with a Lychnis and two Grasses, and these were soon followed by a Nepeta, four species of Potentilla, a Fern, a Gnaphalium, and two Carices. These may be considered specimens of the most alpine vegetation on some of the mountains of India. On the Sikkim Himalaya Hooker found herbaceous plants sufficiently abundant in certain spots at 18,000 feet, and shrubby ones, as Lonicera and Rhododendron, at 17,000, along with Gnaphalium and Ephedra. A species of Urtica attains this elevation, as well as Zannichellia and Ranunculus. Compositæ are among the most alpine, this order being represented by species of Gnaphalium, Saussurea, Artemisia, and Erigeron, at 17,000 to 17,500 feet, together with Astragalus and Valeriana.†

1627. On the mountains of Kurdistan the following zones have been observed:—1. From the plains of Mesopotamia to the height of 1000 feet is the zone of Glycyrrhiza, Robinia, Nigella damascena, Wild Vine, Pistachio, Oleander, Rosa, Plane-tree, Syringa argentea, and the country of Rice, Grapes, Melons, Maize, &c. 2. From 1000 to 4000 feet, the zone of Quercus Ægilops and infectoria, and other Oaks, and the country of Pears, Apples, Plums, &c. 3. From 4000

* Trans. Brit. Assoc. 1851, p. 73.

† For full details relative to the Himalayan Flora, see Thomson's Travels in Thibet and Hooker's Journal of an Oriental Naturalist.

to 5000 feet, the zone of Lonicera alpigena, Jasmine, Amygdalus nana and Astragalus verus. 4. From 5000 to 7000 feet, the zone of Astragalus Tragacantha, Rhamnus saxatilis, Pæony, Fennel, Primula Auricula, Eranthis hyemalis, Crocus alpestris. 5. From 7000 to 9000 feet, the zone of Saxifrages, Alchemilla alpina, Gentiana asclepiadea, Veronica aphylla and saxatilis, and Polytrichum septentrionale.

1628. If we examine the vegetation of the mountains of Europe we shall find a series of similar changes. In the regions of the plains and lower hills of the Alps, extending to 1700 feet, the Vine grows; to this succeeds the zone of Chestnuts, which extends to 2500 feet; the zone of the Beech, and of the higher dicotyledonous trees, reaches from 2500 to 4000 feet; we then come to the sub-alpine region, the zone of Coniferæ, extending to about 6000 feet, in which are found the Scotch Fir, the Spruce, the Larch, and the Siberian Pine, along with certain sub-alpine forms of herbaceous plants; next comes the alpine region, or the zone of shrubs, extending to 7000 feet, characterised by Rhododendron hirsutum, and R. ferrugineum, which represent the Bejarias of the Andes; finally, we reach the subnival region, extending to 8500 feet, and comprehending the part between the limits of shrubs and the snow-line, where we meet with numerous species of Ranunculus, Draba, Saxifraga, Gentiana, Primula, and Poa, besides other genera belonging to Ranunculaceæ, Cruciferæ, Caryophyllaceæ, Leguminosæ, Compositæ, Gramineæ, Lichenes, and Musci. On some of the Alps we find flowering plants reaching to the height of between 10,000 and 11,000 feet or more. Schlagintweit* found, on the central and southern Alps, at from 10,650 to 11,700 feet, Androsace glacialis, A. helvetica, Cerastium latifolium, Cherleria sedoides, Chrysanthemum alpinum, Gentiana bavarica, Ranunculus glacialis, Saxifraga bryoides, S. oppositifolia, and Silene acaulis. The extreme limit of Mosses in the Alps is in general little above that of Phanerogamous plants. The last Lichens are to be found on the highest summits of the Alps, attached to projecting rocks, without any limitation of height.

1629. On the Pyrenees the following zones are observed :—1. The zone of Vine and Maize cultivation, and of the Chestnut woods. 2. A zone extending from the limit of the Vine to about 4200 feet, at which limit the cultivation of Rye ceases; here we meet with Buxus sempervirens, Saxifraga Geum, Erinus alpinus, Arnica montana, &c. 3. From the limit of the cultivation of esculent vegetables at 4200 feet, to the zone of the Spruce Fir. 4. From the limit of the Spruce Fir zone at 6000 to 7200 feet, characterised by the presence of the Scotch Fir. 5. From 7200 to 8400 feet, is an alpine zone, characterised by the dwarf Juniper, Draba aizoides, Saxifraga bryoides, Soldanella alpina, Juncus trifidus, &c. 6. A zone above 8400 feet, exhibits a few alpine species, as Ranunculus glacialis, Draba nivalis, Stellaria cerastoides, Androsace alpina, and Saxifraga gröenlandica.

* Pflanzengeographie Untersuchungen. See Annals Nat. Hist. July 1851, and Linn. Trans.

1630. Desmouslins, in his Flora of the Pyrenees, mentions the limits of several alpine species.

	French Feet.		French Feet.
Cochlearia pyrenaica	5500 to 6000	Parmelia chrysoleuca	5400 to 9000
Herniaria pyrenaica .	3000 to 7500	„ cartilaginea, elegans, cinerea, badia	9000
Astragalus depressus	7500 to 8400	Lecidea geographica .	9000
Vicia pyrenaica . .	8500	Umbilicaria cylindrina	6000 to 9000
Pedicularis pyrenaica	9000		
Anictangium ciliatum	8400		

Massot gives the following limits of ligneous plants on the Canigou in the Pyrenees, which rises to the height of 9136 feet.

	Feet.		Feet.
Cultivation of Olive . . .	1378	Lonicera Xylosteum . . .	5134
Abundant cultivation of Vine	1804	Corylus Avellana	„
Euonymus europæus . . .	„	Fagus sylvatica	5324
Acer monspessulanum . .	2296	Limit of cultivation of Potato, and Rye harvest in beginning of September.	„
Attempted cultivation of Vine	2460	Amelanchier vulgaris . . .	„
Sarothamnus scoparius . .	„	Populus tremula	5380
Alnus glutinosa	2624	Pyrus Aucuparia	6029
Castanea vesca	2624	Pinus Picea	6396
Rye harvest middle of July .	„	Sambucus racemosa . . .	6768
Cornus sanguinea	„	Pinus Abies	7921
Ilex Aquifolium	3240	Genista purgans	„
Prunus spinosa	3444	Rhododendron ferrugineum .	8332
Cratægus Oxyacantha . . .	4100		
Rubus fruticosus	4336		
Pyrus Aria	5134		

1631. There are thus in lofty mountain districts evident belts of vegetation. At the lower part is the region of Lowland Cultivation, where the ordinary cultivated plants of the country thrive. In cold regions this is very limited, while in warm regions it is extended; on Teneriffe and Ætna it rises to 3000 feet, and includes the Vine district, while on the Andes its limit is from 5000 to 6000 feet. To this region succeeds that of Trees. In high northern latitudes, as at 70°, it reaches to between 700 and 800 feet; on Ætna to 6200; on the Andes to 10,800, and it is marked by Escallonia myrtilloides, Aralia avicennifolia, and Drymis Winteri; on the mountains of Mexico to 12,000 feet, and is marked by Pinus Montezumæ; on the south side of the Himalaya to 11,500, and on the north side to 14,000,—being limited on the former by Quercus semecarpifolia and Coniferæ, and on the latter by the Birch. On the Pyrenees its limits are marked at about 7000 feet by Pinus uncinata, on the Alps at about 6000 feet by Pinus Picea, on the Caucasian mountains at 6700 feet, and in Lapland at about 1500 feet by the Birch. Next in order comes the Shrubby region, the limits of which in Europe are marked by Rhododendrons, which cease on the Alps at 7400 feet, and on the Pyrenees at 8332 feet; on the Andes it is limited by Bejarias and shrubby Compositæ, at a height of 13,420 feet; on the south side of the Himalaya, by species of Juniper, Willow, and Ribes, at an elevation of 11,500 feet, and on the north side by Genista versicolor, at 17,000 feet. In Lapland, species of Willow and Vaccinium, with the dwarf Birch, reach 3300 feet. As Rhododendron hirsutum and ferrugineum succeed the arborescent vegetation of the Swiss Alps, and R. ferrugineum that of the Pyrenees, so does R. lapponum succeed the Conifers in Lapland and R. caucasicum on the Caucasus. The next region is that of Grasses, which on the Andes and the Himalaya, extends to between 14,000 and 15,000 feet. On the Andes the limit of flowering plants may be said to be at about 13,000 or 14,000 feet; and there we meet with the yellow flowering Compositæ, Culcitium rufescens, C. ledifolium, and C. nivale, along with Sida pichinchensis, Ranunculus nubigenus, and R. Gusmanni, Myrrhis Andicola, and Fragosa aretioides. Saxifraga Boussingaulti has been found on Chimborazo at the height of 15,773 feet. In the Mexican part of the tropics the zone nearest snow exhibits Cnicus nivalis, and Chelone gentianoides; on the cold mountain region of New Grenada we meet with the woolly Espeletia grandiflora, E. corymbosa, and E. argentea, which represent the Culcitiums of the Andes. Finally, we come to the region of Cryptogamic plants, which extend to the snow-line, Lichens being the last plants met with.

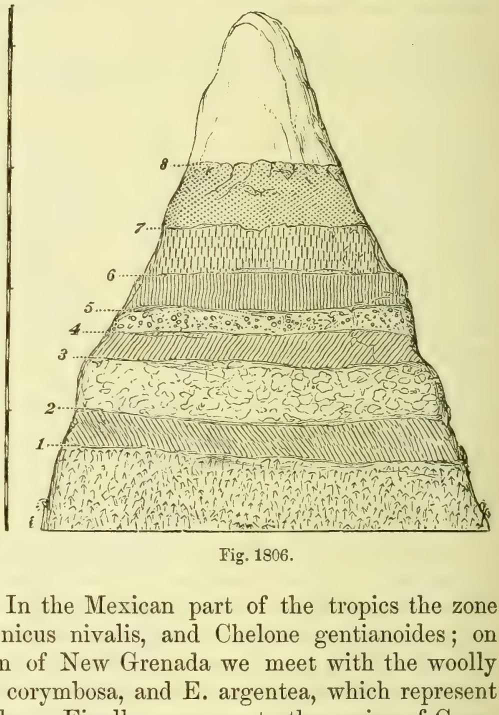

Fig. 1806.

1632. In contrasting the zones of altitude with those of latitude, Meyen gives the following regions of alpine vegetation:—The region of Palms and Bananas (equatorial) extending from the sea level to 1900 feet; the region of Tree-ferns and of Figs (tropical) 1900 to 3800 feet; the region of Myrtles and Laurels (subtropical) 3800 to 5700 feet; region of evergreen dicotyledonous trees (warm temperate) 5700 to 7600 feet; region of deciduous dicotyledonous trees

Fig. 1806. Plan of a lofty mountain in the torrid zone, with a scale indicating the number of feet, each division of the scale being equal to about 1000 feet. 1, Region of Palms. 2, Region of Tree Ferns. 3, Regions of the Vine. 4, Limit of ordinary large trees. 5, Limit of Cinchona. 6, Shrubby region. 7, Region of Grasses. 8, Region of Lichens.

(cold temperate) 7600 to 9500 feet; region of Abietineæ (subarctic) 9500 to 11,400 feet; region of Rhododendrons (arctic) 11,400 to 13,300 feet; region of alpine plants (polar) 13,300 to 15,200. In Figure 1806, a representation is given of the forms of vegetation on a tropical mountain. No. 1 is the region of Palms and Bananas, which is 3000 to 4000 feet above the level of the sea, the temperature ranging from 81° to 71°. No. 2, the region of Tree-ferns, reaching to about 5000 feet, mean temperature 66°. No. 3 indicates the limit of the Vine in lat. 16°.24′ S. at about 7000 feet. No. 4, the limit of ordinary great trees, mean temperature being 61°. No. 5, limit of Cinchona, extending to 9000 or 10,000 feet on the Andes. No. 6, shrubby region, marked on the Andes by Bejarias at about 10,000 feet. No. 7, region of Grasses. No. 8, region of Lichens, and the snow-line at about 15,000 or 16,000 feet.

X—SCHOUW'S PHYTO-GEOGRAPHIC REGIONS.

1633. In dividing the globe into Phyto-geographic regions, Schouw takes into account the nature of the flora in regard to species, genera, and orders, irrespective of the effects they may produce on the physiognomy of the country. In constituting a botanical region, he lays down the principle that at least one-half of the species and one-fourth of the genera should be peculiar to it, and that individual orders should either be peculiar to it or reach their maximum in it. He constitutes 25 Regions :—1. Region of Saxifrages and Mosses. 2. Region of Umbelliferæ and Cruciferæ. 3. Region of Labiatæ and Caryophyllaceæ. 4. Region of Asters and Solidagos. 5. Region of Magnolias. 6. Region of Camellias and Teas. 7. Region of Zingiberaceæ. 8. Himalayan Alps. 9. Asiatic Islands. 10. Mountains of Java. 11. Islands of the Pacific. 12. Region of Balsam trees. 13. The Desert Region. 14. Region of Tropical Africa. 15. Region of Cactuses and Peppers. 16. Mountains of Mexico. 17. Region of the Medicinal Barks. 18. Region of Calceolarias and Escallonias. 19. West Indian Region. 20. Region of Palms and Melastomas. 21. Region of Tree Compositæ. 22. Antarctic Region. 23. Region of Mesembryanthemums and Stapelias. 24. Region of Epacridaceæ and Eucalypti. 25. Region of New Zealand.

1634. Region I.—The region of Saxifragaceæ (p. 822) and Musci (p. 957), or the Alpine Arctic Flora.—This embraces the north polar lands from the limits of ice to the zone of trees, or what is called the Arctic flora, in which Carices abound; and the upper parts of the mountains of Europe and northern Asia from the snow-line down to the arborescent belt, or the Alpine flora, in which Primulaceæ and Phyteumas are prevalent. The region in general is characterised by the abundance of Mosses and Lichens, by the presence of Saxifragaceæ, Gentianaceæ, Caryophyllaceæ, Cyperaceæ, and Salicaceæ, by the total absence of tropical orders, by a marked decrease in the forms peculiar to the temperate zone, by forests of Coniferæ and Betulaceæ, by the small number of annual plants and the prevalence of perennial species, and by the liveliness of the colours of the flowers. The mean temperature of the arctic division is 41° to 66°, that of the alpine districts is 36° to 47°. In this region there is no cultivation.

1635. REGION II.—The region of Umbelliferæ (p. 824) and Cruciferæ (p. 758).—This extends over northern Europe and Asia from the southern limit of the last region to the Pyrenees, the Alps, the Balkan mountains, the Caucasus, and the Altai; the mean temperature being 36° to 57°. It is distinguished by the presence of Umbelliferous and Cruciferous plants. Coniferæ, Amentiferæ, Ranunculaceæ, Rosaceæ, and Fungi, are abundant. The trees are usually deciduous. In the northern part of this region Cichoraceæ prevail, while in its southern, as in Asiatic Russia, Cynarocephalæ, Astragaluses, and Saline plants seem to have their maximum. Barley, Oats, Rye, Wheat, and Buckwheat, are cultivated along with the ordinary fruit-trees and culinary vegetables of temperate regions.

1636. REGION III.—The region of Labiatæ (p. 866) and Caryophyllaceæ (p. 767) or the Mediterranean Flora.—This comprises the countries of the Mediterranean Sea, Spain, the south of France, Italy, Greece, Asia Minor, Egypt, the whole of northern Africa to the Sahara and the great Atlas chain, the Canaries, and Madeira. The upper mountain regions belong to Schouw's first region and the middle to his second. The mean temperature is 54° to 72°. The region is characterised by the prevalence of plants belonging to the Labiate and Clovewort orders. Species of Compositæ, Galiaceæ, and Boraginaceæ also abound, and there is an increase in the plants belonging to the orders Leguminosæ, Malvaceæ, Solanaceæ, Urticaceæ, and Euphorbiaceæ. Some tropical families are represented by Palms, Laurels, Arums, Pistacias, and Millet. It is the region of evergreen trees. In Spain species of Cistus are prevalent, in the south of France and in Italy aromatic Labiatæ and Scabiosas. Besides the plants cultivated in the last region, there are also Rice, Guinea-corn, the Olive, Fig, Almond, Orange, and Cotton. Among the plants of the Mediterranean flora, requiring both a warm summer and a warm winter, may be enumerated Oleander, Aloe, Chamærops humilis, Phœnix dactylifera, Capparis, Ceratonia Siliqua, Cyclamen Clusii, Ornithogalum arabicum, arborescent species of Dianthus, several Ferns; and of cultivated plants, Ricinus communis, Egg-plant, Hibiscus esculentus, Capsicum, Acacia Farnesiana, Phaseolus Caracalla, Sterculia platanifolia, and Schinus Molle. In the island of Madeira we meet with Erica arborea, Vaccinium maderense, and many peculiar species. Of 596 species inhabiting Madeira and Porto Santo 108 are endemic, and of the 108, 28 are common to Madeira and the Azores. Of the Azorean species

4-5ths are European, and may have been carried by man; of the remaining fifth nearly the whole are peculiar to the Azores or to the archipelago of the Atlantic Islands, which includes also Madeira and the Canaries. In the latter we meet with Pinus canariensis.

1637. Region IV.—The region of Asters and Solidagos.—This extends over the northern part of North America from the limits of the first region to the parallel of 36° north. Besides the number of species of Aster and Solidago (belonging to Compositæ, p. 835), this region is marked by a great variety of Oaks and Firs, by numerous species of Vaccinium, by the smallness of the number of Cruciferæ, Umbelliferæ, Cinchonaceæ, Cynarocephalæ, and by the absence of the genus Erica. The mean temperature is 54° to 72°. In the northern part of the region there is no cultivation. In the southern the cultivated plants are similar to those of the second region, and Maize is very frequent.

1638. The Californian and Oregon districts, to the west of North America, constitute a region not yet fully explored. Many showy Polemoniaceæ are found here; also Eschscholtzia californica, species of Platystemon, Nemophila, Gilia, Collinsia, Clarkia, Bartonia, and Eutoca. Many interesting Coniferæ also occur, such as Abies Douglasii, Pattoniana, nobilis, amabilis, grandis, lasiocarpa, Pinus Lambertiana, Sabiniana, insignis, Jeffreyi, ponderosa, monticola, californica, Fremontiana, Coulteri, flexilis, muricata, tuberculata, Libocedrus decurrens, Thuja gigantea, Sesquoia gigantea, Juniperus dealbata and occidentalis, Castanea chrysophylla. In the upper Oregon districts Geyer enumerates Umbelliferæ, Scrophulariaceæ, Asphodeleæ, Polemoniaceæ, Boraginaceæ, Vacciniaceæ, Ranunculaceæ, Cruciferæ, Onagraceæ, Rosaceæ, Polygonaceæ, Labiatæ, Caryophyllaceæ, Compositæ, Gramineæ, species of Mahonia, Lewisia, Geranium, Ribes, Lobelia, Clintonia, Pentstemon, Camassa, Horkelia, and Eriogonum. The bulk of the wood in upper Oregon is composed of Pinus ponderosa, and along with it occur Abies balsamea, canadensis, Douglasii, nobilis, and alba. In the basaltic plains of upper Oregon, Geyer says there are no Papaveraceæ, Urticaceæ, Violaceæ, Vitaceæ, Solanaceæ, Jasminaceæ, Amaranthaceæ, Eleagnaceæ, Oxalidaceæ. Vivid colours mark this region. Blue and purple eastward; scarlet with golden-yellow westward; glaucous green reigns in the herbage over the plains; deep saturated green in the valleys.* In Vancouver's Island, there are many interesting Pines and Oaks, also Rhododendron macrophyllum.

1639. Region V.—The region of Magnolias (p. 750).—This embraces the southern part of North America between the parallels of 30° and 36°. Here we meet with numerous tropical forms, as Zingiberaceæ, Cycadaceæ, Anonaceæ, Sapindaceæ, Melastomaceæ, and Cactaceæ. From the corresponding latitudes in the Old World, it is further distinguished by a smaller proportion of Labiatæ and Caryophyl-

* Hooker's Journal of Botany, 1846, *et seq.*

laceæ, and by having more trees with broad shining foliage and showy blossoms, such as Magnolia, Liriodendron, Æsculus, and with pinnated leaves, as Robinia, Gleditschia, and Acacia. Mean temperature 59° to 72°. The cultivated plants are the same as those of Schouw's 3d region; Rice is a common grain here, and the Sugar-cane and Cotton are productive.

1640. Region VI.—The region of Ternstrœmiaceæ (p. 773) and Celastraceæ (p. 794) or the Japanese region.—This extends between the parallels of 30° and 40° north latitude, and embraces Japan, the north of China, and Chinese Tartary, constituting the eastern temperate parts of the Old World. The flora seems to be intermediate between that of the Old and the New World. The vegetation is more tropical than European, for we meet with Zingiberaceæ, Musaceæ, Palmæ, Cycadaceæ, Anonaceæ. The genera Camellia, Thea (Figs. 1420 and 1421, p. 773), Citrus, Rhamnus, and Lonicera, are abundant. Among the more characteristic species are Eriobotrya japonica the Loquat, Cryptomeria japonica, Salisburia adiantifolia, Pæonia Moutan, Anemone japonica, Stillingia sebifera the Tallow-tree, Camphora officinalis, Azalea sinensis, Wistaria sinensis, Gossypium religiosum, Enkianthus quinqueflorus, Cymbidium sinense, Pinus sinensis, P. Jezöensis, Juniperus rigida, J. chinensis, Podocarpus Nageia, and species of Biota. The mean temperature is 54° to 68°. The cultivated plants are Wheat, Barley, Oats, Rice, Millet, and Buckwheat, the ordinary fruits of temperate climates, along with the Orange, Melon, and Cotton.

1641. Region VII.—The region of Zingiberaceæ (p. 921) or the Indian Flora.—This embraces India, the island of Ceylon, and the south-eastern peninsula, to the height of 4500 to 5500 feet above the level of the sea. There are here numerous species belonging to the Ginger order as well as to Leguminosæ, Cucurbitaceæ, and Tiliaceæ. The Coco-nut, Mangosteen, Turmeric, Cinnamon, Cotton, Indigo, Clove, and Pepper, are abundant. In the island of Ceylon we meet with Salvadora persica, Feronia Elephantum, Thespesia populnea, Chloroxylon Swietenia, Schleucheria trijuga, and Borassus flabelliformis. Rice and various kinds of Millet and Guinea-corn are cultivated in this region. Mean temperature 65°.75 to 81°.50.

1642. The south of China and Cochin-China may be considered as a distinct region. It partly resembles that of India, but contains many peculiar plants. In the island of Formosa occurs Aralia papyrifera the Rice-paper plant; near Hong Kong are found Chirita sinensis, Rhodoleia Championi, Arundina sinensis, Spathoglottis Fortuni, Cunninghamia sinensis, Olea fragrans, Campanula grandiflora, Brassica chinensis, Enkianthus reticulatus, and the Litchi and Longan fruits.

1643. Region VIII.—The Emodic region.—This embraces the alpine region of India south of the ridge of the Himalaya, including Sirmore, Gurwal, Kemaon, Nepal, and Bhotan, to a height of from 4500 to 10,700 feet above the level of the sea. Some European species are met with in these high districts, for instance, Ranunculus sceleratus, Nasturtium officinale, Veronica Anagallis, and Polygonum amphibium. Cedrus Deodara, Pinus excelsa, P. longifolia, Picea Webbiana, and other Coniferæ, along with Chamærops Khasyana, species of Oak, Dammar, Rhododendron, Berberis, Primula, &c., also occur. In the lower parts of the region tropical plants grow. The mean temperature is 37° to 66°. Many European grains and fruits are cultivated along with mountain Rice.

1644. Region IX. — The region of the Asiatic Islands. — This comprises the mountainous districts of the islands between the south-eastern peninsula and Australia, to a height of 5500 feet above the level of the sea. Myristica moschata, Dryabalanops Camphora, and Dammara orientalis, grow in this region. Much of it is still unexplored. The same plants are cultivated as in India, and we also find Carica Papaya (Fig. 1494, p. 815), Artocarpus incisa (Fig. 1653, p. 890), Jatropha Manihot, Broussonetia papyrifera, Gossypium vitifolium. The mean temperature is 66° to 84°.

1645. Region X. — The region of Upper Java. — This comprehends those districts of the island of Java, and probably also the numerous islands of the Asiatic archipelago, having an absolute elevation of 5500 feet above the level of the sea. Little is known in regard to the vegetation.

1646. Region XI.— The Polynesian region. — This comprises all the islands of the Pacific ocean within the tropics. Among the plants of this region may be mentioned Artocarpus incisa, Tacca pinnatifida the Pia, which yields a kind of Arrow-root, Cocos nucifera (Fig. 166, p. 70), Lodoicea seychellarum (Fig. 1277, p. 640), Jambosa malaccensis the Ohiaai, and many species of Arum, Dioscorea, Musa, and Ficus. The genera Dissochæta, Orophea, Pterisanthes, Arthrophyllum, and Visenia, occur in this region. The mean temperature is 72° to 82°. Many valuable fruits are cultivated as food. In the Sandwich Islands, belonging to the Hawaiian group, nearly one-third of the vegetation is composed of Ferns. There are three Palms, the Coco-nut and two species of Livistona. The rest of the flora consists of Myrtles, Grasses, Sedges, Mimoseæ, and Arums. Acacia heterophylla, called Koa, yields durable timber. The root of Dracæna terminalis, called Ki, is eaten. The fruit of Physalis pubescens is used; also the fruit of Pandanus odoratissimus, called Lahala; that of Osteomeles anthyllidifolia, the Ulei; that of Morinda citrifolia, the Noni; and that of Morus indica, the Kilica. Colocasia esculenta, the Kalo, is used as a vegetable. Cloth is made from Broussonetia papyrifera and Boehmeria albida, cordage from Paritium tiliaceum, water-flasks from Lagenaria vulgaris, and Macropiper methysticum is the great remedy for diseases. Peculiar Compositæ, Lobeliaceæ, Goodeniaceæ, and Cyrtandreæ, are met with in those islands.

1647. Region XII.—The region of Amyridaceæ (p. 798).— This includes the south-western part of the highlands of Arabia. In the flora are many trees yielding gum and balsamic resins, such as species of Mimosa, Acacia, Balsamodendron, and Amyris. Coffee and the Sensitive-plant occur here. In this district are cultivated Maize and Millet, the Date, the Vine, Sugar-cane, Cotton, and Indigo.

1648. Region XIII. — The Desert region. — This comprehends northern Africa, to the south of the Atlas Mountains, between lat. 15° and 30° north, and the northern part of Arabia. Phœnix dactylifera (Fig. 1743, p. 934) and Hyphæne thebaica (Fig. 1745, p. 935) are characteristic plants of the region. The cultivation of Guinea-corn, Wheat, Millet, and other grains of the south of Europe and India, is confined to the banks of the Nile and the Oases. The mean temperature is 72° to 86°.

1649. Region XIV.—The region of tropical Africa.—This comprises that part of Africa which lies between 15° north latitude and the Tropic of Capricorn, or more correctly, between the northern and southern limits of periodical rains, with the exception of Abyssinia and the unknown countries of the interior. On the western part of this region, Elais guineensis the Palm-oil plant (Fig. 82, p. 37), and Adansonia digitata the Baobab (Fig. 176, p. 73), grow. Vogel noticed near Cape Coast Castle, Arachis africana, Bignonia tulipifera, Euphorbia drupifera, Hibiscus populneus, and Blighia sapida the Akee. He also mentions in this West African flora, Sarcocephalus esculentus, Schmidelia africana, Borreria kohautiana, and a species of Stylosanthes. On the coast of Guinea and Congo, the flora is intermediate between that of America and Asia, but chiefly resembling the latter. Species of Sorghum, Sterculia acuminata the Kola-nut, and the Poison-bean of Calabar, belong to this region. Near Abbeokouta, Dr. Irving noticed in cultivation, Cotton, Indigo, Tobacco, Sugar-cane, Ginger, Yams, Cassada, Rice, Maize, Guinea-corn, Arrow-root, Bananas, Coco-nuts, Papaw, Oranges, Pine-apples, Bamboo, and Hibiscus esculentus or Ochro. On the eastern part of this region, which includes Madagascar, we meet with Tanghinia venenifera, species of Ambora, Danais, Didymomeles, Dombeya, Dufourea, and Senacea. The mean temperature of the region is 72° to 86°.

1650. Region XV. — The region of Cactaceæ (p. 819), and Piperaceæ (p. 894).—This embraces Mexico, Guatemala, the Isthmus of Panama, and South America as far as the river Amazon, and to an elevation of 5500 feet above the level of the sea, between lat. 30° N. and the equator. Guiana, New Grenada, and certain parts of Peru are included. Cactuses and Peppers abound in this region. Seemann says that the Isthmus of Panama is characterised in part by the leaves of the plants being covered with hair and tomentum, by the abundance of greenish, yellow, and white flowers, and by the numerical superiority of Leguminosæ, Melastomaceæ, Compositæ, Cinchonaceæ, Orchidaceæ, and Filices. In the northern part of South America, Mauritia flexuosa, the Murichi or Ita Palm, is found. In this region, as well as in the whole of the warm parts of eastern

South Ameriea, Victoria regia (Fig. 235, p. 107) occurs. Phytelephas macrocarpa, the vegetable ivory palm, is a native of Columbia and Peru; Humboldt found it in New Grenada, and on the banks of the Magdalena river. Anona Cherimolia yields the Cherimoyer, a famous Peruvian fruit. Many tropical plants are cultivated here, such as Maize, Guinea-corn, Yams, Plantains, Coco-nut, Chocolate, Vanille, Sugar, Coffee, and Cotton.

1651. Region XVI.—The region of the Mexican Highlands.—This embraces the districts of Mexico which have an elevation of more than 5500 feet above the level of the sea. Some important Coniferæ are met with here, such as Pinus religiosa, P. apulcensis, P. Hartwegii, P. Montezumæ, and Taxodium distichum. The mean temperature is 64° to 78°. Maize and many European grains and plants are cultivated.

1652. Region XVII. — The region of Cinchonas or medicinal Bark-trees (p. 829). This comprehends the Cordilleras of South America, between the parallels of 5° N. lat. and 20° S. lat., at an elevation of 5000 to 9600 feet. The mean temperature is 59° to 68°. The Cinchona region is seen on Humboldt's map, which is appended. Here the various kinds of yellow, red, and pale Bark thrive. In the lower part of the region Coffee and Maize are cultivated, and in the higher regions the European grains and fruits, along with the Potato and the Chenopodium Quinoa. Ceroxylon Andicola (Fig. 83, p. 37) is also found in this region of the Andes.

1653. Region XVIII.—The region of Escallonias (p. 822) and Calceolarias (p. 866). — This comprises the highest districts in South America above the upper limit of Cinchonas. The mean temperature varies from 59° to 84°. Besides Escallonias and Calceolarias, we meet with many alpine plants, such as species of Gentiana, Ranunculus, Saxifraga, Stellaria, Draba, Potentilla, Lobelia, Geranium, Salvia, Tussilago, Espeletia, Aster, also Drimys Winteri, Junci, Carices, and Grasses.

1654. Region XIX. — The West Indian region. — This region comprehends the West Indian Islands, the flora of which may be said to be intermediate between that of Mexico and the northern parts of South America. Ferns and Orchids prevail. Mean temperature 59° to 78°. Many tropical fruits are met with, such as Mango, Guava, Banana, Avocado-pear, and Custard-apple. The cultivated plants are the same as those in the 15th region.

1655. Region XX. — Region of Palms (p. 934) and Melastomas (p. 808). — This comprises that part of South America to the east of the Andes which lies between the equator and the tropic of Capricorn. Mean temperature 59° to 82°. Here we have the luxuriant Brazilian flora, as illustrated in Humboldt's map; Palms, Melastomaceæ, Myrtaceæ, Tree-ferns, and Crotons, form the thick underwood, and beneath these, delicate herbaceous Ferns. Dorstenias, Heliconias, with a few tall Grasses, are found in the open parts. Arborescent Solanums, Vernonias, and large Compositæ, species of Ficus, Laurus, Cassia, Lasiandra, Solandra, and Fuchsia occur. Gardner states,—"In place of the few Mosses and Lichens which cover the trunks and boughs of the forest trees of temperate climes, in Brazil they are bearded from the roots to the very extremities of the smallest branches, with Ferns, Araceæ, Tillandsias, Cactuses, Orchids, Peperomias, Gesneras, and other epiphytic plants. Many large trunks are encircled with twining stems of Bignonias, and shrubs of similar habit; the branches of which frequently become thick, and compress the tree so much, that it perishes in the too close embrace." On the mountains of Minas Geraes, species of Vellozia, Lichnophora, and Eriocaulon, give a peculiar feature to the vegetation. Tropical plants are cultivated.

1656. Region XXI.—The region of arborescent Compositæ.—This embraces South America on both sides of the Andes from the tropic of Capricorn to lat. 40° south. In it are included the southern part of Brazil, La Plata, and Chili. Mean temperature 59° to 75°. In many respects the flora resembles that of the mountainous districts, in the presence of Calceolarias, Escallonias, species of Weinmannia, Buddlea, and Campanula. In Chili there are many genera which also are represented in Australia and at the Cape of Good Hope; among which may be noticed Protea, Gunnera, Goodenia, Araucaria, and Ancistrum. Araucaria imbricata, the Banksian or Chili Pine, is a hardy Conifer of this district, extending on the Chilian Andes from 37° to 40° S. lat. Thuja chilensis occurs on the mountains of south Chili. In this region we also meet with Thuja tetragona the Alerse of Chili, and Podocarpus chiliana. Araucaria braziliana is found on the mountains near Rio Janeiro in the province of St. Pauls. Many European plants are cultivated; among others, Wheat, the Vine, and the Peach.

1657. Region XXII.—The Antarctic region.—This embraces the southern part of America, the straits of Magalhaens, Tierra del Fuego or Fuegia, the Falkland Islands, and others more to the south. Mean temperature 41° to 46°. Many mountainous plants are found in this region. The vegetable forms of the north temperate and arctic zones prevail. Species of Saxifraga, Gentiana, Arbutus, and Primula, with many other European genera, abound. In Fuegia the Evergreen Beech, Fagus Forsteri, which never sheds its coriaceous foliage, is a very prevalent tree, also the Deciduous Beech, Fagus antarctica, the leaves of which change colour and fall, and Drymis Winteri (Fig. 1358, p. 750). These three trees occupy exactly the same position in Fuegia that the Birch, Oak, and Mountain Ash do in Scotland. The vegetation of Fuegia includes a number of British plants, though 106 degrees of ocean roll between, and some of the species in question inhabit no intermediate latitudes. The genera are in a great measure identical with those of Britain. Fuegia is the native place of the Fuchsia. In the Falkland Islands there are about 120 flowering plants, consisting chiefly of those found on the mountains of Fuegia, and on the arid coast and plains of Patagonia. Grasses and Bolax glebaria the Balsam-bag (one of the Umbelliferæ), form the chief botanical features. Dactylis cæspitosa, the Tussac-grass (Fig. 1767, p. 949), appears, Hooker remarks, like a forest of miniature Palms. It forms hillocks about six feet high, and 4-5 in diameter, some of the blades of grass being six feet long. Bolax glebaria forms hard hummocks four feet high and the same diameter, which give out a balsamic resinous smell. Their form and occurrence on this barren soil has given rise to the name of Misery-balls. Among shrubby plants may be noticed Veronica elliptica and decussata, Chiliotrichum amelloides, Empetrum rubrum, and Pernettia empetrifolia. Of Ferns, Lomaria alpina and L. magellanica are found. Lichens abound, and the Usnea melaxantha forms a miniature shrubbery on the rocks. In the islands farther south, Mosses and Lichens form the chief flora.

1658. Region XXIII.—The region of Mesembryanthemums (p. 818) and Stapelias (p. 852).—This embraces southern Africa from the tropic of Capricorn to the Cape Coast. Mean temperature 55° to 73°. Besides species of Mesembryanthemum and Stapelia (Fig. 1570, p. 852), there are a prodigious number of species of Erica. The latter genus attains its maximum here. We also meet with species of Gnaphalium, Elichrysum, Pelargonium, and Aloe, with plants belonging to the orders Iridaceæ, Bruniaceæ, and Selaginaceæ. Pachylepis cupressoides and P. juniperoides are Cape Conifers. Thalictrum caffrorum and Conium africanum are South African species. On Table Mountain at the Cape, peculiar species of Disa are found. Many European grains and fruits are in cultivation along with Sorghum caffrorum and Convolvulus Batatas. In Natal, where the mountains rise to nearly 10,000 feet, Krauss distinguishes a coast or forest region where species of Rhizophora, Avicennia, Ficus, Tabernæmontana, Zygia, and Phœnix reclinata, are found; a hilly pasture region with species of Acacia, Aloe, Euphorbia, Andropogon, and tropical Leguminosæ, Labiatæ, Acanthaceæ, and Scrophulariaceæ; a mountainous region with species of Podocarpus, Ixia, Hypoxis, Watsonia, also Ferns, Cyperaceæ, Orchids, Proteaceæ, and Geraniaceæ.

1659. Region XXIV.—The region of Epacridaceæ (p. 848) and Eucalypti (p. 810).—This comprehends Australia beyond the tropics with the island of Tasmania or Van Diemen's Land. Mean temperature 52° to 72°. The number of known Australian plants amounts to about 7000 or 8000. Müller makes the following observations on the flora of Australia.* The flora of Australia approaches in its tropical portion to the plants of India, and in its extra-tropical portion to those of South Africa. The flora may be divided into a western, southern, eastern, and Tasmanian flora. In the western districts Leguminosæ and Proteaceæ predominate, forming one-fourth of the entire vegetation; Ferns and Grasses are rare. In the southern flora, Compositæ and Leguminosæ abound along with Salsolas, Myoporaceæ, Halorageaceæ,

* Hooker's Journal of Botany, or Kew Garden Miscellany, 1853, p. 65.

