THE

SCIENCE OF BOTANY.

BY

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CONSIDER THE LILIES OF THE FIELD.

Sixth Thousand.

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INTRODUCTION.

Botany, from the Greek word, Βοτανη (*Botane*), an herb or plant, is the term applied to the science which treats of plants, embracing an account of the structure, functions, and methods of classifying the objects which compose the vegetable creation.

Plants are highly interesting objects, and, presenting many curious phenomena to the observer, will reward a little study. A seed falls to the ground, by accident, as it were, but it does not remain inactive like a lump of inert matter. It sends forth a root, and fixes itself; levies contributions from the surrounding bodies, air, earth, and water; gradually enlarges and changes its form; rises above the surface and grows towards air and light; in course of time becomes a stately tree, increasing yearly in thickness, spreading its branches far and wide in the air, and its roots in the soil; annually puts forth its buds, which expand and clothe it with foliage, or adorn it with blossom; repays nature for her bounties in a rich return of fruit and seed; continuing the same course, for hundreds or even thousands of years, remains an object of wonder and admiration to successive races of men; becoming associated with many a tradition, many a tale of olden time, handed down from father to son, is regarded with a respect approaching almost to veneration; and still flourishes, while generation after generation pass away and are forgotten.

The phenomena of life are indeed wonderful: and present a thousand varying aspects. In plants we find an apparatus, more or less complex, designed for the performance of particular offices necessary to maintain their existence, advance their growth, and form the useful products they are destined to bear. They present an infinite variety both in external form and internal structure, calculated to interest the inquiring mind; and, combining beauty alike for the eye and the understanding, with utility in the great scheme of creation, must always be regarded as among the most delightful objects of study which man can contemplate.

What were the face of earth without the vegetable creation—a dreary waste, a desert—as in the arid sands of Africa, or the desolate regions around the Poles. It is plants that invest with charms the scenery of nature, and clothe with beauty the world around us. Presenting a rich and variegated array of colours and every variety in form, it is the vegetable creation that lends beauty to the landscape. It is plants which we admire in the verdure of the fields and meadows, in the flowers which enliven the banks and road sides, in the trees and forests which adorn the prospect. We welcome reanimating nature in the buds and opening flowers of spring, and to these expanded by a genial sun, the bright and joyous Summer owes its bloom.

Of various and opposite qualities, presenting many interesting phenomena during the course of their existence, animate beings like ourselves, passing through the same stages of youth, maturity, old age, and decay, and subject to vicissitudes like human life—the eye of the poet delights to dwell on the forms of plants, and the changes which they undergo, and he draws thence many of his finest illustrations.

The Botanist, in his walks in the country, has many sources of delight. A little knowledge of Botany gives a new life and character to the scenery of nature. At every step the botanist meets something to attract and interest him, at every turn a friend, an old acquaintance in every familiar plant that strikes his eye, silent and unobtrusive, but not the less a friend: it abstracts him for a while from the cares and anxieties of life, furnishes materials for thought, suggests many curious analogies or contrasts, recalls some interesting points in vegetable economy, or perhaps awakens some pleasing association or recollection of former times, excites some speculation or inquiry, or, leading from details to principles, from individual facts to general laws, directs his mind to that train of thought which has been characterised as the most desirable, the contemplation of the adaptations, connections, and mutual dependence in the works of nature—thus keeping the mind excited, interested, employed.

In the commonest plant, as a Dandelion, for example, there is much to interest the observer. In one, the infant flower is closely surrounded by its mantle or flower-cup, to protect it from cold, and if examined early, the flowers will be found enveloped by a fine cottony down, as a further security against being nipped in the bud. In a second this green flower-cup is expanded and folded back, to spread out the bright yellow flowers now matured, and, like the butterfly, courting air and light, and rejoicing to sport in the sun. In another, the flower-cup is raised again, and closely wrapped round the now faded flowers, to protect the ripening seeds; and others present themselves to him in the last stage, with their splendid globe of wings spread out as if inviting the breeze, and the flower-cup finally opened and turned down to allow the wind to disperse abroad the feathery seeds. While tracing its progress from the bud till it attains maturity, and recalling a thousand interesting peculiarities in the structure, habits, properties, affinities of this plant, and the tribe to which it belongs, a little parachute floats past him in the breeze. He intercepts it for a while. It is a seed of the same plant, wafted by the wind from its native soil, and going forth to fulfil its mission. He considers the beautiful adaptation of its slender stalk with its crown of radiating feathers to its roaming habit admires the lightness, simple beauty, and elegance of its form, wonders withal at its minuteness and delicacy—releases it to pursue its aerial pilgrimage, and continues his course, meditating on the wonders of that world, in the great operations of which the most insignificant object has its allotted part to perform, and rejoicing that he can thus commune with nature, and find

> Tongues in trees, books in the running brooks,
> Sermons in stones, and good in every thing.

Now, a very little previous study will qualify any one to observe plants botanically, and derive much pleasure from examining their structure, contrasting the many varieties, and watching their various changes. It is hoped that this little work may be sufficient to point out the way to the study of Botany—not to make Botanists, but to instruct how to become Botanists—to teach what to look for in the phenomena of vegetation, to furnish a key with which to unlock the cabinet and unfold the treasures of the vegetable kingdom.