Caryophyllaceæ, and Cruciferæ. The genus Mesembryanthemum is here seen as a connecting link with the South African flora; Nitraria with the Siberian, and Crantzia with the North American flora. In the eastern flora Proteaceæ and Epacridaceæ are found, with fewer Compositæ than in the south, and a larger number of Ferns and Grasses than in the western district. On Brisbane mountains, near Moreton Bay, we meet with Araucaria (Eutassa) Bidwillii, the Bunya-Bunya, and in the same district Araucaria (Eutassa) Cunninghami, the Moreton Bay Pine. The Tasmanian flora is an insular one. Ferns abound, Goodeniaceæ are scarce, Loranthaceæ and Cæsalpinieæ are awanting. Plants are found belonging to the natural orders Stackhousiaceæ, Tremandraceæ, Proteaceæ, Stylidiaceæ, Myrtaceæ, Restiaceæ, Diosmeæ, Casuarinaceæ, and Mimoseæ. In South Australia Compositæ form 1-8th of the whole vegetation; Compositæ and Leguminosæ form together one-third of the whole of the Dicotyledons. Nearly 100 of the plants now growing wild have been introduced from Europe and the Cape. The introduction of European culture is changing the aspect of Australia as well as its climate. Rain now falls where none did before. The flora of South Australia has been divided into two marked forms, that of the Grass-land and that of the Scrub. Grass-land resembles European pastures. Along with it there are associated light park-like forests of Eucalypti, with their smooth stems robbed of their outer bark, standing at regular intervals, and their crowns never in contact with each other. In poorer soil Casuarinas grow, also gummiferous Acacias, as A. retinoides and pycnantha, and species of Bursaria, and Grevillea, along with occasional Melaleucas or Leptospermums, especially in the beds of rivers dried up in summer. The Scrub shows no turf; a few scattered Stipas and Neurachnes constitute the only grasses. There is profusion of bushes and small trees. The plants have a heath-like foliage or vertically-placed leaves, and their colour is of a dead blue-green in general. The Palm forms which occur in Australia are species of Livistona, Seaforthia, and Corypha. In the British colonies of Australia the European grains and fruits are cultivated. In Norfolk Island, which may be connected with the Australian flora, Araucaria (Eutassa) excelsa, the Norfolk Island Pine (Fig. 59, p. 26) grows to a great size. Van Diemen's Land contains 10 Coniferæ endemic to the island, according to Hooker. These are Callitris australis, Oyster-Bay Pine, 50-70 feet high; C. Gunnii, native Cypress, 6-10 feet; Arthrotaxis selaginoides, A. cupressoides, and A. laxifolia; Microcachrys tetragona, 15-20 feet; Podocarpus alpina, P. Lawrencii; Phyllocladus asplenifolia, celery-topped or Adventure Bay Pine, 50-60 feet; Dacrydium Franklinii, Huon Pine, 60 to 100 feet high, with a diameter of 2 to 8 feet. The banks of the Huon river are clothed with the loftiest and most valuable timber-trees of the colony. Sir John Ross measured some trees 180 feet high and 28 in circumference. One tree was shown to him which exceeded 200 feet in height, and was 38 feet in circumference about 3 feet from the ground.

1660. REGION XXV.—The region of New Zealand.—This includes the islands of New Zealand and those which are adjacent. Between lat. 34° and 36° S. the mean temperature is 61° to 63°. Here we meet with Phormium tenax, the New Zealand Flax-plant (Fig. 48, p. 24), Corypha australis, the southern Palm, abundance of Ferns, many of them arborescent, species of Dracæna, and many Myrtaceæ. The New Zealand Coniferæ consist of Dammara australis, Kaudi, Cowdie, or Kauri Pine, Podocarpus spicata, Mai or Matai, P. ferruginea, Miro or Maira, P. Totarra, Totarra, P. dacrydioides, Kaikatia, and others; also Dacrydium cupressinum, the Dimon Pine, D. Colensoi, D. laxifolium, and Phyllocladus trichomanoides, Tauehaha. Many European plants are cultivated. The known flora of New Zealand amounts to about 1900 or 2000 species, of which 730 are flowering plants, thus making Phanerogams to Cryptogams nearly as 2 to 3. The Phanerogamous flora of New Zealand shows a large amount of absolutely peculiar or endemic plants, which are said by Hooker to amount to 507 species, and to constitute more than 2-3ds of the whole. Among the orders to which the endemic species belong may be noticed Coniferæ, Scrophulariaceæ, Epacridaceæ, Compositæ, Araliaceæ, Umbelliferæ, Myrtaceæ, and Ranunculaceæ. The remaining 1-3d of the flora is thus analysed by Hooker—193 species are Australian, 89 are South American, 77 species common to both these countries, 60 are European, and 50 are species of the Antarctic Islands, Fuegia, &c. Among the peculiar genera of New Zealand are enumerated Anisotome, Hoheria, Phormium, Carmichælia, Tupeia, and Alseuosmia. In New Zealand there are of European species 60 Phanerogams, 50 Mosses, 13 Hepaticæ, 45 Algæ, 50 Fungi, and 100 Lichens.* The flora of the Auckland group and Campbell's Island may be considered as a continuation of that of New Zealand, differing only in being more typical of the antarctic regions. In the Auckland group the country is generally covered by Pteris esculenta, Leptospermum scoparium, Phormium tenax, and Cordyline stricta. We also meet with Vitex littoralis, Knightia excelsa, species of Metrosideros, the Kauri Pine, Cyathea dealbata, Areca sapida, and numerous Ferns. Some European plants, as Cardamine hirsuta, Montia fontana and Callitriche, are found. The woods consist of 4 or 5 species of trees or large shrubs, which are enumerated by Hooker in the order of their abundance. 1. Metrosideros lucida. 2. Dracophyllum longifolium. 3. Panax simplex. 4. Ve-

* See full details, along with interesting views of the distribution of plants, in Hooker's Flora of New Zealand, Introductory Remarks. Hooker, who adopts the view of specific centres, endeavours to account for the plants found in the New Zealand Flora, by assuming that there was at one time a land communication by which the Chilian plants were interchanged; that at the same or another epoch the Australian, at a third the Antarctic, and at a fourth the Pacific floras were added to the assemblage. The presence of antarctic plants on the lofty mountains is accounted for by attributing this to a change of climate, induced by changes in the relation between sea and land. The presence of a large continent connecting the antarctic islands, would render New Zealand as cold as Great Britain during the glacial epoch. The isolation of New Zealand afterwards would lead to an amelioration of climate, and at the same time to the retirement of the plants to the summit of the New Zealand mountains.

ronica elliptica. 5. Coprosma fœtidissima. Under the shade of these, near the sea-beach, about 15 different Ferns grow abundantly, the most remarkable of which is Aspidium venustum.

XI.—ZONES OF MARINE VEGETATION.

1661. The ocean, as well as the land, possesses its vegetable forms, which are of a peculiar kind, and exist under different conditions of pressure, of surrounding medium, and of light. Some sea-weeds, Harvey remarks, are cosmopolitan or pelagic, as species of Ulva and Enteromorpha, which are equally abundant in high northern and southern latitudes, as they are under the equator, and in temperate regions. Codium tomentosum, Ceramium rubrum, C. diaphanum, species of Ectocarpus, and several Confervæ, have a range nearly as wide. Plocamium coccineum and Gelidium corneum are common to the Atlantic and Pacific oceans; Rhodymenia palmata, the common Dulse of Britain, is found at the Falkland Islands and Tasmania. Fucus tuberculatus extends from Ireland to the Cape of Good Hope; Fucus vesiculosus occurs on the north-west coasts of America, and on the shores of Europe; while Desmarestia ligulata is found in the north Atlantic and Pacific oceans, as well as at the Cape of Good Hope and Cape Horn. Many Diatomaceæ are distributed from pole to pole. In the antarctic ocean, Hooker found the siliceous coats of Diatoms constituting a bank which stretched 200 miles north from the base of Victoria Barrier, at an average depth of 1800 feet.

1662. In general, however, Sea-weeds are more or less limited in their distribution, so that different marine floras exist in various parts of the ocean. Lamouroux estimates the marine species at 5000 to 6000, and he has shown that they are distributed in various regions. The northern ocean, from the pole to the 40th degree, the sea of the Antilles, the eastern coasts of South America, those of New Holland, the Indian Archipelago, the Mediterranean, the Red Sea, the Chinese and Japanese seas, all present so many large marine regions, each of which possesses a peculiar vegetation. The degree of exposure to light, and the greater or less motion of the waves, are very important in the distribution of Algæ. The intervention of great depths of the ocean has a similar influence on sea plants as high mountains have on land plants. Laminariæ are confined to the colder regions of the sea; Sargassa only vegetate where the mean temperature is considerable. Under the influence of the gulf-stream, Sargassum is found along the east coast of America, as far as lat. 44°; and the cold south polar current influences the marine vegetation of the coasts of Chili and Peru, where we meet with species of Lessonia, Macrocystis, D'Urvillæa, and Iridæa, which are characteristic of the antarctic flora. Melanospermeæ, according to Harvey, increase as we approach the tropics, where the maximum of the species, though, perhaps, not of individuals, is found; Rhodospermeæ chiefly abound in the temperate zone; while Chlorospermeæ form the majority of the vegetation of the polar seas, and are particularly abundant in the colder temperate zone. The green colour is characteristic of those Algæ, which grow either in fresh water or in the shallower parts of the sea; the olive-coloured Algæ are most abundant between the tide-marks; while the red-coloured species occur chiefly in the deeper and darker parts of the sea.

1663. Marine vegetation varies both horizontally and vertically, but less so than land plants, owing probably to the more uniform temperature. The ocean has been divided into different provinces of marine vegetation:—1. The Northern Ocean, from the pole to the 60th parallel of north latitude. 2. The North Atlantic, between the 60th and 40th parallels, which is the province of the species of Fucus proper. 3. The Mediterranean, which is a sub-region of the warmer temperate zone of the Atlantic, lying between the 40th and 23d northern parallels. 4. The tropical Atlantic, in which Sargassum abounds. 5. The Antarctic American regions from Chili to Cape Horn, and the whole circumpolar ocean south of the 50° of latitude. 6. The Australian and New Zealand province. 7. The Indian Ocean and Red Sea. 8. The Japan and China seas; besides certain provinces in the Pacific.

1664. As regards perpendicular direction, Forbes remarks, that one great marine zone lies between high and low water-marks, and varies in species according to the kind of coast, but exhibits similar phenomena throughout the northern hemisphere. A second zone begins at low water-mark, and extends to a depth of 7 to 15 fathoms. This is the region of the large Laminarias and other Fuci. Marine vegetation, including the lower forms, extends to about 50 fathoms in the British seas; to 70, 80, or 100, in the Mediterranean and the Ægean Sea. Ordinary Algæ, however, seem scarcely to exist below 50 fathoms. Diatomaceæ exist in the deep abysses of the ocean, and Nullipora and Corallines increase as other Algæ diminish, until they characterize a zone of depth, where they form the whole obvious vegetation. Forbes gives the following instances of the depth to which marine vegetation extends in the Mediterranean:—Codium flabelliforme and Microdictyon umbilicatum, 30 fathoms; Rityphlæa tinctoria, Chrysymenia uvaria, Dictyonemia volubilis, and Constantinea reniformis, 50 fathoms; Nullipora polymorpha, 95 fathoms. As we descend in the ocean, we reach apparently a zero of vegetable life.

1665. The distribution varies also in a latitudinal or horizontal direction. Chorda Filum lies in beds of 15 to 20 miles in length, and only about 600 feet in breadth, in the North Sea and the British Channel. Sargassum bacciferum constitutes the Gulf-weed, which has been noticed by all who have crossed the Atlantic. The Sargasso Sea occupies the eddy or whorl caused by the revolution of the current in the Atlantic, and occupies a space of 260,000 square miles.

There are two principal banks of Gulf-weed;—one, the largest, extending from 25° to 36° of north latitude, and a little west of the meridian of Fayal; the other, a short way west of the Bahamas, between the 22d and 26th degrees of latitude. The Gulf-weed has never been found attached, but always floating. In that state it is healthy, pushing out new fronds, but no fructification has been seen. Harvey conjectures that it may be a pelagic variety of Sargassum vulgare, in the same way as the variety subecostatus of Fucus vesiculosus has never been found attached, but growing in salt marshes. The most remarkable of marine plants, both for their size and the extent of their range, are the Macrocystis pyrifera and the Laminaria radiata. Immense masses of the Macrocystis, like green meadows, are found in every latitude. It ranges from the antarctic to the arctic circle through 120 degrees of latitude. It requires a mean depth of 6 or 9 fathoms. Many specimens have been seen 300 feet long. Hooker estimated some, in a strait between the Crozet Islands, at 700 feet. It girds the globe in the southern temperate zone, but not in the tropics nor in the northern hemisphere. The tribe Fucoideæ abounds towards the poles, and there the plants attain their greatest bulk, diminishing rapidly towards the equator and ceasing some degrees from the Line itself. Cystoseireæ represent the Fucoideæ in the higher latitudes of the southern hemisphere. Hooker remarks, that throughout all latitudes the two tribes Fucoideæ and Cystoseireæ form the prevailing marine vegetation, and that the genera of north cool zones are represented by others in the south. The genera Fucus and Himanthalia, in the north, are represented by D'Urvillæa and Sarcophycus in the south; so also the genera Cystoseira and Halidrys of the former are represented by Cystophora and Scytothalia in the latter. Laminarias abound in the antarctic ocean and northwards to the Cape of Good Hope. The red, green, and purple Lavers of the British seas are found at the Falkland Islands. Lessonia, with a stem 10 feet long and 12 inches in circumference, and its fronds 2-3 feet long and about 3 inches broad, is found in immense masses off the Patagonian regions. D'Urvillæa utilis is another large antarctic Sea-weed, which, along with Lessonias, is often found at the Falkland Islands, formed by the surf into enormous vegetable cables, several hundred feet long, and thicker than the human body. The stems of Lessonia, when washed ashore, look like dead wood. Of the strictly antarctic marine plants, Hooker has identified 1-5th with those of Britain. In the north-west American Sea we meet with the remarkable Nereocystis, consisting of a very long thread-like stalk bearing a large vesicle and fronds; while in the Australian and New Zealand regions we have the peculiar genera of Cystophora, Hormosira, Lansburghia, and others.

1666. The marine vegetation of the Mediterranean, compared with that of the neighbouring seas, presents a somewhat peculiar aspect. Species which inhabit the Red Sea scarcely occur in the Mediterranean, with the exception of certain cosmopolites which are almost universally distributed. The genera which are most characteristic of the Red Sea and most numerous in species, Sargassum and Caulerpa, are represented in the Mediterranean by very few, and those distinct, species. The difference is also great between the marine vegetation of the Mediterranean and Atlantic. The genus Fucus, which abounds in the Atlantic, is altogether wanting in the Mediterranean, or represented by mere floating specimens, which assume, however, a peculiar form in the Adriatic. Many species of Florideæ which abound in the open seas do not adorn the rocks in the Mediterranean.

XII.—DISTRIBUTION OF PLANTS IN BRITAIN.

1667. The climate of Britain is warmer than that of other places in the same parallel of latitude. Its most striking feature is the absence of extremes, either as regards cold or heat. It is, generally speaking, mild and damp. Dove gives the following statement as to the monthly excess of temperature in the British Isles, above the respective average temperature of other places in the same parallel of latitude :—

January.	Orkney, 31°.5 ; Edinburgh, Dublin, 27° ; London, 18°.
February.	Orkney, 27° ; Edinburgh, Dublin, 22°.5 ; London, 18°.
March.	Orkney, 22° ; Aberdeen, Glasgow, Dublin, 18°, London, 14°.
April.	Orkney, 13° ; Middle of England and Ireland, 9°, London, 6°.
May.	Great Britain and Ireland, 5°-6°.
June.	Great Britain and Ireland, 2°.
July.	Great Britain and Ireland, 2°.
August.	Great Britain and Ireland, about 3°.
September.	Great Britain, 4°-5° ; Ireland, 3°.
October.	Great Britain and Ireland, 9° to 14°.
November.	North of Scotland, 22°, Edinburgh, Dublin, 18°, London, 14°.
December.	Hebrides, 27°, Orkney, Dublin, 22°, Cornwall, 18°, London, 16°.

—While the winters are mild, the heat of the three summer months, June, July, and August, in which the growth and ripening of crops take place, is by no means great, being very little above that due to the latitude. The heat of these months is most important. It should be noticed that the day and night may be both mild during these months, and thus give rise to a high average temperature. But the important thing is to have high temperature during the day, even although the nights are cool. The eastern coasts of Britain partake more of the continental climate, while on the western the climate is of an insular and equable character. The mean temperature varies from 46° to 52° F. Some of the mountains rise to the height of 4400 feet, and there is a fall of 1° of the thermometer for every 240 or 250 feet of ascent. The number of Phanerogamous species of plants amounts to about 1600, while the Cryptogamous are about 2800.

1668. In considering the distribution of British plants as regard areas, Watson divides Britain (excluding Ireland and the Channel Islands) into 18 provinces, or groups of counties which together constitute the basin of a principal river, or have some other physical peculiarity in common. In each of these provinces he notices the heights attained by the loftiest mountains. The details connected with those provinces are given in his Cybele Britannica. Many of the British species appear to have been introduced, and some appear to have little claim to be included in the flora. Hence Mr. Watson distinguishes—1. Native species, apparently aboriginal, such as Corylus, Calluna, Bellis, Teesdalia. 2. Denizen species, doubtfully native, although maintaining their habitats without the aid of man, as Aconitum, Pæonia, Viola odorata, Impatiens noli-me-tangere. 3. Colonist species, or weeds occurring in cultivated land and about houses, perhaps owing their presence to the operations of man, as Adonis, Papaver, Agrostemma. 4. Alien species, originally introduced, although now more or less naturalised, as Sempervivum, Mimulus, Hesperis, Camelina. 5. Incognitæ, or species reputed British but requiring confirmation, as Ranunculus gramineus, Gentiana acaulis, Tussilago alpina, Echinophora spinosa.

1669. According to the nature of the localities in which British plants grow, they have been thus divided by Watson:—1. Pratal, plants of meadows or rich and damp grass lands, as Geranium pratense; 2. Pascual, plants of pastures and grassy commons, as Trifolium repens; 3. Ericetal, plants of moors and heaths, as Calluna and Erica; 4. Uliginal, plants of swamps and boggy ground, as Drosera and Pinguicula; 5. Lacustral, immersed or floating plants, as Subularia and Nymphæa; 6. Paludal, plants of wet marshy ground, as Typha; 7. Inundatal, plants of places liable to be inundated in wet weather, as Nasturtium terrestre; 8. Viatical, plants of roadsides and rubbish heaps, as Lamium album and Urtica dioica; 9. Agrestal, plants of cultivated ground, as Papaver; 10. Glareal, plants of dry exposed ground, chiefly gravel or sand, as Ornithopus and Sedum acre; 11. Rupestral, rock and wall plants, as Cotyledon and Asplenium Ruta-muraria; 12. Septal, hedge plants, as Bryony; 13. Sylvestral, plants of woods, as Paris; 14. Littoral, plants of the sea-shore, as Statice and Convolvulus Soldanella.

1670. Taking a general view of the distribution of British flowering plants and Ferns (excluding the Hibernian and Sarnian species), Watson recognises the following types:—1. British type—species widely spread over Britain—found in all or nearly all the 18 provinces, and forming probably 2-5ths of the British species, such as Alnus glutinosa, Betula alba, Corylus Avellana, Salix capræa, Rosa canina, Lonicera Periclymenum, Hedera Helix, Sarothamnus scoparius, Calluna vulgaris, Ranunculus acris, Cerastium triviale, Potentilla Tormentilla, Trifolium repens, Stellaria media, Lotus corniculatus, Bellis perennis, Senecio vulgaris, Carduus palustris, Leontodon Taraxacum, Myosotis arvensis, Prunella vulgaris, Plantago lanceolata, Polygonum aviculare, Urtica dioica, Potamogeton natans, Lemna minor, Juncus effusus, Carex panicea, Poa annua, Festuca ovina, Anthoxanthum odoratum, Pteris aquilina, Polypodium vulgare, Lastrea Filix-mas. 2. English type—species chiefly or exclusively found in England, and decreasing in frequency northwards, constituting about 1-5th of the whole flora, as Rhamnus catharticus, Ulex nanus, Tamus communis, Bryonia dioica, Hottonia palustris, Chlora perfoliata, Sison Amomum, Moenchia erecta, Linaria Elatine, Ranunculus parviflorus, Lamium Galeobdolon, Hordeum pratense, Alopecurus agrestis, Ceterach officinarum, besides very local plants such as Cyperus longus and Cicendia filiformis. 3. Scottish type—species chiefly prevalent in Scotland or the north of England, forming about 1-20th of the flora, as Empetrum nigrum, Rubus saxatilis, Trollius europæus, Geranium sylvaticum, Trientalis europæa, Habenaria albida, Haloscias scoticum, Mertensia maritima; also Primula farinosa, Goodyera repens, Corallorhiza innata, and Saxifraga Hirculus, which are comparatively limited in their distribution and partial in their localities; besides some very local plants such as Arenaria norvegica, Primula scotica, and Ajuga pyramidalis. 4. Highland type—species either limited to the Scottish Highlands or extending to the mountains of the north of England and Wales; a more boreal flora than the last, the species being especially limited to the mountains or their immediate vicinity, and forming probably about 1-15th of the flora, as Azalea procumbens, Veronica alpina, Alopecurus alpinus, Phleum alpinum, Juncus trifidus, Sibbaldia procumbens, Erigeron alpinus, Gentiana nivalis; to these may be added the following, which, however, descend also lower, Salix herbacea, Silene acaulis, Saxifraga stellaris, Oxyria reniformis, Thalictrum alpinum, Luzula spicata, Juncus triglumis, Rubus Chamæmorus, Epilobium alsinifolium, Draba incana, Dryas octopetala, Alchemilla alpina; likewise some very local species, as Lychnis alpina and Oxytropis campestris. 5. Germanic type—species chiefly seen in the east and south-east of England (bounded by the German ocean eastward)—forming about 1-15th or 1-20th of the flora, as Frankenia lævis, Anemone Pulsatilla, Reseda lutea, Silene noctiflora, Silene conica, Bupleurum tenuissimum, Pimpinella magna, Pulicaria vulgaris, Lactuca Scariola, Halimus pedunculatus, Aceras Anthropophora, Ophrys aranifera, Spartina stricta; also very local plants such as Veronica verna. 6. Atlantic type—species found in the west and south-west of England and Wales, having a tendency to the western or Atlantic parts of the island—forming about 1-15th or 1-20th of the flora, as Sinapis monensis, Matthiola sinuata, Raphanus maritimus, Sedum anglicum, Cotyledon Umbilicus, Eufragia viscosa, Pinguicula lusitanica, Euphorbia Peplis and E. Portlandica, Scirpus Savii; also more limited species, as Sibthorpia europæa, Erica vagans, E. ciliaris, Physospermum cornubiense, Polycarpum tetraphyllum, Adiantum Capillus-Veneris, Cynodon Dactylon. 7. Local or doubtful type—species which cannot be referred to any of the preceding types, as Potentilla rupestris, Lloydia serotina, confined to peculiar mountains in Wales, Draba aizoides and Cotoneaster vulgaris, found on the rocky coasts of Wales very locally, Draba muralis and Hutchinsia petræa; also Eriocaulon septangulare, found in the Isle of Skye, and formerly included under Watson's Hebridean type. If Ireland and the Channel Islands are also taken into account, Hibernian and Sarnian types would be added.

1671. On ascending lofty mountains in Britain, there is a marked variation in the nature of the vegetation. On Ben-muich-Dhui, which attains an elevation of upwards of 4000 feet, Watson gives a full list of the species observed in succession. On leaving the plants of the low country we find Myrica Gale, extending on this mountain to 1400 feet, and in succession we come to the upper limits of the following species:—Erica cinerea, Pinus sylvestris, Carex pauciflora, Pedicularis sylvatica at 1838 feet, Tofieldia palustris, Erica Tetralix, at 2370 feet, Arctostaphylos Uva-Ursi, Thalictrum alpina, Vaccinium Vitis-Idæa, Hieracium alpinum, Juniperus communis *var.* nana, at 2660 feet, Potentilla Tormentilla, Calluna vulgaris, at 2690 feet, Azalea procumbens, Armeria maritima, Cochlearia gröenlandica, Arabis petræa, Rubus Chamæmorus, Epilobium alpinum, E. angustifolium, Vaccinium uliginosum, Sibbaldia procumbens, Saxifraga stellaris, Alchemilla alpina, Empetrum nigrum, Juncus trifidus, Gnaphalium supinum, and on the summit Silene acaulis, Carex rigida, Luzula arcuata and L. spicata, Salix herbacea.

1672. A very full list has been given by Watson of the plants of the Grampians, viewed in their relations to altitude.* Examples of the altitudinal limits of some alpine species are given below:—

	Lower Limit. Feet.	Upper Limit. Feet.
Thalictrum alpinum	1050	3900
Draba rupestris	3700	3900
—— incana	2000	3300
Thlaspi alpestre		2400
Arabis petræa	2000	3200
Cochlearia grœnlandica	0	3900
Silene acaulis	1250	4300
—— maritima	0	3300
Lychnis alpina		3200
Alsine rubella	2550	3900
Cherleria sedoides	2550	3900
Spergula saginoides	1950	2550
Stellaria cerastoides	2700	3900
Cerastium alpinum	2550	3900
——— latifolium	3000	3750
Astragalus alpinus		2700
Oxytropis campestris		2100
Dryas octopetala	2500	2700
Potentilla alpestris	1500	2700
Rubus Chamæmorus	1750	3300
Sibbaldia procumbens	1500	4200
Alchemilla alpina	450	4200
Epilobium alpinum	1400	3900
——— alsinifolium	800	2900
Sedum Rhodiola		3900
Saxifraga cernua	3750	3900
——— rivularis	3000	3600
——— nivalis	2000	4000
——— hypnoides	1200	3900
——— oppositifolia	950	4000

* Hooker's Lond. Journ. of Bot. i. 50 and 241.

	Lower Limit. Feet.	Upper Limit. Feet.
Saxifraga stellaris	1400	4300
——— cæspitosa		3900
——— aizoides		3150
Cornus suecica	1750	2850
Gnaphalium supinum	1400	4350
Erigeron alpinus	2450	2700
Saussurea alpina	2000	4000
Apargia Taraxaci	2300	3000
Hieracium alpinum	1850	3000
Mulgedium alpinum	2200	2850
Vaccinium uliginosum	1500	3300
Phyllodoce cærulea		2700
Azalea procumbens	1850	3550
Arctostaphylos Uva-Ursi		2850
———— alpina	1850	2700
Gentiana nivalis	2500	3900
Bartsia alpina	1800	3000
Veronica alpina	2500	3600
——— saxatilis	2200	2700
——— humifusa	2000	3750
Myosotis alpestris	3100	3900
Armeria maritima		3600
Plantago maritima		1350
Oxyria reniformis	800	3900
Empetrum nigrum		3900
Salix arenaria	1050	2550
—— lanata	2400	2700
—— reticulata	2550	3300
—— herbacea	1850	4350
Betula nana	1650	2700
Tofieldia palustris	1050	2550
Luzula arcuata		4350

	Lower Limit. Feet.	Upper Limit. Feet.
Luzula spicata	1600	4350
Juncus trifidus	2000	4200
——— castaneus	2400	3000
——— biglumis	2700	3300
——— triglumis	1750	2700
Carex rupestris	2100	2700
—— Vahlii	2400	2550
—— leporina		3600
—— rigida	1850	3900
—— Persoonii		3600
—— aquatilis	900	3300
—— saxatilis	2550	3150
—— atrata	2500	3800
—— vaginata	2400	3000
—— capillaris	1700	2700
—— rariflora	2400	3000
Poa alpina	2500	3900
— Balfourii		3000
— laxa	3000	3600
Alopecurus alpinus	2100	3600
Phleum alpinum	2100	3600
Aira alpina	2700	4100
Sesleria cærulea		2700
Lycopodium annotinum		2700
———— alpinum		3600
Asplenium viride		2850
Polystichum Lonchitis		3300
Cystopteris montana		3000
Allosorus crispus		3000
Polypodium alpestre	2000	3000
Woodsia hyperborea		2700
Pteris aquilina		1950

1673. Considering British plants in climatic or ascending zones, they are divided by Watson into—

I. Agrarian Region—limited generally by the Pteris aquilina, and indicating the region of Corn cultivation. In the Highlands it may be said to extend as high at least as 1200 feet.

It is subdivided into three zones :—

1. *Infer-agrarian Zone*—embracing all the country southward from the Dee and Humber, except the mountainous parts of Wales, and the higher hills and moors in the provinces of the Severn and Peninsula (including Gloucester, Worcester, Warwick, Stafford, Hereford, Monmouth, Cornwall, Devon, and Somerset). Some of the peculiar species are Clematis Vitalba, Rubia peregrina, Cyperus longus, Erica ciliaris, Sibthorpia europæa, and Scilla autumnalis.

2. *Mid-agrarian Zone*—all the low grounds, clear from the mountains, situate between the entrance of the Clyde and Tay on the north, and those of the Humber and Dee on the south, also probably a narrow coast-line of the East Highlands, extending from Perth to Aberdeen, and possibly even to Inverness. Also a narrow belt extending round the hills of Wales. Rhamnus catharticus and Frangula, Tamus communis, Bryonia dioica,

Acer campestre, Ulex nanus, Viburnum Lantana, Euonymus europæus, and Cornus sanguinea, occur in this zone, but are not restricted to it. There is no Clematis.

3. *Super-agrarian Zone*—coast-line and low plains and moors in the north and north-west of Scotland, where alpine plants descend to the sea shore; such as Thalictrum alpinum, Draba incana, Saxifraga oppositifolia, Arctostaphylos alpina, and Dryas octopetala. Also other parts where the elevation of the ground leads to the production of the same species, or of such plants as Arctostaphylos Uva-Ursi, Saxifraga stellaris, Alchemilla alpina, Tofieldia palustris, Juncus triglumis. Also tracts of slight elevation in the proximity of high mountains, upon which a corresponding flora prevails. At its lower limits appear Ilex, Corylus, Quercus, Fraxinus, Lonicera, Cratægus, and fruticose Rubi.

II. Arctic Region—characterised by the absence of Corn cultivation.

1. *Infer-arctic Zone*—this has its terminal line at the limit of Erica Tetralix.
2. *Mid-arctic Zone*—space above the limit of Erica Tetralix, and within or below that of Calluna vulgaris. In this zone most of the rare alpine plants are found, such as, Saxifraga nivalis, Gentiana nivalis, Erigeron alpinus, Astragalus alpinus, Veronica alpina, Alopecurus alpinus, &c.
3. *Super-arctic Zone* — above the limit of Calluna, characterized by Saxifraga cernua and rivularis, and Luzula arcuata.

1674. These six climatic zones are thus presented in a tabular form :—

I. Agrarian Region.

1. *Infer-agrarian Zone*—Clematis, Rubia, Cyperus longus.
2. *Mid-agrarian Zone*—Rhamnus catharticus without Clematis.
3. *Super-agrarian Zone*—Pteris aquilina without Rhamnus, &c.

II. Arctic Region.

4. *Infer-arctic Zone*—Erica Tetralix without Pteris.
5. *Mid-arctic Zone.*—Calluna vulgaris without Erica.
6. *Super-arctic Zone*—Salix herbacea without Calluna.

1675. Edward Forbes has followed Watson in his views of distribution, and has promulgated a theory in regard to the origin of the flora of Britain.* He considers the vegetation of Great Britain and Ireland as composed of several floras, which are to be reckoned outposts separated by geological changes from more extended areas. The following five floras, according to him, make up the vegetation of Britain and Ireland: 1. A west Pyrenean flora (Iberian or Asturian type), confined to the mountainous districts of the west and south-west of Ireland, characterized by botanical peculiarities, which depend on the presence of a few prolific species belonging to the families Saxifragaceæ, Ericaceæ, Lentibulariaceæ, and Cruciferæ. The nearest parts where these plants are native is the north of Spain. The species are Saxifraga umbrosa, S. elegans, S. hirsuta, S. Geum, S. hirta, S. affinis, Erica Mackaiana, E. mediterranea, Daboecia polifolia, Arbutus Unedo, Pinguicula grandiflora, Arabis ciliata. 2. A flora in the south-west of England and

* Forbes on the connexion between the distribution of the existing Fauna and Flora of the British Isles and certain Geological changes. Mem. Geol. Society of Great Britain, i. 336.

south-east of Ireland (Armorican type), which is intimately related to that of the Channel Isles and the neighbouring coast of France (Brittany and Normandy). This is Watson's Atlantic type. In the Channel Isles, we have such peculiar plants as Ranunculus ophioglossifolius, Sinapis Cheiranthus, Erucastrum incanum, Arthrolobium ebracteatum, Linaria pelisseriana, Echium violaceum, Orchis laxiflora, Gymnogramma leptophylla, &c. Again, in the south-west of England, we meet with Helianthemum polifolium, Tamarix gallica, Hypericum linarifolium, Oxalis corniculata, Corrigiola littoralis, Physospermum cornubiense, Lobelia urens, Scilla autumnalis, Trichonema Columnæ, &c. While in the south-east of Ireland the following plants connect the flora with that of Devonshire and Cornwall :—Matthiola sinuata, Senebiera didyma, Linaria Elatine, Sibthorpia europæa, Erica vagans, Cicendia filiformis, and others. 3. The flora of the south-east of England, where the rocks of the Cretaceous system are chiefly developed, and in which many species occur common to this district and the opposite coast of France. This corresponds nearly to Watson's Germanic type. Among the characteristic plants may be noticed, Thlaspi perfoliatum, Linum perenne, Genista pilosa, Inula Conyza, Centaurea Calcitrapa, Phyteuma orbiculare, Gentiana Pneumonanthe, several species of Verbascum, Salvia pratensis, Ajuga Chamæpitys, and many chalk Orchids. 4. An alpine flora (Boreal or Scandinavian type), developed chiefly on the mountains of Scotland, and also partially on those of Cumberland and Wales. The species found on the latter are all, with the exception of Lloydia serotina, inhabitants also of the Scotch Highlands. The Scotch alpines all occur in Scandinavia, where they are associated with numerous additional species. This flora corresponds nearly to Watson's Highland type. This flora is represented in Shetland by Arenaria norvegica, and in Orkney by Primula scotica. It is largely developed on the Scottish Alps, the species being those already noticed at page 1028. 5. The general flora of the British islands, identical with that of central and western Europe, and which is called a Germanic flora. It corresponds to Watson's British, English, and Scottish types. It is a flora which overspreads many local floras throughout Europe, and gives a general character to the vegetation by the presence of such common species as Bellis perennis, Primula vulgaris, Ranunculus acris, R. Ficaria, Cardamine hirsuta, and our most common trees and shrubs. Certain species are more limited in their distribution, and characterize particular districts. Some are limited to the eastern counties of England, others occur in Scotland and England, and not in Ireland. Certain species flourish best on limestone, others in sandy soils.

1676. There are in Britain a few sporadic plants, which are met with only in one or two localities. Thus Oxytropis campestris is limited to a single rock in Glen Fiadh, Clova; Lychnis alpina to a small alpine summit, Little Gilrannoch; Astragalus alpinus to a rock in Glen Dole, Clova, and to Little Craigindal, a mountain in Bræmar; Saxifraga cernua to the summit of Ben Lawers; Eriocaulon septangulare to the Isle of Skye in Scotland, and to Connemara in Ireland. The last-mentioned plant belongs to an American genus, and is supposed by some to have migrated from the New World.

1677. Forbes endeavours to prove that the specific identity, to any extent, of the plants of one area with those of another, depends on both areas forming, or having formed, part of the same specific centre, or on their having derived their vegetable population by transmission, through migration, over continuous or closely contiguous land, aided, in the case of alpine floras, by transportation on floating masses of ice. According to him, "the oldest of the floras now composing the vegetation of the British isles, is that of the mountains of the west of Ireland. Though an alpine flora, it is southernmost in character, and is quite distinct as a system from the floras of the Scottish and Welsh Alps. Its very southern character, its limitation, and its extreme isolation, are evidences of its antiquity, pointing to a period when a great mountain barrier extended across the Atlantic from Ireland to Spain. The distribution of the second flora, next in point of probable date, depended on the extension of a barrier, the traces of which still remain, from the west of France to the south-east of Britain, and thence to Ireland. The distribution of the third flora depended on the connexion of the coast of France and England towards the eastern part of the channel. Of the former existence of this union no geologist doubts. The distribution of the fourth, or alpine flora of Scotland and Wales, was effected during the glacial period, when the mountain summits of Britain were low islands, or members of chains of islands, extending to the area of Norway through a glacial sea, and clothed with an arctic vegetation, which in the gradual upheaval of those islands and consequent change of climate, became limited to the summits of the new-formed and still existing mountains. The distribution of the fifth, or Germanic flora, depended on the upheaval of the bed of the glacial sea, and the consequent connexion of Ireland with England, and of England with Germany, by great plains, the fragments of which still exist, and upon which lived the great elk, and other quadrupeds now extinct. The breaking up or submergence of the first barrier led to the destruction of the second; that of the second to that of the third; but the well-marked epoch of migration of the Germanic flora indicates the subsequent formation of the straits of Dover and of the Irish Sea, as now existing."