Botany is peculiarly adapted for a recreative pursuit in this respect, that a practical knowledge, which every one desires if it be easily attained, is within the reach of all. In Botany, more easily than in any other department of science, the student may become practically acquainted with his subject. No apparatus is required except what every one is provided with, hands and eyes—and nature furnishes the materials free, and in the richest profusion.*

* The uses of Botany in the arts—to the physician—to the agriculturist—are obvious. There is another class of artists of whom there are a very great number in this country, and who would find it of much use in their profession to have a knowledge of Botany—painters, sculptors, architects, pattern drawers, engravers, lithographers, &c. Now,

By thus investing the scenery of nature with the charms which philosophy can bestow, Botany forms an

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leaves and flowers, trees and herbs—the vegetable kingdom in short, is the great storehouse from which such artists procure the copies or patterns for their ornamental designs. Nature furnishes an inexhaustible supply of beauty, elegance, and variety—and he will be most successful in producing beautiful designs, who, other things being equal, is best acquainted with the great original which is the source of them all. In all cases a better, more vivid, more accurate drawing is produced, when taken from the flowers or leaves themselves than from a copy—or if from a copy, when the drawer has seen and has some knowledge of the original. *And, I have been assured by artists, that, even when they make a drawing from a copy the subject of which they have never seen, it is a very great advantage to know the general structure of the parts, as they then can understand better their relations, and thus make the copy with much more spirit and freedom.*

In those fancy designs which do not profess to follow nature closely—even in these, though some latitude is allowed—still there are bounds beyond which the artist must not pass—even in these he must adhere to some general rules which are found to prevail among the works of nature; and he who has the best knowledge of nature, will have far greater freedom with his pencil—will be able to invent new designs—while another who does not know the forms which nature admits will be but a slavish copyist—or an inventor of such monstrosities as rather disgust than please.

The great standard of taste to which all refer—is nature inducement for those who might otherwise remain immured in counting-rooms and manufactories,—never refreshing their lungs with a draught of the pure atmosphere of heaven, never blessed with a glimpse of blue sky, except at the end of a street, through two long

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—or the ideas of nature which every one forms to himself. But if it be essential that nature should be followed to a certain extent even in fancy designs, how much more necessary is it that the design should be correct in those cases—now very numerous and very much run upon—in which some particular specimen is proposed to be copied.

What can we think of a Scots thistle with a vine leaf—or of the Rose of England with the leaf of the Shamrock. Certainly, if we can judge from the drawings on sign boards, patterns on pottery ware, &c., there seems a most rigid determination on the part of many of the artists who execute these designs, to obey the second command to the letter. A very slight knowledge of Botany would instruct the artist in some general laws in the growth of plants, which would prevent many gross errors, while his taste would be insensibly improved by the familiarity with their forms which he would acquire in studying them. In the evidence given before the late Parliamentary Committee on Arts and Manufactures, most of the gentlemen who were examined, stated that the want of Museums and Botanic gardens—placed the artists of this country at a decided disadvantage compared with those on the continent. This defect may be supplied to a considerable extent by artists themselves by occasionally prosecuting at their leisure hours, a pursuit which, independently of any professional object, they will find agreeable, and healthful, especially to individuals of their sedentary habits.

stiff lines of well smoked, gloomy, cadaverous looking grey walls—to escape at times from their murky dens, and enjoy the contrast of fresh and variegated beauty, which nature, even in her dullest mood, presents to he admirers.

Oh! how canst thou renounce the boundless store
Of charms which nature to her votary yields!
The warbling woodland, the resounding shore,
The pomp of groves, and garniture of fields—
All that the genial ray of morning gilds,
And all that echoes to the song of even:
All that the mountain's shelt'ring bosom shields,
And all the dread magnificence of heaven;
Oh! how canst thou renounce, and hope to be forgiven?

In every respect, the study of Botany is particularly adapted for those who, engaged in the mechanical routine of the ordinary avocations of life, desire some pleasing, harmless, and improving pursuit, as an occasional relaxation from the cares and fatigues of business. And it presents many attractions for all who delight to inquire into the constitution of external nature and gratify that curiosity which every one feels regarding the varied objects in the world around him; who desire to extend their ideas, expand their minds, cultivate and exercise their mental faculties, by investigating the varied properties and relations of bodies, the different modes of action which nature employs, and the various principles, methods of inquiry, and modes of reasoning in the different sciences;—and who feel that the study of nature has always a tendency to abstract from grovelling pursuits—to soften—to refine—and to elevate.—For such, this little work is intended, as a popular introduction to the study of

Botany; and, should it be the means of directing attention to the vegetable kingdom, which presents so many interesting aspects, of opening the minds of any to the knowledge of a new department of creation, giving them some idea of the "honey that may be extracted from flowers," assisting them in observing points of interest in vegetables, drawing attention to a pursuit of a very harmless and agreeable nature, and highly conducive to health, and thus adding to their stores of rational enjoyment, it will not be without its use.

SCIENCE OF BOTANY.

I. WHAT IS A PLANT?

1. What is a Plant? This is a question not easily answered. There is not one absolute and exclusive character by which a plant can be defined,—which would include *all* plants and exclude all objects but plants. A mathematical figure can be defined with great precision, as for example, a parallelogram,—a plane right-lined four-sided figure, of which the opposite sides are parallel to each other. But it is not so with the objects of the vegetable kingdom;—we cannot define them by positive qualities, as there are none such belonging to plants which are not found in animals;—nor can we distinguish them by negatives, as there are many undoubted animals which yet approximate very closely to vegetables in the absence of those features which characterise the generality of the animal creation. We must supply the place of a definition of plants, by a general view of their station among the works of nature.