1678. "To determine the probable geological epoch of the first or west-Irish flora—a fragment, perhaps with that of north-western Spain, of a vegetation of the true Atlantic—we must seek among fossil-plants for a starting-point. This we get in the flora of the London clay, or Eocene, which is tropical in character, and far anterior to the oldest of the existing floras. The geographical relations of the Miocene sea, indicated by the fossils of the crag, give an after-date certainly to the second and third of the above floras, if not to the first. The epoch of the red or middle crag was probably coeval with the second flora; that of the mammaliferous crag with the third. The date of the fourth is too evident to be questioned; and the glacial region in which it flourished is to be regarded as a local climate, of which no true traces—as far as animal life is concerned—exist southwards of the second and third barriers. This was the newer Pliocene epoch. The period of the fifth flora was that of the post-tertiary, when the present aspect of things was organised. Adopting such a view of the relations of these floras in time, the greatest difficulties in the way of changes of the earth's surface and destruction of barriers, deep sea being found where land (probably high land) was, are removed when we find that those greater changes must have happened during the epoch immediately subsequent to the Miocene period; for we have undoubted evidence that elsewhere, during that epoch, the Miocene sea-bed was raised 6000 feet in the chain of Taurus, and the barriers forming the westward boundary of the Asiatic Eocene lakes so completely annihilated, that a sea several hundred fathoms deep now takes their probable place. The changes required for the events which are supposed to be connected with the peculiar distribution of the British flora are not greater than these. The distribution of endemic animals, especially that of the terrestrial mollusca, seems to support these views."

1679. While there are evident and distinct features in the plants which constitute the floras of different parts of Britain, there are many difficulties to be overcome before we can adopt the speculative views of Forbes. The connection between the Tertiary and the present epoch is not made out as far as the species of plants are concerned, and we are disposed to look upon the existing flora of the globe as a distinct and independent one. Schouw differs from Forbes in his explanation of the flora of the British islands. He does not believe in the migration and geological changes to which Forbes alludes. He thinks that the west and south-west coast of Britain and Ireland had at first a mild climate, especially in winter, and that in consequence plants were produced there common to the analogous climates of Spain and the south of France; while the Scotch and English mountains were distinguished throughout by a polar climate, and produced nearly the same vegetation as the Lapland and Scandinavian mountains.

1680. D'Archiac* says, that in a botanical point of view, it would perhaps be desirable to determine whether the external circumstances under which the five floras of Great Britain now live, such as latitude, altitude, temperature, winds, humidity or dryness, exposure, nature of the soil, greater or less distance from the coast, &c., are altogether insufficient to explain their different characters. We know that plants have very different geographical limits. Thus there are some which we meet with over an extent of 25° in latitude, and much more in longitude, while others occupy only zones extremely restricted in both senses; it would, therefore, be useful to study the five British floras in this point of view. The radiation of plants from a centre is

* Hist. des Progrès de la Géologie de 1834 à 1845, ii. 128. Paris. 1848. Edin. New Phil. Journal, xlviii. 23.

by no means satisfactorily proved; and it may be asked, for example what is the original centre from which the species common to North America and southern Europe could have radiated? D'Archiac thinks that inconvenience arises from an attempt to give an account of facts hitherto inexplicable in our science, by drawing from another science suppositions made, as it appears, with the sole view of these explanations, and for which there is no sufficient authority. Proofs drawn from geology must rest on more certain data, he thinks, than those which have been adduced by Professor Forbes.

1681. Martins considers the flora of Britain as a derivative one, originating partly from Europe, and partly from America. Arctic plants, he thinks, have been carried from Greenland, by Iceland and the Faroe Islands, to Shetland and the mountains of Scotland; and have also been transported from Scandinavia. A few species, such as Eriocaulon, have been carried by the Gulf Stream from America to the western coast of Britain, while the great mass of the flora has been derived from the continent of Europe. Martins accounts for the transport of seeds to Britain by the following agents:—1. Currents. These are concerned in distribution of maritime and littoral plants. These currents carry seeds to a great distance. The Gulf Stream carries seeds from America to shores of Scotland. Seeds of Entada scandens are thus wafted to the western islands. M. Martins has picked these seeds at North Cape, and they have also been picked on the shores of White Sea, and on the shores of Iceland. 2. Winds are another means of transport. On 2d September 1845, at 9 A. M., there was an eruption of Hecla in Iceland; and, on the morning of 3d September, ashes were carried by the N.W. wind to the Faroe Islands. On the same day similar ashes were found in Shetland and Orkney. A similar occurrence took place in February 1847. Such a wind would easily transport small seeds. 3. Agency of birds. Myriads of sea-birds, during the whole summer, leave the shores of Europe, and repair to Shetland, Faroe, and Iceland; among them may be mentioned, species of Larus, Mormon, Alca, Uria, Procellaria, Tringa, Anas, Lestris, Colymbus, Sterna, &c., many of which pick up seeds.

1682. Martins mentions as examples of an Alpine flora passing from Greenland to Scotland by Iceland and Faroe, Thalictrum alpinum, Draba incana, Silene acaulis, Cerastium latifolium, Sedum Rhodiola, Saxifraga oppositifolia, Sibbaldia procumbens, Haloscias scoticum, Azalea procumbens, Empetrum nigrum, Gymnadenia albida, Poa alpina, &c. &c. He also gives the following tabular view of the number of European and American-European species found in Shetland, the Faroe Islands, and Iceland:—

Species common to	Shetland, Faroe, and Iceland	146	American-European	142
			European	4
	Shetland and Faroe	37	American-European	19
			European	18
	Shetland and Iceland	40	American-European	34
			European	6
	Faroe and Iceland	67	American-European	63
			European	4

Species peculiar to	Shetland	74	American-European	34
			European	40
	Faroe	31	American-European	19
			European	12
	Iceland	132	American-European	108
			European	24

1683. The marine flora of Britain, with the exception of such plants as Zostera, Zannichellia, and Naias, is Cryptogamic, and does not present very definite zones of distribution. Cryptogamic plants in general can endure great vicissitudes of climatal conditions. Species of Ulva, Enteromorpha, and other genera seem to be universally distributed from pole to pole. There are, however, Algæ of a higher type which are more limited, and the diffusion of which is determined by lines of coast and depth of water. British marine vegetation presents two well marked types according to Forbes, a southern and a northern. The genera Padina and Halyseris have their northern limit on the south coast of England, where they are rare. The genera Cystoseira, Sporochnus, Cutleria, and certain species of Sphacelaria, Mesogloia, Rhodymenia, Gigartina, and Dictyota, mark out a southern region, including the British Channel and part of the east coast, the Bristol Channel, and the south and west of Ireland; while the presence of Odonthalia dentata, Rhodomela cristata, R. lycopodioides, and Fucus Mackaii, characterise a northern flora, on the coasts of Scotland, the north of England and of Ireland.

1684. On the shores of Britain, Dr. Greville remarks, it is easy to perceive that some species, as Gelidium corneum, Phyllophora rubens, and Sphærococcus coronopifolius, become more plentiful and more luxuriant as we travel from north to south; and, on the other hand, that Ptilota plumosa, Rhodomela lycopodioides, Rhodymenia sobolifera, and several others, occur more frequently and in a finer state as we approach the south. Odonthalia dentata and Rhodymenia cristata are confined to the northern parts of Great Britain, while the species of Cystoseira, Fucus tuberculatus, Halyseris polypodioides, Rhodymenia jubata, R. Teedii, Microcladia glandulosa, Rhodomela pinastroides, Laurencia tenuissima, Iridæa reniformis, and many others, are confined to the southern parts. The proportion of the different marine plants on the shores of Britain are as follows:—Melanospermeæ 1-5th, Rhodospermeæ 3-8ths, and Chlorospermeæ 1-4th of the whole.

1685. Dickie, in speaking of the British Algæ which have a southern type, says that they may be classed under three heads—1. Those confined to the southern parts of Great Britain and Ireland; 2. Species of a more extensive range, which extend to the north of Ireland and south-west of Scotland; and 3. Those found abundantly in the south of England, and ranging along the western coasts of both islands as far as Orkney and Shetland. The species comprehended under these three heads, and amounting to at least 20, seem to be absent from a certain part of the east coast of Scotland. A considerable portion of them re-appear in Shetland and Orkney. He thinks that the appearance of southern forms of Algæ, at the extreme northern parts, is to be attributed to the influence of the Gulf Stream as regards temperature.

1686. British Algæ are variously distributed, some in deep, others in shallow water. Laminaria digitata only extends to the low line of ebb during stream tides; L. saccharina flourishes along an inner belt, partially uncovered during the ebbs of the larger neaps; Fucus serratus and F. nodosus thrive in a zone still less deeply covered by water, and which even the lower neaps expose; F. vesiculosus occurs in a zone higher still, altering its form as it goes farther inland; F. canaliculatus also rises high on rocky beaches. If landsprings escape from the beach there may be found an upper terminal zone of Confervæ mixed with Ulva latissima, Porphyra laciniata, and Enteromorpha compressa. In the lake of Stennis at Stromness, Orkney, there occur at the part where the sea enters, specimens of Fucus nodosus and vesiculosus in their ordinary form, along with Halidrys siliquosa. A little further in, where there is more fresh water, Halidrys and Fucus nodosus disappear; F. vesiculosus becomes stunted, its air-bladders being altered or disappearing; and ultimately, it becomes narrowed like the Confervæ, and altogether loses its usual aspect.*

1687. The British marine plants, according to Forbes, are distributed in depth or bathymetrically in a series of zones or regions which extend from high water mark down to the greatest explored depths. The first or littoral zone is that tract which lies between high and low water marks, and therefore is very variable in extent according to the amount of rise and fall of the tides. It has been divided into sub-regions characterised by the prevalence of certain marine species. 1. The sub-region of Fucus canaliculatus. 2. The sub-region of Lichina. 3. The sub-region of Fucus articulatus, F. nodosus, and Corallina officinalis. 4. The sub-region of Fucus serratus. The Littoral zone is succeeded by narrow belts of such Sea-weeds as Himanthalia lorea, Conferva rupestris, Laurencia pinnatifida, Chondrus crispus, and C. mammillosus. The second or Laminarian zone commences at low water mark, and extends to a depth of from 7 to 15 fathoms. Here we meet with the great Tangle Sea-weeds and deep water Fuci. Species of Laminaria, Rhodymenia, and Delesseria, are found in an upper sub-region of this zone. In the lower sub-region they are rare, and are succeeded by the coral-like Nullipore. The zones below them are entitled the Coralline zone, extending from 15 to 50 fathoms, and the region of the deep sea corals from 50 to beyond 100 fathoms. These zones do not exhibit any conspicuous vegetable forms; they are characterised by the presence of certain animals. At the depth of 50 fathoms in the British seas, there seems to be a total absence of vegetable life.†

* Hugh Miller, Footprints of the Creator.

† For fuller details in regard to Botanical Geography, the following works may be consulted:— Humboldt de distributione geographica plantarum; Humboldt, Aspects of Nature. De Candolle,

1688. Recapitulation of the chief points connected with Botanical Geography :—

1. The distribution of plants over the globe is regulated by climate, more especially by temperature and moisture.
2. The climate suited to a plant is that in which it can perform all its functions properly, and produce its characteristic secretions.
3. The globe, as regards temperature, is divided latitudinally and altitudinally into different zones, and the nature of the vegetation in these zones varies.
4. To ascertain the temperature which a plant will bear, we require to know not merely the mean annual temperature, but the mean summer and winter heat, and particularly the mean monthly and daily temperature during the period when vegetation is active.
5. Lines passing through places having the same mean annual temperature are called Isothermal; those through places with an equal mean summer heat are Isotheral, and with an equal mean winter temperature Isocheimal.
6. The lines of equal mean monthly temperature are denominated monthly Isotherms, and they are of more importance in Botanical Geography than annual Isotherms.
7. A plant requires a certain amount of temperature during a given epoch, and this may be communicated more or less rapidly in different climates. Hence the rapidity of the epochs of vegetation varies in different countries.
8. In an altitudinal point of view, or hypsometrically, the temperature varies, the fall being on an average about 1° for every 300 or 400 feet of ascent.
9. The nature of the soil influences in some measure the distribution of plants, but the connection between different rocks and the plants growing on them, is still obscure. Some plants seem to prefer limestone rocks, others trap, and so on.
10. There are differences in the nature of the localities in which different species of plants grow. Some are aquatic, others terrestrial; some have their roots in the earth, others are epiphytic and parasitic; some prefer dry soil, others marshy ground; some grow on rocks or stones, others in sand or clay, and so on.
11. Some plants are generally diffused over the globe, and have a wide geographical range; others are endemic, and are confined within narrow limits.
12. The same species are sometimes found in very distant parts of the globe; at other times the species of one country are represented by allied species in another.
13. The orders and genera of one country have frequently marked representatives in another.
14. It would appear that the same species have been in many instances originally placed in very widely separated localities; while at other times species have been created on one spot, and have only extended a short distance from a centre.
15. The dissemination of plants has been effected by the agency of man, water, winds,

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Essai élémentaire de Geographie Botanique; also Geographie Botanique in Dict. de Sciences Nat. xviii. Schouw, Grundzuge der Pflanzen Geographie, translated into German from the Danish. Schouw's Earth and Man, translated by Henfrey; Schouw, Europa. Meyen's Botanical Geography, in Ray Society's publications. Berghaus, Grundriss der Geographie in Linnæa, i.; Physikalischen Atlas. Hooker on Botanical Geography, in Murray's Encyclopædia of Geography. Martius die Physiognomie des Pflanzen-reiches in Brazilien. Malte Brun's Physical Geography. Schlagintweit, on the Periodical Phenomena of Vegetable Life on the Alps, Trans. in Journ. Hort. Soc. viii. 61. Hinds, the Regions of Vegetation. Royle, Himalayan Flora. Gardner's Travels in Brazil. Thomson's Western Himalaya and Thibet. Hooker, Journal of an Oriental Naturalist. Hooker's Antarctic and New Zealand Flora. De Candolle, Alph. on the effect of Heat on Plants, in Lond. Hort. Soc. Journ. v. 178. Quetelet, Observations sur la floraison des plantes. Martins de la delimitation des Regions Végétales sur l'Europe. Henfrey, Vegetation of Europe. Grisebach, Reports on Botanical Geography, in Ray Society's publications for 1845 and 1849. Johnston's Physical Atlas, Botanical part. Black's Atlas. Traill's Physical Geography. Harvey's Nereis Australis, Nereis Boreali-Americana, and Manual of British Algæ. Besides these, the Floras of different countries may be consulted, for a list of which, see Pritzel's Thesaurus Literaturæ Botanicæ, where the works are classified according to the countries.

and animals. The Cerealia have been distributed very extensively by man, and bear a wide range of temperature. Many common weeds have been dispersed also in this way.

16. The general physiognomy of a country is often marked by the prevalence of certain conspicuous plant forms. Social plants, or those growing naturally in masses, particularly give a character to a country.
17. The physiognomy of vegetation is represented by certain forms, such as Palms, Bananas, Cactuses, Coniferæ, Heaths, Mimosas, Grasses, Ferns, Willows, Myrtles, Dicotyledonous trees, Mosses, and Lichens, &c.
18. These physiognomic forms characterise different countries, and sometimes those of one country have their representatives in similar forms in another.
19. The prevalence of certain colours also contributes to the physiognomy of vegetation in different countries.
20. By the statistics of vegetation is meant the number of species or genera on the globe, the relative proportion of classes and orders, or the proportion of species of a particular genus or order in different countries.
21. Zones of vegetation are given by different authors both in a latitudinal and altitudinal point of view.
22. Meyen divides the vegetation of the globe into eight distinct zones. These zones are reckoned both as regards latitude and altitude, and are characterised by particular orders and genera of plants.
23. Schouw divides the globe into 25 phyto-geographic regions, marked by the prevalence of certain orders and genera. Many of them are ill-defined on account of the want of data, and it is not to be expected that they can be accurate until the floras of the different quarters of the globe have been carefully ascertained.
24. Marine vegetation is also divided into zones according to depth, or bathymetrically.
25. Forbes characterises a Littoral, a Laminarian, and a Deep-sea zone. At great depths there is an absence of vegetation. Different seas have marine plants peculiar to them.
26. The British Flora has been divided into different types, both as regards latitude and altitude. The climatic zones in Britain are divided into Agrarian and Arctic, and each of these is subdivided into three.
27. The British Flora partakes more or less of the characters of that of different parts of Europe, and there are certain American forms also represented.
28. Forbes endeavours to account for the differences in the floras of Britain, by considering them as outposts, separated by geological changes from larger areas.

PART V.

PALÆONTOLOGICAL BOTANY,

OR THE STUDY OF FOSSIL PLANTS.

1689. The changes which have taken place in the nature of living beings since their first appearance on the globe till the period when the surface of the earth having assumed its present form, has been covered by the creation which now occupies it, constitutes one of the most important departments in geology. It is, as Brongniart remarks, the history of life and its metamorphoses. The researches of geologists show clearly that the globe has undergone various alterations since that " beginning" when " God created the heavens and the earth." At various periods of the world's history, new mineral beds have covered the surface of the earth, and elevations of different portions of its crust have taken place, while at the same time the living beings inhabiting it have been buried in sedimentary deposits, to be replaced by a creation more or less different from the preceding. Some of these epochs have been marked apparently by great changes in the physical state of our planet, and they have been accompanied with equally great modifications in the nature of the living beings which inhabited it. The study of the fossil remains of animals is called Palæozoology, while the consideration of those of vegetables is denominated Palæophytology. Both are departments of the science of Palæontology, which has been the means of bringing geology to its present state of advancement. The study of these extinct forms has afforded valuable indications as to the physical state of the earth and as to its climate at different epochs.

1690. The vegetation of the globe, during the different stages of its formation, has undergone very evident changes. At the same time there seems to be no reason to doubt that the plants may all be referred to the great classes distinguished at the present day, namely, Thallogens, Acrogens, Gymnosperms, Endogens, and Exogens. The relative proportion of these classes, however, has been different, and the predominance of certain forms has given a character to the vegetation of different epochs. The farther we recede in geological history from the present day the greater is the difference between the fossil plants and those which now occupy the surface. At the time when the coal-beds were formed, the plants covering the earth belonged to genera and species not recognised at the present day. As we ascend higher, the similarity between the ancient and the modern flora increases, and in the latest stratified rocks we have in certain instances an apparent identity, at least as regards genera. At early epochs the flora appears to have been uniform, to have presented less diversity of forms than at present, and to have been similar in the different quarters of the globe. The vegetation also seems to indicate that the nature of the climate was different from that which characterises the countries in which these early fossil plants are now found.

1691. Fossil plants are by no means so easily examined as recent species. They are seldom found in a complete state. Fragments of stems, leaves, and fruits are the data by which the plant is to be determined. It is very rare to find any traces of reproductive organs. The parts of fossil plants are usually separated from each other, and it is very difficult to ascertain what are the portions which should be associated together so as to complete a specimen. The anatomical structure of some of the organs, especially of the stem, can sometimes be detected by thin microscopic slices being placed under the microscope; and in the case of Coniferous wood, the punctated woody tissue (Fig. 1807) has proved of great service as regards fossil Botany.

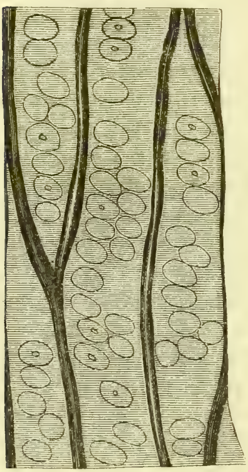


Fig. 1807.

1692. Brongniart* says that the mode in which plants are preserved in a fossil state may be referred to two principal classes:—1. The impression or cast of the plants, accompanied with the complete destruction of the vegetable tissue, and the preservation of few of its constituent parts. 2. Petrifaction or Carbonization, which preserves more or less completely the structure of the tissues of vegetable organs, by changing completely or only modifying their nature. The first state is rather rare, but it is the usual state of fossil vegetables in the variegated sandstone and tertiary limestones. The place of the vegetable is either empty or replaced by a substance of a ferruginous, calcareous, or earthy nature, having no organisation. The second state or the impression with some preserved portion of vegetable tissue, is very frequent in the case of stems found in the coal formation. This is their ordin-

Fig. 1807. Section of Peuce Withami, after Lindley and Hutton, a fossil Conifer of the coal epoch. The punctated woody tissue is shown.

* Brongniart, Tableau des Végétaux Fossiles.

ary mode of preservation. In such stems we must carefully distinguish the different zones of tissue, and their external and internal surfaces, which produce so many different appearances. So also as regards fossil fruits. The thickness of the pericarp often gives rise to two very different forms, and frequently cavities are caused by the destruction of tissue.

1693. Carbonized vegetables, or those which have passed into the state of Lignites, often undergo modifications which render it difficult to understand them rightly. Sometimes a portion of the organs of vegetables, passed into the state of lignite, is transformed into pyrites, or else pyrites of a globular shape is found in the middle of the tissue, and may be taken for a character of organisation. The section of certain dicotyledonous fossil woods, in that case, may resemble Monocotyledons. Petrifaction, as in the case of silicified woods, often preserves all the tissues equally, at other times the soft tissues are altered or destroyed; the cellular tissue being replaced by amorphous chalcedony, while the ligneous and vascular tissues alone are petrified, so as to preserve their forms. In some cases the reverse takes place as to these tissues; the fibrous portions disappear, leaving cavities, while the cells are silicified. Sometimes we find the parts regularly silicified at one place, so as to retain the structure, while at another an amorphous mass of silica is found. In such cases there appear, as it were, distinct silicified ligneous bundles in the midst of an amorphous mass, resembling some anomalous Brazilian stems. The appearance depends, however, merely on irregular silicification or partial petrifaction. Fossil woods, by means of chemical tests, are shown to possess portions of vegetable tissues cemented into a mass by silica. In some cases we find the vessels and cells separately silicified, without being crushed into a compact mass. In these cases, the intercellular membrane not being silicified, the mass breaks down easily; whereas, when complete silicification takes place, the mass is not friable. Coniferous wood is often friable, from silicified portions being still separated from each other by vegetable membrane more or less entire. During silicification it frequently happens that the plant has been compressed, broken, and deformed, and that fissures have been formed filled with crystallised or amorphous silica.

1694. The silicified stems of trees have been observed in various parts of the world, with their structure well preserved, so that their Endogenous and Exogenous character could be easily determined. The Rev. W. B. Clarke notices the occurrence of a fossil Pine-forest at Kurrur-Kurrân, in the inlet of Awaaba, on the eastern coast of Australia. In the inlet there is a formation of conglomerate and sandstone, with subordinate beds of lignite—the lignite forming the so-called Australian coal. Throughout the alluvial flat, stumps and stools of fossilized trees are seen standing out of the ground, and one can form no better notion of their aspect than by imagining what the appearance of the existing living forest of Eucalypti and Casuarinæ would be if the trees were all cut down to a certain level. In a lake in the vicinity there are also some fossilized stumps of trees, standing vertically. In Derwent Valley, Van Diemen's Land, fossil silicified trees, in connection with trap rocks, have been found in an erect position. One was measured with a stem 6 feet high, a circumference at the base of 7 feet 3 inches, and a diameter at the top of 15 inches. The stems are Coniferous, resembling Araucaria. The outer portion of the stem is of a rich brown glossy agate, while the interior is of a snowy whiteness. One hundred concentric rings have been counted. The tissue falls into a powdery mass. Silica is found in the inside of the tubes, and their substance is also silicified.

1695. In order to study fossil plants well, there must be an acquaintance with systematic botany, a knowledge of the microscopical structure of all the organs of plants, such as their roots, stems, barks, leaves, fronds, and fruit; of the markings which they exhibit on their different surfaces, and of the scars which some of them leave when they fall. It is only thus we can expect to determine accurately the living affinities of the fossil. Brongniart says, that before comparing a fossil vegetable with living plants, it is necessary to reconstruct as completely as possible the portion of the plant under examination, to determine the relations of these portions to the other organs of the same plant, and to complete the plant if possible, by seeing whether, in the fossils of the same locality, there may not be some which belong to the same plant. The connection of the different parts of the same plant is one of the most important problems in Palæophytology, and the neglect of it has perhaps led to a needless multiplication of fossil species; portions of the same plant having been described as separate species or genera. In some instances the data have been sufficient to enable botanists to refer a fossil plant to a genus of the present day, so that we have fossil species of the genera Ulmus, Alnus, Pinus, &c. Sometimes the plant is shown to be allied to a living genus, but differing in some essential point, or wanting something to complete the identity, and it is then marked by the addition of the term *ites*, as Pinites, Thuites, Zamites, &c.

1696. Before drawing conclusions as to the climate or physical condition of the globe at different geological epochs, the botanist must be well informed as to the vegetation of different countries, as to the soils and localities in which certain plants grow, whether on land or in the sea, or in lakes, in dry or marshy ground, in valleys or on mountains, or in estuaries, in hot, temperate, or cold regions. It is only by a careful consideration of all these particulars that any correct inferences can be drawn as to the condition of the globe.

1697. The rocks of which the globe is composed are divided into two great classes, those which contain fossil remains, and which are called fossiliferous, and those having no such remains, and which are designated non-fossiliferous or azoic. The igneous unstratified rocks, included under the names of Granitic and Trappean, show no appearance of animal or vegetable remains. Trap rocks, however, have in some cases covered or enclosed vegetable structures, and these are found in an altered condition. Thus, in Antrim, near the Giant's Causeway, lignite is found in connection with the basalt, showing distinct dicotyledonous structure charred, with the bark, &c., along with chalk flints. Dicotyledonous wood and charcoal have also been found by the Duke of Argyll under trap in the Island of Mull. In trap rocks near Edinburgh, lignite with distinct structure has also been detected. Silicified wood and coal, imbedded in trap rocks, have been seen in Kerguelen's Land. The wood is found enclosed in basalt, whilst the coal crops out in ravines, in close contact with the overlying porphyritic and amygdaloidal greenstone. Hooker has also seen silicified wood, in connection with trap, in Macquarrie's plains, in Tasmania.

1698. Fossil remains have not been found in certain rocks having a stratified appearance, and which, from the changes they have undergone, were denominated by Hutton Metamorphic. These include Gneiss and Mica-slate, which are looked upon as stratified rocks, which have probably been formed at a high temperature, and have been subsequently altered by the effects of heat. The absence of organic remains in rocks, however, is not always sufficient to enable us to state that these rocks were formed before animals or vegetables existed. Forbes has shown that, even at the present day, there are depths in the ocean which are destitute of organic life. Hence rocks deposited at such depths might contain no organic remains.

1699. The stratified rocks which contain fossils, have been divided into three great groups, the Palæozoic, the Secondary, and the Tertiary. The formations included under these are exhibited in the following table, as condensed from Ansted's geology :—

I. Palæozoic Rocks, containing the earliest fossil remains. They include the Transition, Primary fossiliferous and Grauwacke rocks.

1. *Lower Palæozoic.*—These comprehend the Silurian and Cambrian rocks.
2. *Middle Palæozoic.*—The Devonian system, or Old Red Sandstone, so well developed in Scotland.
3. *Upper Palæozoic.*—The Carboniferous system, or the Coal Measures, with millstone grit, carboniferous limestone and shales; and the Permian system, or the magnesian limestone.

II. Secondary or Mezozoic Rocks, constituting a second great epoch in the history of fossils.

1. *Lower Secondary.*—The upper New Red Sandstone of Britain, or the Triassic system of Germany. Here we meet with Red Sandstone and conglomerates, saliferous red and variegated marls.
2. *Middle Secondary.*—The Liassic system, with its limestones and marls; the Oolitic divided into Lower Oolite (Calcareous sand, Stonesfield slate, Bradford clay, &c.), Middle Oolite (Oxford clay, Coral clay, Calc grit, &c.), and Upper Oolite (Kimmeridge clay, Portland stone); the Wealden, as illustrated in Purbeck beds and Hastings sand.
3. *Upper Secondary.*—The Cretaceous system, with its lower and upper greensand and chalks, and the Gault.

III. Tertiary or Cainozoic Rocks, constituting the third grand fossiliferous epoch. These are well developed in Asia, America, and in the south of Europe, and only partially in Britain.

1. *Lower Tertiary or Eocene.*—This is seen in the London clay, the Paris basin, the Basin of Brussels, &c.
2. *Middle Tertiary or Miocene.*—This is shown in the Coralline and Red Crag of Britain, the Basin of the Rhine, of the Loire, and Garonne, &c.
3. *Upper Tertiary or Pliocene.*—This is illustrated by the Norwich crag, the Till of the Clyde, the Brown coal of Germany, &c.
4. *Superficial Deposits, or Pleistocene.*—These consist of diluvium or diluvial drift, formed of gravel, with boulders, which indicate the violent action of water; and alluvium or deposits of fine mud, resembling those caused by ordinary fluviatile action. The tertiary formations and those of the present day appear to pass into each other.

1700. The plants found in different strata are either terrestrial or aquatic, and the latter exhibit species allied to the salt and fresh water vegetables of the present day. Their state of preservation depends much on their structure. Cellular plants have probably in a great measure been destroyed, and hence their rarity; while those having a woody structure have been preserved. The following is the number of fossil genera and species, as compiled from Unger's work on Palæophytology :—*

	Genera.	Species.
DICOTYLEDONES.		
Thalamifloræ	24	84
Calycifloræ	56	182
Corollifloræ	23	60
Monochlamydeæ Angiospermæ	48	221
——— Gymnospermæ	56	363
MONOCOTYLEDONES.		
Dictyogenæ	2	5
Petaloideæ	36	125
Glumiferæ	5	12
ACOTYLEDONES.		
Thallogenæ	31	203
Acrogenæ	121	969
Doubtful	35	197
	437	2421

These plants are arranged in the different strata as follows :—

Lower and Middle Palæozoic.	Cambrian, Silurian, Devonian, and Old Red Sandstone	73
Upper Palæozoic.	Carboniferous	683
	Lower New Red Sandstone (Permian)	76
	Magnesian Limestone (Do.)	21
Lower Secondary.	Upper New Red Sandstone (Triassic)	38
	Shell Limestone (Do.)	7
	Variegated Marls (Do.)	70
Middle Secondary.	Lias	126
	Upper, Middle, and Lower Oolite	168
	Wealden	61
Upper Secondary.	Upper and Lower Greensand, Upper and Lower Chalk	122
Tertiary.	Eocene	414
	Miocene	496
	Pliocene	35
	Pleistocene	31
	Fossil Species	2421

* Unger, Genera et Species Plantarum fossilium, 1850.

1701. Among the fossil Thalamifloral Dicotyledons, Unger mentions species belonging to the orders—

Magnoliaceæ.	Byttneriaceæ.	Sapindaceæ.
Anonaceæ.	Tiliaceæ.	Cedrelaceæ.
Nymphæaceæ.	Aurantiaceæ.	Zygophyllaceæ.
Capparidaceæ.	Malpighiaceæ.	Xanthoxylaceæ.
Malvaceæ.	Aceraceæ.	Coriariaceæ.

Among Calycifloral Dicotyledons—

Celastraceæ.	Rosaceæ.	Halorageaceæ.
Rhamnaceæ.	Calycanthaceæ.	Cucurbitaceæ.
Anacardiaceæ.	Combretaceæ.	Cornaceæ.
Amyridaceæ.	Melastomaceæ.	Loranthaceæ.
Leguminosæ.	Myrtaceæ.	Rubiaceæ.

Among Corollifloral Dicotyledons—

Ericaceæ.	Aquifoliaceæ.	Apocynaceæ.
Styracaceæ.	Sapotaceæ.	Gentianaceæ.
Ebenaceæ.	Oleaceæ.	

Among Monochlamydeous Angiosperms—

Nyctaginaceæ.	Euphorbiaceæ.	Betulaceæ.
Lauraceæ.	Urticaceæ.	Altingiaceæ.
Proteaceæ.	Artocarpaceæ.	Platanaceæ.
Aquilariaceæ.	Ceratophyllaceæ.	Corylaceæ.
Samydaceæ.	Salicaceæ.	Juglandaceæ.
Santalaceæ.	Myricaceæ.	Rafflesiaceæ.

Among Monochlamydeous Gymnosperms—

Coniferæ.	Taxaceæ.	Gnetaceæ.	Cycadaceæ.

Among Dictyogenous Monocotyledons—

Smilaceæ.

Among Petaloid Monocotyledons—

Orchidaceæ.	Palmæ.	Typhaceæ.
Zingiberaceæ.	Pandanaceæ.	Naiadaceæ.
Musaceæ.	Araceæ.	Restiaceæ.
Liliaceæ.		

Among Glumiferous Monocotyledons—

Cyperaceæ. Gramineæ.

Among Acrogenous Acotyledons—

Filices.	Lycopodiaceæ.	Musci.
Marsileaceæ.	Equisetaceæ.	Hepaticæ.

Among Thallogenous Acotyledons—

Lichenes.	Characeæ.	Algæ.	Fungi.

1702. On taking a general survey of the known fossil plants, Brongniart thinks that he can trace three periods of vegetation, characterised by the predominance of certain marked forms of plants. In the most ancient period there is a predominance of Acrogenous Cryptogamic plants; this is succeeded by a period in which there is a preponderance of Gymnospermous Dicotyledons; while a third period is marked by the predominance of Angiospermous Dicotyledons. There is thus—1. The reign of Acrogens, which includes the plants of the Carboniferous and Permian periods. During these periods, there seems to be a predominance of Ferns, a great development of Lycopodiaceæ, arborescent forms of Lepidodendron and Sigillaria, Gymnosperms allied to Araucaria, and anomalous Gymnosperms, as Nöggerathia. 2. The reign of Gymnosperms, comprehending the lower and middle secondary periods. Here we meet with numerous Coniferæ and Cycadaceæ, while Ferns are less abundant. 3. The reign of Angiosperms, embracing the Cretaceous and the Tertiary periods. This is characterised by the appearance of Angiospermous Dicotyledons, a class of plants which constitute more than three-fourths of the present vegetable productions of the globe, and which appear to have acquired a predominance from the commencement of the Tertiary formations. These plants appear even at the beginning of the Chalk formation.

1703. I. Reign of Acrogens.—In the lower Palæozoic strata the plants which have been detected are few. In the Silurian, Cambrian, and Old Red Sandstone systems, we meet with the remains of ancient marine plants, as well as a few terrestrial species. In the Lower Silurian or Grauwacke, near Girvan, Hugh Miller has found a species resembling Zostera in form and appearance. In the lower Old Red Sandstone of Scotland, he has detected Fucoids, a Lepidodendron, and Lignite with a distinct Coniferous structure resembling that of Araucaria,* besides a remarkable pinnate frond. In the middle Old Red of Forfarshire, as seen in the Arbroath pavement, he has collected specimens of a peculiar plant, bearing organs which resemble in appearance small receptacles of Nelumbium, besides a Fern with reniform pinnæ and a Lepidodendron; while, in the upper Old Red near Dunse, a Neuropteris, like N. gigantea, of the Coal Measures, and a Calamite have been discovered by him.† In the Old Red Sandstone rocks at Oporto, Bunbury detected Pecopteris Cyathea, P. muricata, and Neuropteris tenuifolia—Ferns allied to those of the Coal Measures.

1704. The Carboniferous period is one of the most important as regards fossil plants. The vegetable forms are numerous and uniform throughout the whole system, whether exhibited in the Old or the New World. The important substance called coal owes its origin to the plants of this epoch. It has been formed under great pressure, and hence the appearance of the plants has been much altered. On examining thin sections of coal under the microscope, we can detect vegetable tissues both of a cellular and vascular nature. In Wigan cannel coal, vegetable structure is seen throughout the whole mass. Such is likewise the case with other cannel, parrot, and gas

* Miller's Footprints of the Creator, 192-199. Doubts have been thrown on the antiquity of this specimen by those who support the erroneous progressive development theory; but the presence, in the same nodule, of a scale of a fish only found in the lower Old Red, puts the matter beyond doubt.

† Specimens of these fossil plants, as well as numerous others, illustrating the fossil flora of Scotland, are to be seen in Mr. Miller's interesting Museum.

coals. In common household coal, also, evident traces of organic tissue have been observed. In some kinds of coal punctated woody fibre has been detected, in others scalariform tissue, as well as cells of different kinds. Sporangia are also occasionally found in the substance of coal, as shown by Mr. Daw in that from Fordel. The structure of coal in different beds, and in different parts of the same bed, seems to vary according to the nature of the plants by which it has been formed. Hence the different varieties of coal which are worked. The occurrence of punctated tissue indicates the presence of Coniferæ in the coal bed, while scalariform vessels point to Ferns, and their allied forms, such as Sigillaria, Stigmaria, and Lepidodendron. The anatomical structure of the stems of these plants will undoubtedly have some effect on the microscopic characters of the coal produced from them. In some cannel coals the structure resembles that of Tree-ferns of the present day. A brownish-yellow substance is occasionally present, which seems to yield abundance of carburetted hydrogen gas when exposed to heat.

1705. It appears that in general each bed of coal is accompanied by the remains of a somewhat limited amount of species Their number, particularly in the most ancient beds, is scarcely more than eight or ten. In other cases the number is more considerable, but rarely more than thirty or forty. In the same coal basin each layer often contains several characteristic species which are not met with either in more ancient or more recent strata. Thus, there are sometimes small local or temporary floras, each of which has given birth to layers of coal. The quantity of carbonaceous and other matter required to form a bed of coal is immense. Maclaren has calculated that one acre of coal, three feet thick, is equal to the produce of 1940 acres of forest.* The proportion of carbon varies in different kinds of coal. Along with it there is always more or less of earthy matter, which constitutes the ashes. When the earthy substances are in such quantity that the coaly deposit will not burn as fuel, then we have what is called a shale. The coal contains plants similar to those of the shales and sandstones above and below it. In a coal-seam there is the Under-clay, containing roots only; then the Coal composed of plants, whose roots are in the clay, with others which have grown along with them, or have been drifted; while above the coal is the Shale bearing evidences of vigorous vegetation, and which appears like a great deposit from water charged with mineral matter, into which broken pieces of plants have fallen. There is no clear division between coal and shale.