2. The objects which compose the material world have been arranged in two grand divisions, according as they possess or are destitute of that mysterious

principle called LIFE or VITALITY,—the *Animate* and the *Inanimate* creation, or *Organic* and *Inorganic* bodies.

3. The former, Animate or Organic bodies, are characterised—1st, by possessing an *Organic Structure*, that is, in being COMPOSED OF A TISSUE OF CELLS, OR CELLS AND TUBES, THROUGH WHICH FLUIDS CIRCULATE; and, in most cases, consisting of a variety of parts (organs), differing from each other in form and structure, and adapted to different uses; being thus of a heterogeneous structure. 2d. By their power of introducing into their internal parts new matter differing from their own substance, forming it into tissue similar to their own, and rendering it a part of themselves; (thus growing or increasing in size by *intussusception*, taking within). 3d. By their power of suspending and resisting to a certain extent the usual action of external agents, and of their own elements upon each other. Where these three features are presented, there is the principle of LIFE; the object is an organised and living being.

4. There are other interesting peculiarities in animate bodies—4. They have the power of forming a being of the same nature as themselves. 5. They decay or die at some definite period, the same in the same kind, and not from the action of external forces (?) but from the simple exhaustion of their organs; being thus decomposed, that is, resolved into the condition of inorganic matter, and obeying the laws to which it is subject. 6. Their component parts are so mutually dependent, that a small portion cut out cannot

maintain a separate existence. 7. They consist of fluid and solid parts, intermixed according to a regular order. 8. Their chemical composition is very complex. 9. Their bulk is limited in each kind. 10. Their external surface is smooth and rounded, seldom or never formed into a regular plane or angle. 11. They cannot be formed by artificial means.

5. Inanimate or Inorganic bodies, constituting the mineral kingdom, are very different. They are of a homogeneous structure, each being all solid, all liquid, or all gaseous; and their particles are similar in form, arrangement, and chemical composition; they grow (increase in size) by the addition of matter already similar to their own, and only at their external surface—by *juxtaposition;* they have no power of resisting external agencies; they have no power of reproduction; they have no definite period of decay, being capable of existing unchanged for an unlimited period, when not subjected to any external destroying influence; any part possesses all the characters which belong to the whole; they are of a simple chemical composition; unlimited in size; their external surface is rough and angular; and they may (many at least) be formed by artificial means.

6. These are the leading distinctions between organic and inorganic bodies. The former are divided into Animals and Vegetables. Sensibility or the consciousness of existence, sensation of impressions from without, and a power of voluntary loco-motion, are the general characteristics of animals; while vegetables appear to be endowed only with a dull and very

limited sensation, and what is termed IRRITABILITY, a power of simple contraction on the application of some external stimulus.

7. Examples of this irritability in plants are within every one's observation. The turning of leaves and flowers to the light, even though repeatedly put away from it, and the opening and closing of flowers, are well known. The stamens of the Rock-rose and the Barberry bend when irritated by any sharp body. The leaves of the *Hedysarum gyrans*, a tropical plant, are almost constantly in a state of motion. The leaves of the Venus' Fly-trap of Canada, and the Sundew of this country are provided with a number of bristles; and when these are irritated, as by an insect, the leaf contracts, becomes folded, and imprisons the little animal. "In still warm weather if two or three smart blows be given to the stem of Verbascum pulverulentum with a cane or stick, all the corollæ (flowers) then open, though not immediately loosened, in a few minutes fall off, separating one after another from their base, and the calyx closes round the germen (seed-case) seeming, as it were to push the blossom off." *English Botany.*—The most remarkable instance of irritability in plants is afforded by the Sensitive plant, the leaflets of which become erect and closely applied to the stalk and to each other, when touched or even agitated by the wind, but gradually resume their usual position. Such is the only kind of motive power possessed by plants.

8. As a general distinction between the three kingdoms of nature, the concise definition by Linnæus is

admirable, "Minerals grow; vegetables grow, and live; animals grow, live, and have feeling." *These distinctions, so well marked in the higher orders of animals and vegetables, as a tree, a man, disappear in the lower grades, where the animal and vegetable kingdoms approximate;* and there are some species about which there is doubt whether they should be reckoned animals or plants. Many of the polypi are destitute of any power of locomotion, and appear to be void of sensibility; while some of the Algæ possess irritability and consequent mobility in a very high degree, and have much of the character of animals. The Sponges (Porifera), apparently the simplest in structure of the various tribes of animals, approximate very closely to vegetables. The *Polypi Vaginanti* were placed among vegetables in Tournefort's arrangement; more lately, some species, formerly supposed to be Confervæ, have been removed from vegetables, and placed among the simplest tribes of animals. Some Botanists hold the singular doctrines, that, in certain cases, metamorphoses of plants into animals, and vice-versa, take place; and that the animal kingdom approaches the other two in some of the simpler Algæ which have somewhat of a crystalline texture.

9. This difficulty of distinguishing between plants and animals is found only in the lower tribes of each. In the HIGHER ORDERS, the differences are marked, as the following comparison will show.