1706. The total thickness of coal in the English coal-fields is about 50 or 60 feet. In the Mid-Lothian field, there are 108 feet of coal. Coal beds are worked at 1725 feet below the sea-level, and probably extend down to upwards of 20,000 feet. They rise to 12,000 feet above the sea-level, and at Huanuco, in Peru, to 14,700.† It is said that the first coal-works were opened in Belgium in 1198, and

* Maclaren, Geology of Fife and the Lothians, p. 116. † Our Coal Fields, by a Traveller under ground.

soon after in England and Scotland; it was not till the 15th century that they were opened in France and Germany. In 1843, the following were the statements as to some of the English collieries :—

NAMES OF COLLIERIES.	Average Depth.	No. of Pits or Collieries.	Men and Boys Employed.	Engine Power in Horses.	Coal raised per annum in Tons.
Tyne River Collieries	510 Feet.	92	12,833	9690	2,468,481
Wear River Collieries	450	88	11,558	8907	2,355,486
Tees River Collieries	330	12	1,379	800	1,682,404

The following calculations have been made as to the extent of the coal formation in different countries, and the amount of coal raised :—

COUNTRIES.	Square Miles of Coal Formation.	Tons of Fuel raised in 1845.
Great Britain	11,859	31,500,000
Belgium	518	4,960,077
United States	133,132	4,400,000
France	1719	4,141,617
Russian States	——	3,500,000
Austrian States	——	659,340

The coal-fields in Great Britain have been estimated at 4251 square miles. M'Culloch estimates the total number of persons employed in the collieries of Great Britain at 160,000 or 180,000, and the total capital employed in the British coal trade at £10,000,000.

1707. Unger enumerates 683 plants of the coal measures, while Brongniart notices 500. Of the last number there are 6 Thallogens, 346 Acrogens, 135 Gymnosperms, and 13 doubtful plants. This appears to be a very scanty vegetation, as far as regards the number of species. It is only equal to about 1-20th of the number of species now growing on the surface of the soil of Europe. Although, however, the number of species was small, yet it is probable that the individuals of a species were numerous. The proportion of Ferns was very large. There are between 200 and 300 enumerated. The following are some of the Cryptogamous and Phanerogamous genera belonging to the flora of the Carboniferous period :—Cyclopteris, Neuropteris, Odontopteris, Sphenopteris, Hymenophyllites, Alethopteris, Pecopteris, Coniopteris, Cladophlebis, Senftenbergia, Lonchopteris, Glossopteris, Caulopteris, Lepidodendron, Lepidostrobus, Lepidophyllum, Ulodendron, Halonia, Knorria, Psaronius, Sigillaria and Stigmaria, Calamites, Asterophyllites, Spenophyllum, Nöggerathia, Walchia, Peuce, Dadoxylon, Pissadendron, Trigonocarpum.

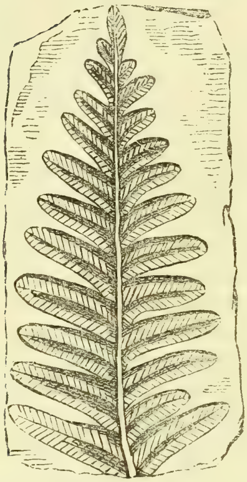
1708. Ferns are the only carboniferous fossil group which present an obvious and recognisable relationship to an order of the present day. While cellular plants and those with lax tissues lose their characters by fossilization, Ferns are more durable, and retain their structure.

It is rare, however, to find the stalk of the frond completely preserved down to its base. It is also rare to find fructification present. In this respect, fossil Ferns resemble Tree-ferns of the present day, the fronds of which rarely exhibit fructification.* Only one surface of the Fern-frond is exposed to view, and that generally the least important in a botanical point of view. Fructification is sometimes evidently seen, as figured by Corda in Senftenbergia. The absence of fructification presents a great obstacle to the determination of fossil Ferns. Circinate vernation, so common in modern Ferns, is not commonly seen in the fossil species, and we do not in general meet with rhizomes. Characters taken from the venation and forms of the fronds are not always to be depended upon, if we are to judge from the Ferns of the present day. There is a great similarity between the carboniferous Ferns of Britain and America. In the English coal measures the species are 140. The preponderance of Ferns over flowering plants is seen at the present day in many tropical islands, such as St. Helena and the Society group, as well as in extra-tropical islands, as New Zealand. In the latter, Hooker picked 36 kinds in an area of a few acres; they gave a luxuriant aspect to the vegetation, which presented scarcely twelve flowering plants and trees besides. An equal area in the neighbourhood of Sidney (in about the same latitude) would have yielded upwards of 100 flowering plants and only two or three Ferns. This Acrogenous flora, then, seems to favour the idea of a humid as well mild and equable climate at the period of the coal formation—the vegetation being that of islands in the midst of a vast ocean.

1709. Among the Ferns found in the clays, ironstones, and sandstones of the Carboniferous period, we may give the characters of some by way of illustration. Pecopteris (Fig. 1808) seems to be the fossil representative, if not congener, of Pteris. Pecopteris heterophylla (Fig. 1809) has a marked resemblance to Pteris esculenta of New Zealand. The frond of Pecopteris is pinnatifid or bi-tri-pinnatifid—the leaflets adhering to the rachis by the whole length of their base, sometimes confluent; the midrib of the leaflets runs to the point, and the veins come off from it nearly perpendicularly, and the fructification when present is at the ends of the veins. Neuropteris (Figs. 1810, 1811, and 1812) has a pinnate or bipinnate frond, with pinnæ somewhat cordate at the base—the midrib of the pinnæ vanishing towards the apex, and the veins coming off obliquely, and in an arched manner. Neuropteris gigantea (Fig. 1811), has a thick bare rachis, according to Miller, and seems to resemble much Osmunda regalis. Odontopteris has leaves like the last, but its leaflets adhere to the stalk by their whole base, the veins spring from the base of the leaflets, and pass on towards the point. Sphenopteris (Fig. 1813), has a twice or thrice pinnatifid frond, the leaflets being narrowed at the base, often wedge-shaped, and the veins generally arranged as if they radiated from the base. Sphenopteris elegans resembled Pteris aquilina in having a

* Hooker states, that of two or three kinds of New Zealand Tree-fern, not one specimen in a thousand bears a single fertile frond, though all abound in barren ones.

stout leafless rachis, which divided at a height of seven or eight inches from its club-like base into two equal parts, each of which con-



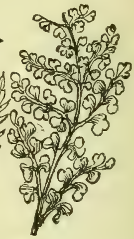


Fig. 1813. Fig. 1809. Fig. 1814.

Fig. 1808. Fig. 1810. Fig. 1811. Fig. 1812.

tinued to undergo two or three successive bifurcations. A little below the first forking two divided pinnæ were sent off. A very complete specimen, with the stipe, was collected in the coal-field near Edinburgh, by Hugh Miller, who has described it as above. Lonchopteris has its frond multi-pinnatifid, and the leaflets more or less united together at the base; there is a distinct midrib, and the veins are reticulated. Cyclopteris (Fig. 1814), has simple orbicular leaves, undivided or lobed at the margin, the veins radiating from the base, with no midrib. Schizopteris resembles the last, but the frond is deeply divided into numerous unequal segments, which are usually lobed and taper-pointed. Caulopteris (Fig. 1815), is the name given to the stems of Tree-ferns found in the coal fields.

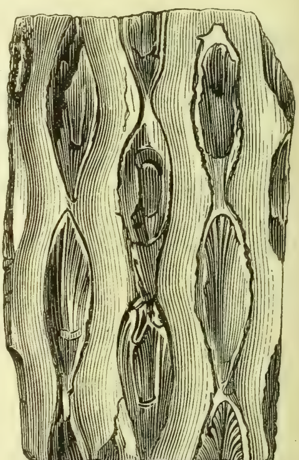


Fig. 1815.

Figures 1808 to 1814 exhibit the fronds of some of the Ferns of the Carboniferous epoch.

Fig. 1808. Pecopteris (Alethopteris) aquilina. Fig. 1809. Pecopteris (Alethopteris) heterophylla Fig. 1810. Neuropteris Lochii. Fig. 1811. Neuropteris gigantea. Fig. 1812. Neuropteris acuminata or smilacifolia. Fig. 1813. Sphenopteris affinis. Fig. 1814. Cyclopteris dilatata.

Fig. 1815. Stem of Tree-fern called Caulopteris or Ptychopteris Macrodiscus.

They are marked externally by oblong scars similar to those of Tree-

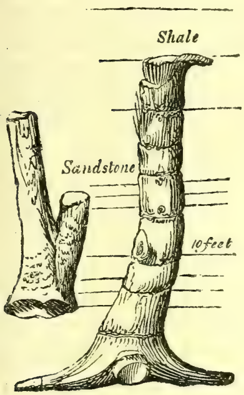


Fig. 1816.

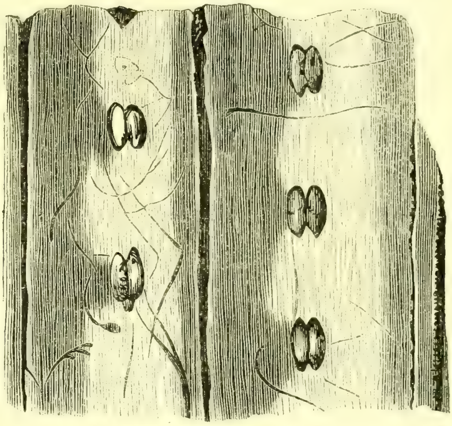


Fig. 1820.

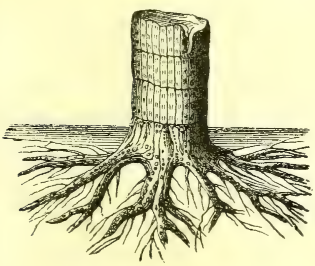


Fig. 1817.

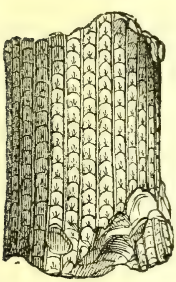


Fig. 1819.

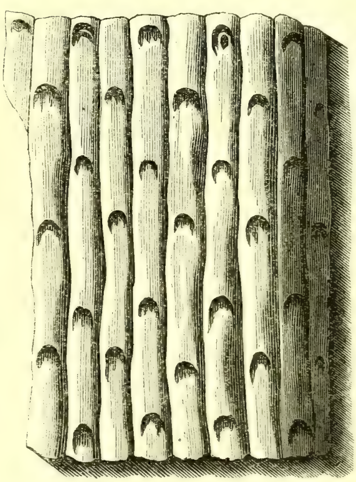


Fig. 1818.

ferns of the present day. These stems probably belong to some of the

Figures 1816 to 1820 exhibit forms of Sigillaria stems found in the shales of the Carboniferous epoch.

Fig. 1816. Stem of Sigillaria pachyderma in an erect position, covered by successive deposits of sandstone and shale; one of the stems is bifurcated. Fig. 1817. Sigillaria stem with its external markings, and roots which are Stigmarias, as proved by Mr. Binney. Fig. 1818. Sigillaria pachy-

fronds to which other names are given, but as they have not been found attached, it is impossible to determine the point. Miller has described a fern as occurring in the coal measures, which at first sight presents more the appearance of a Cycadaceous frond than any other vegetable organism of the Carboniferous age yet seen. He thus describes it:—" From a stipe about a line in thickness there proceed at right angles, and in alternate order, a series of sessile lanceolate leaflets, rather more than two inches in length, by about an eighth part of an inch in breadth, and about three lines apart. Each is furnished with a slender mid-rib; and, what seems a singular, though not entirely unique feature in a Fern, the edges of each are densely hirsute, and bristle with thick short hair. The venation is not distinctly preserved."

1710. Sigillaria is perhaps the most important plant in the coal formation. It is found in all coal shales over the world. There are upwards of 60 species. It occurs in the form of lofty stems, 40-50 feet high, and 5 feet broad (Figs. 1816 and 1817). Many stems of Sigillaria may be seen near Morpeth, standing erect at right angles to the planes of alternating strata of shale and sandstone (Fig. 1816). They vary from 10 to 20 feet in height, and from one to three feet in diameter. Sir W. C. Trevelyan counted 20 portions of these trees within the length of half a mile, of which all but four or five were upright. Brongniart mentions similar erect stems as being found near St. Etienne. The stem of Sigillaria is fluted in a longitudinal manner, and has a succession of single and double scars, which indicate the points of insertion of the leaves (Figs. 1818 and 1819). When the outer part of the stem separates like bark, it is found that the markings presented by the inner surface differ from those seen externally (Fig. 1820). This has sometimes given rise to the erroneous supposition that they belong to different genera. In Sigillaria elegans there is a woody system similar to that to be noticed in Stigmaria, which is broken up into cuneiform plates, separated by medullary rays, and there is another vascular system, forming a series of bundles in the medullary axis of the stem, each placed opposite the wedges of wood. The bundles which go directly to the leaves are placed opposite to the woody wedges externally (not as in Stigmaria, opposite to the medullary rays). It is probable that, in Sigillaria, the outer and inner bundles of tissue communicate by the medullary rays, and that they are thus both connected with the leaves. There is a curious crucial mark quartering the base of the root, and corresponding with four main roots which proceed from it.

1711. It has been recently ascertained by Mr. Binney of Man-

derma after Lindley and Hutton, from the shale of Killingworth Colliery, showing the scars or places through which the vessels of the stem passed to the leaves. The bark remains on the specimen, and the scars are clear, broad, and well defined. Fig. 1819. Sigillaria (Favularia) tessellata, from the Denbigh coal shale, showing the fluted stem with scars. Fig. 1820. Sigillaria reniformis after Lindley and Hutton, decorticated, that is to say, with the bark removed, showing contiguous oval scars arranged in pairs. When the plant is corticated, or has the bark entire, then the scars are roundish, kidney-shaped, having a point in the centre, and at a little distance on each side a curved mark.

chester, that the plant called Stigmaria (Fig. 1821) is not a separate genus, but the root, or rather the rhizome of Sigillaria. It is one of the most common productions of the coal measures, and consists of long rounded or compressed fragments, marked externally by shallow circular, oblong, or lanceolate cavities (Fig. 1822) in the centre of slight tubercles, arranged irregularly, but sometimes in a quincuncial manner. The cavities occasionally present a radiating appearance. The axis of the fragments is often hollow, and different in texture from the parts around. This axis consists of a vascular cylinder or woody system, divided into wedge-shaped masses by medullary rays of various breadths. In these rays there is another system of smaller tubes, which originate probably from the outer cellular axis, and not from the central woody cylinder. From the scars and tubercles arise long ribbon-shaped processes, which appear to have been hollow roots compressed. Stigmaria ficoides (Fig. 1821) is often found creeping in the under-clay of a coal seam, sending out numerous roots from its tubercles, and pushing up its aerial stem, in the form of a fluted Sigillaria. On the Bolton and Manchester Railway, Mr. Binney discovered Sigi-

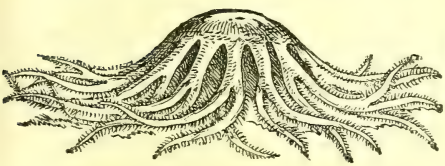


Fig. 1821.

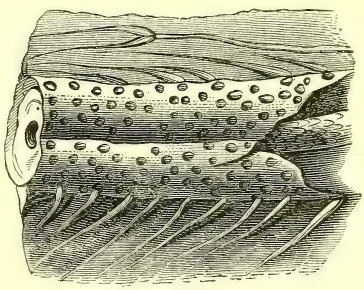


Fig. 1822.

larias standing erect, and evidently connected with Stigmarias which extended 20 feet or more.* While the rhizomes, stem, and roots have thus been determined, we have no means of ascertaining the foliage. Mr. King and others suppose that the Fern-like frond called Neuropteris is connected with Sigillaria, but this is a mere conjecture. It is probable that Sigillaria was an acrogenous plant allied to Lycopodiaceæ, although of higher organization. Brongniart reckons it among peculiar Gymnosperms, and King considers it intermediate between Ferns and Cycadaceæ, and says, " if, in imagination, we delineate a channelled stem of any height between 12 and 100 feet, crowned with a

Fig. 1821. Stigmaria ficoides, consisting of the lower part of a stem of Sigillaria, with roots or rhizomes, bearing fibrils.

Fig. 1822. Stigmaria ficoides (S. Anabathra of Corda), which is considered as the root or rhizome of a Sigillaria. The markings are the points whence rootlets proceed.

* The imbedding of plants in an erect state in strata is similar to what was noticed at the present day by Gardner in Brazil, where stems of recent Coco-nut Palms were seen covered with sand to the depth of 50 feet.

pendent Fern-like foliage, furnished with wide-spreading thickly fibril-

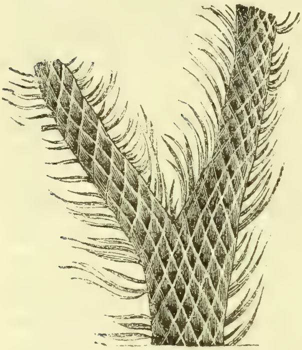


Fig. 1823.

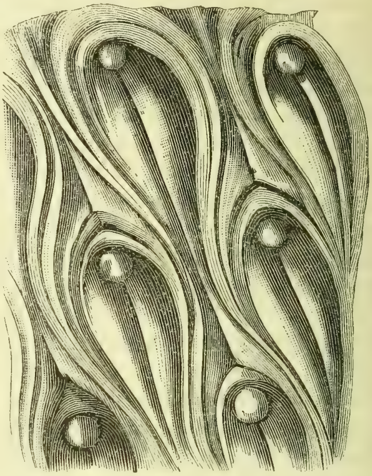


Fig. 1824.

led roots, and growing in some densely-wooded swamp of an ancient Mississippi, then we shall have formed a tolerably close restoration of a Sigillaria vegetating in its true habitat."

Fig. 1825.

Fig. 1826.

1712. Lepidodendron (Figs. 1823 and 1824) is another genus of the coal measures which differs from those of the present day. It seems to occupy an intermediate place between Lycopodiaceæ and Coniferæ. The stem is from 20 to 45 feet high, marked outside by peculiar scaly-like scars (Fig. 1824), hence the name of the plant. The linear or lanceolate leaves are arranged in the same way as those of Lycopodiums or of Coniferæ, and the branches fork like the former. There is a

Figures 1823 to 1825 exhibit the stems of Lepidodendron.

Fig. 1823. Bifurcating stem of Lepidodendron obovatum (elegans), showing the scale-like scars, and the narrow-pointed leaves, resembling those of Lycopodium. Fig. 1824. Scars on the stem of Lepidodendron obovatum taken from the Bensham coal-seam at Jarrow colliery (after Lindley and Hutton) The marks on the outside are obovate areolæ, with a rounded apex and tapering base, bearing a nearly circular scar at the top of the areola. Fig. 1825. Lepidostrobus ornatus, after Lindley and Hutton, from the Bensham coal-seam of the Jarrow colliery, showing central axis with leaflets. It seems to be the fructification of a Lepidodendron.

Fig. 1826. Trigonocarpum olivæforme, an ovate, acuminate, three-ribbed and striated fruit or seed which some suppose to be a sporangium of a Lepidodendron, others refer it to Cycadaceæ.

double vascular system in the trunk, one in the centre, and another placed externally to the woody mass. The latter vascular system forms a continuous zone outside the wood; its inner edge is well defined, and its outer, whence bundles are given off to the leaves, is sinuous. Although the scars on Lepidodendron are usually flattened, yet in some species they occupy the faces of diamond-shaped projections, elevated one-sixth of an inch or more above the surface of the stem, and separated from each other by deep furrows;—the surface bearing the leaf being perforated by a tubular cavity, through which the bundle of vessels that diverged from the vascular axis of the stem to the leaf passed out. The fruit of Lepidodendron is seen in Lepidostrobus (Fig. 1825), which appears to consist of scales covering sporangia, in the interior of which are spores, consisting of three or four angular sporules, which have been seen in a separate state. It is probable that many other fossil forms are connected with or allied to Lepidodendrons. Thus Lepidophyllum is probably the leaf of some species of the genus, while Strobilites is a form of the fruit. The slender terminal branches are noticed under the name of Lycopodites, and it is likely that one or more of the kinds of Trigonocarpum (Fig. 1826) are sporangia of a Lepidodendron. In coal from Fordel, Mr. Daw has detected innumerable bodies which appear to be sporangia of Lycopodites. Bothrodendron and Knorria appear to be forms allied to Lepidodendron. Some think that Halonia is the root of Lepidodendron. Ulodendron appears to be a distinct genus. Hugh Miller states that Ulodendron minus, found in ferruginous shale in the Water of Leith, near Colinton, exhibits beautiful sculptured scars, ranged rectilinearly along the stem. The surface is covered with small sharply-relieved obovate scales, most of them furnished with an apparent midrib, and with their edges slightly turned up. The circular or oval scars of this genus are probably impressions made by a rectilinear range of almost sessile cone-like fructification placed on either side. When decorticated, the stem is mottled over with minute dottings arranged in a quincuncial manner, and its oval scars are devoid of the ordinary sculpturings.

Fig. 1828.

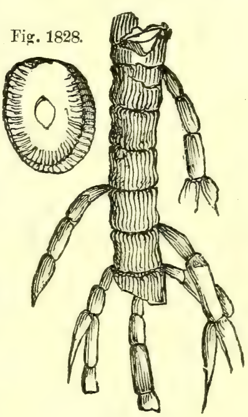


Fig. 1827.

1713. Calamites (Figs. 1827 and 1828) is a reed-like fossil, having a subcylindrical, furrowed, and jointed stem, the furrows of the joints alternating and often converging. The stem is often crushed and flattened, and may probably have been originally hollow. At the joints, (Fig. 1828), there are toothed sheaths or tubercles, which are

Fig. 1827. Calamites Lindleyi (C. Mougeotii L. and H. foss. flora), a jointed reed-like stem, with furrows on the surface. Stem with branches according to some, roots according to Binney.
Fig. 1828. Calamites Lindleyi. Partition of one of the joints.

disposed symmetrically between the furrows. The fructification is unknown. There appears to have been a bark which could be separated from the woody tissue below. The plants have been seen erect by Mr. Binney, and he has determined that what were called leaves or branches by some, are in reality roots. There are 51 species recorded. They have been compared to Equisetaceæ.

1714. True Exogenous trees exist in the coal-fields both of England and Scotland, as at Lennel Braes and Allan Bank, in Berwickshire, High-Heworth, Fellon, Gateshead, and Wideopen, near Newcastle-upon-Tyne, and in quarries to the west of Durham; also in Craigleith quarry, near Edinburgh, and in the quarry at Granton. In the latter localities, they lie diagonally athwart the strata, at an angle of about 30°, with the thicker and heavier part of their trunks below, like snags in the Mississippi. From their direction, we infer that they have been drifted by a stream which has flowed from nearly north-east to south-west. At Granton, one of the specimens exhibits roots. In other places the specimens are portions of stems, one of them six feet in diameter by 61 feet in length, and another four feet in diameter by 70 feet in length. These Exogenous trees are Gymnosperms, having woody tissue like that of Coniferæ. We see under the microscope punctated woody tissue, the rows of disks being usually two, three, or more, and alternating. They seem to be allied in these respects to Araucaria and Eutassa of the present flora. Dadoxylon or Pinites Withami is one of the species found in Craigleith quarry; the concentric layers of the wood are obsolete; there are 2, 3, or 4 rows of disks on the wood, and 2-4 rows of small cells in the medullary rays. Along with it there have also been found Dadoxylon medullare, with inconspicuous zones, 2, 3, and 4 rows of disks, and 2-5 series of rows of cells in the rays. Pissadendron antiquum (Pitus antiqua), having 4-5 series of cells in the medullary rays, and P. primævum (Pitus primæva), with 10-15 series of cells in the medullary rays, occur at Tweedmill and Lennel Braes in Berwickshire; Peuce Withami (Fig. 1807, p. 1040) at Hilltop, near Durham, and at Craigleith; P. Lindleyana, at Whitby and Scarborough; P. australis in Van Diemen's Land; and P. Pritchardi in Ireland. Sternbergia is considered by Williamson as a Dadoxylon, with a discoid pith like that seen now-a-day in the Walnut and Jasmine, as well as in some species of Euphorbia.* Sternbergia approximata is named by him Dadoxylon approximatum. Nöggerathia and a few other plants, such as Flabellaria and Artisia, are referred by Brongniart to Cycadaceæ. Nöggerathia has pinnate leaves, cuneiform leaflets, sometimes fan-shaped; the veins arise from the base of leaflets, are equal in size, and either remain simple or bifurcate, the neuration or venation being similar to that of some Zamias.

1715. Our knowledge of the real state of the vegetation of the earth when coal was formed must be very limited, when we reflect

* Williamson on the Structure and Affinities of Sternbergiæ, in Manch. Lit. and Phil. Soc. Mem. ix.

how seldom the fructification of coniferous trees has been met with in the coal measures. One example is given in Lindley and Hutton's work, under the title of Pinus anthracina. Lyell never saw one fossil fir-cone of the Carboniferous epoch, either in the rocks or museums of North America or Europe. Bunbury never heard of more than one example, that noticed by Lindley and Hutton. Sir Charles Lyell remarks—" To prevent ourselves, therefore, from hazarding false generalizations, we must ever bear in mind the extreme scantiness of our present information respecting the flora of that peculiar class of stations to which in the Palæozoic era the coal measures probably belonged. I have stated elsewhere my conviction that the plants which produced coal were not drifted from a distance, but nearly all of them grew on the spot where they became fossil. They constituted the vegetation of low regions, chiefly the deltas of large rivers, slightly elevated above the level of the sea, and liable to be submerged beneath the waters of an estuary or sea, by the subsidence of the ground to the amount of a few feet. That the areas where the carboniferous deposits accumulated were low, is proved not only by the occasional association of marine remains, but by the enormous thickness of strata of shale and sandstone to which the seams of coal are subordinate. The coal measures are often thousands of feet, and sometimes two or three miles in vertical thickness, and they imply, that for an indefinite number of ages a great body of water flowed continuously in one direction, carrying down towards a given area the detritus of a large hydrographical basin, draining some large islands or continents, on the margins of which the forests of the coal period grew. If this view be correct, we can know little or nothing of the upland flora of the same era, still less of the contemporaneous plants of the mountainous or alpine regions. If so, this fact may go far to account for the apparent monotony of the vegetation, although its uniform character may doubtless be in part owing to a greater uniformity of climate then prevailing throughout the globe. Mr. Bunbury has successfully pointed out that the peculiarity of the carboniferous climate consisted more in the humidity of the atmosphere and the absence of cold, or rather the equable temperature preserved in the different seasons of the year, than in its tropical heat; but we must still presume that colder climates existed at higher elevations above the sea."

1716. The plants of the coal measure seem to be evidently terrestrial plants, and fresh-water aquatics. Brongniart agrees with Lyell in thinking that the layers of coal have in general accumulated in the situation where the plants forming them grew. The remains of these plants covered the soil in the same way as layers of peat, or the vegetable mould of great forests. In a few instances, however, the plants appear to have been transported from a distance, and drifted into basins. Phillips is disposed to think that this was the general mode of formation of coal basins. He is led to this conclusion by observing the fragmentary state of the stems and branches, the general absence of roots, and the scattered condition of all the separable organs. Those who support the drift theory, look on the coal plants as having been swept from the land on which they grew by watery currents at different times, and deposited in basins and large sea-estuaries, and sometimes in lakes. The snags in the Mississippi, the St. Lawrence, and other large rivers, are given as instances of a similar drifting process.

1717. The nature of the vegetation during the Permian Period, which is associated with the Carboniferous, under the reign of Acrogens, has not been positively determined. Brongniart has enumerated the fossils in three different localities, which he refers doubtfully to this period. 1. The flora of the bituminous slates of Thuringia, composed of Algæ, Ferns, and Coniferæ. 2. Flora of the Permian sandstones of Russia, comprehending Ferns, Equisetaceæ, Lycopodiaceæ, and Nöggerathiæ. 3. Flora of the slaty schists of Lodève, composed of Ferns, Asterophyllites, and Coniferæ. The genera of Ferns here met with are also found in the Carboniferous epoch; the Gymnosperms are chiefly species of Walchia and Nöggerathia. Lepidodendron elongatum, Calamites gigas, and Annularia floribunda, are also species of this period.

1718. II. Reign of Gymnosperms.—In this reign the Acrogenous species are less numerous, the Gymnosperms almost equal them in number, and ordinarily surpass them in frequency. There are two periods of this reign, one in which Coniferæ (p. 906) predominate, while Cycadaceæ scarcely appear, and another in which the latter family preponderates as regards the number of species, and the frequency and variety of generic forms. Cycadaceæ (p. 911) occupied a more important place in the ancient than in the present vegetable world. They extend more or less from the coal formation, up to the Tertiary. They are rare in the Grèsbigarré, or lower strata of the Triassic system, and in the Chalk. They attain their maximum in the Lias and Oolite, in each of which upwards of 40 species have been enumerated, and they disappear in the Tertiary formations.

1719. In Brongniart's Vosgesian period, the Grès-bigarré, or the Red Sandstones and Conglomerates of the Triassic system, there is a change in the flora. Sigillarias and Lepidodendrons disappear, and in their place we meet with Gymnosperms, belonging to the genera Voltzia, Haidingera, Zamites, Ctenis, Æthophyllum, and Schizoneura. Species of Neuropteris, Pecopteris, and other acrogenous coal genera are still found, along with species of Anomopteris and Crematopteris—peculiar Fern-forms, which are not found in later formations. Stems of arborescent Ferns are more frequent than in the next period.

1720. The Triassic period of Brongniart embraces the Keupric epoch or variegated marls of the Triassic system, the Liassic epoch, the Oolitic, and the Wealden. The flora of the Keupric epoch differs from that of the Grès-bigarré of the Vosges. The Acrogens are changed as regards species, and frequently in their genera. Thus we have the genera Camptopteris, Sagenopteris, and Equisetum. Among Gymnosperms, the genera Pterophyllum and Taxodites occur.

1721. In the Lias the essential characters of the flora are the predominance of Cycadaceæ, in the form of species of Cycadites, Otozamites, Zamites, Ctenis, Pterophyllum (Fig. 1829), and Nilsonia (Fig. 1830), and the existence among the Ferns of many genera

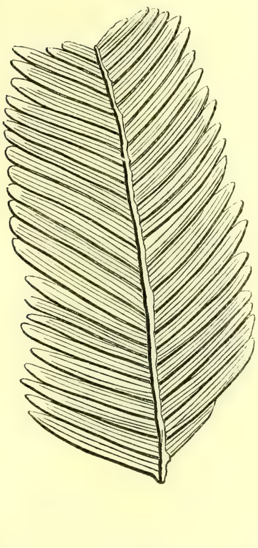


Fig. 1829.

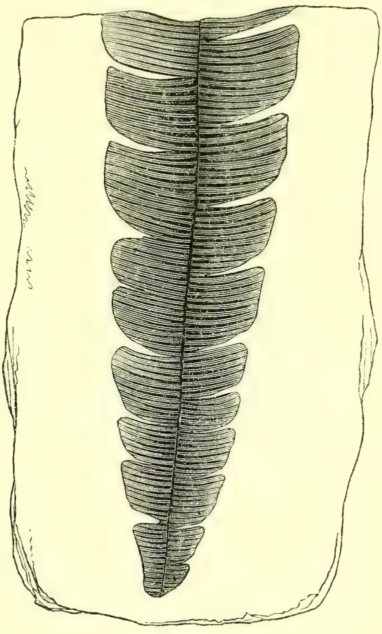


Fig. 1830.

with reticulated venation, such as Camptopteris and Thaumatopteris, some of which began to appear at the Keupric epoch. Coniferous genera, as Brachyphyllum, Taxodites, Palissya, and Peuce are found. In the Lias near Cromarty, Miller found a cone with long bracts like those of Pinus bracteata.

1722. In the Oolitic epoch, the flora consists of numerous Cycadaceæ and Coniferæ, some of them having peculiar forms. Its dis-

Figures 1829 and 1830. Cycadaceæ of the Jurassic epoch of Brongniart.

Fig. 1829. Pterophyllum Preslianum (Zamia pectinata of Brongniart, and Lindley and Hutton), a pinnated leaf, with a slender rachis. The pinnæ are linear, somewhat obtuse, with slender equal ribs. It is found in the Oolite of Stonesfield (Lindley and Hutton). Fig. 1830. Nilsonia compta (Pterophyllum comptum of Lindley and Hutton), from the Oolite of Scarborough. Lower part of the pinnatifid leaf, with blunt almost square divisions. There are numerous veins, slightly varying in thickness, while in Pterophyllum there are numerous veins of equal thickness, in Cycadites there is a solitary vein forming a thick midrib.

tinctive characters are, the rarity of Ferns with reticulated venation, which are so numerous in the Lias, the frequency of the Cycadaceous genera Otozamites and Zamites, which are most analogous to those now existing, and the diminution of Ctenis, Pterophyllum (Fig. 1829), and Nilsonia (Fig. 1830), genera far removed from the living kinds; and lastly, the greater frequency of the coniferous genera, Brachyphyllum and Thuites, which are much more rare in the Lias. In the Scotch Oolite at Helmsdale, Miller has detected about 60 species of plants, including Cycadaceæ and Coniferæ, with detached cones, and Fern forms resembling Scolopendrium. He also discovered a species of Equisetum, and a Calamite which is a connecting link between the Oolitic and Carboniferous epochs.

1723. There is an absence of true coal fields in the secondary formations generally; but in some of the Oolitic series, as in the lower Oolite at Brora, in Sutherlandshire, and the Kimmeridge clay of the

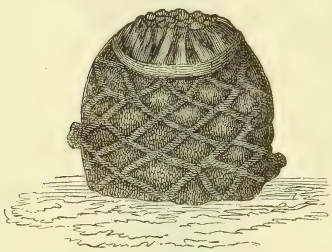


Fig. 1831.

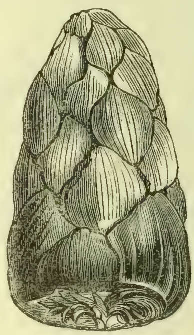


Fig. 1832.

upper Oolite, near Weymouth, there are considerable deposits of carbonaceous matter, but the vegetable remains are only in the state of imperfect lignite. In the sandstones and shales of the Oolitic series, especially in the lower Oolite of the north of England, as at Whitby and Scarborough, as well as in Stonesfield slate, the Portland Crag of the middle, and the Portland beds of the upper Oolite, numerous fossil plants are found. The upper Oolite at Portland contains an interesting bed about a foot in thickness, of a dark brown substance, containing much earthy lignite. This is the Dirt-bed, made up of black loam, which, at some far distant period, nourished the roots of trees, fragments of whose stems are now found fossilized around it. These consist of an assemblage of silicified stumps or stools of large trees,

Fig. 1831. Cycadoidea megalophylla (Mantellia nidiformis of Brongniart), a subglobose depressed trunk, with a concave apex, and with the remains of the petioles disposed in a spiral manner, the markings being transversely elliptical. It is found in the Oolite of the Island of Portland, in a silicified state.

Fig. 1832. Zamiostrobus ovatus (Zamia ovata of Lindley and Hutton), an ovate cone with a truncated base and obtuse apex. The genus seems to be intermediate between Encephalartos and Zamia. It is found in the green-sand at Faversham (Lindley and Hutton).

standing from 1-3 feet from the mould. Most of them are erect, some slightly inclined, and the roots remain attached to the earth in which they grew. They appear to resemble Cycadaceæ. One of these is Cycadoidea megalophylla, shown in Figure 1831.

1724. The flora of the Wealden epoch is characterised in the north of England by the abundance of the Fern called Lonchopteris Mantellii, and in Germany by the predominance of the Conifer denominated Abietites Linkii, as well as by numerous Cycadaceæ, such as species of Cycadites, Zamites, Pterophyllum, Zamiostrobus (Fig. 1832), Cycadoidea, Clathraria. Mantell states that he has found 40 or 50 fossil cones in the Wealden of England. The remains are those of land vegetables. The Wealden fresh water formation terminates the reign of Gymnosperms.

1725. III. Reign of Angiosperms.—This reign is characterised by the appearance of Angiospermous Dicotyledons, plants which constitute more than three-fourths of the present vegetable productions of the globe, and which appear to have acquired the predominance from the commencement of the Tertiary epoch. These plants, however, appear even at the beginning of the Cretaceous period. In this reign, therefore, Brongniart includes the upper secondary period, or the Cretaceous system, and all the Tertiary period. The Cretaceous may be considered as a sort of transition period between the reign of Gymnosperms and Angiosperms. The Chalk flora is characterised by the Gymnospermous almost equalling the Angiospermous Dicotyledons, and by the existence of a considerable number of Cycadaceæ, which do not appear in the Tertiary period. The genus Credneria is one of the characteristic forms. In this period we find Algæ represented by Cystoseirites, Confervites, Sargassites, and Chondrites; Ferns by peculiar species of Pecopteris and Protopteris; Naiadaceæ by Zosterites; Palms, by Flabellaria and Palmacites; Cycadaceæ, by Cycadites, Zamites, Microzamia, and Zamiostrobus; Coniferæ, by Brachyphyllum, Widdringtonites, Cryptomeria, Abietites, Pinites, Cunninghamites, Dammarites, Araucarites; and Angiospermous Dicotyledons, by Comptonites, Alnites, Carpinites, Salicites, Acerites, Juglandites, and Credneria. Between the Chalk and the Tertiary period, there is a Fucoidean epoch, characterised by deposits rich in Algæ, of a very peculiar form, belonging to the genera Chondrites and Munsteria. No land plants have been found mingled with these marine species.

1726. The Tertiary period is characterised by the abundance of Angiospermous Dicotyledons and of Monocotyledons, more especially of Palms. By this it is distinguished from the more ancient periods. Angiosperms at this period greatly exceed Gymnosperms. Cycadaceæ are completely awanting in the European Tertiary strata, and the Coniferæ belong to genera of the temperate regions. Although the vegetation throughout the whole of the Tertiary period presents pretty uniform characters, still there are notable differences in the generic and specific forms, and in the predominance of certain orders at different epochs. Brongniart does not entirely agree with Unger as to these epochs. Many of the formations classified by Unger in the Miocene division he refers with Raulin to the Pliocene. He divides the Tertiary period, as regards plants, into the Eocene, Miocene, and Pliocene epochs, and gives the following comparative results from an examination of their floras :—

Classes and Sub-Classes.	Eocene Epoch.	Miocene Epoch.	Pliocene Epoch.
Thallogenæ	16	6	6
Acrogenæ	17	4	7
Monocotyledones	33	26	4
Dicotyledones—			
Gymnospermæ	40	19	31
Angiospermæ	103	78	164
	209	133	212

In the Eocene formation, the fossil fruits of the Isle of Sheppey increase the number of Phanerogamous plants. This is an exceptional locality, and is perhaps an example of the effects of currents in conveying exotic plants from remote climates. The number of plants as given by Brongniart is much smaller than that mentioned by Unger (p. 1044). The latter includes in his enumeration a considerable amount of uncertain species.