PLANTS	ANIMALS
Are fixed, having no power of locomotion, no system of contractile muscles.	Have a set of contractile fibres (muscles), and hence the power of locomotion.
Have no consciousness of existence, no experience of any wants, no power of selecting food.	Have consciousness of existence, a feeling of wants which they endeavour to supply, a power of selection among the materials they find.
Insensible to all external impressions.	Possessed of a nervous system, and senses, for communication with the external world.
Can live on inorganic matter alone.	Feed only on organized bodies, animals, and vegetables.
Have no internal cavity or sac (stomach) for receiving their food.	Have a stomach, or internal receptacle, into which the food is received.
Contain much solid matter.	Contain a large proportion of fluids.
Consist of few elements.	Elements more numerous.
Carbon (charcoal) their leading element, and contain little or no nitrogen.	All contain a large quantity of nitrogen.
Slowly decomposed when dead.	Decompose rapidly when dead.

10. Generally speaking, then, a plant is a living being, destitute of sensation and any power of voluntary motion, arising from the growth of a seed or bud, consisting of a tissue of cells or CELLS AND TUBES, which contain and circulate fluids, fixed to one spot by a ROOT, from which a stalk or STEM grows upwards, which bears and spreads out to air and light LEAVES and FLOWERS, from the latter of which proceeds the FRUIT, containing the SEED, similar to that from which the plant sprung. Such a plant is shown in page 18, and the letterpress at the side gives the name, Linnæan Class and Order, Natural Family, characters of the genus (Saxifraga), by which it is distinguished from other genera (kinds) of plants, and character of the species (Saxifraga granulata), by which it differs from other species of Saxifrage. There are a great number of species of Saxifrage, and accordingly they are arranged in sections—the line commencing with the four asterisks showing the character of the section to which S. *granulata* belongs. See par. 202. The description of the plant will be better understood after the Flower has been studied and the accounts of the Linnæan and natural systems of classification perused.

SAXIFRAGA *granulata* (white meadow Saxifrage.)

Linn: Class, DECANDRIA, Order, DIGYNIA. Natural Family, SAXIFRAGEÆ.

SAXIFRAGA, *Calyx* superior, or inferior, or ½ inferior, in 5 segments. *Corolla* of 5 petals. *Capsule* with 2 beaks, 2-celled, many-seeded. *Seeds* upon a receptacle attached to the dissepiment.

* * * * *Calyx spreading. Leaves more or less lobed. Flowering stems erect, more or less leafy.*

S. *granulata.* Radical leaves reniform, on long foot-stalks, obtusely lobed, those of the upper part of the stem nearly sessile, acutely lobed, stem panicled, root granulated.

II. CELLS AND TUBES; OR, CELLULAR AND VASCULAR TISSUE.

11. VEGETABLES are composed of solids and fluids; the former give firmness and stability to the vegetable frame; according to their mode of arrangement, determine the peculiar form of the plant; contain and circulate the vegetable juices, and deposit them in their proper places;—the latter support the growth of the vegetable, by supplying it with nutritious matter. This matter is modified and deposited in appropriate situations by the previously existing solids excited to action by peculiar stimuli, and regulated by the vital principle; and thus forms successively the various solid parts and fluid secretions which constitute the vegetable.

12. The solid part of vegetables, when minutely examined, is found to consist of fine membrane and slender fibre, forming, by the different modes in which they are folded, two elementary tissues, called Cellular Tissue and Vascular Tissue.

13. The cellular tissue consists of minute cells, utricles, or vesicles, with thin and transparent sides. The form of the cells varies in different parts; where they are subjected to little pressure, they are globular, as in the leaf; when only exposed to the equal pressure of the adjacent cells, they become hexagonal, as in the medulla or pith; when strongly pressed by the vascular tissue or woody parts, they are stretched,

and assume an elongated cylindrical, or tubular form, as in the bark and in the wood. The cellular tissue is the pulp or parenchyma of old authors.

14. The most regular figure of compressed cellular tissue is the rhomboidal dodecahedron, having twelve equal rhomboidal sides, but the pressure is seldom so equal as to constitute this, and the cells are generally elongated from the great lateral compression. They vary in diameter from 1–30th to 1–1000th of an inch, 1–300th or 400th being a common size.

15. Each cell is complete in itself, the wall or partition between two cells being double, or formed of two layers of membrane. Frequently the cells do not adhere to each other at every point, in which case what are called "*intercellular spaces*" exist between them. When a number of these spaces are placed one above another, they constitute the "*intercellular canals.*"

16. The membrane of which the cellular tissue is formed, is destitute of visible pores : it must be pervious, however, as the cells frequently contain fluids which afterwards disappear from them. Small dots observed on the sides of the cells have been supposed to be apertures for the passage of fluids.

17. The cellular tissue is found in all vegetables; and many, as Sea-weeds (*Algæ*) and Mushrooms (*Fungi*), consist of it alone. In the higher orders of vegetables, as trees, it alone forms the pith; it exists compressed and elongated in the wood and in the bark; it extends transversely from the pith to the bark, forming the medullary rays; in the leaf fills up the spaces between the veins; and forms a chief part of

the flower. In many parts of plants the cells occasionally contain nothing but some kind of gas, but in general they are filled with fluids, as in fruits the juices of which are contained in the cellular tissue.