1727. The Eocene epoch in general is characterised by the predominance of Algæ and marine Naiadaceæ, such as Caulinites and Zosterites ; by numerous Coniferæ, the greater part resembling existing genera among the Cupressineæ, and appearing in the form of Juniperites, Thuites, Cupressites, Callitrites, Frenelites, and Solenostrobus ; by the existence of a number of Extra-European forms, especially of fruits, such as Nipadites, Leguminosites, Cucumites, and Hightea ; and by the presence of some large species of Palm belonging to the genera Flabellaria and Palmacites. Amber is considered to be the produce of many Coniferæ of this epoch, such as Peuce succinifera. It occurs in east Prussia in great quantity, and it is said that many pieces of fossil wood occur there, which, when moderately heated, give out a decided smell of amber. Connected with these beds are found cones belonging to Pinites sylvestris and P. Pumilio, others to Pinites Thomasianus and P. brachylepis. The latter two being forms not resembling the species which now exist. Berkeley has detected in amber fossil Fungi, which he has named Penicillium curtipes, Brachycladium Thomasinum, and Streptothrix spiralis.* Some Characeæ are also met with, as Chara medicaginula and C. prisca, with

* Annals and Mag. of Nat. Hist. 2d Ser. ii. 380.

a fossil called Gyrogonites, which is supposed to be the nucule, or, in other words, the fructification of these plants.

1728. The most striking characters of the Miocene epoch consist in the mixture of exotic forms of warm regions with those of temperate climates. Thus we meet with Palms, such as species of Flabellaria and Phœnicites, a kind of Bamboo called Bambusium sepultum, Lauraceæ, as Daphnogene and Laurus, Combretaceæ, as Getonia and Terminalia, Leguminosæ, as Phaseolites, Desmodophyllum, Dolichites, Erythrina, Bauhinia, Mimosites, and Acacia, all plants of warm

Fig. 1833.

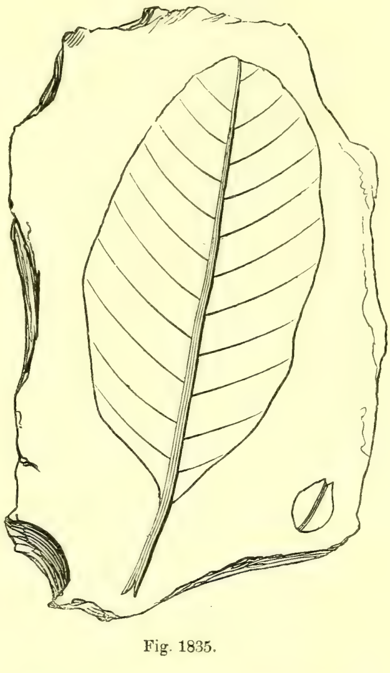


Fig. 1835.

climates; Echitonium, Plumiera, and other Apocynaceæ of equatorial regions, and Steinhauera, a tropical Cinchonaceous genus; mingled with species of Acer (Fig. 1833), Ulmus (Fig. 1834), Rhamnus (Fig. 1835), and Amentiferous forms, such as Comptonia, Myrica, Betula, Alnus (Fig. 1836), Quercus, Fagus, Carpinus, all belonging to temperate and cold climates. There are a very small number of plants belonging to orders with gamopetalous corollas. As connected with

Figures 1833 to 1836 show the leaves of plants belonging to the Miocene epoch.

Fig. 1833. Acer trilobatum, a three-lobed palmate leaf, like that of the Maple, with the lobes unequal, inciso-dentate, the lateral ones spreading, found at Œningen. Fig. 1834. Ulmus Bronnii, a petiolate leaf, like that of the Elm, unequally ovato acuminate, feather-veined and toothed, found in Bohemia. Fig. 1835. Rhamnus Aizoon, a petiolate eliptical obtuse feather-veined leaf, with an entire margin, found in Styria. Fig. 1836. Alnus gracilis, an ovate-oblong leaf, like that of the Alder, found in Bohemia.

the Miocene epoch, we may notice the leaf-buds found at Ardtun in the island of Mull by the Duke of Argyll.* Above and below these beds basalt occurs, and there are peculiar tuff beds alternating with the leafy deposits. These tuff beds are either of volcanic origin, or are a conglomerate stratified deposit altered in a metamorphic manner. The beds are associated with chalk and flints. The leaves are those of plants allied to the Yew, Rhamnus, Plane, and Alder, along with the fronds of a peculiar Fern, and the stems of an Equisetum. The

Fig. 1834.

Fig. 1837.

Fig. 1838.

genera are Taxites or Taxodites (Fig. 1837), Rhamnites (Fig. 1838), Platanites, Alnites, Filicites, and Equisetum (Fig. 1839).

1729. The flora of the Pliocene epoch has a great analogy to that of the temperate regions of Europe, North America, and Japan. We meet with Coniferæ, Amentiferæ, Rosaceæ, Leguminosæ, Rhamnaceæ, Aceraceæ, Aquifoliaceæ, Ericaceæ, and many other orders. There is

Figures 1837 to 1839 exhibit fragments of plants which occur in the leaf bed at Ardtun Head, in Mull, and which is referred to the Miocene epoch. The figures are taken from the Duke of Argyll's paper.

Fig. 1837. Taxites, or perhaps Taxodites Campbellii, a branch with leaves resembling those of the Yew, or rather those of Taxodium. Fig. 1838. Rhamnites multinervatus, a leaf resembling that of Rhamnus. Fig. 1839. Equisetum Campbellii, a stem like that of an Equisetum of the present day.

* Trans. Geol. Soc. of London, vii.

a small number of Dicotyledons with gamopetalous corollas. The twenty species with such corollas recognised by Brongniart are referred

Fig. 1836.

Fig. 1839.

to the Hypogynous Gamopetalous group of Exogens, which in the general organisation of the flowers approach nearest to Dialypetalæ. In this flora there is the predominance of Dicotyledons in number and variety; there are few Monocotyledons and no Palms. No species appear to be identical, at least with the plants which now grow in Europe; and if in some rare cases identity appears to exist, it is between these plants and American species. Thus the flora of Europe, even at the most recent geological epoch, was very different from the European flora of the present day.

1730. Taking the natural orders which have at least four representatives, Raulin* gives the following statement as to the Tertiary flora of central Europe. The Eocene flora of Europe is composed of 128 species, of which 115 belong to Algæ, Characeæ, Pandanaceæ, Palmæ, Naiadaceæ, Malvaceæ, Sapindaceæ, Proteaceæ, Papilionaceæ, and Cupressineæ. The Miocene flora has 112 species, of which 69 belong to Algæ, Palmæ, Naiadaceæ, Apocynaceæ, Aceraceæ, Lauraceæ, Papilionaceæ, Platanaceæ, Quercineæ, Myricaceæ, and Abietineæ. The Pliocene flora has 258 species, of which 226 belong to Algæ,

* Raulin, sur les Transformations de la Flore de l'Europe centrale pendant la periode Tertiaire.—Ann. des Sc. Nat. 3d ser. Bot. x. 193.

Fungi, Musci, Filices, Palmæ, Ericaceæ, Aquifoliaceæ, Aceraceæ, Ulmaceæ, Rhamnaceæ, Papilionaceæ, Juglandaceæ, Salicaceæ, Quercineæ, Betulaceæ, Taxaceæ, Cupressineæ, and Abietineæ. The Eocene species are included in genera which belong at the present day to inter-tropical regions, comprising in them India and the Asiatic islands of Australia. Some are peculiar to the Mediterranean region. The aquatic plants, which form almost one-third of the flora, belong to genera now peculiar to the temperate regions of Europe and of North America, or occurring everywhere. The Miocene species belong to genera, of which several are found in India, tropical America, and the other inter-tropical regions, but which for the most part inhabit the sub-tropical and temperate regions, including the United States. Some of the genera are peculiar to the temperate regions. The aquatic genera, poor in species, occur everywhere, or else solely in the temperate regions. The Pliocene species belong to genera which almost all inhabit the temperate regions, either of the old continent or of the United States. A few only are of genera existing in India, Japan, and the north of Africa. These various floras, which present successively the character of those of inter-tropical, sub-tropical, and temperate regions, show that central Europe has, since the commencement of the Tertiary period, been subjected, during the succession of time, to the influence of these three different temperatures. It would appear then, Raulin remarks, that the climate of Europe has during the Tertiary period gradually become more temperate. This may proceed either from a displacement of the earth's axis or from the gradual cooling of the earth, or from a different proportion of land and water.

1731. Brown coal occurs in the upper Tertiary beds, and in it vegetable structure is easily seen under the microscope. Goeppert, on examining the brown coal deposits of northern Germany and the Rhine, finds that Coniferæ predominate in a remarkable degree; among 300 specimens of bituminous wood collected in the Silesian brown coal deposits alone, only a very few other kinds of Dicotyledonous wood occur. This seems remarkable, inasmuch as in the clays of the brown coal formation in many other places leaves of deciduous Dicotyledonous trees have been found; and yet the stems on which we may suppose them to have grown are wanting. They seem to have disappeared by disintegration on account of the non-durability of their wood. The coniferous plants of these brown coal deposits belong to Taxineæ and Cupressineæ chiefly; among the plants are Pinites protolarix and Taxites Ayckii. Many of the Coniferæ exhibit highly compressed, very narrow annual rings, such as occur in Coniferæ of northern latitudes. Goeppert has described a trunk, or rather the lower end of a trunk, of Pinites protolarix, discovered in 1849 in the brown coal of Laasan in Silesia. It was found in a nearly perpendicular position, and measured more than 32 feet in circumference. Sixteen vast roots ran out almost at right angles from the base of the trunk, of which about four feet stood up perfect in form, but stripped of bark. Unfortunately the interior of the stem was almost entirely filled with structureless brown coal, so that only two cross sections could be obtained from the outer parts, one sixteen inches, the other three feet six inches broad. In the first section Goeppert counted 700, in the second 1300 rings of wood, so that for the half-diameter of $5\frac{1}{2}$ feet, at least 2200 rings must have existed. Since there is no reason to believe that the rings were more frequently formed in earlier ages than the annual zones are now, this tree would appear to have been from 2200 to 2500 years old. Dicotyledonous stems in lignite are often of great size and age. In a trunk near Bonn, Nöggerath counted 792 annual rings. In the turf bogs of the Somme, at Yseux near Abbeville, a trunk of an Oak tree has been found above 14 feet in diameter.

1732. We have thus seen that the vegetation of the globe has undergone various changes at different periods of its history, and that the farther back we go, the more are the plants different from those of the present day. There can be no doubt that there have been successive deposits of stratified rocks, and successive creations of living beings. We see that animals and plants have gone through their different phases of existence, and that their remains in all stages of growth and decay have been imbedded in rocks superimposed upon each other in regular succession. It is impossible to conceive that these were the result of changes produced within the limits of a few days. Considering the depth of stratification, and the condition and nature of the living beings found in the strata at various depths, we must conclude (unless our senses are mocked by the phenomena presented to our view) that vast periods have elapsed since the Creator in the beginning created the heavens and the earth. The six days in which the present state of the globe was formed is what is recorded in Genesis. All the previous epochs are passed over, and are only marked in the palæontological records, which are brought to view and decyphered by geologists.

1733. When we find animals and plants of forms unknown at the present day, in all conditions as regards development, we read a lesson in regard to the history of the earth's former state as conclusive as that which is derived from the Nineveh relics (independent of Revelation) in regard to the history of the human race. There is no want of harmony between Scripture and geology. The Word and the Works of God must be in unison, and the more we truly study both, the more they will be found to be in accordance. Any apparent want of correspondence proceeds either from imperfect interpretation of Scripture or from incomplete knowledge of science. The changes in the globe have all preceded man's appearance on the scene. He is the characteristic of the present epoch, and he knows by Revelation that the world is to undergo a further transformation, when the elements shall melt with fervent heat, and when all the present state of things shall be dissolved ere the ushering in of a new earth, wherein righteousness is to dwell.*

1734. Recapitulation of the chief points connected with Fossil Botany :—

1. The vegetation of the globe has varied at different epochs of the earth's history.
2. The farther we recede in geological history from the present day, the greater is the difference between the fossil plants and those which now occupy the surface.
3. All fossil plants may be referred to the great classes of plants of the present day, Acotyledons, Monocotyledons, and Dicotyledons.
4. The fossil genera and species are different from those of the present flora, and it is only when we reach the recent Tertiary period that we meet with some apparently identical genera.
5. Fossil plants are preserved in various conditions according to the nature of their structure, and the mode in which they have been acted upon.
6. Cellular plants have rarely been preserved, while woody species, and especially Ferns, which are very indestructible, have retained their forms in many instances.
7. In some cases, especially when silicified or charred, the structure of the woody stems can be easily seen in thin sections under the microscope.
8. The determination of fossil plants is a matter of great difficulty, and requires a thorough knowledge of structure, and of the markings on stems, roots, &c.
9. The rocks containing organic remains are called fossiliferous, and are divided into Palæozoic, Secondary, and Tertiary, each of these series being characterised by a peculiar flora.
10. The mere absence of organic remains will not always be a correct guide as to the state of the globe, for rocks deposited in a deep sea may show no such remains.
11. The number of fossil species has been estimated at between 2000 and 3000, but many parts of plants are probably described as separate species, or even genera, and hence the number is greater than perhaps it ought to be.
12. Brongniart divides the fossil flora into three great epochs :—1. The reign of Acrogens; 2. The reign of Gymnosperms; 3. The reign of Angiosperms.
13. The reign of Acrogens embraces the Carboniferous and Permian epochs, in which there was a predominance of that class of plants, associated, however, with others of a higher class.
14. The reign of Gymnosperms embraces the lower and middle Secondary periods, and is characterised by the presence of numerous Coniferæ and Cycadaceæ.
15. The reign of Angiosperms includes the Cretaceous and Tertiary periods, and is marked by the appearance of Angiospermous Dicotyledons.
16. Coal is a vague term, referring to all kinds of fuel formed by plants, and displaying a greater or less amount of vegetable structure under the microscope.
17. When there is a great admixture of mineral matter, so that it will not burn as fuel then a shale is produced.

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* On the subject of Fossil Botany the following works may be consulted:—Bowerbank, Fossils of the London Clay. Brongniart, Histoire des Végétaux Fossiles; Prodrome d'une Histoire des Végétaux Fossiles; Observations sur la Structure interieure du Sigillaria, &c., in Archives du Museum, i. 405; Exposition chronologique des Periodes de Végétation, in Ann. des Sc. Nat. 3d ser. Bot. xi. 285. Coal Plants, in Penny Cyclopædia, vii. Corda, Flora der Vorwelt. Goeppert, Systema Filicum Fossilium, in Nova Acta, xvii. suppl.; Monographie der Fossilen Coniferen, 1850. Giebel, Palæontologie. Hooker on the Vegetation of the Carboniferous Period, in Mem. of Geol. Survey ii. King on Sigillaria, &c., in Edin. New Phil. Journal, xxxvi. Lindley and Hutton, Fossil Flora. Our Coalfields, by a Traveller under ground. Schouw's Earth and Man, translated by Henfrey. Raulin sur la Flore de l'Europe pendant la periode Tertiaire, in Ann. des Sc. Nat. 3d ser. x. 193. Unger, Genera Plantarum Fossilium; Chloris Protogæa; Le Monde Primitive (a work which contains picturesque views of the supposed state of the earth at different geological epochs). Witham on the Structure of Fossil Vegetables. Besides geological works such as those of Lyell, Ansted, Mantell, and Beudant.

18. The microscopic structure of Coal varies according to the nature of the plants of which it is composed, and the changes produced by pressure, heat, and other causes. Cellular tissue, punctated woody fibres, and scalariform vessels have been detected in it.
19. Certain temporary and local floras seem to have given origin to peculiar layers of coal.
20. At the Carboniferous epoch we meet with Ferns, Sigillarias and their roots or rhizomes called Stigmarias, Lepidodendrons, Lycopodiaceæ, Ulodendrons, Calamites, and Dicotyledonous Gymnosperms, &c.
21. The plants forming coal appear frequently to have grown in the basin where the coal has been found; but some plants seem also to have been drifted like snags.
22. The strata between the Permian epoch and Chalk display numerous Gymnosperms, especially belonging to the Cycadaceous order. Some of them exhibit limited coal deposits.
23. The Chalk and Tertiary strata display not only Acrogens and Gymnogens, but also Angiospermous Dicotyledons, some of which, at the Miocene period, belong apparently to genera of the present day.
24. Raulin thinks, that during the Tertiary epoch the flora of Europe has gradually assumed a more temperate character.

APPENDIX.

I. DIRECTIONS FOR COLLECTING AND PRESERVING BOTANICAL SPECIMENS.*

1.—INSTRUMENTS REQUIRED FOR THE EXAMINATION OF PLANTS.

1735. We have already adverted to the examination of specimens by the aid of lenses and microscopes (p. 12.) It is sufficient to state here that the student requires for the determination of the orders, genera, and species of the plants he gathers, a lancet-pointed knife, a pocket lens for $\frac{1}{4}$ to 1 inch focus, and a pair of small forceps. With the view of holding the object steadily, the blades of the forceps may be made so as to be fastened by a sliding button.

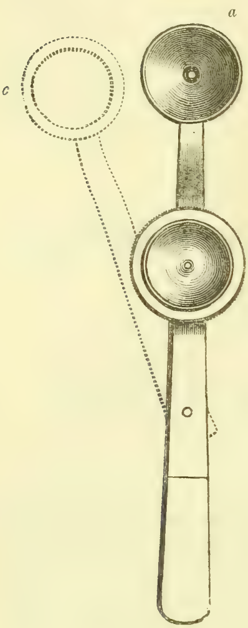
1736. When examining minute plants, such as Diatomaceæ and Desmidieæ, during an excursion, it is useful to have a simple microscope similar to that represented in Figs. 1840 and 1841.† It consists of a Wollaston's doublet, fixed in a round plano-concave brass disc (Fig. 1840, *a*), attached to a small brass handle (Fig. 1840, *b*.) For ordinary botanical purposes a lens magnifying 65 to 70 diameters is enough; but the lenses may be procured with a power of 150 to 220 diameters. On the plane side of this brass disc, there is a ring of silver (Fig. 1840, *c*), in which a thin piece of glass is fixed, also supported by a brass handle, which acts as a spring, so as to keep the two rings in contact. In the handle of the first-mentioned disc, there is a screw (Fig. 1841, *d*), which passes through it, and by the motion of which the two handles can be separated or allowed to come close to each other. By this means an exact focal distance can be obtained.

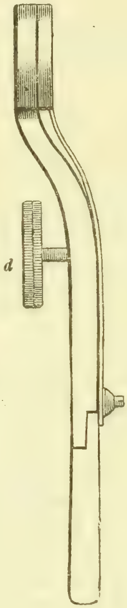
* In these directions, we have followed in a great measure those drawn up by Dr. Greville and Professor Christison, and published by the Botanical Society of Edinburgh.

† This instrument, called Gairdner's portable simple microscope, is manufactured by Mr. Bryson, 24 Princes Street, Edinburgh, and is fitted in a case so as to be easily carried in the pocket. It is described in Dr. Bennett's Lectures on Clinical Medicine, from which the figures are taken.

A drop of fluid containing Diatoms, &c. is placed on the outside of the thin glass in the silver ring, and it is then covered by a similar piece of thin glass, which adheres by means of the fluid. The object being brought into focus, as in Figure 1841, the observer can distinguish the characters of the minute plant, so as to determine whether it is necessary to take specimens home for more careful examination by the compound microscope.

1737. We have already stated that for the purposes of classification a





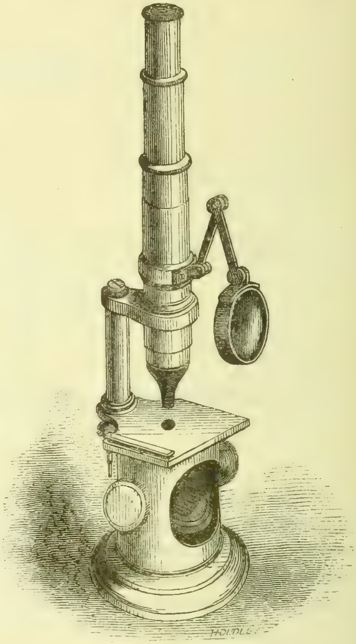


Fig. 1840. Fig. 1841. Fig. 1842.

simple microscope is that which is most serviceable to the botanical student, while for physiological researches, a compound instrument is indispensable. Very good students' instruments are made by Smith and Beck in London, and by Nachet and Oberhäuser in Paris. One of the latter as used by Dr. Bennett, is shewn in Figure 1842, which is taken from his lectures on Clinical Medicine. The figure is one-fourth of the real size of the instrument. The body consists of a telescope tube eight inches in length, held by a split tube three inches long. It may be elevated or depressed by the hand by a cork-screw movement, and this constitutes the coarse adjustment. It is attached to a cross-bar and pillar, at the lower portion of the latter of which there is a fine

Figures 1840 and 1841 represent Gairdner's portable simple microscope.

In Fig. 1840 there is given a front view of the instrument, showing the posterior silver ring, *c*, enclosing a piece of thin glass, separated and turned aside from the disc, *a*, containing the doublet, to which the eye of the observer is applied. Fig. 1841 exhibits a lateral view of the instrument, with the screw, *d*, by means of which the handles are separated or approximated, so as to bring the object into focus.

Fig. 1842. Oberhäuser's portable student's microscope.

adjustment screw. The stage is three inches broad, and two and a half inches deep, with a circular diaphragm below it. The base of this portable instru-

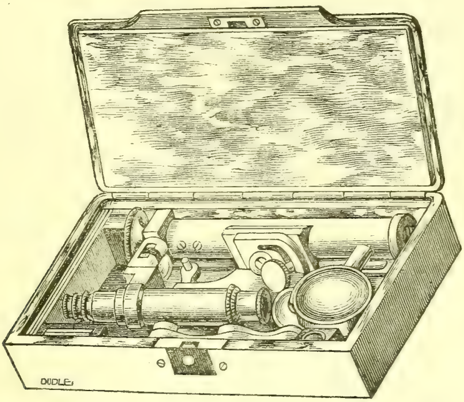


Fig. 1843.

ment is loaded with lead so as to give it steadiness. A similar instrument is made by Nachet, in which there is a broader stage, and a broader base,

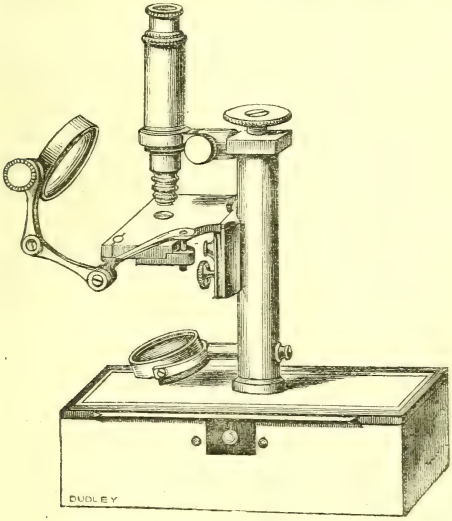


Fig. 1844.

as well as a means of inclining the body of the instrument. It has been preferred by botanical students in Edinburgh, and it is cheaper than Ober-

Figures 1843 and 1844 represent Gruby's portable compound microscope one-half its real size.
Fig. 1843. The instrument in its case. Fig. 1844. The instrument mounted. A full description is given by Dr. Bennett in the Edinburgh Monthly Medical Journal for December 1846.

häuser's.* As a portable compound microscope is sometimes wanted by a student, Dr. Bennett has given the accompanying figures of one recommended by Gruby of Paris. In Figure 1843 the instrument is shewn in its case, and in 1844 it is mounted. The woodcuts are exactly one-half the real size, and give a good idea of the instrument, a detailed description of which is not required. The markings on some of the Diatomaceæ are good tests for microscopes. Messrs. Sollitt and Harrison of Hull give the following statements in regard to the number of cross striæ on certain Diatoms, with the power of lens required for them and the angle of aperture :

Focal length of Objective.	Name of Diatom.	No. of Striæ in an Inch.	Angle of Aperture.
$\frac{1}{2}$ inch of Nachet.	Pleurosigma strigilis	34,000	40
$\frac{1}{4}$ inch of Nachet.	P. Hippocampus (fresh water)	42,000	60
	P. Spencerii	50,000	70
	P. strigosum.....................	60,000	80 (P. strigosum and P. quadratum, large)
	P. quadratum, large	60,000	
	——— small	70,000	90 (P. quadratum, small and P. angulatum, large)
$\frac{1}{8}$ inch of Nachet.	P. angulatum, large	70,000	
	——— small	80,000	95
	P. Fasciola	90,000	110
	Nitzschia sigmoidea............	105,000	120
$\frac{1}{12}$ inch of Ross or Powell	Navicula Acus (Amphipleura pellucida)	130,000	150

In using these tests, the observer must have glasses with a large angle of aperture and the finest definition ; and there must be a careful management in some instances of oblique light.† Besides these, the following are mounted as test objects by Messrs. Smith and Beck, London :

Nitzschia lanceolata.
Navicula rhomboidea.
Pleurosigma elongatum.
——— intermedium.
——— littorale.
——— lacustre.

Pleurosigma Nubecula.
——— delicatulum.
——— obscurum.
——— acuminatum.
——— attenuatum.
——— macrum.

* The following are the powers (linear measurement) of Nachet's student's compound achromatic microscope:—

Objectives (Object-Glasses).	Oculars (Eye-Pieces).		
	1	2	3
1	70	90	140
3	190	250	400
5	280	360	600

The price of the instrument, with all these powers, is 190 francs, exclusive of duty and carriage ; without No. 2 ocular, and No. 5 objective, it is 150 francs.

† For illumination, the Parisian Moderator Lamp seems to be the best. It can be procured in Edinburgh, from Mr. John Millar, 2 South St. Andrew Street.

2.—SELECTION OF SPECIMENS FOR THE HERBARIUM.

1738. Specimens should, if possible, be gathered in fine weather, and free from external moisture. In selecting them, care should be taken to have the plants in a perfect state of growth, with all the parts from which characters are taken. The entire plant, with roots, stem, leaves, and flowers, when practicable, should be preserved ; and the roots should be washed before being put into the box of the collector. In the case of very large herbaceous plants or shrubs or trees, portions only can be taken. These should always be carefully selected so as to exhibit the characteristic organs. In plants, such as Hieracia, where the root and stem leaves differ, both should be preserved. In the case of tall and slender Gramineæ and Cyperaceæ, the specimens may be folded once or twice backwards and forwards, and thus suited to the size of the paper used in forming the herbarium ; and the folds may be secured during drying by being pushed into slits in small strips of paper, to be afterwards noticed. Ferns and many other tall plants may be preserved entire in the same way. A thick branch or stem should be split, so as to allow of pressure being applied ; and very thick roots, as well as bulbs and corms, may be similarly treated.

1739. Plants belonging to such orders as Leguminosæ, Rosaceæ, Umbelliferæ, Compositæ, &c., require that we should have both the flowers and the fully matured fruit preserved. In the case of diœcious plants, it is obvious that male and female flowers must be taken. This may be illustrated in the species of Salix, of which, moreover, it is requisite to dry both the flowering shoot and the leaf-bearing branch. This implies collecting the specimens at different periods of the year, care being taken that they are procured from the same plant. The species of Rubus cannot be recognised without having the young barren shoots preserved, as well as the flowering and fruiting ones. Care must be taken that the characters are recognisable after the plant has been glued on paper ; thus both sides of the fronds of Ferns must be displayed, and this may be done either by folding or by having two fronds. Specimens should be taken from different districts and from different localities with the view of recording their geographical distribution. Varieties are also of importance ; and monstrosities, as illustrating morphology.

1740. Dissections of the different parts of plants, dried separately and afterwards glued on paper in proper order, are most valuable to the student in fixing in his mind the characters of plants. Beautiful specimens of such dissections made by Dr. Murchison, Dr. Lauder Lindsay, Dr. Priestley, and Mr. Maclaren, are to be seen in the Museum of Economic Botany at the Edinburgh Botanic Garden. When examining a plant carefully, with the view of determining its genus, it is useful to make a dissection of those parts of the flower whence the generic characters are taken, and to preserve in an envelope, along with the specimen, the separate portions after being dried. This will render the herbarium specimen very valuable for future reference. No bad specimens should be preserved. Dr. Greville says that it should be adopted as a canon by the botanical collector, that no specimen is to be admitted under the idea that it will do for a duplicate, if it would not do for his own herbarium.

3.—APPARATUS REQUISITE FOR COLLECTING AND PRESERVING PLANTS.

1741. The Digger.—This is a sort of trowel (Fig. 1845) seven or eight inches long, the iron or steel spud $2\frac{1}{2}$ inches long, $2\frac{1}{2}$ inches wide at the top, narrowing gradually to two inches at the bottom, the lower angles being slightly rounded. It should be made sufficiently strong to resist considerable force in digging out plants from the crevices of rocks, &c. The iron portion which unites the spud to the handle should be particularly attended to in this respect. This small spade is put into a leather sheath which is fastened round the waist by means of a strap. A long string passed through the handle fastens the spade to the strap, and prevents it from being lost.

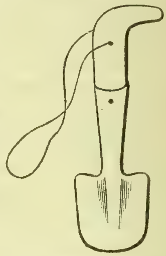


Fig. 1845.

1742. The Vasculum or Botanical Box.—This is a japanned tin-case, convex on both sides (Fig. 1846), not less than twenty inches long, so as to contain full-sized herbarium specimens. The width and depth will vary according to the fancy of the collector; but a box eight or nine inches wide by five inches deep is found not to be too large in productive herborizations. A good sized handle is placed at one end of the box, and wire loops are firmly fastened at each end, *a*, on the lower side, so as to receive a strap by means of which the box is carried on the back. It is of importance to have the lid of the vasculum large, occupying nearly the whole of the upper surface, in order that the specimens may be put in without being folded or crushed. The best mode of securing the lid is by a wire passing into a tin sheath, and so formed as not to be liable to slip out when the box is held by the handle. The specimens should be put in the box in a uniform manner, the flowers at one end and the roots at the other; and care should be taken to have the former (which should be the end where the handle is) always kept in the higher position when carried on the shoulders. Besides this larger box, which Greville calls the Magnum, there should be a small pocket vasculum of a similar form for holding Mosses and small plants. In collecting minute aquatic plants, as Desmidieæ and Diatomaceæ, it is necessary to have small glass bottles or test-tubes fitted to a small case. The corks should be numbered to facilitate notes being taken at the time of the localities in which the specimens were collected.

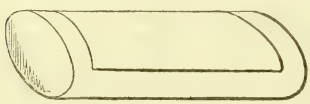


Fig. 1846.

1743. The Field Book.—In many instances, it is found of advantage to put plants into paper during the course of a walk. This is especially necessary in the case of species whose flowers fall off, such as Trientalis europæa, Rubus Chamæmorus, and Veronica saxatilis, as well as some delicate plants, as Ferns, whose fronds easily shrivel. This is accomplished by having a field book, which may be made of any size, from that of a large pocket

Fig. 1845. Botanical digger, to be carried in a leather sheath, fastened round the waist by means of a strap.

Fig. 1846. The form of the botanical box recommended. For dimensions, see the description in the text.

book to a folio, and is in fact a portfolio, containing a quantity of absorbent paper, temporary pressure being given by a couple of straps (Fig. 1847). A convenient field-book used by students in Edinburgh is represented by Figure 1848. It is made of two mahogany boards about nine inches long by five broad, containing from 12 to 24 parcels of paper, each parcel consisting of four sheets, the back of the parcels being covered with strips of leather or cloth. The boards may be rendered firm by being made each of two thin layers of crossed wood fastened together in the way afterwards noticed when speaking of large boards. Two narrow leather straps pass through two holes in one margin of each of the boards, and also through slits in the leather-covered backs of the parcels of the paper, *a*, so as to prevent them from falling

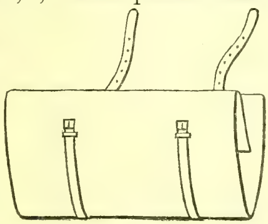


Fig. 1847.

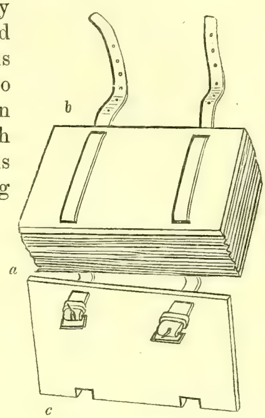


Fig. 1848.

out when the field-book is opened. In the case of one of the boards the two straps also pass through perforations in its other margin, *b*, and under these another strap is passed for the purpose of suspending the field book round the neck. The two small straps pass through grooves in the margin of the other board, *c*, and are thus buckled so as to apply pressure. An oil cloth covering may be attached to be used in wet weather.

1744. Paper.—The paper used for the process of drying plants should be moderately absorbent, so as to take up the moisture of the plants, and at the same time to dry rapidly after being used. That which is generally employed in Edinburgh is Weir's botanical drying paper.* Bentall's paper is also used, and is equally good. The size recommended is eighteen inches long by eleven broad. In the case of very delicate plants which cannot be easily removed, it is best to put them at first carefully within a sheet of very thin crown tea-paper of the same size as the drying paper, and when transferring the specimens into dry paper, to remove the thin paper and its contents without disturbing the specimens. This is useful in the case of such plants as Myriophyllum, Ceratophyllum, Vallisneria, and other aquatics, as well as Viola lutea, whose petals collapse if removed in the ordinary way after a day's pressure. In order to keep the paper dry during travelling, a cover of oil cloth is requisite. It should be put round the paper, while the thick boards are placed on the outside. When plants are in the process of drying, the oil cloth acts prejudicially, in preventing evaporation. It should not therefore be used in such circumstances, unless positively necessary.

Fig. 1847. A portfolio which may be used as a field-book, pressure being applied by means of straps, and an oil-cloth cover being used when required.

Fig. 1848. Field-book generally used in Edinburgh.

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* This paper can be had from Cowan & Co., 17 Princes Street, Edinburgh, under the name of the Edinburgh Botanical Drying Paper.

1745. Boards.—In order to subject the specimens to pressure, boards of different kinds must be used. These should be exactly the size of the drying paper. Two of the boards should be thicker and stouter than the rest, so as to serve for outside boards, without being liable to split. These outside boards are often made double, and $\frac{1}{2}$ or $\frac{3}{4}$ of an inch thick; each double board being composed of two thin ones, the grain of the one crossing that of the other (as in the case of the field boards already mentioned), closely glued together, and firmly secured by small screws along the edge, at intervals of three inches. They may be rounded on their outer margins. Besides these, there ought to be provided eight inside boards about $\frac{3}{8}$ of an inch in thickness. These ten boards form a set which will serve for two reams of paper. When the plants are dried by the pressure of a weight, it is well to have the lower board raised above the floor by a couple of flat cross bars on its under surface. Some sheets of stout pasteboard are convenient for separating the plants, and for packing them as they become dry, and particularly for preventing woody plants from injuring those placed above and below them.

1746. Press.—There are various modes of applying pressure. Some use screw presses of different kinds, with the screw applied in the centre, or at both ends. The simplest method is to employ iron weights, or a heavy square stone, with an iron ring fixed in the centre. The pressure is in this way never relaxed, as is the case with the screw press. The weight used should not be less than 100 pounds. In travelling, the best mode of applying pressure is by straps, or by means of a stout rope passed round the ends and margin of the boards and paper in a cross manner, and then tightened by means of a rack-pin. In order to allow free ventilation, and thus to dry plants more rapidly, Mr. Twining recommends, instead of boards, frames made of crossed bars with spaces between them; the surface applied to the paper being flat,—the other being ribbed by means of prominent cross bars, so as to leave a ventilating space between the one

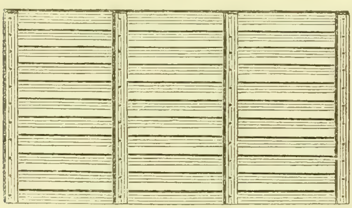

Fig. 1849.

Fig. 1850.

frame and the other (Figs. 1849 and 1850). By an apparatus consisting of eight of such inner frames, and two outer frames of a stouter nature, so as to bear pressure, the plants as well as the paper may be dried rapidly. The apparatus, with paper and plants firmly strapped, is suspended in a draft of air coming through a partially closed window, or on the branch of a tree in sunshine; and it is said that desiccation of the plants and paper is accomplished in four days. By the use of artificial heat in an open and airy

Figures 1849 and 1850 show the kind of boards recommended by Mr. Twining.

Fig. 1849 is a frame composed of bars of wood, with thick cross pieces, which, when applied to another frame of a similar nature, leave open spaces. Fig. 1850. The side view of the frames, showing the mode in which the cross bars act in allowing ventilation. *a*, Side view of a single frame with its four cross bars; *b* and *c*, side view of two frames laid one on the other, kept half an inch apart by means of the transverse slips of wood.

place, as, for instance, by being placed before the fire, the drying may be accomplished in twenty-four or forty-eight hours. Mr. Twining, when in Switzerland, first pressed the plants tightly for 24 hours, and then piled them properly in the frame-work apparatus, which was hung up in the hot air of a drying room, and in twenty-four hours more they were ready for packing, the paper also which contained them being perfectly dry and bibulous.* Henslow recommends that, with the view of ventilating plants during drying, holes should be made in the ordinary boards at regular intervals, and that two of the inner boards should always be placed together, separated by flat cross bars which may either be fastened to the boards by liquid glue prepared from shell lac, or may be kept loose, and inserted when required. A complicated apparatus is suggested by M. Gannal, the particulars of which are given in the Botanical Gazette, ii. 55; and there also another mode of drying is described, in which plants, after having been kept in a press for a few hours, are exposed to the sun, or placed on a stove or in an oven, in an apparatus called the Coquette. This consists of two open covers made of strong iron-wire network fastened into frames made of light iron rod, pressure being applied by straps or ropes, as already mentioned. The open frames allow the moisture to escape freely. A sand-bag is sometimes useful in equalizing the pressure on the plants, more particularly when some of them have thick stems.