18. The vascular tissue consists of bundles of tubes or *vessels*. Several kinds have been described—*porous vessels*, continuous tubes, with a number of opaque dots or points in their sides, generally considered as pores; *false spirals*, or slit vessels, tubes with many transverse slits in their sides; *spirals*, which consist of tubes of very delicate elementary membrane with a fibre rolled up spirally within. If a ribbon be wound spirally, edge to edge, round a stick, and the stick be pulled out, the ribbon will represent the form of the fibre in the tube of a spiral vessel. They are found chiefly in the medullary sheath, and in the leaf and flower, never in the bark, seldom in the root or wood, and only in plants provided with flowers (141). They have been called *tracheæ*, from the opinion that they convey some kind of gas. They may be found in the leaves of many plants, and the coil unfolded with great ease, tearing the membrane, which it carries along with it. Their diameters vary between the 250th and 3000th part of an inch. There are also *beaded vessels*, or vessels *en chapelet*, porous tubes contracted at various distances, so as to present an appearance like that of a string of beads; a particular kind of vessel, tapering at each end, is called *Woody Fibre*, and constitutes a large part of the hard, tough, and fibrous parts, as the wood.

19. Vessels are found in the generality of plants—a few, as Lichens, Sea-weeds, are without them.

III. THE ROOT.

20. This is the lower extremity of the plant, fixes it to the soil or the substance on which it grows, preventing it being rooted up or upset by animals or the force of the wind, and absorbs nutritious matter for its support. Almost all plants are provided with distinct roots, except some of the simpler kinds, which absorb nutritious matter at every point, and seem to have stem, leaf, root, all in one.

21. The root is formed by the growth of the radicle the little conical body which is well seen on splitting open a pea or bean. This body, when growing, tends downwards, and in whatever other position it may be placed, it turns and descends perpendicularly in the soil.

22. The roots of most plants terminate inferiorly in small delicate fibres called *radicles* or *rootlets;* see the figure, page 18. These are the *essential* part of the root, as it is these that imbibe the nutritious matter from the soil. This absorbing power resides in the extremity of each *radicle*, at which part there is an expansion of the cellular tissue, called a *spongiole*, provided with numerous pores, through which the fluids enter the plant.

23. A root consisting merely of these fibres is called a FIBROUS ROOT, as those of most of the grasses.

24. The root is never of a green colour,—has no pores (stomata) for evaporating fluids, and has no leaves. It has no pith, and spiral vessels are never found in it.

25. All parts of the root have the power of emitting rootlets, and hence the primary root divides into many branches under ground in the same manner as the stem in the air. The root is thus enabled to draw more nutritious matter for the support of the plant, having more absorbing mouths or spongioles and the command of a greater extent of soil. The depth to which many roots descend, and the extent to which they spread, are surprising; the Dandelion, Lucern, and Rest-harrow, (so called from the toughness of its long roots,) are good illustrations of this. One of the principal uses of ploughing, besides admitting air, is to crumble down and divide the masses of earth, and enable the rootlets easily to penetrate into the soil.

26. The extension of the root enables some plants to perform an important office in the economy of nature; namely, protecting banks of rivers and coasts where there is much loose shifting sand, from being broken down by the winds or the waves, and preventing the neighbouring fields from being overrun with sand. The roots of many of the grasses (Carex arenaria, Elymus arenarius, Ammophila arundinacea, and others,) run to a great extent under ground, and being much entangled there, bind the loose sand, and form a coherent bank, which is better able to resist the action of the wind or the encroachments of the ocean. In many places in England the

growth of these plants is encouraged with this view, and acts of Parliament have been passed for their preservation

27. The stem and branches also possess a power of emitting rootlets: if a branch be placed in the earth, or surrounded with earth on the tree, an incision being made in the bark, it will emit rootlets from its sides, and become, if properly treated, an entire and independent tree. Hence, the propagation of plants by slips and layers. Indian corn and other plants of the grass tribe emit from the knots on the stem, rootlets which descend and take root in the soil, and many other plants, besides the main root, have other subsidiary ones thrown out by the stem from above.

28. The famous Banyan tree of India, affords a striking illustration of the power of branches in throwing out roots. These descend perpendicularly to the earth, where they take root, spread in the soil, and support the growth of the tree in the usual manner. The part between the branch and the ground increases in diameter after it has taken root, and becomes another stem, giving nutriment and firm support to the branches with which it is connected, so that these can extend laterally still further from the main trunk. New roots descend from these extended branches, become new stems, and thus one tree spreads over a great extent of ground. One Banyan tree was found to throw a shadow at noon 1116 feet in circumference—being thus about 350 feet in diameter, and it had about fifty or sixty stems. Another

covered a space of about 1700 square yards. This remarkable tree is held in great veneration by the Hindoos.

29. On the other hand, roots often throw out stems, ascending into the air and becoming independent plants, as the Poplar and some Elms, which throw up branches very freely; and particularly those roots called "CREEPING,"—but in fact, subterraneous stems—as the Couch-grass, a very troublesome plant, being so difficult to eradicate. Its stem or root creeps horizontally under ground, shooting up at intervals herbage which takes root, and continuing its subterraneous course, extends far and wide under ground.