1747. Having all the necessary apparatus, the following is the mode of procedure in the operation of preparing plants for the herbarium. Greville suggests that the collector should in the first place provide himself with a number of slips of paper two inches long by one inch broad, with a slit half an inch in length cut in the centre, and should have his knife and an ordinary pair of surgeon's forceps at hand. A parcel of not less than four sheets of paper is put on one of the outside boards, then one or more specimens are laid on the sheet according to their size. The specimens should be spread out carefully, their natural habit being preserved as far as possible. When plants require to be folded, the slips of paper already mentioned are passed over the bent portions, so as to retain them in their position. Having placed one specimen or set of specimens on the sheet, another parcel of not less than four sheets is laid over them, and in doing this, the leaves and other parts are arranged with the hand or the forceps. The same process is repeated until a dozen or more such parcels have been arranged one over the other. Then a thin board is inserted, and other parcels of paper and specimens are arranged above it, until they are exhausted, or until the bundle is of sufficient size. Another outer board is then laid on the top, and the whole is subjected to pressure. The paper is changed after twelve hours' pressure, the plants being lifted by means of the forceps, and placed in dry parcels of paper, while that which is moist is hung up to dry. The intervals between the changing of the paper may be increased or diminished according to circumstances. Very succulent and wet plants require frequent changing, grasses scarcely require any. In eight or ten days, moist specimens will be so dry as to require only a slight pressure. Succulent plants, such as species of Sedum, are so tenacious of life, that they will continue to live even under great pressure. They must be first killed by immersion in boiling water for five or ten minutes, then dried between coarse napkins, and finally committed to paper. Unless this is done, the plants will continue to live for many weeks,

* See a description and drawing of this apparatus, in Botanical Gazette, ii. 59.

and the leaves die and fall off by degrees. Some have recommended scarification in the case of succulent plants, in order to allow the sap to flow out rapidly. Orchids and other plants which take a long time to dry, and lose their colour during desiccation, should be put into hot paper which must be changed several times daily. In the case of some thick-headed plants, as Thistles, the capitula must either be cut, or they must be crushed between paper by temporary pressure from the foot ; this treatment must also be applied to such plants as Eryngium maritimum and the Holly. Sometimes the flower or parts of the flower may be separated advantageously during drying by the insertion of small pieces of blotting paper. Viscid bulbs may also be surrounded by separate bits of paper, to prevent them from adhering to the drying paper. Aquatic plants and those collected in rainy weather should be dried as far as possible by means of napkins before being put into paper. The wet paper is to be hung up in parcels of four sheets in some warm room, and in the course of twelve hours it will be ready for use a second time. Along with the specimens, there ought to be inserted a label containing the name of the country, and of the station, its elevation above the level of the sea if possible, the nature of the locality in which the plant grew, and the date of collection. Every observation made when examining or collecting the plant should be carefully recorded at the time. In the course of long excursions, it is necessary to devote every now and then some time to the proper arranging and tallying of the specimens. On this subject Greville says, " half a day, therefore, at least, in the middle of the week, say the morning of every Wednesday till two o'clock, should be appropriated to the preservation and arrangement of your plants ; and a part or the whole of every Saturday should invariably be set apart for the same purpose, in order that they may not be injured by remaining untouched on the Lord's Day."

1748. In preparing Cryptogamic plants during an excursion, it is not necessary to take such pains at first in their preparation, in as much as they may be moistened subsequently, and dried more carefully. Specimens of Cryptogamic plants may be easily picked up by travellers, and, after being allowed to dry in the air, without any further trouble and preparation they may be sent home in a state fit for after examination, as well as for the herbarium. Sea-weeds in such circumstances should be dried in the shade, without any previous washing in fresh water. Many excellent Algæ may be gathered in pools on the rocks at low water, and after storms the beach is often strewed with good specimens. None should be gathered in a state of decay, or with their colours altered. Those which grow on other species should be dried so as to show their natural attachment. Mosses and Jungermanniæ may be collected in tufts or masses of considerable size, always selecting such as are in fructification. These tufts can be dried by moderate pressure, and afterwards separated, moistened, and subjected to more careful preparation. Lichens may be treated like Mosses. Some of them, however, adhere to rocks or trees, portions of which must be taken along with the plants. Such specimens cannot be subjected to pressure, but are left to dry, and are then wrapped in paper. Fungi are with difficulty preserved in a dry state. In preparing species of Agaricus, Boletus, &c., a thin slice is taken from the centre, extending from the upper part of the pileus to the lower part of the plant. This is dried separately. The loose cellular tissue is then removed from the interior of the stalk, and the lamellæ from the lower side of the pileus, and these organs are then dried. By these means the form of the

Fungus is shown, and the nature of its hymenium, &c. Sea-weeds are prepared by being first washed in fresh water, and when delicate they are floated out on stiff white paper, which is cut into regular sizes, by dividing sheets into a given number of parts. Many of them adhere to this white paper when dry. The larger Melanospermous Algæ should be put into boiling water until the mucus is all given out, and then wiped with a coarse napkin before being committed to paper. Minute Diatomaceous plants, as well as other Cryptogamic species of a small size, are best preserved on covered pieces of glass or mica.*

1749. After specimens have been thoroughly dried, a selection is made for the herbarium. Such selected specimens are fastened by means of thin fine glue on thick white paper, 17 inches long and 10½ broad.† The specimen is laid on a common newspaper, and the glue is then applied lightly with a camel's hair pencil to the surface, or to portions of the surface; and, the place it is to occupy on the fine paper having been marked with a pencil, the specimen is raised with the forceps, and is carefully placed in its position. After this any glue which may have spread on the paper is removed, and the whole is subjected to slight pressure for an hour or two between sheets of the usual drying paper. The name of the plant, its locality, date of collecting, and other particulars are then marked on the paper, and the specimen is ready for being placed in the drawers of the herbarium case. Thick or naked stems are best fastened by strips of gummed paper, or, what is stronger, especially for stout plants, paper covered with glue, which should always be ready for use, and of the same shade of colour as the herbarium paper. All dried specimens, especially those sent from abroad, should be touched with a strong solution of corrosive sublimate in camphorated spirit or in naphtha (half a drachm to the ounce) before being glued. This is the only effectual mode of preventing the attack of insects. The species of a genus after being glued should be put into one or more envelopes made of similar paper, or of cartridge paper, and the name of the genus attached at the lower part of the sheet on the outside, so as to allow of easy reference. The natural orders should also be separated by thin pasteboard of the same size as the herbarium paper, each piece of pasteboard having the name of the order suspended from it in front.

1750. The size of the wooden Case for the herbarium must of course depend on the extent of the collection. In a private collection it is better to have numerous small Cases which are easily removed at pleasure along with the specimens. This should be particularly attended to by medical students and others who have the prospect of going abroad, and who may wish to transport their collections to foreign countries. In such instances, the Cases should be strongly made, and should be not more than four feet high, with two rows of drawers. These drawers are made open in front, and should slide freely in the Case. In the Edinburgh University Herbarium, the size of the drawers or trays is—depth (inside measurement), 4 inches, length 19 inches, and breadth 11½ inches. The size of the trays should of course correspond to that of the herbarium paper. Some collectors have peculiar fancies in regard to the size of their herbarium. Thus a

* For full directions as to collecting and preserving Sea-weeds, see Harvey's Nereis Boreali-Americana, Part ii. p. 28. For Diatoms see Smith's British Diatomaceæ.

† The paper used in Edinburgh is sold by Cowan and Co., Princes Street, under the name "M. B. Laid Medium, flat 4to." They have also Generic Envelopes to suit, made of the same paper, or of cartridge paper.

valuable collection of Cryptogamic plants and grasses left by Menzies to the Edinburgh Botanic Garden has the following dimensions:—Height of the mahogany cases 30 inches, breadth in front $28\frac{1}{2}$, from front to back 11; depth of the trays (inside measurement) $4\frac{1}{2}$ inches, length $9\frac{1}{2}$, breadth 6.

4.—PRESERVATION OF FRUITS AND OTHER BOTANICAL SPECIMENS FOR A MUSEUM, &c.

1751. Fruits, specimens of wood and bark, large roots, Lichens, and minute Algæ on rocks or stones, and other specimens which cannot be preserved in a herbarium, may be either placed in drawers, in glazed cases, or in glass jars. The jars should be of regular sizes as regards height, say 4, 6, 8, 12, or 16 inches, their breadth varying according to the size of the specimen. Succulent fruits and roots are best preserved in a strong solution of salt and water, or in pyroligneous acid diluted with 3-5 parts of water, or in alcohol. In some instances a solution of 4 ounces of bay salt, 2 ounces of burnt alum, and 5 grains of corrosive sublimate in 2 quarts of boiling water, has been used. The solution, after being made, is filtered. All these solutions are apt to cause greater or less change in the colour of the specimens. Specimens in diluted pyroligneous acetic acid often become pulpy and brittle after a few years, so as not to admit of being handled, and most colours are altered by it. Spirit renders all colours alike brown. It is better adapted for delicate specimens, which are afterwards to be used for dissection. Before being put up in jars, fresh specimens should be kept for a month or more in the solution, so as to allow any colouring matter and other impurities to be separated, otherwise the preparation will become obscure and require to be re-adjusted. For the top of the jar a glass cover is the best, either luted or held in its place by a metallic ring (Fig. 1851, *a*), which is fitted carefully to it, and covers a portion of the glass lid. Two grooves may be made on the inner side of the rim at the top of the jar for holding a piece of whalebone, to which the specimen may be attached by means of a thread, as seen in the figure. In the case of dry preparations, the metallic ring already mentioned answers well.

Fig. 1851.

1752. It is difficult to keep the solution of salt in the preparation jar. Dr. Christison says:—"The most effectual method, when the mouth of the jar does not exceed 2 or $2\frac{1}{2}$ inches in diameter, is to have a space half an inch or more at the top without fluid, to clean and dry the top of the jar thoroughly, to drop melted sealing-wax on the upper surface of the top, so as to form a uniform ring over it, to place over the mouth a watch-glass of such size as to cover the whole lip, and even to overhang it a little, to press this gently down with one finger, and to fuse the wax between the top of the jar and the watch-glass, by moving a large spirit flame around the edge." Where the mouth of the jar is large, then a round flat piece of glass may be used, or sheet caoutchouc. The latter, after being gently heated, is

Fig. 1851. Form of jar recommended for preparations in a Museum. Specimens are seen in the Edinburgh Museum of Economic Botany, made by Stevenson, 9 Lothian Street, Edinburgh.

stretched moderately, not strongly, by one, or still better, by two persons, while a third secures round the neck two or three folds of stout twine as a temporary ligature. A stout thin cord is then drawn steadily and tightly round three or four times above the former, taking care that the caoutchouc is not cut, and that the turns of the twine lie regularly above each other; and finally, that a secure knot is made.

1753. Small specimens for the microscope, such as Diatoms and Desmidieæ, and many small Sea-weeds, as well as vegetable tissues, are put up in slides 3 inches long by 1 broad (Fig. 1852), in the centre of which there is a circular cavity formed by a layer of asphalte,* and covered by a circular piece of thin glass. The asphalte is applied by means of a hair pencil, the slide being placed on a moveable brass disk (Fig. 1853), which has circular marks on it corresponding to the required dimensions of the cavity. The depth of the cavity can be varied according to circumstances, by putting one or more layers of asphalte. After the thin glass cover is put on, it is luted carefully with asphalte. The cavity is filled with distilled water, weak pyroligneous acid, alcohol, diluted glycerine, a very weak solution of creazote (one drop to the ounce of distilled water), or some other fluid. When specimens are very minute, the asphalte-cell is not required; the thin glass is applied at once to the slide, a drop or two of the fluid being inserted along with the specimen. In the case of some dry preparations, as pollen-grains, and the fine-lined Diatoms, no fluid whatever is required, but precautions must be taken against the access of damp. Canada balsam is useful in some instances. The specimen is put on a slide, then a minute portion of the balsam is put above it, and the thin glass above all; the slide is heated gently below by means of a spirit lamp until the balsam becomes quite fluid, and until all the air has been expelled by the weight of the glass cover. It is then set aside to dry, and ultimately a rim of asphalte is put round the margin of the glass cover. Canada balsam is well fitted for many Diatoms, and for thin sections of woods. In putting up woods, the specimen is placed in the centre of the glass, a drop of turpentine is put on it to expel the air, Canada balsam is then applied before the turpentine dries, and the same procedure is followed as above. For preparing fossil woods

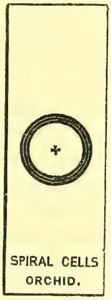

Fig. 1852.

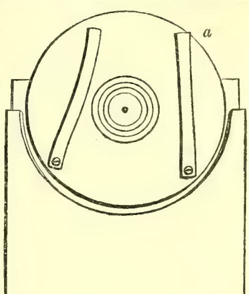

Fig. 1853. b

Fig. 1852. Glass slide for microscopic preparations, 3 × 1 inch. In the centre is a ring of asphalte, forming a cell to contain fluid; the object, marked by a × in the centre, is covered by a circular piece of thin glass fitted to the asphalte rim. The name of the object is often written on the glass, but perhaps it is preferable to write the name on coloured paper, and attach it to the glass by isinglass or fine bookbinder's glue.

Fig. 1853. Apparatus for aiding in making the circular rim of asphalte; *b*, a piece of mahogany; *a*, a circular piece of brass, which can be moved round by the hand, and has two brass springs on

* Prepared Asphalte is much better than gold size or black japan varnish, inasmuch as it dries more rapidly, and is less liable to run. It can be procured from Smith and Beck, 6 Coleman Street, London, and from Bryson, 24 Princes Street, and Stark, 145 Princes Street, Edinburgh.

Nicol gives the following directions:—Cut off a thin slice in the required direction, grind it flat, and polish it. The smooth surface is then cemented to a piece of plate-glass by means of Canada balsam, of which a thin layer is to be applied to the slice of fossil wood, and another to the glass. They are then placed on a plate of metal, and gradually heated over a slow fire, so as

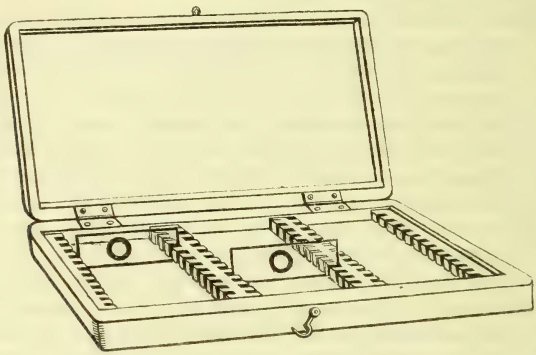

Fig. 1854.

to inspissate the balsam, care being taken not to raise the heat so high as to produce air-bubbles in the fluid. The slice and glass are then removed and placed upon each other; the superfluous part of the balsam being squeezed out by a slight degree of pressure, accompanied with a sliding motion. When the preparation has cooled, the portion of balsam adhering to the edges of the slice is to be removed with a pen-knife, and the slice is ground down to the requisite degree of thickness, and polished.* In all instances slides should be labelled with the name, locality, and date, and they should be numbered and catalogued so that they may be easily referred to when put up in Cases such as that shown in Figure 1854, or in cabinets.†

1754. The Diatomaceæ being either free, or attached to Algæ, &c., diffe-

its surface for holding a glass slide firm. In the centre of the brass disc are circular markings fitted for the size of asphalte cells required. These marks being seen through the slide laid above them, guide the hand in making the circular asphalte rim, the brass disc being turned round during the application.

Fig. 1854. A Case for containing slides after being prepared. There are three divisions, each containing twelve slides, two of which are shown projecting above the lower division of the box, the lid being hollowed to receive them. Numbers corresponding to those on the slides are fastened on the partitions at the sides of the grooves which retain the slides. On the front of the box a notice of the numbers contained in it should be fastened. Corresponding numbers, with full particulars as to the preparations, ought to be inserted in a book which serves as a catalogue, in which there should be first a numeral progressive series, and then an alphabetical register for genera. Card boxes for holding 24 slides are made by Smith and Beck and others, price one shilling each. They are excellent for forming a general collection. Cabinets are also made for slides, consisting of drawers half-an-inch deep (including the bottom) divided so as to hold 30, 40, or 50 slides, all on their back; the drawers being slightly bevelled at their divisions on one side, so that the slides may be tilted up by pressing them down. Smith and Beck charge for a cabinet of Honduras mahogany, capable of holding 500 slides, four guineas; 750 slides, five pounds; 1000 slides, six guineas; and 2000 slides, eleven pounds.

* Witham's Fossil Vegetables, p. 76.

† In making sections of minute objects, such as Diatoms, they are mixed up with plaster of Paris and mucilage, and then the whole is sliced by means of a sharp razor. Small pieces of wood are sometimes put into a slit in a cork, and then the whole sliced.

rent modes must be resorted to for collecting them. Those which are attached require only (either at the time or after being dried) to be rinsed gently in fresh water to get rid of the sand or mud, and salt if any, and then placed in a small saucer in boiling water, with a few drops of nitric or muriatic acid. The cuticle being corroded, the Diatoms fall to the bottom, the floating Algæ are taken out with a glass rod, and the residue washed. This step is merely preparatory to that of burning or boiling the objects. If the Diatoms be free, they should, as far as possible, be gathered free from sand or mud, by skimming the surface of the pond or pool with an iron spoon ; but as much mud and sand may still be mixed with them, they ought to be afterwards placed in a saucer in a little water, and exposed to the sun for a day or two. A tumbler or hand-glass will prevent too much evaporation. Diatoms, if recently gathered and alive, will come to the surface of the sediment, or water, or both, and this affords an easy mode of separating certain species. They may now be skimmed off with a small spoon, or, what is preferable, a camel's hair pencil, and removed to clean water; and this process is to be repeated till the mud is got rid of entirely. As for preparing the specimens, they may be either burned, or boiled in nitric acid. For the isolated Diatoms,* as Navicula, Pleurosigma, Cocconeis, &c. boiling is preferable ; but for the others, as Synedra, Fragilaria, Melosira, Meridion, &c., if one wishes to have a few frustules cohering together to show their habit, then burning must be adopted, as the acid separates them joint by joint, and valve from valve. This is accomplished by arranging the specimens in the centre of a glass slide, and laying them on a thin iron-slide, and placing the whole within a little iron tray, closed in the form of a slipper, to exclude ashes. This is exposed to the fire till the slide is red hot. The slide is now allowed to cool, and the specimen is ready for being covered either with or without the intervention of balsam. The latter is called *dry* mounting, and is best accomplished by making a ring of asphalte, and following the same process as for liquid mounting, but without liquid. When nitric acid is to be used, the cleaned Diatoms are put into a large-sized test tube of German glass, with as little water as possible, and about one part of nitric acid to four of water. After being boiled for two or three minutes over a spirit-lamp, the Diatoms must be allowed to subside, and as much liquor as possible poured off with any fragments of vegetable matter floating in it. This boiling sometimes suffices, but it is always preferable to add some of the strong acid, and boil the whole again for a few minutes, so as to dissolve any vegetable or animal substances remaining. As the silicious covering is very thin, and easily broken by a sudden change of temperature, care must be taken in washing away the acid, either to use boiling water, or to allow the Diatoms in the test tube to cool. When a sufficient supply of *pure distilled* water can be easily got, it alone ought to be used for washing them ; but, when that is not the case, ordinary water may be employed for the first washing, but the after washings must be all made with distilled water until the acid is got rid of. After being thoroughly washed, the Diatoms are kept in a small test-tube with some distilled water. In taking the specimens from the test-tube, in order to put them on the slide, a pipette or dropping-tube is employed, having a bore of about 1-30th to 1-50th of an inch at its lower end.

* By free Diatoms are meant those that are not parasitical. By isolated or solitary Diatoms are meant those not connected nor cohering together into threads or plates, or by a stipe, tube, or gelatine.

1755. Mr. Jackson remarks that it is desirable that no object submitted to a higher power than a quarter-inch objective of 75° aperture should ever be mounted under a cover thicker than 1-140th of an inch ; if the aperture exceeds 120°, the best thickness for the cover is 1-250th of an inch.* Glass of this thickness can easily be cut with a good writing diamond, when laid on a piece of plate glass.† To clean the covers, he recommends putting them in strong sulphuric acid for a day or two, and then washing them repeatedly with water ; after that placing them, a few at a time, on a tightly stretched clean cambric handkerchief, and rubbing them very gently with another handkerchief on the finger. They should then be removed to a clean box. with forceps, and carefully kept from dust and from contact with the fingers. The covers should be sorted according to their thickness, and this is done at once by Ross's "lever of contact," which consists of a long slender index, having a projecting *touch* near the centre of motion, which is kept in contact with a plane surface by means of a spring. When a piece of glass is inserted under the touch, the index points to the thickness on a graduated arc. The thickness may also be measured in the usual way by placing a fragment in the pliers, with the edge upwards, under the microscope, armed with an inch object-glass and an eye-piece micrometer.‡

1756. In sending home succulent fruits or roots, &c. from abroad, collectors should put them into strong brine in a barrel, sewing up each specimen in cloth of some kind, and attaching a wooden label numbered by branding ; a list with corresponding numbers opposite the names or descriptions being transmitted at the same time. The specimens should be loosely packed, and yet so as not to change their position easily. In regard to the transmission of plants in a living state, details have been given at p. 484, and the best mode of sending seeds is noticed at p. 626.

* I am informed by a friend, that on account of the brittleness of the glass, covers thinner than 1-140th or 1-150th of an inch are, in the hands of most manipulators, practically useless, as they break by the mere wiping or mounting, and that glass 1-150th of an inch is not too thick either for Smith and Beck's 1-5th object-glass with 100° of aperture, or Ross's 1-8th with 156° of aperture; but that when dry mounting is adopted, the object ought to be arranged on the under side of the cover, thus bringing it as near the lenses as possible.

† Quekett on the Microscope. 2d Edit. p. 265. ‡ Quarterly Journal of Microsc. Science, i. 141.

II. GLOSSARY,

OR

EXPLANATION OF SOME OF THE MOST IMPORTANT BOTANICAL TERMS.

A, *alpha* privative of the Greek, placed before a Greek or Latin word, indicates the absence of the organ; thus, *aphyllous*, without leaves.

ABAXIAL or ABAXILE, not in the axis, applied to the embryo when out of the axis of the seed.

ABORTION, non-development of a part.

ABRUPT, ending in an abrupt manner, as the truncated leaf of the Tulip tree; *abruptly-pinnate*, ending in 2 pinnæ, in other words, pari-pinnate; *abruptly-acuminate*, a leaf with a broad extremity from which a point arises.

ABSCISSION, cutting off, applied to the separation of the segments or frustules of Diatoms.

ACAULIS or ACAULESCENT, without an evident stem.

ACCRESCENT, when parts continue to grow and increase after flowering, as the calyx of Physalis.

ACCRETE, grown together.

ACCUMBENT, applied to the embryo of Cruciferæ, when the cotyledons have their edges applied to the folded radicle.

ACEROSE, narrow and slender, with a sharp point.

ACHENE or ACHÆNIUM, a monospermal seed-vessel which does not open, but the pericarp of which is separable.

ACHLAMYDEOUS, having no floral envelope.

ACHROMATIC, applied to lenses which prevent chromatic aberration, *i. e.*, show objects without any prismatic colours.

ACICULAR, like a needle in form.

ACICULUS, a strong bristle.

ACINACIFORM, shaped like a sabre or scimitar.

ACOTYLEDONOUS, having no cotyledons.

ACROCARPI, Mosses having their fructification terminating the axis.

ACROGEN and ACROGENOUS, a stem which increases by its summit, and which has a peculiar arrangement of vascular tissue.—See Index.

ACULEUS, a prickle, a process of the bark, not of the wood, as in the Rose; *Aculeate*, furnished with prickles.

ACUMINATE, drawn out into a long point.

ACUTE, terminating gradually in a sharp point.

ADELPHOUS or ADELPHIA, in composition, means union of filaments.

ADHERENT, united, adhesion of parts that are normally separate, as when the calyx is united to the ovary.

ADNATE, when an organ is united to another throughout its whole length, as the stipules in Rose, and the filament and anther in Ranunculus.

ADPRESSED or APPRESSED, closely applied to a surface, as some hairs.

ADUNCUS, crooked or hooked.

ADVENTITIOUS, organs produced in abnormal positions, as roots, from äerial stems.

ÆSTIVATION, the arrangement of the parts of the flower in the flower-bud.

AFFINITY, relation in all essential organs.

AGAMOUS, the same as *Cryptogamous.*

ALA, a wing, applied to the lateral petals of a papilionaceous flower, and to membranous appendages of the fruit, as in the Elm, or of the seed, as in Pines.

ALBUMEN, the nutritious matter stored up with the embryo, called also *Perisperm* and *Endosperm.*

ALBURNUM, the outer young wood of a Dicotyledonous stem.

ALGOLOGY, the study of Sea-weeds.

ALSINACEOUS, a polypetalous corolla, in which there are intervals between the petals, as in Chickweed.

ALTERNATE, arranged at different heights in the same axis, as when each leaf is separated by internodes by those next it.

ALVEOLÆ, regular cavities on a surface, as in the receptacle of the Sunflower, and in that of Nelumbium which is called *Alveolate.*

AMENTUM, a catkin or deciduous unisexual spike; plants having catkins are *Amentiferous.*

AMNIOS, the fluid or semi-fluid matter in the embryo-sac.

AMORPHOUS, without definite form.

AMPHISARCA, an indehiscent multilocular fruit with a hard exterior, and pulp round the seeds, as seen in the Baobab.

AMPHITROPAL, an ovule curved on itself, with the hilum in the middle.

AMPLEXICAUL, embracing the stem over a large part of its circumference.

AMPULLA, a hollow leaf, as in Utricularia.

ANALOGOUS, when a plant strikingly resembles one of another genus, so as to represent it.

ANASTOMOSIS, union of vessels; union of the final ramifications of the veins of a leaf.

ANATROPAL or ANATROPOUS, an inverted ovule, the hilum and micropyle being near each other, and the chalaza at the opposite end.

ANCEPS, two-edged.

ANDRŒCIUM, the male organs of the flower.

ANDROGYNOUS, male and female flowers on the same peduncle, as in some species of Carex.

ANDROPHORE, a stalk supporting the stamens, often formed by a union of the filaments.

ANER, male or stamen, in composition, *Andro* and *Androus.*

ANFRACTUOSE, wavy or sinuous, as the anthers of Cucurbitaceæ.

ANGIENCHYMA, vascular tissue in general.

ANGIOSPERMOUS, having seeds contained in a seed-vessel.

ANISOS, in composition, means unequal.

ANISOSTEMONOUS, stamens not equal in number to the floral envelopes, nor a multiple of them.

ANNOTINUS, a year old.

ANNULUS, a ring, applied to the elastic rim surrounding the sporangia of some Ferns, also to a cellular rim on the stalk of the Mushroom, being the remains of the veil.

ANTERIOR, same as *inferior*, when applied to the parts of the flower in their relation to the axis.

ANTHELA, the cymose panicle of Juncaceæ.

ANTHER, the part of the stamen containing pollen.

ANTHERIDIUM, male organ in Cryptogamic plants, frequently containing moving filaments.

ANTHEROZOA, moving filaments in an antheridium.

ANTHESIS, the opening of the flower.

ANTHOCARPOUS, applied to multiple or polygynœcial fruits, formed by the ovaries of several flowers.

ANTHODIUM, the capitulum or head of flowers of Composite plants.

ANTHOPHORE, a stalk supporting the inner floral envelopes, and separating them from the calyx.

ANTHOS, a flower, in composition, *Antho;* in Latin *Flos.*

ANTHOTAXIS, the arrangement of the flowers on the axis.

ANTICUS, placed in front of a flower, as the lip of Orchids; *Antheræ Anticæ*, anthers which open on the surface next the centre of the flower; same as *Introrse.*

ANTITROPAL, applied to an embryo whose radicle is diametrically opposite to the hilum.

APERISPERMIC, without separate albumen; same as *Exalbuminous.*

APETALOUS, without petals, in other words, monochlamydeous.

APHYLLOUS, without leaves.

APICAL or APICULAR, at the apex; often applied to parts connected with the ovary.

APICULATE, having an apiculus.

APICULUS or APICULUM, a terminal soft point springing abruptly.

APOCARPOUS, ovary and fruit composed of numerous distinct carpels.

APOPHYSIS, a swelling at the base of the theca in some Mosses.

APOTHECIUM, the rounded, shield-like fructification of Lichens.

APTEROUS, without wings.

ARACHNOID, applied to fine hairs so entangled as to resemble a cobweb.

ARCHEGONIUM, the young female organ in Cryptogamic plants.

ARCUATE, curved in an arched manner, like a bow.

AREOLATE, divided into distinct angular spaces, or *Areolæ.*

ARILLUS and ARILLODE, an extra covering of the seed, the former proceeding from the placenta, the latter from the exostome, as in Mace.

ARISTA, an awn, a long pointed process, as in Barley and many grasses which are called *Aristate.*

ARMATURE, the hairs, prickles, &c., covering an organ.

ARTICULATED, jointed, separating easily and cleanly at some point.

ASCENDING, applied to a procumbent stem, which rises gradually from its base; to ovules attached a little above the base of the ovary; and to hairs directed towards the upper part of their support.

ASCIDIUM, a pitcher or folded leaf, as in Nepenthes.

ASCUS, a bag, applied to the thecæ of Lichens, and other Cryptogams, containing sporidia or spores.

ASPERITY, roughness, as on the leaves of Boraginaceæ.

ATRACTENCHYMA, tissue composed of spindle-shaped cells.

ATROPOUS or ATROPAL, the same as *Orthotropous.*

AURICULATE, having appendages, applied to leaves having lobes or leaflets at their base.

AWN and AWNED, see *Arista* and *Aristate.*

AXIL, the upper angle where the leaf joins the stem.

AXILE or AXIAL, belonging to the axis.

AXILLARY, arising from the axil of a leaf.

AXIS, is applied to the central portion of the young plant, whence the plumule and radicle are given off, and the name is given in general to the central organ bearing buds; in Grasses, the common stem of a locusta.

BACCA, berry, a unilocular fruit having a soft outer covering and seeds immersed in pulp. All such fruits are called *Baccate.*

BALAUSTA, the fruit of the Pomegranate.—See reference in Index.

BARK (cortex), the outer cellular and fibrous covering of the stem; separable from the wood in Dicotyledons.

BASAL or BASILAR, attached to the base of an organ.

BASIDIUM, a cell bearing on its exterior one or more spores in some Fungi, which are hence called *Basidiosporous.*

BAST or BASS, the inner fibrous bark of dicotyledonous trees.

BIDENTATE, having two tooth-like processes.

BIFARIOUS, in two rows, one on each side of an axis.

BIFID, two-cleft, cut down to near the middle into two parts.

BIFORINE, a raphidian cell with an opening at each end.

BILAMELLAR, having two lamellæ or flat divisions, as in some stigmas.

BILOCULAR, having two loculaments.

BIPARTITE, cut down to near the base into two parts.

BIPINNATE, a compound leaf divided twice in a pinnate manner.

BIPINNATIFID, a simple leaf, with lateral divisions extending to near the middle, and which are also similarly divided.

BIPINNATIPARTITE, differing from bipinnatifid in the divisions extending to near the midrib.

BIPOROSE, having two rounded openings.

BIS, twice, in composition *Bi.*

BISERRATE, or duplicate-serrate, when the serratures are themselves serrate.

BITERNATE, a compound leaf divided into three, and each division again divided into three.

BLADE, the lamina or broad part of a leaf, as distinguished from the petiole or stalk.

BLANCHING, see *Etiolation.*

BLETTING, a peculiar change in an austere fruit, by which, after being pulled, it becomes soft and edible.

BOLE, the trunk of a tree.

BOTHRENCHYMA, dotted or pitted vessels, with depressions on the inside of their walls.

BRACHIATE, with decussate branches.

BRACT, a leaf more or less changed in form, from which a flower or flowers proceed; flowers having bracts are called *Bracteated.*

Bracteole or Bractlet, a small bract at the base of a separate flower in a multifloral inflorescence.

Bryology, the study of Mosses; same as *Muscology*.

Bulb, an underground bud covered with scales

Bulbil or Bulblet, separable buds in the axil of leaves, as in some Lilies.

Bulbous-based, applied to hairs which are tumid at the base.

Byssoid, very slender, like a cobweb.

Caducous, falling off very early, as calyx of Poppy.

Cæspitose, growing in tufts.

Calathiform, hemispherical or concave, like a bowl or cup.

Calathium, same as *Capitulum* and *Anthodium*.

Calcar, a spur, a projecting hollow or solid process from the base of an organ, as in the flowers of Larkspur and Snapdragon; such flowers are called *Calcarate* or spurred.

Calceolate, slipper-like, applied to the hollow petals of some Orchids, also to the petals of Calceolaria.

Callosity or Callus, a leathery or hardened thickening on a limited portion of an organ.

Calycifloræ, a sub-class of Polypetalous Exogens, having the stamens attached to the calyx.

Calyculus or Caliculus, an outer calycine row of leaflets, giving rise to a double or calyculate calyx.

Calyptra, the outer covering of the sporangium of Mosses.

Calyx, the outer envelope of the flower; when there is only one envelope, it is the calyx.

Cambium, mucilaginous cells, between the bark and the young wood, or surrounding the vessels.

Campanulate, shaped like a bell, as the flower of Hare-bell.

Campulitropal or Campylotropal, a curved ovule with the hilum, micropyle and chalaza near each other.

Canaliculate, channelled, having a longitudinal groove or furrow.

Cancellate, latticed, composed of veins alone.

Capillary, filiform, thread-like or hair-like.

Capitate, pin-like, having a rounded summit, as some hairs.

Capitulum, head of flowers in Compositæ.

Capreolate, having tendrils.

Caprification, the ripening of the Fig, by means of the wild fig or Caprificus (see Embryogeny, in Index).

Capsule, a dry seed-vessel, opening by valves, teeth, pores, or a lid.

Carina, keel, the two partially united lower petals of papilionaceous flowers.

Carinal, applied to æstivation when the carina embraces the other parts of the flower.

Carnose, fleshy, applied to albumen having a fleshy consistence.

Carpel or Carpidium, the leaf forming the pistil. Several carpels may enter into the composition of one pistil.

Carpology, the study of fruits.

Carpophore, a stalk bearing the pistil, and raising it above the whorl of the stamens, as in Lychnis and Caper.

Carpos, fruit, in composition *Carpo*.

Caruncula, a fleshy or thickened appendage of the seed.

Caryopsis or Cariopsis, the monospermal seed-vessel of Grasses, the pericarp being incorporated with the seed.

Catkin, same as *Amentum*.

Caudate, having a tail or feathery appendage.

Caudex, the stem of Palms and of Tree-ferns.

Caudicle, Caudicula, the process supporting the pollen mass in Orchids.

Caulescent, having an evident stem.

Caulicle, Cauliculus, stalk connecting the axis of the embryo and the cotyledons.

Caulis, an aerial stem.

Cellulose, the chemical substance of which the cell-wall is composed.

Centimetre, a French measure, equal to 0.3937079 British inch.

Centrifugal, applied to that kind of inflorescence in which the central flower opens first.

Centripetal, applied to that kind of inflorescence in which the flowers at the circumference or base open first.

Ceramidium, an ovate conceptacle having a terminal opening, and with a tuft of spores arising from the base; seen in Algæ.

Cereal, applied to Wheat, Oats, Barley, and other grains.

Cernuous, pendulous, nodding.

Chalaza, the place where the nourishing vessels enter the nucleus of the ovule.

Chlamys, covering, applied to the floral envelope, in composition *Chlamydeous*.

Chlorophyll, the green colouring matter of leaves.

Chloros, green, in composition *Chloro*.

Chorisis or Chorization, separation of a lamina from one part of an organ so as to form a scale or a doubling of the organ; it may be either transverse or collateral.

Chroma, colour, in composition *Chrom*.

Chromogen and Chromule, the colouring matter of flowers.

Chrysos means yellow like gold, in composition *Chryso*.

Cicatricula, the scar left after the falling of a leaf; also applied to the hilum or base of the seed.

Cilia (Cilium), short stiff hairs fringing the margin of a leaf; also delicate vibratile hairs of zoospores.

Cinenchyma, laticiferous tissue, formed by anastomosing vessels.

Circinate, rolled up like a crozier, as the young fronds of Ferns.

Circumscissile, cut round in a circular manner, such as seed-vessels opening by a lid.

Circumscription, the periphery or margin of a leaf.

Cirrhus, a tendril, or modified leaf in the form of a twining process.

Cladenchyma, tissue composed of branching cells.

Clados, a branch, in composition *Clado*.

Clathratus, latticed like a grating.

Clavate, club-shaped, becoming gradually thicker towards the top.

Claw, the narrow base of some petals, corresponding to the petiole of leaves.

Cleft, divided to about the middle.

Clinandrium, the part of the column of Orchids bearing the anther.

Clinanthium, the common receptacle of the flowers of Compositæ.

Cline, a bed, in composition *Clin*, used in reference to parts on which the floral organs are inserted.

Cloves, applied to young bulbs, as in the Onion.

Clypeate, having the shape of a buckler.

Coccidium, a rounded conceptacle in Algæ without pores, and containing a tuft of spores.

Coccus and Coccum, applied to the portions composing the dry elastic fruit of Euphorbiaceæ.

Cochlear, a kind of æstivation, in which a helmet-shaped part covers all the others in the bud.

Cochleariform, shaped like a spoon.

Coleorhiza, a sheath covering the radicles of a monocotyledonous embryo.

Collateral, placed side by side, as in the case of some ovules.

COLLENCHYMA, the inter-cellular substance which unites cells.
COLLUM, neck, the part where the plumule and radicle of the embryo unite.
COLPENCHYMA, tissue composed of wavy or sinuous cells.
COLUMELLA, central column in the sporangia of Mosses; also applied to the carpophore of Umbelliferæ.
COLUMN, a part in the flower of an Orchid supporting the anthers and stigma, and formed by the union of the styles and filaments.
COMA, applied variously, to tufts of hairs, to bracteæ occurring beyond the inflorescence and to the general arrangement of the leaf-bearing branches of a tree, &c.
COMMISSURE, union of the faces of the two achenes in the fruit of Umbelliferæ.
COMOSE, furnished with hairs, as the seeds of the Willow.
COMPOUND, composed of several parts, as a leaf formed by several separate leaflets, or a pistil formed by several carpels either separate or combined.
COMPRESSED, flattened laterally or lengthwise.
CONCEPTACLE, a hollow sac containing a tuft or cluster of spores.
CONDUCTING TISSUE, applied to the loose cellular tissue in the interior of the canal of the style.
CONDUPLICATE, folded upon itself, applied to leaves and cotyledons.
CONE, a dry multiple fruit, formed by bracts covering naked seeds.
CONENCHYMA, conical cells, as hairs.
CONFERVOID, formed of a single row of cells, or having articulations like a Conferva.
CONJUGATION, union of two cells, so as to develope a spore.
CONNATE, applied to two leaves united by their bases.
CONNECTIVE, the part which connects the anther lobes.
CONNIVENT, when two organs, as petals, arch over so as to meet above.
CONTORTED, when the parts in a bud are imbricated and regularly twisted in one direction.
CONVOLUTE or CONVOLUTIVE, when a leaf in the bud is rolled upon itself.
CORALLINE, like Coral, as the root of Corallorhiza.
CORCULUM, a name for the embryo.
CORD, the process which attaches the seed to the placenta.
CORDATE, heart-shaped, a plane body with the division or broad part of the heart next the stalk or stem.
CORDIFORM, a solid body having the shape of a heart.
CORIACEOUS, having a leathery consistence.
CORM, thickened underground stem, as in the Colchicum and Arum.—See Index.
CORMOGENÆ, having a corm or stem.
CORNU, a horn; *Corneous*, having the consistence of horn; *Bicornis* or *Bicornute*, having two horns.
COROLLA, the inner envelope of the flower.
COROLLIFLORÆ, Gamopetalous Exogens, with hypogynous stamens.
CORONA, a corolline appendage, as the crown of the Daffodil.
CORRUGATED, wrinkled or shrivelled.
CORTEX, the bark; *Cortical*, belonging to the bark; *Corticated*, having the bark.
CORTINA, the remains of the veil which continue attached to the edges of the pileus in Agarics.
CORYMB, a raceme in which the lower stalks are longest, and all the flowers come nearly to a level above; *Corymbiferous* or *Corymbose*, bearing a corymb, or in the form of a corymb.
COSTA, a rib, applied to the prominent bundles of vessels in the leaves; *Costate*, provided with ribs.
COTYLEDON, the temporary leaf or lobe of the embryo.
CRAMPONS, a name given to adventitious roots which serve as fulcra or supports, as in the Ivy.
CREMOCARP, the fruit of Umbelliferæ, composed of two separable achenes or mericarps.
CRENATE, having superficial rounded marginal divisions.
CRENATURES, divisions of the margin of a crenate leaf.
CREST, an appendage to fruits or seeds, having the form of a crest.
CRISP, having an undulated margin.
CROWN OF THE ROOT, the short stem which is at the upper part of the root of perennial herbs.
CRUCIFORM and CRUCIATE, arranged like the parts of a cross, as flowers of Cruciferæ.
CRUSTACEOUS, hard, thin, and brittle; applied to those Lichens which are hard and expanded like a crust.
CRYPTOGAMOUS, organs of reproduction obscure.
CRYPTOS, inconspicuous or concealed, in composition *Crypto.*
CUCULLATE, formed like a hood.
CULM, stem or stalk of grasses.
CUNEIFORM or CUNEATE, shaped like a wedge standing upon its point.
CUPULA, the cup of the acorn, formed by aggregated bracts.
CURVEMBRYEÆ, with the embryo curved.
CUSPIS, a long point large at the base, and gradually attenuated; *Cuspidate*, prolonged into a cuspis, abruptly acuminate.
CUTICLE, the thin layer that covers the epidermis.
CYATHIFORM, like a wine-glass; concave, in the form of a reversed cone.
CYCLOGENS, applied to Dicotyledons with concentric woody circles.
CYCLOSIS, movement of the latex in laticiferous vessels.—See Index.
CYLINDRENCHYMA, tissue composed of cylindrical cells.
CYMBIFORM, shaped like a boat.
CYME, a kind of definite inflorescence, in which the flowers are in racemes, corymbs, or umbels, the successive central flowers expanding first; *Cymose*, inflorescence in the form of a cyme.
CYPSELA, monospermal fruit of Compositæ.
CYSTIDIA, sacs containing spores; a kind of fructification in Fungi.
CYTOBLAST, the nucleus of a cell.
CYTOBLASTEMA, mucilaginous formative matter of cells, called also *Protoplasm.*
CYTOGENESIS, cell-development.
CYTOS, a cell, in composition, *Cyto.*

DÆDALENCHYMA, entangled cells.
DECA, ten, in Greek words, same as the Latin *Decem;* as *decandrous*, having ten stamens; *decagynous*, having ten styles.
DECIDUOUS, falling off after performing its functions for a limited time, as calyx of Ranunculus.
DECIDUOUS TREES, which lose their leaves annually.
DECIMETRE, the tenth part of a metre or ten centimetres.
DECLINATE or DECLINING, directed downwards from its base, applied to stamens of Amaryllis.
DECOMPOUND, a leaf cut into numerous compound divisions.
DECORTICATED, deprived of bark.
DECUMBENT, lying flat along the ground, and rising from it at the apex.
DECURRENT, leaves which are attached along the side of a stem below their point of insertion. Such stems are often called *Winged.*
DECUSSATE, opposite leaves crossing each other in pairs at right angles.
DEDUPLICATION, same as *Chorisis.*

DEFINITE, applied to inflorescence when it ends in a single flower, and the expansion of the flowers is centrifugal; also when the number of the parts of an organ is limited, as when the stamens are under twenty.

DEFLEXED, bent downwards in a continuous curve.

DEFOLIATION, the fall of the leaves.

DEGENERATION, when an organ is changed from its usual appearance and becomes less highly developed, as when scales take the place of leaves.

DEHISCENCE, mode of opening of an organ, as of the seed-vessel and anther.

DELTOID, like the Greek Δ in form, properly applied solely to describe the transverse section of solids.

DENTATE, toothed, having short triangular divisions of the margin. The term is also applied to the superficial divisions of a gamosepalous calyx and a gamopetalous corolla.

DENTICULATE, finely-toothed, having small tooth-like projections along the margin.

DEPRESSED, flattening of a solid organ from above downwards.

DETERMINATE, applied to definite or cymose inflorescence.

DEXTRORSE, directed towards the right.

DIACHÆNIUM, same as *Cremocarp*, fruit composed of two achenes.

DIACHYMA, the parenchyma of the leaf.

DIADELPHOUS, stamens in two bundles, united by their filaments.

DIALYCARPOUS, pistil or fruit composed of distinct (separate) carpels.

DIALYPETALOUS, a corolla composed of separate petals.

DIALYSEPALOUS or DIALYPHYLLOUS, calyx composed of separate sepals.

DICHLAMYDEOUS, having calyx and corolla.

DICHOTOMOUS, stem dividing by twos.

DICLINOUS, unisexual flowers, either monœcious or diœcious.

DICOTYLEDONOUS, embryo having two cotyledons.

DICTYOGENOUS, applied to monocotyledons having netted veins.

DIDYMOUS, twice, union of two similar organs.

DIDYNAMOUS, two long and two short stamens.

DIGITATE, compound leaf composed of several leaflets attached to one point.

DIGYNOUS, having two styles.

DILAMINATION, same as *Deduplication* and *Chorisis.*

DIMEROUS, composed of two pieces.

DIMIDIATE, split into two on one side, as the calyptra of some Mosses.

DIŒCIOUS, staminiferous and pistilliferous flowers on separate plants.

DIPLOOS, double, in composition, *Diplo.*

DIPLOPERISTOMI, Mosses with a double peristome.

DIPLOSTEMONOUS, stamens double the number of the petals or sepals.

DIPTEROUS, having two wings.

DIS, twice, in composition, *Di*, same as Latin *Bis* or *Bi*; as *disepalous*, having two sepals, *dispermous*, two seeded.

DISCIFORM and DISCOID, in the form of a disc or flattened sphere; *discoid pith*, divided into cavities by discs.

DISCOID, also applied to the flosculous or tubular flowers of Compositæ.

DISCS, the peculiar rounded and dotted markings on coniferous wood.

DISK, a part intervening between the stamens and the pistil in the form of scales, a ring, &c.

DISPERMOUS, having two seeds.

DISSECTED, cut into a number of narrow divisions.

DISSEPIMENT, a division in the ovary; *true*, when formed by edges of the carpels; *false*, when formed otherwise.

DISSILIENT, applied to fruit which bursts in an elastic manner.

DISTICHOUS, in two rows, on opposite sides of a stem.

DISTRACTILE, separating two parts to a distance from each other.

DITHECAL, having two loculaments.

DIVARICATING, branches coming off from the stem at a very wide or obtuse angle.

DODECA, twelve; in Latin *Duodecim.*

DODECANDROUS, having twelve stamens.

DOLABRIFORM, shaped like an axe.

DORSAL, applied to the suture of the carpel which is farthest from the axis.

DORSIFEROUS, Ferns bearing fructification on the back of their fronds.

DORSUM, the back, the part of the carpel which is farthest from the axis.

DOUBLE FLOWER, when the organs of reproduction are converted into petals.

DRUPE, a fleshy fruit like the Cherry, having a stony endocarp. *Drupels*, small drupes aggregated to form a fruit, as in the Raspberry.

DUMOSE, having a low shrubby aspect.

DURAMEN, the inner heart-wood of Dicotyledonous trees.

DYNAMIS, power, in composition means superiority in length; as *didynamous*, two stamens longer than two others.

E or EX, in composition corresponds to *alpha* privative; as *ebracteated*, without bracts, *exaristate* without awns, *edentate*, without teeth, *ecostate*, without ribs.

ELATER, spiral fibres in the spore-cases of Hepaticæ.

ELLIPTICAL, having the form of an ellipse.

EMARGINATE, with a superficial portion taken out of the end.

EMBRYO, the young plant contained in the seed.

EMBRYO-BUDS, nodules in the bark of the Beech and other trees.

EMBRYOGENY, the development of the embryo in the ovule.

EMBRYOLOGY, the study of the formation of the embryo.

EMBRYO-SAC or EMBRYONARY-SAC, the cellular bag in which the embryo is formed.

EMBRYOTEGA, a process raised from the spermoderm by the embryo of some seeds during germination, as in the Bean.

ENDOCARP, the inner layer of the pericarp next the seed.

ENDOCHROME, the colouring matter of cellular plants.

ENDOGEN, an inside grower, having an endogenous stem.—See reference in Index.

ENDON, within or inwards, in composition *Endo.*

ENDOPHLŒUM, the inner bark or liber.

ENDOPLEURA, the inner covering of the seed.

ENDORHIZAL, numerous rootlets, arising from a common radicle, and passing through sheaths, as in endogenous germination.

ENDOSMOSE, movement of fluids through a membrane.—See reference in Index.

ENDOSPERM, albumen formed within the embryo-sac.

ENDOSPOROUS, Fungi having their spores contained in a case.

ENDOSTOME, the inner foramen of the ovule.

ENDOTHECIUM, the inner coat of the anther.

ENERVIS, without veins.

ENNEA, nine; in Latin *Novem.*

ENNEANDROUS, having nine stamens.

ENSIFORM, in the form of a sword, as the leaves of Iris.

ENTIRE (*integer*), without marginal divisions; (*integerrimus*, without either lobes or marginal divisions.)

ENVELOPES, FLORAL, the calyx and corolla.

EPI, upon, in composition, means on the outside or above, as *epicarp*, the outer covering of the fruit, *epigynous*, above the ovary.
EPICALYX, outer calyx, formed either of sepals or bracts, as in Mallow and Potentilla.
EPICARP, the outer covering of the fruit.
EPICHILIUM, the label or terminal portion of the strangulated or articulated lip (labellum) of Orchids.
EPICOROLLINE, inserted upon the corolla.
EPIDERMIS, the cellular layer covering the external surface of plants.
EPIGEAL, above ground, applied to cotyledons.
EPIGONE, the cellular layer which covers the young sporangium in Mosses and Hepaticæ.
EPIGYNOUS, placed above the ovary by adhesion to it.
EPIPETALOUS, inserted upon the petals.
EPIPHYLLOUS, growing upon a leaf.
EPIPHYTE, attached to another plant, and growing suspended in the air.
EPIRRHEOLOGY, the influence of external agents on plants.
EPISPERM, the external covering of the seed.
EPISPORE, the outer covering of some spores.
EQUITANT, applied to leaves folded longitudinally, and overlapping each other without any involution.
ERECT, applied to an ovule which rises from the base of the ovary; also applied to innate anthers.
EROSE, irregularly toothed, as if gnawed.
ERUMPENT, prominent, as if bursting through the epidermis, as seen in some tetraspores.
ETÆRIO, the aggregate drupes forming the fruit of Rubus.
ETIOLATION, blanching, losing colour in the dark.
EXALBUMINOUS, without a separate store of albumen or perisperm.
EXANNULATE, without a ring, applied to some Ferns.
EXCENTRIC, removed from the centre or axis, applied to a lateral embryo.
EXCIPULUS, a receptacle containing fructification in Lichens.
EXCURRENT, running out beyond the edge or point.
EXINTINE, one of the inner coverings of the pollen-grain.
EXO, in composition, on the outside.
EXOGEN, outside grower, same as Dicotyledon.
EXORHIZAL, radicle proceeding directly from the axis, and afterwards branching, as in Exogens.
EXOSMOSE, the passing outwards of a fluid through a membrane.—See reference in Index.
EXOSPOROUS, Fungi having naked spores.
EXOSTOME, the outer opening of the foramen of the ovule.
EXOTHECIUM, the outer coat of the anther.
EXSERTED, extending beyond an organ, as stamens beyond the corolla.
EXSTIPULATE, without stipules.
EXTINE, the outer covering of the pollen-grain.
EXTRA-AXILLARY, removed from the axil of the leaf, as in the case of some buds.
EXTRORSE, applied to anthers which dehisce on the side farthest removed from the pistil.
EXUTIVE, applied by Miers to seeds wanting the usual integumentary covering, as in Olacaceæ.

FALCATE or FALCIFORM, bent like a sickle.
FARINACEOUS, mealy, containing much starch.
FASCIATION, union of branches or stems, so as to present a flattened ribband-like form.
FASCICLE, a shortened umbellate cyme, as in some species of Dianthus.
FASTIGIATE, having a pyramidal form, from the branches being parallel and erect.
FAVELLA, a kind of conceptacle in Algæ.
FEATHER-VEINED, a leaf having the veins passing from the midrib at a more or less acute angle, and extending to the margin.
FENESTRATE, applied to a replum or leaf with openings in it, compared to windows.
FIBRO-CELLULAR tissue, composed of spiral cells.
FIBROUS, composed of numerous fibres, as some roots.
FIBRO-VASCULAR tissue, composed of vessels containing spiral and other fibres.
FID, in composition, cleft, cut down to about the middle.
FILAMENT, stalk supporting the anther.
FILAMENTOUS, a string of cells placed end to end.
FILIFORM, like a thread.
FIMBRIATED, fringed at the margin.
FISSIPAROUS, dividing spontaneously into two parts, by means of a septum.
FISSURE, a straight slit in an organ for the discharge of its contents.
FISTULOUS, hollow, like the stem of Grasses.
FLABELLIFORM, fan-shaped, as the leaves of some Palms.
FLAGELLUM, a runner, a weak, creeping stem bearing rooting buds at different points, as in the Strawberry.
FLEXUOSE or FLEXUOUS, having alternate curvations in opposite directions; bent in a zig-zag manner.
FLOCCI, woolly filaments with sporules in Fungi and Algæ.
FLOCCOSE, covered with wool-like tufts.
FLORAL ENVELOPES, the calyx and corolla.
FLOSCULOUS, the tubular florets of Compositæ.
FOLIATION, the development of leaves.
FOLIOLA, same as *Phylla* and *Sepala*.
FOLLICLE, a fruit formed by a single carpel, dehiscing by one suture, which is usually the ventral.
FOOT, French, equal to 1.07892 foot British.
FORAMEN, the opening in the coverings of the ovule.
FOVEATE or FOVEOLATE, having pits or depressions called foveæ or foveolæ.
FOVILLA, minute granular matter in the pollen-grain.
FROND, the leaf-like organ of Ferns bearing the fructification; also applied to the thallus of many Cryptogamics.
FRONDOSE, applied to Cryptogams with foliaceous or leaf-like expansions.
FRUSTULES, the parts or fragments into which Diatomaceæ separate.
FRUTEX, a shrub; *Fruticose*, shrubby.
FUGACIOUS, evanescent, falling off early, as the petals of Cistus.
FULVOUS, tawny-yellow.
FUNICULUS, the umbilical cord connecting the hilum of the ovule to the placenta.
FURCATE, divided into two branches, like a two-pronged fork.
FURFURACEOUS, scurfy or scaly.
FUSIFORM, shaped like a spindle.

GALBULUS, the polygynœcial succulent fruit of Juniper.
GALEA, applied to a sepal or petal shaped like a helmet; the part is called *Galeate*.
GAMO, in composition, means union of parts.
GAMOPETALOUS, same as *Monopetalous*, petals united.
GAMOPHYLLOUS and GAMOSEPALOUS, same as *Monophyllous* and *Monosepalous*, sepals united.
GEMINATE, twin, organs combined in pairs.
GEMMA, a leaf-bud; *Gemmation*, the development of leaf-buds.
GEMMIFEROUS, bearing buds.
GEMMIPAROUS, reproduction by buds.
GEMMULE, same as *Plumule*, the first bud of the embryo.
GENICULATE, bent like a knee.
GERMEN, a name for the ovary.
GERMINAL VESICLE, a cell contained in the embryo sac, from which the embryo is developed.

GERMINATION, the sprouting of the young plant.
GIBBOSITY, a swelling at the base of an organ, such as the calyx or corolla.
GIBBOUS, swollen at the base, or having a distinct swelling at some part of the surface.
GLABROUS, smooth, without hairs.
GLAND, an organ of secretion consisting of cells, and generally occurring on the epidermis of plants.
GLANDULAR HAIRS, hairs tipped with a gland, as in Drosera and Chinese Primrose.
GLANS, nut, applied to the Acorn or Hazel-nut, which are enclosed in bracts.
GLAUCOUS, covered with a pale-green bloom.
GLOBULE, male organ of Chara.
GLOCHIDIATE, barbed, applied to hairs with two reflexed points at their summit.
GLOMERULUS, a rounded, cymose inflorescence, as in Urtica.
GLUMACEOUS, of the nature of glumes.
GLUME, a bract covering the organs of reproduction in the spikelets of Grasses, which are hence called *Glumiferous.*
GLUMELLE and GLUMELLULE, a name applied to the palea or pale of a Grass.
GONIDIA, green germinating cells in the thallus of Lichens.
GONUS or GONUM, in composition, means either kneed or angled; in the former case the *o* is short, in the latter long. *Polygonum,* many-kneed; *Tetragonum,* four-angled.
GRAIN, caryopsis, the fruit of Cereal Grasses.
GRAINS of pollen, minute cells composing the pollen.
GRANULATED, composed of granules.
GRUMOUS, collected into granular masses.
GYMNOGEN, a plant with naked seeds, *i. e.,* seeds not in a true ovary.
GYMNOS, naked, in composition *Gymno.*
GYMNOSPERMOUS, plants with naked seeds, *i. e.,* seeds not in a true ovary, as Conifers.
GYMNOSPORE, a naked spore; *Gymnosporous,* having naked spores.
GYMNOSTOMI, naked-mouthed, Mosses without a peristome.
GYNANDROUS, stamen and pistil united in a common column, as in Orchids.
GYNE, female, and GYN, GYNOUS, and GYNO, in composition, refer to the pistil or the ovary.
GYNIZUS, the position of the stigma on the column of Orchids.
GYNOBASE, a central axis to the base of which which the carpels are attached.
GYNŒCIUM, the female organs of the flower.
GYNOPHORE, a stalk supporting the ovary.
GYNOSTEMIUM, column in Orchids bearing the organs of reproduction.
GYRATE, same as *Circinate.*
GYRATION, same as *Rotation* in cells

HABIT of a plant, its general external appearance.
HALOPHYTES, plants of salt-marshes, containing salts of soda in their composition.
HASTATE, halbert-shaped, applied to a leaf with two portions at the base projecting more or less completely at right angles to the blade.
HAULM, dead stems of herbs, as of the potato.
HAUSTORIUM, the sucker at the extremity of the parasitic root of Dodder.
HEART-WOOD, same as *Duramen.*
HELICOIDAL, having a coiled appearance like the shell of a snail, applied to inflorescence.
HELMET, the upper petaloid sepal of Aconitum.
HEMI, half; same as Latin *Semi.*
HEMICARP, one of the achenes forming the cremocarp of Umbelliferæ.
HEPTA, seven; same as Latin *Septem.*
HEPTANDROUS, having seven stamens.
HERB, a plant with an annual stem, opposed to a woody plant.
HERBACEOUS, green succulent plants which die down to the ground in winter; annual shoots; green-coloured cellular parts.
HERMAPHRODITE, stamens and pistil in the same flower.
HESPERIDIUM, the fruit of the Orange, and other Aurantiaceæ.—See reference in Index.
HETEROCEPHALOUS, Composite plants having male and female capitula on the same plant.
HETERODROMOUS, running in different directions.
HETEROGAMOUS, Composite plants having hermaphrodite and unisexual flowers on the same head.
HETEROPHYLLOUS, presenting two different forms of leaves.
HETERORHIZAL, rootlets proceeding from various points of a spore during germination.
HETEROS, dissimilar or diverse, in composition *Hetero.*
HETEROTROPAL, ovule with the hilum in the middle, and the foramen and chalaza at opposite ends.
HEXA, six; same as Latin *Sex.*
HEXANDROUS, having six stamens.
HILUM, the base of the seed to which the placenta is attached either directly or by means of a cord. The term is also applied to the mark at one end of some grains of starch.
HIRSUTE, covered with long stiff hairs.
HISPID, covered with long very harsh hairs.
HISTOLOGY, the study of microscopic tissues.
HOLOSERICEOUS, covered with minute silky hairs, discovered better by the touch than by sight.
HOMODROMOUS, running in the same direction.
HOMOGAMOUS, Composite plants having the flowers of the capitula all hermaphrodite.
HOMOGENEOUS, having a uniform structure or substance.
HOMOS and HOMOIOS, similar, in composition *Homo.*
HOMOTROPAL, same as *Orthotropal.*
HOROLOGICAL, flowers opening and closing at certain hours.
HUMIFUSE, spreading along the ground.
HYALINE, transparent or colourless, applied by Barry to the part where the cell-nucleus appears.
HYBRID, a plant resulting from the fecundation of one species by another.
HYMENIUM, the part which bears the fructification in Agarics.
HYPANTHODIUM, the receptacle of Dorstenia—see Index.
HYPO, under or below, in composition *Hyp.*
HYPOCARPOGEAN, plants producing their fruit below ground.
HYPOCHILIUM, the lower part of the labellum of Orchids.
HYPOCRATERIFORM, shaped like a salver, as the corolla of Primula.
HYPOGEAL or HYPOGEOUS, under the surface of the soil, applied to Cotyledons.
HYPOGYNOUS, inserted below the ovary or pistil.
HYPOTHALLUS, the mycelium of certain Entophytic Fungi as Uredines.
HYPSOMETRICAL, measurement of altitude.

ICOSANDRIA, having twenty stamens or more inserted on the calyx; *Icosandrous,* having twenty stamens.
ICOSI, twenty; in composition *Icos.* Same as Latin *Viginti.*
IMBRICATE or IMBRICATED, parts overlying each other like tiles on a house. *Imbricated æstivation,* the parts in the flower-bud alternately overlapping each other, and arranged in a spiral manner.
IMPARI-PINNATE, unequally-pinnate, pinnate leaf ending in an odd leaflet.
INARCHING, a mode of grafting by bending two growing plants towards each other, and causing a branch of the one to unite to the other.

Inarticulate, without joints or interruption to continuity.
Inch, French, is equal to 1.06578 inch British.
Incised, cut down deeply.
Included, applied to the stamens when enclosed within the corolla, and not pushed out beyond its tube.
Incumbent, cotyledons with the radicle on their back.
Indefinite, applied to inflorescence with centripetal expansion; also to stamens above twenty, and to ovules and seeds when very numerous.
Indehiscent, not opening.
Indeterminate, applied to indefinite inflorescence.
Indigenous, an aboriginal native in a country.
Induplicate or Induplicative, edges of the sepals or petals turned slightly inwards in æstivation.
Indusium, epidermal covering of the fructification in some Ferns.
Indutive, applied by Miers to seeds having the usual integumentary covering.
Inermis, unarmed, without prickles or thorns.
Inferior, applied to the ovary when it seems to be situated below the calyx; and to the part of a flower farthest from the axis.
Inflorescence, the mode in which the flowers are arranged on the axis.
Infundibuliform, in shape like a funnel; as seen in some gamopetalous corollas.
Innate, applied to anthers when attached to the top of the filament.
Innovations, buds in Mosses.
Intercellular Space, same as *Lacuna*.
Interfoliar, between two opposite leaves.
Internode, the portion of the stem between two nodes or leaf-buds.
Interpetiolar, between the petioles of opposite leaves; as the stipules of Cinchona.
Interruptedly-pinnate, a pinnate leaf in which pairs of small pinnæ occur between the larger pairs.
Intextine, one of the inner coverings of the pollen-grain.
Intine, the inner covering of the pollen-grain.
Introrse, applied to anthers which open on the side next the pistil.
Involucel, bracts surrounding the partial umbel of Umbelliferæ.
Involucre, bracts surrounding the general umbel in Umbelliferæ, the heads of flowers in Compositæ, and in general any verticillate bracts surrounding numerous flowers. It is also used in the same sense as the Indusium of Ferns.
Involute or Involutive, edges of leaves rolled inwards spirally on each side, in æstivation.
Irregular, a flower in which the parts of any of the verticils differ in size.
Isocheimal or Isocheiminal, lines passing through places which have the same mean winter temperature.
Isomeric, applied chemically to substances which, though differing in qualities, have the same elements in the same proportions.
Isomerous, when the organs of a flower are composed each of an equal number of parts.
Isos, equal, in composition *Iso*.
Isostemonous, when stamens and floral envelopes have the same number of parts or multiples.
Isotheral, lines passing through places which have the same mean summer temperature.
Isothermal, lines passing through places which have the same mean annual temperature.

Juga, a name given to the ribs on the fruit of Umbelliferæ.
Jugum, a pair of leaflets; *jugate*, applied to the pairs of leaflets in compound leaves; *unijugate*, one pair; *bijugate*, two pairs, and so on.

Keel, same as *Carina*.

Label, the terminal division of the lip of the flower in Orchids.
Labellum, lip, one of the divisions of the inner whorl of the flower of Orchids. This part is in reality superior, but becomes inferior by the twisting of the ovary.
Labiate, lipped, applied to irregular gamopetalous flowers, with an upper and under portion separated more or less by a hiatus or gap.
Laciniated, irregularly cut into narrow segments.
Lactescent, yielding milky juice.
Lacuna, a large space in the midst of a group of cells.
Lævigatus, having a smooth polished appearance.
Lævis, even.
Lamellæ, gills of an Agaric; also applied to flat divisions of the stigma.
Lamina, the blade of the leaf, the broad part of a petal or sepal.
Lanceolate, narrowly elliptical, tapering to each end.
Lanuginous, woolly, covered with long flexuous interlaced hairs.
Lateral, arising from the side of the axis, not terminal.
Latex, granular fluid contained in laticiferous vessels.
Laticiferous, vessels containing latex, which anastomose.
Latiseptæ, Cruciferous plants having a broad replum in their silicula.
Legume, a pod composed of one carpel, opening usually by ventral and dorsal suture, as in the Pea. For varieties of Legume see reference in Index.
Lenticel, a small process on the bark of the Willow and other plants, whence adventitious roots proceed.
Lenticular, in the form of a doubly-convex lens.
Lepidote, covered with scales or scurf; *lepis*, a scale.
Lianas or Lianes, twining woody plants.
Liber, the fibrous inner bark or endophlœum.
Lieberkuhn, a metallic mirror attached to the objective of a microscope for the purpose of throwing down light on opaque objects.
Lignine, woody matter which thickens the cell-walls.
Ligulate, strap-shaped florets, as in Dandelion.
Ligule, a process arising rrom the petiole of grasses where it joins the blade.
Liguliforæ, Composite plants having ligulate florets.
Limb, the blade of the leaf; the broad part of a petal or sepal; when sepals or petals are united, the combined broad parts are denominated collectively the limb.
Line, the 12th part of an inch; *Line*, French, is equal to 0.088815 inch British.
Linear, very narrow leaves, in which the length exceeds greatly the breadth.
Lirella, sessile linear apothecium of Lichens.
Lobe, large division of a leaf or any other organ; applied often to the divisions of the anther.
Loculicidal, fruit dehiscing through the back of the carpels.
Loculus or Loculament, a cavity in an ovary, which is called *unilocular* when it has one cavity, *bilocular* with two, and so on. The terms are also applied to the anther.
Locusta, a spikelet of grasses formed of one or several flowers.
Lodicule, a scale at the base of the ovary of Grasses.
Lomentum and Lomentaceous, applied to a legume or pod with transverse partitions, each division containing one seed.

LUNATE, crescent-shaped.
LYRATE, a pinnatifid leaf with a large terminal lobe, and smaller ones as we approach the petiole.

MACROS, large, in composition *Macro*.
MALPIGHIACEOUS HAIRS, peltate hairs, such as are seen in Malpighiaceæ.
MARCESCENT, withering, but not falling off until the part bearing it is perfected.
MARGINATE, applied to calyx, same as *Obsolete*.
MASKED, same as *Personate*.
MATH, a term sometimes used for crop; an agricultural term.
MATTULLA, the fibrous matter covering the petioles of Palms.
MEDULLA, the cellular pith.
MEDULLARY RAYS or PLATES, cellular prolongations uniting the pith and the bark.
MEDULLARY SHEATH, sheath containing spiral vessels surrounding the pith in Exogens.
MEIOSTEMONOUS or MIOSTEMONOUS, the stamens less in number than the parts of the corolla.
MEMBRANACEOUS or MEMBRANOUS, having the consistence, aspect, and structure of a membrane.
MENISCUS, a lens having a concave and a convex face, with a sharp edge.
MERENCHYMA, tissue composed of rounded cells.
MERICARP, carpel forming one-half of the fruit of Umbelliferæ.
MERITHAL, a term used in place of internode; applied by Gaudichaud to the different parts of the leaf.
MESOCARP, middle covering of the fruit.
MESOCHILIUM, middle portion of the labellum of Orchids.
MESOPHLŒUM, middle layer of the bark.
MESOPHYLLUM, the parenchyma of the leaf.
MESOS, the middle, in composition *Meso*.
MESOSPERM, applied to a covering of the seed derived from the secundine.
METRE, equal to 39.37079 inches British.
MICROMETER, instrument for measuring microscopic objects.
MICROPYLE, the opening or foramen of the seed.
MICROS, small, in composition *Micro*.
MILLIMETRE, equal to 0.03937079 English inch, or 25.39954 millimetres equal to an English inch.
MITRIFORM, shaped like a mitre, as the calyptræ of some Mosses.
MONADELPHOUS, stamens united into one bundle by union of their filaments.
MONANDROUS, having one stamen.
MONEMBRYONY, having a single embryo.
MONILIFORM, beaded, cells united, with interruptions, so as to resemble a string of beads.
MONOCARPIC, producing flowers and fruit once during life, and then dying.
MONOCHLAMYDEOUS, flower having a single envelope, which is the calyx.
MONOCLINOUS, stamens and pistils in the same flower.
MONOCOTYLEDONOUS, having one cotyledon in the embryo.
MONŒCIOUS, stamens and pistils in different flowers on the same plant.
MONOGYNŒCIAL, applied to simple fruits, formed by the pistil of one flower.
MONOGYNOUS, having one pistil or carpel; also applied to plants having one style.
MONOPETALOUS, same as *Gamopetalous*.
MONOPHYLLOUS, same as *Gamosepalous*.
MONOS, one, in composition *Mono* and *Mon*, as *monandrous*, one stamen; sometimes applied to the union of parts into one, as *monopetalous*, meaning combined petals; same as Latin *Unus*.
MONOSEPALOUS, same as *Gamosepalous*.
MONOSPERMOUS or MONOSPERMAL, having a single seed.
MONOTHECAL, having a single loculament.
MONSTROSITY, an abnormal development, applied more especially to double flowers.
MORPHOLOGY, the study of the forms which the different organs assume, and the laws that regulate their metamorphoses.
MUCRO, a stiff point abruptly terminating an organ; *Mucronate*, having a mucro.
MUCUS, definite, peculiar matter forming a covering of certain sea-weeds.
MULTICOSTATE, many-ribbed.
MULTIFID, applied to a simple leaf divided laterally to about the middle into numerous portions; when the divisions extend deeper it is *Multipartite*.
MULTILOCULAR, having many loculaments.
MULTIPLE, applied to anthocarpous or polygynœcial fruits formed by the union of several flowers.
MURICATE, covered with firm, short points or excrescences.
MURIFORM, like bricks in a wall; applied to cells.
MUSCOLOGY, the study of Mosses.
MUTICUS, without any pointed process or awn.
MYCELIUM, the cellular spawn of Fungi.

NAKED, applied to seeds not contained in a true ovary; also to flowers without any floral envelopes.
NAPIFORM, shaped like a turnip.
NATURALISED, originally introduced by artificial means, but become apparently wild.
NAVICULAR, hollowed like a boat.
NECTARIFEROUS, having a honey-like secretion; applied to petals having depressions or furrows at their base, which contain a sweet secretion.
NECTARY, any abnormal part of a flower. It ought to be restricted to organs secreting a honey-like matter, as in Crown Imperial.
NERVATION or NEURATION, same as *Venation*.
NETTED, applied to reticulated venation, also covered with raised lines disposed like the threads of a net.
NITIDUS, having a smooth and polished surface.
NODE, the part of the stem from which a leaf-bud proceeds.
NODOSE, having swollen nodes or articulations.
NODULOSE, applied to roots with thickened knots at intervals.
NOSOLOGY, vegetable, the study of the diseases of plants.
NOTORHIZEÆ, radicle on the back of the cotyledons, as in some Cruciferæ.
NUCLEUS, the body which gives origin to new cells; also applied to the central cellular portion of the ovule and seed.
NUCULANIUM, applied to the fruit of the Medlar having nucules; some also apply this term to the Grape.
NUCULE, hard carpel in the Medlar, also one of the parts of fructification in Characeæ.
NUCUMENTACEOUS, Cruciferæ having a dry monospermal fruit.
NUT, properly applied to the glans, but also applied to any hard nut-like fruit, as in Carex and Rumex.

OB, in composition, means reversed or contrariwise.
OBCOMPRESSED, flattened in front and behind, not laterally.
OBCORDATE, inversely heart-shaped, with the divisions of the heart at the opposite end from the stalk.
OBLONG, about $\frac{3}{4}$ as long as broad; elliptical, obtuse at each end.
OBOVATE, reversely ovate, the broad part of the egg being uppermost.
OBSOLETE, imperfectly developed or abortive; applied to the calyx when it is in the form of a rim.

OBTUSE, not pointed, with a rounded or blunt termination.
OBVOLUTE, margins of one leaf alternately overlapping those of the leaf opposite to it.
OCHREA, boot, applied to the sheathing stipule of Polygonaceæ.
OCTANDROUS, having eight stamens.
OCTO, eight, in composition *Oct.*
OCTOGYNOUS, having eight styles.
ŒCIUM and ŒCIOUS, in composition, have reference to the position of the reproductive organs, as *Andrœcium*, the staminal organs; *Diœcious*, stamen and pistil in different flowers.
OFFICINAL, sold in the shops.
OLERACEOUS, used as an esculent potherb.
OLIGANDROUS, stamens under twenty.
OLIGOS, few or in small number, in composition *Oligo* and *Olig.*
OMPHALODE, the central point of the hilum where the nourishing vessels enter.
OOPHORIDIUM, organ in Lycopodiaceæ containing large spores.
OPAQUE, dull, not shining.
OPERCULUM, lid, applied to the separable part of the theca of Mosses; also applied to the lid of certain seed-vessels; *Operculate*, opening by a lid.
OPPOSITE, applied to leaves placed on opposite sides of a stem at the same level.
ORBICULAR, rounded leaf with petiole attached to the centre of it.
ORGANOGENY, the development of organs.
ORGANOGRAPHY, the description of the organs of plants.
ORTHOPLOCEÆ, Cruciferæ having conduplicate cotyledons.
ORTHOS, straight, in composition *Ortho*, same as Latin *Rectus.*
ORTHOTROPAL and ORTHOTROPOUS, ovule with foramen opposite to the hilum; embryo with radicle next the hilum.
OVAL, elliptical, blunt at each end.
OVARY, the part of the pistil which contains the ovules.
OVATE, shaped like an egg, applied to a leaf with the broader end of the egg next the petiole or axis; *Ovate-lanceolate*, a lanceolate leaf, which is somewhat ovate.
OVENCHYMA, tissue composed of oval cells.
OVULE, the young seed contained in the ovary.