30. Some floating aquatic plants have roots which descend in the water and absorb nourishment, but do not reach the bottom and fix the plant—as Duckweed. In like manner, some plants which adhere to the branches of trees, drop roots into the air (not descending to the ground) for the absorption of nutritious matter from the atmosphere. These are called air-plants. Many aquatic plants have two roots—one fixed in the ground—another floating loosely in the water. The sea-weed tribe are firmly fixed by their bases to rocks, from which, however, they draw no nourishment.

31. Plants which insert their roots in other plants, and draw their nourishment from them, are called PARASITICAL, as Broomrape, Misseltoe, (which is parasitic on old oaks, apple trees, hawthorns,) and Dodder, &c. The latter grows from a root fixed in the soil, but this withers away as soon as the young

plant has attached itself to the plant round which it twines by a sufficient number of the rootlets which it inserts.

32. Roots are divided, according to their duration, into *Annual*, *Biennial*, and *Perennial* roots.

33. ANNUAL roots produce the herbage, flowers, and fruit, in one season, and then the whole plant perishes. These roots generally consist of a bunch of rootlets, as seen in the grasses. Barley and Red Poppy are examples.

34. BIENNIAL roots produce herbage in the first summer, live through the ensuing winter, bring forth flowers and fruit next summer, and then entirely perish. They are of a more substantial nature than the preceding. Parsnep, Carrot, and Foxglove are examples. If an annual or biennial do not produce its seed in the usual season, and the ensuing winter be mild, it will survive till the following summer, when it will perish after bearing seed. It is after the seed is perfected, that annual and biennial plants wither and die

35. PERENNIAL roots annually send forth herbaceous stems, which bear flowers and fruit in one season, and then decay and die; the root remaining, retaining its vitality, and sending forth another stem in the ensuing season, and so on for years. Asparagus.

36. Some annual roots vegetate for two seasons or more when transferred to a warmer climate and a richer soil; and perennial plants frequently become annual when brought from a warm to a cold climate. The Castor-oil plant, the Mignonette, and the Indian Cress are perennial and even woody trees or shrubs

in their native climes, but annual in our cold latitude.

37. Perennial roots are *merely under-ground stems*, being somewhat analogous to the stem in their function; they are not true roots—they do not draw nutritious matter from the soil; the real roots are the small fibres which they throw out from their lower surface. They are of many different forms Sometimes they creep horizontally under the surface, as Couch-grass, and Water Iris or Corn-flag, having a cylindrical form. Sometimes they are of a spherical shape, as Potato; they are then called *tuberous*, the part being termed a *tuber* or *tubercle*. Sometimes they are composed of concentric hollow spheres, as in Onion, Squill; or of scales, as in the Lily; or the concentric spheres are sometimes compressed, as in the Crocus, Colchicum, resembling the tuber. These kinds are called ***Bulbous***.

38. In every instance of the growth of a new plant, whether an entire plant from a seed, bulb, or bud, or herbage and flowers from a perennial root, there is a stock of food previously provided for the young plant.

39. In the Orchis, which has two tubercles, and the stem of which dies annually, one of the tubercles affords nourishment in its early stage to the annual stem, shrinks and disappears. The other, not fully grown till about the end of the season, contains nutrient matter for the growth of the stem of the succeeding season, and disappears in its turn; and so on. The wild Tulip throws out from its root a long stout fibre, at the extremity of which a bulb grows

which produces the plant of the ensuing season. At the base of the bulbs of the Snow-drop and Lily small bulbs are found, and sometimes on the stem, as in the Orange Lily,—these become detached, and form new plants. In Ranunculus bulbosus the bulb for the next season is formed above the old one—in Herminium monorchis the new bulb is produced from the end of the rootlets.

40. The economy of Poa bulbosa is curious in this respect. " This grass is peculiarly fitted to inhabit dry sandy ground. Its bulbs grow in clusters, resembling little onions, and during most part of summer remain inactive, blown about at random. With the autumnal rains they vegetate, fix themselves by long downy radicles, then produce thick tufts of leaves (a grateful spring food for cattle); and in April or May they flower, having in the meanwhile formed young bulbs, which, as soon as the herbage withers, are dispersed like their predecessors."—*English Botany.*

41. Thus, Perennial plants, which live and flourish during many seasons, have either a bulb, a tuber, or a woody subterraneous stem, which preserves the vital principle during the suspension of vegetation, and contains a store of nutritious matter for the early growth of the new herbage. This arises from a bud, which is seen in the *eyes* of the potato, in the centre of the bulb, and, in the stem-like perennial root of other plants, at the extremity where the stem and herbage of the preceding season had arisen. A mere bundle of fibres would be unable to survive excessive

cold or much moisture, could not contain a store of ready formed vegetable matter, and would not be adapted to convert readily the material drawn from the soil into nutritious matter. The bulb was denominated by Linnaeus "the winter quarters of the future plant."

42. The tuber with eyes (buds) and bulb with the interior bud must not be confounded with the tubercles found on the roots of some plants, as the Dropwort, which are mere reservoirs of nourishment to enable the plant to resist drought. And some plants which in ordinary situations have no bulb or tuber, acquire one, as a storehouse, when they are in a dry situation or one where their supplies of moisture are scanty and irregular; as Alopecurus geniculatus, the roots of which become bulbous, and Phleum pratense, in which the roots become swelled and very succulent; the plant is then named Phleum nodosum.

43. Roots, then, have two principal functions to perform, to fix the plant, and to absorb nutritious matter for its support.

IV. THE STEM.

44. The Stem is an organ possessed by most plants. It grows upwards from the root, gives support to the leaves, the flowers, and the fruit, and transmits to them the nutritious fluids absorbed in the earth.

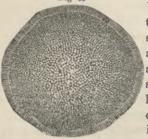
45. With respect to structure, stems may be divided into three great classes, which correspond

with the three natural classes into which vegetables are divided,—Cellular, Endogenous, and Exogenous Stems.

46. CELLULAR STEMS. These consist of a homogeneous mass of cellular vegetable matter, covered by a thin cuticle. Some of them are apparently of a fibrous texture, but are composed of elongated cells placed parallel to one another. Mushrooms (*Fungi*), Lichens, Sea-weeds, the lower orders of plants, make up this class, the leading character of which is to consist of cellular tissue alone. The Ferns, and one or two others, have certain kinds of vascular tissue, but resembling this class in other respects, have generally been included in it. Plants of this kind are *Flowerless* or *Cryptogamic* (169), and are termed *Acrogenous*, growing only by addition at their external points.

47. ENDOGENOUS STEMS. These consist of bundles of vessels irregularly dispersed through cellular tissue. The Sugar-cane, Solomon's Seal, the Lily, the Palm, and the Iris, have this kind of structure, the cellular and vascular tissues being blended together through the entire substance of the stem. The adjoining figure shows the appearance of a horizontal section of a stem of this kind; close and compact exteriorly—loose and soft in the centre.

Fig 2.



48. Stems of this kind are called *Endogenous*,

because the new matter by which they increase in diameter is added interiorly. Their growth is carried on by means of the thick cluster of leaves by which they are terminated superiorly. From them the new matter descends along the centre of the stem, an l pushes outwards the parts first formed. The upper parts of the leaves perish, having performed their functions; their bases remain, are pressed together, and form at the top the new external part of the stem. In the middle of the crown of leaves is the terminal bud, which is next to be developed, rise a little above the former, become a cluster of leaves, and in its turn be pushed outwards by a succeeding central bud.

49. The oldest and hardest part of such stems is that nearest to the circumference. The more the external parts are pressed by the descent of the new matter, the more close and compact they become, the outer parts being soon incapable of being much farther pushed out, and the whole being thus compressed and condensed. The prickly Pole-palm is like whalebone externally, and some palms are so hard there as to resist the stroke of the axe—yet quite soft in the centre.

50. From the mode of growth in this stem it never can attain a great thickness, the new matter having to force outwards all the previously formed matter, which is every season increasing in quantity and becoming harder.

51. From the same cause they have no lateral buds—no branches. Buds (which produce branches) originate from the soft and juicy parts of the tree—but

in endogenous trees this is surrounded by a thick hard compact casing through which the buds cannot penetrate. Their only branches are, the splendid crown of leaves which proceeds from their *one* bud at the summit.

52. Hence the peculiar form of the Palm trees which present so striking a feature in the scenery of tropical climes, and form such a contrast with the

Fig. 3.

trees in more temperate latitudes; raising a narrow unbranched stem often to a height of about 150 feet, crowned by a magnificent cluster of leaves many feet in length bending elegantly outwards, and presenting altogether one of the most graceful objects which can adorn a landscape. From their great height, which renders them tottering, and their manner of growth, which causes them in time to become hard and compressed, even in the centre, so that they cannot transmit juices from the root, or new wood from the leaves—the age of Palms is limited—perhaps not exceeding two or three centuries at the utmost.

53. Plants with endogenous stems have only one cotyledon (lobe) in the seed (hence called monocotyledonous), and have leaves with veins proceeding in simple lines from the base to the summit, not forming a net-work as in the leaves of the Lime tree, Cabbage, Primrose, &c. Contrast, in this respect, the

plants just mentioned with the grasses, onion, or lily tribe (167–8.)

54. Exogenous Stems. The third class of stems consists of those in which are observed concentric layers of vascular tissue, arranged symmetrically round a central column of cellular tissue, intersected by rays of cellular tissue proceeding from the centre towards the circumference, and enclosed by a hollow cylinder of bark. The figure adjoining (Fig. 4.) shows the appearance of a horizontal section of the stem, presenting a series of concentric circles. The parts which this kind of stem presents for consideration are,—1. The Epidermis; 2. The Cellular or Herbaceous Integument; 3. The Bark; 4. The Wood, 5. The Medullary Rays; 6. The Medulla or Pith.

Fig. 4.

55. 1. *The Epidermis or Cuticle.* The epidermis is a thin membrane, resembling much the cuticle of animals, and extending over the whole plant. It is described as consisting of a layer of fine membrane provided with pores, and covering a sort of cellular network. These pores open by an oval aperture, surrounded by a small prominence (which is supposed to open or shut the aperture as circumstances may require), into the cellular network, in which the ves-

sels terminate. On the leaf the cuticle is a very important organ.

56. These pores or stomata give free passage to moisture. They are found only on parts exposed to the air, and which evaporate freely. Roots, fleshy fruits, and seeds, and those parts of aquatic plants which are submersed, are destitute of stomata.

57. The cuticle is supposed to protect the parts underneath from the too direct action of air and water, and to prevent too great evaporation of the fluids. It affords little protection from heat or cold, except when covered by a thick hair or wool, as in the Great Mullein. On the trunks of the Fir, the Plane, the Oak, and other trees, the office of the cuticle seems to be performed by dead layers of bark, or of herbaceous integument, which are pushed outwards, having performed the functions for which they were made.