PAGINA, applied to the surface of the leaf, or any flat surface.
PALÆONTOLOGY, the study of Fossils.
PALÆOPHYTOLOGY, the study of Fossil plants.
PALATE, the projecting portion of the under lip of personate flowers.
PALEA or PALE, the part of the flower of Grasses within the glume; also applied to the small scaly laminæ which occur on the receptacle of some Compositæ.
PALEACEOUS, chaffy, covered with small erect membranous scales.
PALMATE and PALMATIFID, applied to a leaf with radiating venation, divided into lobes to about the middle.
PALMATIPARTITE, applied to a leaf with radiating venation, cut nearly to the base in a palmate manner.
PANDURIFORM, shaped like a fiddle, applied to an oblong leaf, with a sinus on each side about the middle.
PANICLE, inflorescence of Grasses, consisting of spikelets on long peduncles coming off in a racemose manner.
PANICULATE, forming a panicle.
PAPILIONACEOUS, corolla composed of vexillum, two alæ, and carina, as in the Pea.
PAPILLATED and PAPILLOSE, covered with small nipple-like prominences.
PAPPUS, the hairs at the summit of the ovary in Compositæ. They consist of the altered calycine limb. *Pappose*, provided with pappus.
PARAPHYSES, filaments, sometimes articulated, occurring in the fructification of Mosses, and other Cryptogams; also applied by some authors to abortive petals or stamens.
PARASITE, attached to another plant, and deriving nourishment from it.
PARENCHYMA, cellular tissue.
PARIETAL, applied to placentas on the wall of the ovary.
PARI-PINNATE, a compound pinnate leaf, ending in two leaflets.
PARTITE or PARTED, cut down to near the base, the divisions being called *Partitions.*
PATELLA, rounded sessile apothecium of Lichens.
PATENT, spreading widely.
PATHOLOGY, vegetable, same as *Nosology.*
PATULOUS, spreading less than when patent.
PECTINATE, divided laterally into narrow segments, like the teeth of a comb.
PEDATE and PEDATIFID, a palmate leaf of three lobes, the lateral lobes bearing other equally large lobes on the edges next the middle lobe.
PEDICEL, the stalk supporting a single flower; such a flower is *Pedicellate.*
PEDUNCLE, the general flower-stalk or floral axis. Sometimes it bears one flower, at other times it bears several sessile or pedicellate flowers.
PELAGIC, growing in many distant parts of the ocean.
PELLICLE, the outer cuticular covering of plants.
PELORIA, a name given to a teratological phenomenon, which consists in a flower, which is usually irregular, becoming regular; for instance, when Linaria, in place of one spur, produces five.
PELTATE, shield-like, fixed to the stalk by a point within the margin; *peltate hairs*, attached by their middle.
PENDULOUS, applied to ovules which are hung from the upper part of the ovary.
PENICILLATE, pencilled, applied to a tufted stigma resembling a camel's hair pencil, as in the Nettle.
PENNI-NERVED and PENNI-VEINED, the veins disposed like the parts of a feather, running from the midrib of the leaf to the margin.
PENTA, PENTE, five, same as *Quinque* in Latin.
PENTAGYNOUS, having five styles.
PENTAMEROUS, composed of five parts; a pentamerous flower has its different whorls in five, or multiples of that number.
PENTANDROUS, having five stamens.
PEPO and PEPONIDA, the fruit of the Melon, Cucumber, and other Cucurbitaceæ.—See reference in Index.
PER, when placed before an adjective, sometimes gives it the value of a superlative, as *perpusillus*, very weak; at other times it means through, as *perfoliate*, through the leaf.
PERCURRENT, running through from top to bottom.
PERENNIAL, living, or rather flowering, for several years.
PERFOLIATE, a leaf with the lobes at the base, united on the side of the stem opposite the blade, so that the stalk appears to pass through the leaf.
PERI, around; in Latin *Circa.*
PERIANTH, a general name for the floral envelope; applied in cases where there is only a calyx, or where the calyx and corolla are alike.
PERICARP, the covering of the fruit.
PERICHÆTIAL, applied to the leaves surrounding the fruit stalk or seta of Mosses.
PERICLADIUM, the large sheathing petiole of Umbelliferæ.
PERICLINIUM and PERIPHORANTHIUM, the involucre of Compositæ.

PERIDERM, a name applied to the outer layer of bark.
PERIDIUM, the envelope of the fructification in Gasteromycetous Fungi.
PERIGONE, same as Perianth. Some restrict the term to cases in which the flower is female or pistilliferous. It has also been applied to the involucre of Jungermannieæ.
PERIGYNIUM, applied to the covering of the pistil in the genus Carex.
PERIGYNOUS, applied to corolla and stamens when attached to the calyx.
PERIPHERICAL, applied to an embryo curved so as to surround the albumen, following the inner part of the covering of the seed.
PERISPERM, the albumen or nourishing matter stored up with the embryo in the seed.
PERISPORE, the outer covering of a spore.
PERISTOME, the opening of the sporangium of Mosses after the removal of the calyptra and operculum.
PERITHECIUM, a conceptacle in Cryptogams, containing spores, and having an opening at one end.
PERSISTENT, not falling off, remaining attached to the axis until the part which bears it is matured.
PERSONATE, a gamopetalous irregular corolla having the lower lip pushed upwards, so as to close the hiatus between the two lips.
PERTUSE, having slits or holes.
PERULÆ, the scales of the leaf bud.
PETALOID, like a petal.
PETALS, the leaves forming the corolline whorl.
PETIOLATE, having a stalk or petiole.
PETIOLE, a leaf-stalk; *Petiolule*, the stalk of a leaflet in a compound leaf.
PHANEROGAMOUS, having conspicuous flowers.
PHANEROS and PHÆNOS, conspicuous, in composition *Phanero* and *Phæno*.
PHLŒUM, a name applied in composition to the bark.
PHORANTHIUM, applied to the receptacle of Compositæ.
PHORUS, PHORUM, and PHORE, in words derived from the Greek, are used as terminations, meaning, that which bears; equivalent to the Latin *Ferus* and *Fer*.
PHRAGMA, transverse division or false dissepiment in fruits.
PHYCOLOGY, the study of Algæ or Sea-weeds.
PHYLLARIES, the leaflets forming the involucre of Composite flowers.
PHYLLODIUM, leaf-stalk enlarged so as to have the appearance of a leaf.
PHYLLOID, like a leaf.
PHYLLOPTOSIS, the fall of the leaf.
PHYLLOTAXIS, the arrangement of the leaves on the axis.
PHYLLUM, leaf, in composition *Phyllo* and *Phyllous*; in Latin *Folium*.
PHYSIOGNOMY, general appearance, without reference to botanical characters.
PHYSIOLOGY, Vegetable, the study of the functions of plants.
PHYTOGENESIS, the development of the plant.
PHYTOGRAPHY, the description of plants.
PHYTOLOGY, the study of plants.
PHYTON, a name given by Gaudichaud to the simple individual plant, as represented by a leaf. In words derived from the Greek, *Phyton* and *Phyto* mean plant.
PHYTOZOA, moving filaments in the antheridia of Cryptogams.
PILEORHIZA, a covering of the root, as in Lemna.
PILEUS, the cap-like portion of the Mushroom, bearing the hymenium on its under side.
PILOSE, provided with hairs; applied to pappus composed of simple hairs.
PINENCHYMA, tissue composed of tabular cells.
PINNA, the leaflet of a pinnate leaf.
PINNATE, a compound leaf having leaflets arranged on each side of a central rib.
PINNATIFID, a simple leaf cut into lateral segments to about the middle.
PINNATIPARTITE, a simple leaf cut into lateral segments, the divisions extending nearly to the central rib.
PINNULE, the small pinnæ of a bipinnate or tripinnate leaf.
PISTIL, the female organ of the flower, composed of one or more carpels; each carpel being composed of ovary, style, and stigma.
PISTILLATE and PISTILLIFEROUS, applied to a female flower or a female plant.
PISTILLIDIUM, the female organ in Cryptogams.
PLACENTA, the cellular part of the carpel bearing the ovule.
PLACENTARY, a placenta bearing numerous ovules.
PLACENTATION, the formation and arrangement of the placenta.
PLATYS, large or broad, in composition *Platy*; in Latin *Latus* and *Late*.
PLEION, several, in composition *Pleio*; in Latin *Pluri*.
PLEIOTRACHEÆ, spiral vessels with several fibres united.
PLENUS, when applied to the flower, means double.
PLEURENCHYMA, woody tissue.
PLEUROCARPI, Mosses with the fructification proceeding laterally from the axils of the leaves.
PLEURORHIZEÆ, Cruciferous plants having the radicle of the embryo applied to the edges of the cotyledons, which are called *Accumbent*.
PLICATE and PLICATIVE, plaited or folded like a fan.
PLUMOSE, feathery, applied to hairs having two longitudinal rows of minute cellular processes.
PLUMULE, the first-bud of the embryo, usually enclosed by the cotyledons.
PLURI, in Latin words means several.
PLURILOCULAR, having many loculaments.
PODETIUM, a stalk bearing the fructification in some Lichens.
PODOCARP, a stalk supporting the fruit.
PODOGYNIUM, a stalk supporting an ovary.
PODOSPERM, the cord attaching the seed to the placenta.
POGON, beard; in Latin *Barba*.
POLLARD-TREES, cut down so as to leave only the lower part of the trunk, which gives off numerous buds and branches.
POLLEN, the powdery matter contained in the anther.
POLLEN-TUBE, the tube emitted by the pollen-grain after it is applied to the stigma. See *Index*.
POLLINIA, masses of pollen found in Orchids and Asclepiads.
POLYADELPHOUS, stamens united by their filaments so as to form more than two bundles.
POLYANDROUS, stamens above twenty.
POLYCARPIC, plants which flower and fruit many times in the course of their life.
POLYCOTYLEDONOUS, an embryo having many cotyledons, as in Firs.
POLYEMBRYONY, having more than one embryo.
POLYGAMOUS, plants bearing hermaphrodite as well as male and female flowers.
POLYGYNŒCIAL, applied to multiple fruits formed by the united pistils of many flowers.
POLYGYNOUS, having many pistils or styles.
POLYMORPHOUS, assuming many shapes.
POLYPETALOUS, a corolla composed of separate petals.
POLYPHYLLOUS, a calyx or involucre composed of separate leaflets.

POLYS, many, in composition *Poly;* in Latin *Multus.*
POLYSEPALOUS, a calyx composed of separate sepals.
POME, a fruit like the Apple and Pear—See reference in Index.
PORES of the leaf, same as *Stomata.*
POROUS vessels, same as Pitted or Dotted vessels.
PORRECT, extended forwards.
POSTERIOR, applied to the part of the flower placed next the axis; same as *Superior.*
POSTICUS, same as *Extrorse;* applied to anthers.
POUCH, the short pod or silicle of some Cruciferæ.
POUS, PODOS, a foot or stalk, in composition *Podo;* in Latin *Pes, Pedis.*
PRÆFLORATION, same as *Æstivation.*
PRÆFOLIATION, same as *Vernation.*
PREMORSE, bitten, applied to a root terminating abruptly, as if bitten off.
PRICKLES, hardened epidermal appendages, of a similar nature to hairs.
PRIMINE, the outer coat of the ovule.
PRIMORDIAL, the first true leaves given off by the young plant; also the first fruit produced on a raceme or spike.
PRIMORDIAL UTRICLE, the lining membrane of cells in their early state.
PRISMENCHYMA, tissue composed of prismatical cells.
PROCESS, any prominence or projecting part, or small lobe.
PROCUMBENT, lying on the ground.
PRO-EMBRYO or PROTHALLUS, names given to the first part produced by the spore of an acrogen in germinating.
PROLIFEROUS, bearing abnormal buds.
PRONE, prostrate, lying flat on the earth.
PROPAGULUM, an offshoot, or germinating bud attached by a thickish stalk to the parent plant.
PROSENCHYMA, fusiform tissue forming wood.
PROTOPLASM, the matter which seems to be concerned in the early formation of nuclei and cells.
PRUINOSE, covered with a coarse granular secretion, as if dusted.
PSEUDO, false; in Latin *Spurius.*
PSEUDO-BULB, the peculiar aerial stem of many epiphytic Orchids.
PSEUDO-SPERMOUS, applied to plants bearing single-seeded seed-vessels, such as Achenes, resembling seeds.
PTERIDOGRAPHIA, a treatise on Ferns.
PUBESCENCE, short and soft hairs covering a surface, which is hence called *Pubescent.*
PULVERULENT, covered with fine powdery matter.
PULVINATE, shaped like a cushion or pillow.
PULVINUS, cellular swelling at the point where the leaf-stalk joins the axis.
PUNCTATED, applied to the peculiar dotted woody fibres of Coniferæ.
PUTAMEN, the hard endocarp of some fruits.
PYRENÆ, stony coverings of the seeds in the Medlar.
PYRIDIUM, same as *Pome.*
PYRIFORM, pear-shaped.
PYXIS and PYXIDIUM, a capsule opening by a lid.

QUADRI, in composition, means four times.
QUADRIFARIOUS, in four rows.
QUADRIFID, four-cleft, cut down into four parts to about the middle.
QUADRIJUGATE, having four pairs of leaflets.
QUADRILOCULAR, having four loculaments.
QUADRIPARTITE, divided deeply into four parts.
QUARTINE, the fourth coat of the ovule, which often is changed into albumen.
QUATERNATE, leaves coming off in fours from one point.
QUINARY, composed of five parts, or of a multiple of five.
QUINATE, five leaves coming off from one point.
QUINCUNX, when the leaves in the bud are five, of which two are exterior, two interior, and the fifth covers the interior with one margin, and has its other margin covered by the exterior. *Quincuncial,* arranged in a quincunx.
QUINQUE, in compound words means five.
QUINQUEFID, five-cleft, cut into five parts as far as the middle.
QUINQUELOCULAR, having five loculaments.
QUINQUEPARTITE, divided deeply into five parts.
QUINTINE, the fifth coat of the ovule, otherwise called the embryo-sac.

RACE, a permanent variety.
RACEME, cluster, inflorescence in which there is a primary axis bearing stalked flowers.
RACEMOSE, flowering in racemes.
RACHIS, the axis of inflorescence; also applied to the stalk of the frond in Ferns, and to the common stalk bearing the alternate spikelets in some Grasses.
RADIANT, applied to flowers which form a ray-like appearance, as seen in Umbelliferæ and in Viburnum, &c.
RADIATE, disposed like the spokes of a wheel; also applied to the florets of the ray or circumference of the capitula of Compositæ.
RADICAL, belonging to the root, applied to leaves close to the ground, clustered at the base of a flower stalk.
RADICLE, the young root of the embryo.
RADIUS, the ray or outer part of the heads of Composite flowers.
RAMAL, belonging to the branches.
RAMENTA, the scales or chaff of Ferns.
RAMOSE and RAMOUS, branched.
RAPHE, the line which connects the hilum and the chalaza in anatropal ovules.
RAPHIDES, crystals found in cells, which are hence called *Raphidian.*
RECEPTACLE, the flattened end of the peduncle or rachis, bearing numerous flowers in a head; applied also generally to the extremity of the peduncle or pedicel.
RECLINATE, curved downwards from the horizontal, bent back up.
RECTEMBRYEÆ, the embryo straight in the axis of the seed.
RECTINERVIS and RECTIVENIUS, straight and parallel-veined.
RECTISERIAL, leaves disposed in a rectilinear series.
RECURVED, bent backwards.
REDUPLICATE, edges of the sepals or petals turned outwards in æstivation.
REGMA, seed-vessel composed of elastic cocci, as in Euphorbia.
REGULAR, applied to an organ, the parts of which are of similar form and size.
RELIQUIÆ, remains of withered leaves attached to the plant.
RENIFORM, in shape like a kidney.
REPAND, having a slightly undulated or sinuous margin.
REPLUM, a longitudinal division in a pod formed by the placenta, as in Cruciferæ.
RESUPINATE, inverted by a twisting of the stalk.
RETICULATED, netted, applied to leaves having a network of anastomosing veins.
RETIFORM, like network.
RETINACULUM, the glandular viscid portion at the extremity of the caudicle in some pollinia.
RETINERVIS and RETIVENIUS, having reticulated veins.
RETRORSE, turned backwards.
RETUSE, when the extremity is broad, blunt, and slightly depressed.
REVOLUTE and REVOLUTIVE, leaf with its edges rolled backwards in vernation.

RHIZA, in words derived from the Greek, means root.
RHIZOME, a stem creeping horizontally, more or less covered by the soil, giving off buds above, and roots below.
RHIZOTAXIS, the arrangement of the roots.
RINGENT, a Labiate flower, in which the upper lip is much arched.
ROSACEOUS, applied to corollas having separate sessile petals like the Rose.
ROSETTE, leaves disposed in close circles forming a cluster.
ROSTELLUM, a prolongation of the upper edge of the stigma in some Orchids.
ROSTRATE, beaked, having a long sharp point.
ROTATE, a regular gamopetalous corolla with a short tube, the limb spreading out more or less at right angles.
ROTATION or GYRATION, a peculiar circulation of the cell sap, seen in Hydrocharidaceæ, &c.
RUDIMENTARY, an organ in an abortive state arrested in its development.
RUGOSE, wrinkled.
RUMINATE, applied to mottled albumen.
RUNCINATE, a pinnatifid leaf with a triangular termination, and sharp divisions pointing downwards, as in Dandelion.

SACCATE, forming a sack or bag, seen in some petals.
SAGITTATE, like an arrow, a leaf having two prolonged sharp-pointed lobes projecting downwards beyond the insertion of the petiole.
SAMARA, a winged dry fruit, as in the Elm.
SARCOCARP and SARCODERM, the mesocarp of the fruit having become succulent.
SARMENTUM, sometimes meaning the same as *Flagellvm*, or runner, at other times applied to a twining stem which supports itself by means of others.
SCABROUS, rough, covered with very stiff short hairs; *Scabriusculus*, somewhat rough.
SCALARIFORM, vessels having bars like a ladder, seen in Ferns.
SCANDENT, climbing by means of supports, as on a wall or rock.
SCAPE, a naked flower-stalk, bearing one or more flowers arising from a short axis, and usually with radical leaves at its base.
SCARIOUS, having the consistence of a dry scale, membranous, dry, and shrivelled.
SCION, the young twig used as a graft.
SCLEROGEN, the thickening matter of woody cells.
SCOBIFORM, in the form of filings, or like fine saw-dust.
SCOBINA, the flexuose rachis of some Grasses.
SCORPIOIDAL, like the tail of a scorpion, a peculiar twisted cymose inflorescence, as in Boraginaceæ.
SCROBICULATE, pitted, having small depressions.
SCUTELLUM, a sort of apothecium in Lichens.
SECUND, all turned to one side.
SECUNDINE, the second coat of the ovule within the primine.
SEGREGATE, separated from each other.
SEMI, half, same as the Greek *Hemi.*
SEMIFLOSCULOUS, same as *Ligulate.*
SEMINAL, applied to the cotyledons, or seed-leaves.
SEPAL, one of the leaflets forming the calyx.
SEPTATE, divided by septa or partitions.
SEPTEM, seven, in Greek *Hepta.*
SEPTENATE, organs approaching in sevens; a compound leaf with seven leaflets coming off from one point.
SEPTICIDAL, dehiscence of a seed-vessel through the septa or edges of the carpels.
SEPTIFRAGAL, dehiscence of a seed-vessel through the back of the loculaments, the valves also separating from the septa.
SEPTUM, a division in an ovary formed by the sides of the carpels.
SERICEOUS, silky, covered with fine, close-pressed hairs.
SERRATE or SERRATED, having sharp processes arranged like the teeth of a saw. *Biserrate*, when these are alternately large and small, or where the teeth are themselves serrated.
SERRATURES, pointed marginal divisions arranged like the teeth of a saw.
SERRULATE, with very fine serratures.
SESQUI, in composition, means one and a-half.
SESSILE, without a stalk, as a leaf without a petiole.
SETA, a bristle or sharp hair; also applied to the gland-tipped hairs of Rosaceæ and Hieracia; and to the stalk bearing the theca in Mosses.
SETACEOUS and SETIFORM, in the form of bristles.
SETIGEROUS, bearing setæ.
SETOSE, covered with setæ.
SEX, in Latin six; same as Greek *Hexa.*
SILICULA or SILICLE, a short pod with a double placenta and replum, as in some Cruciferæ.
SILICULOSÆ, bearing a silicle.
SILIQUA, a long pod similar in structure to the silicula.
SILIQUÆFORM, fruit like a siliqua in form.
SILIQUOSÆ, bearing a siliqua.
SIMPLE, not branching, not divided into separate parts; *Simple fruits* are those formed by one flower.
SINISTRORSE, directed towards the left.
SINUATED, the margin having numerous large obtuse indentations.
SINUOUS, with an wavy or flexuous margin.
SOBOLES, a creeping under-ground stem.
SOCIAL PLANTS, such as grow naturally in groups or masses.
SOREDIA, powdery cells on the surface of the thallus of some Lichens.
SOROSIS, a compound or polygynœcial succulent fruit, such as Breadfruit and Mulberry.
SORUS, a cluster of sporangia in Ferns.
SPADIX, a succulent spike bearing male and female flowers, as in Arum.
SPATHACEOUS, having the aspect and membranous consistence of a spathe.
SPATHE, large membranous bract covering numerous flowers.
SPATHELLÆ, another name for the glumellæ of Grasses.
SPATHULATE, shaped like a spathula, applied to a leaf having a linear form, enlarging suddenly into a rounded extremity.
SPAWN, same as *Mycelium.*
SPECIFIC CHARACTER, the essential character of a species.
SPERMATIA, motionless spermatozoids in the conceptacles of Fungi.
SPERMATOZOIDS, moving filaments contained in the antheridia of Cryptogams; called also phytozoa and antherozoids.
SPERMODERM, the general covering of the seed. Sometimes applied to the episperm or outer covering.
SPERMOGONE, a conceptacle containing fructification in Fungi.
SPHÆRENCHYMA, tissue composed of spherical cells.
SPIKE, inflorescence consisting of numerous flowers sessile on an axis.
SPIKELET, small cluster of flowers in Grasses.
SPINE or THORN, an abortive branch with a hard sharp point.
SPINESCENT or SPINOSE, bearing spines.
SPIRAL VESSELS or SPIROIDEA, having a spiral fibre coiled up inside a tube.
SPIRILLUM, same as *Spermatozoid.*
SPIROLOBEÆ, Cruciferæ having the cotyledons twice folded, the radicle being dorsal.
SPONGIOLE or SPONGELET, the cellular extremity of a young root.

SPORANGIUM, a case containing spores.
SPORE, a cellular germinating body in Cryptogamic plants.
SPORIDIUM, a cellular germinating body in Cryptogamics containing two or more cells in its interior.
SPOROCARP, the involucre or ovoid-sac containing the organs of reproduction in Marsileaceæ.
SPOROPHORE, a stalk supporting a spore.
SPOROZOID, a moving spore furnished with cilia or vibratile processes.
SQUAMA, a scale; also applied to bracts on the receptacle of Compositæ, to bracts in the inflorescence of Amentiferæ, and to the lodiculæ of Grasses.
SQUAMOSE, covered with scales.
SQUARROSE, covered with processes spreading at right angles or in a greater degree.
STACHYS and STACHYA, in Greek words signifies a spike.
STAMEN, the male organ of the flower, formed by a stalk or filament and the anther containing pollen.
STAMINATE and STAMINIFEROUS, applied to a male flower, or to plants bearing male flowers.
STAMINODIUM, an abortive stamen.
STANDARD, same as *Vexillum.*
STELLATE or STELLIFORM, arranged like a star.
STERIGMATA, cells bearing naked spores.
STERILE, male flowers not bearing fruit.
STICHIDIA, pod-like receptacles containing spores.
STICHOUS, at the termination of words means a row, as *distichous,* in two rows.
STIGMA, the upper cellular secreting portion of the pistil, uncovered with epidermis; *Stigmatic,* belonging to the stigma.
STIMULUS, a sting, applied to stinging hairs with an irritating secretion at the base.
STIPE, the stem of Palms and of Tree-ferns; also applied to the stalk of Fern-fronds, and to the stalk bearing the pileus in Agarics.
STIPEL, a small leaflet at the base of the pinnæ or pinnules of compound leaves.
STIPITATE, supported on a stalk.
STIPULARY, applied to organs occupying the place of stipules, such as tendrils.
STIPULATE, furnished with stipules.
STIPULE, leaflet at the base of other leaves, having a lateral position, and more or less changed either in form or texture.
STOLON, a sucker, at first aerial, and then turning downwards and rooting.
STOLONIFEROUS, having creeping runners which root at the joints.
STOMATES and STOMATA, openings in the epidermis of plants, especially in the leaves.
STRANGULATED, contracted and expanded irregularly.
STRIA, a narrow line or mark.
STRIATED, marked by streaks or striæ.
STRIGOSE, covered with rough, strong, adpressed hairs.
STROBILUS, a cone, applied to the fruit of Firs as well as to that of the Hop.
STROPHIOLE, a sort of aril or swelling on the surface of a seed.
STRUMA, a cellular swelling at the point where a leaflet joins the midrib; also a swelling below the sporangium of Mosses.
STUPOSE, having a tuft of hairs.
STYLE, the stalk interposed between the ovary and the stigma.
STYLOPOD, an epigynous disk seen at the base of the styles of Umbelliferæ.
SUBEROUS, having a corky texture.
SUBICULUM, same as *Hypothallus.*
SUBTERRANEAN, under ground, same as *Hypogeal.*
SUBULATE, shaped like an awl.
SUFFRUTICOSE, having the characters of an undershrub.
SULCATE, furrowed or grooved.
SUPERIOR, applied to the ovary when free or not adherent to the calyx; to the calyx when it is adherent to the ovary; to the part of a flower placed next the axis.
SUPERVOLUTE or SUPERVOLUTIVE, a leaf rolled upon itself in vernation.
SURCULUS, a sucker, a shoot thrown off underground, and only rooting at its base.
SUSPENDED, applied to an ovule which hangs from a point a little below the apex of the ovary.
SUSPENSOR, the cord which suspends the embryo, and is attached to the radicle in the young state.
SUTURAL, applied to that kind of dehiscence which takes place at the sutures of the fruit.
SUTURE, the part where separate organs unite, or where the edges of a folded organ adhere; the *ventral suture* of the ovary is that next the centre of the flower; the *dorsal suture,* corresponds to the midrib.
SYCONUS, a multiple or polygynœcial succulent hollow fruit, as in the Fig.—See reference in Index.
SYMMETRY, applied to the flower, has reference to the parts being of the same number, or multiples of each other.
SYN, in composition, means united.
SYNANTHEROUS, anthers united.
SYNANTHOS, flowers united together.
SYNCARPOUS, carpels united so as to form one ovary or pistil.
SYNGENESIOUS, same as *Synantherous.*
SYNOCHREATE, stipules uniting together on the opposite side of the axis from the leaf.

TAPHRENCHYMA, pitted vessels, same as *Bothrenchyma.*
TAP-ROOT, root descending deeply in a tapering undivided manner.
TAXONOMY, principles of the classification of plants.
TEGMEN, the second covering of the seed, called also *Endopleura.*
TEGMENTA, scales protecting buds.
TERATOLOGY, study of monstrosities and morphological changes.
TERCINE, the third coat of the ovule, forming the covering of the central nucleus.
TERETE, nearly cylindrical, the transverse section nearly circular.
TERNARY, parts arranged in threes.
TERNATE, compound leaves composed of three leaflets.
TESTA, the outer covering of the seed; some apply it to the coverings taken collectively.
TESTICULATE, root having two oblong tubercules.
TETRA, in Greek words four; in Latin *Quater* or *Quadri.*
TETRADYNAMOUS, four long stamens and two short, as in Cruciferæ.
TETRAGONOUS or TETRAGONAL, having four angles, the faces being convex.
TETRAGYNOUS, having four carpels or four styles.
TETRAMEROUS, composed of four parts; a flower is tetramerous when its envelopes are in fours, or multiples of that number.
TETRANDROUS, having four stamens.
TETRAPTEROUS, having four wings.
TETRAQUETROUS, having four angles, the faces being concave.
TETRASPORE, a germinating body in Algæ composed of four spore-like cells; but also applied to those of three cells.
TETRATHECAL, having four loculaments.
THALAMIFLORAL, parts of the floral envelope inserted separately into the receptacle or thalamus.—See Index.
THALAMUS, the receptacle of the flower, or the part of the peduncle into which the floral organs are inserted.

THALLOGENS or THALLOPHYTES, plants producing a thallus.
THALLUS, cellular expansion in Lichens and other Cryptogams, bearing the fructification.
THECA, sporangium or spore-case containing spores.
THECAPHORE, a stalk supporting the ovary.
THECASPOROUS, applied to Fungi which have the spores in thecæ.
THROAT, the orifice of a gamopetalous flower.
THYRSUS, a sort of panicle, in form like a bunch of grapes, the inflorescence being mixed.
TIGELLUS, the young embryonic axis.
TOISE, is equal to 1.94904 metres or 6.39459 English feet.
TOMENTOSE, covered with cottony, entangled pubescence called *tomentum*.
TORULOSE, presenting successive rounded swellings, as in the moniliform pods of some Cruciferæ.
TORUS, another name for thalamus; sometimes applied to a much developed thalamus, as in Nelumbium.
TRACHEÆ, a name for spiral vessels.
TRACHENCHYMA, tissue composed of spiral vessels.
TRANSPIRATION, the exhalation of fluids by leaves, &c.
TREIS, three; TRIS, thrice, in composition *Tri*.
TRIADELPHOUS, stamens united in three bundles by their filaments.
TRIANDROUS, having three stamens.
TRIANGULAR, having three angles, the faces being flat.
TRICHOTOMOUS, dividing successively into three branches.
TRICOCCOUS, formed by three elastic monospermal carpels.
TRICUSPIDATE, having three long points or cuspides.
TRICOSTATE, three-ribbed, ribs from the base.
TRIDENTATE, having three teeth.
TRIFARIOUS, in three rows, looking in three directions.
TRIFID, three-cleft, a leaf divided into three segments which reach to the middle.
TRIFOLIATE or TRIFOLIOLATE, same as *Ternate*. When the three leaves come off at one point the leaf is *ternately-trifoliolate*, when there is a terminal stalked leaflet and two lateral ones, it is *pinnately-trifoliolate*.
TRIGONOUS, having three angles, the faces being convex.
TRIGYNOUS, having three carpels or three styles.
TRIJUGATE, having three pairs of leaflets.
TRILOCULAR, having three loculaments.
TRIMEROUS, composed of three parts; a *trimerous flower* has its envelopes in three or multiples of three.
TRINERVIS, having three ribs springing together from the base.
TRIPARTITE, deeply divided into three.
TRIPINNATE, a compound leaf three times divided in a pinnate manner.
TRIPINNATIFID, a pinnatifid leaf with the segments twice divided in a pinnatifid manner.
TRIPLICOSTATE, three ribs proceeding from above the base of the leaf.
TRIQUETROUS, having three angles, the faces being concave.
TRISTICHOUS, in three rows.
TRITERNATE, three times divided in a ternate manner.
TROPHOSPERM, a name for the placenta.
TRUNCATE, terminating abruptly, as if cut off at the end.
TUBER, a thickened underground stem as the potato.
TUBERCULE, the swollen root of some terrestrial Orchids.
TUBEROUS, applied to roots in the form of tubercules.
TUBULAR, applied to the regular florets of the Compositæ.
TUBULAR-BELL-SHAPED, applied to a campanulate corolla which is somewhat tubular in its form.
TUNICATED, applied to a bulb covered by thin external scales, as the Onion.
TURBINATE, in the form of a top.
TURIO, a young shoot covered with scales sent up from an underground stem, as in Asparagus.
TYPE, the perfect representation or idea of anything.
TYPICAL, applied to a specimen which has eminently the characteristics of the species, or to a species or genus characteristic of an order.

UMBEL, inflorescence in which numerous stalked flowers arise from one point.
UMBELLULE, a small umbel, seen in the compound umbellate flowers of many Umbelliferæ.
UMBILICATE, fixed to a stalk by a point in the centre.
UMBILICUS, the hilum or base of a seed.
UMBO, a conical protuberance on a surface.
UMBONATE, round, with a projecting point in the centre, like the boss of an ancient shield.
UMBRACULIFEROUS, in the form of an expanded umbrella.
UNCINATE, provided with an *uncus* or hooked process.
UNDECIM, eleven, in Greek *Endeca*.
UNGUIS, claw, the narrowed part of a petal; such a petal is called *Unguiculate*.
UNI, in composition one, same as Greek *Mono*.
UNICELLULAR, composed of a single cell, as some Algæ.
UNILATERAL, arranged on one side, or turned to one side.
UNILOCULAR, having a single *loculus* or cavity.
UNISEXUAL, of a single sex, applied to plants having separate male and female flowers.
URCEOLATE, urn-shaped, applied to a gamopetalous globular corolla, with a narrow opening.
USTULATE, blackened.
UTRICLE, a name for a thin-walled cell, or for a bladder-like covering.
UTRICULUS, applied to a kind of fruit like the achene, but with an inflated covering; also to the persistent confluent perigone of Carex.

VAGINA, sheath, lower sheathing portion of some leaves.
VALLECULA, an interval between the ribs on the fruit of Umbelliferæ.
VALVATE, opening by valves, like the parts of certain seed-vessels, which separate at the edges of the carpels.
VALVATE ÆSTIVATION and VERNATION, when leaves in the flower-bud and leaf-bud are applied to each other by their margins only.
VALVES, the portions which separate in some dehiscent capsules. A name also given to the parts of the flower of grasses.
VASCULAR TISSUE, composed of spiral vessels and their modifications. See *Index*.
VASIFORM TISSUE, same as *Dotted vessels*.
VEINS, bundles of vessels in leaves.
VELUM, veil, the cellular covering of the gills of an Agaric, in its early state.
VELUTINOUS, having a velvety appearance.
VENATION, the arrangement of the veins.
VENTRAL, applied to the part of the carpel which is next the axis.
VENTRICOSE, swelling unequally on one side.
VERMICULAR, shaped like a worm.
VERNATION, the arrangement of the leaves in the bud.
VERRUCOSE, covered with wart-like excrescences.
VERSATILE, applied to an anther which is attached by one point of its back to the filament, and hence is very easily turned about.

Verticil, a whorl, parts arranged opposite to each other at the same level, or, in other words, in a circle round an axis. The parts are said to be *Verticillate.*
Verticillaster, a false whorl, formed of two nearly sessile cymes placed in the axils of opposite leaves, as in Dead-nettle.
Vesicle, another name for a cell or utricle.
Vessels, tubes with closed extremities. See *Index.*
Vexillary, applied to æstivation when the vexillum is folded over the other parts of the flower.
Vexillum, standard, the upper or posterior petal of a papilionaceous flower.
Viginti, twenty; same as Greek *Icosi.*
Villous, covered with long soft hairs, and having a woolly appearance.
Virgate, long and straight like a wand.
Viscous, clammy, like bird-lime.
Vitellus, the embryo-sac when persistent in the seed.
Vittæ, cells or clavate tubes containing oil in the pericarp of Umbelliferæ.
Viviparous, plants producing leaf-buds in place of fruit.
Volubile, twining, a stem or tendril twining round other plants.
Volva, wrapper, the organ which encloses the parts of fructification in some Fungi in their young state.

Whorled, same as *Verticillate.*
Wings, the two lateral petals of a papilionaceous flower, or the broad flat edge of any organ.

Xanthos, yellow, in composition *Xantho.*

Zoospore, a moving spore provided with cilia; called also *Zoosperm* and *Sporozoid.*
Zootheca, a cell containing a spermatozoid.

ABBREVIATIONS AND SYMBOLS.

The names of Authors are abridged in Botanical works, by giving the first letter or syllable, &c.—Thus, L. stands for Linnæus; DC. for De Candolle; Br. for Brown; Lam. and Lmk. for Lamarck; Hook. for Hooker; Hook. fil. for Hooker junior; Lindl. for Lindley; Arn. for Arnott; H. and B. for Humboldt and Bonpland; H. B. and K. for Humboldt, Bonpland, and Kunth; W. and A. for Wight and Arnott; Berk. for Berkeley; Bab. for Babington, &c.

The symbol ∞ or 00 means an indefinite number; in the case of stamens, it means above 20.

○ ⊙ ① or A. means an annual plant.

♂ ⊙⊙ ⊙ ② or B. means a biennial plant.

♃ △ or P means a perennial plant.

♄ ♄̄ or Sh. means a Shrub; T. a Tree.

) turning to the left; (turning to the right.

O = Cotyledons accumbent, radicle lateral.

O || Cotyledons incumbent, radicle dorsal.

O≫ Cotyledons conduplicate, radicle dorsal.

O || || Cotyledons plicate or folded twice, radicle dorsal.

O || || || Cotyledons folded thrice, radicle dorsal.

☿ Hermaphrodite flower, having both stamens and pistil.

♂ Male, staminiferous, staminate, or sterile flower.

♀ Female, pistilliferous, pistillate, or fertile flower.

♂ ♀ Unisexual species, having separate male and female flowers.

♂ — ♀ Monœcious species, having male and female flowers on the same plant.

♂ : ♀ Diœcious species, having male and female flowers on different plants.

☿ ♂ ♀ Polygamous species, having hermaphrodite and unisexual flowers on the same or different plants.

! Indicates certainty as to a genus or species described by the author quoted.

? Indicates doubt as to the genus or species.

O Indicates absence of a part.

V. V. S. Vidi vivam spontaneam, indicates that the author has seen a living native specimen of the plant described by him.

V. V. C. Vidi vivam cultam, indicates that he has seen a living cultivated specimen.

V. S. S. Vidi siccam spontaneam, indicates that he has seen a dried native specimen.

V. S. C. Vidi siccam cultam, indicates that he has seen a dried cultivated specimen.

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