58. "In forest trees, and in the larger shrubs, the bodies of which are firm and of a strong texture, it is a part of little importance," except in the young and tender state of the plant; "but in the reeds, the grasses, canes, and the plants having hollow stalks, it is of great use, and is exceedingly strong; and, by the microscope, seems composed of a kind of glassy network, which is principally siliceous earth. This is the case in Wheat, in the Oat, in different species of Equisetum, and, above all, in the Rattan, the epidermis of which contains a sufficient quantity of flint to give light when struck by steel. The siliceous epidermis serves as a support, protects the bark from the

action of insects, and seems to perform a part in the economy of these feeble vegetable tribes, similar to that performed in the animal kingdom by the shell of the crustaceous insects. I have ascertained, by experiment, that siliceous earth generally exists in the epidermis of the hollow plants*."

59. 2. *Herbaceous or Cellular Integument.* This is the layer of cellular tissue, which lies immediately under the epidermis, and gives to the leaves and young stems their green colour. It forms the substance of the leaf, and in it the changes effected on the sap by the atmosphere take place.

60. 3. *Liber, Cortex, or Bark.* This is found immediately under the herbaceous integument, and consists of a vascular net-work, the spaces between the vessels being filled up by cellular tissue. The bark presents concentric layers, composed chiefly of woody fibre and cellular tissue; and its tissue is easily distended and torn. There is only one layer in young shoots one year old. A new layer of bark is formed in each succeeding year *within the old one;* and thus, in trees, the bark is made up of as many vascular layers as the tree is years old; the older layers being pushed outwards by the growth of the new layers, becoming a lifeless crust, and being often thrown off. Hence the bark may be called *endogenous*, or growing at its inner surface.

61. In the newly formed layers of bark, the sap, which has been modified in the leaves by the action of

* Davy's Agricultural Chemistry.

the air, descends to nourish and promote the growth of the plant; hence many of the valuable properties of plants are found in the bark, as in the oak. The outer bark serves the purpose of protecting the new layers of wood and bark from injury, the old and hardened layers forming an excellent protection from external violence.

62. The bark, being the part in which the sap descends to supply the plant, is essential for its increase. If part of the bark be removed from a tree all round, so as to leave the wood bare, the part beneath will not grow, the medium by which the nutritious fluids were conveyed to it having been removed, and the tree will ultimately perish. A graft will not take if its bark be not in contact with that of the tree in which it is inserted; and a branch will not take root when surrounded with earth, if the part be deprived of its bark.

63. 4. *The Wood.* The wood lies immediately under the bark, and makes the principal bulk of the trunk and branches. It consists of concentric layers, or rather cylinders, composed chiefly of vascular tissue. In young shoots, one year old, there is only one layer, which lies upon the medullary sheath (69). In each succeeding year there is another layer formed. Hence the age of a stem of this kind may be known by counting the number of concentric vascular cylinders in the wood.

64. The external woody layers next the bark are called the *alburnum*, and differ from the internal layers or true wood in being younger, softer, more succulent, and of a ligh[illegible]

65. The true wood or heart wood is formed by the inner layers of the alburnum, which gradually acquire a greater degree of hardness: the transition from alburnum to true wood is, however, almost imperceptible.

66. A new layer of alburnum is formed annually next the bark: it is pushed inwards, and becomes more compact by the pressure of each succeeding annual layer, till at last it becomes almost solid, the sides of the vessels and cells being squeezed together: hence the greater hardness of such trees in the centre. Thus the wood in such stems is *exogenous*, or growing at its outer surface.

67. 5. *Medullary Rays.* The fasciculi, or bundles of vessels which compose the cylindrical layers, are separated at different points by masses of cellular tissue, extending from the centre or pith towards the circumference, causing an appearance of alternate rays of vessels and cellular tissue. These are called MEDULLARY RAYS (from their radiated appearance), medullary prolongations or insertions, or, *the silver grain.* The medullary rays most probably convey the proper juice (the descending sap) from the bark to the interior of the stem.

68. The wood gives passage to the sap from the root to the buds and leaves, and contains many of the secretions of the plant. The sap rises chiefly through the alburnum (the vessels of which, being young, soft, and not compressed, are well adapted for the passage of fluids), and is conveyed to the leaves, there to undergo changes which render it fit to promote the

growth of the plant. Little is known with respect to the particular function of each part of the wood, excepting the alburnum, the latest formed layer of which gives passage upwards to the sap. Thus it would seem that the new layer of alburnum is formed for the nourishment of the plant, by conveying the sap to the leaves; and this explains why a serious injury of this part is so fatal. When it is destroyed, its office is very imperfectly performed by an old layer, filled with secretions, or hardened, and with the vessels contracted by pressure. But a tree may live and flourish with a large piece of the bark and alburnum decayed and removed, if not wanting all round. There is an instance of this in a venerable Hawthorn tree near Edinburgh, in which there is a large and deep scar on one side, *patched up with stone and lime.*

69. 6. *The Pith or Medulla.* The pith is in the centre of the stem, and is contained in the *medullary sheath* or *canal,* which is composed of vessels, chiefly spiral, disposed in a longitudinal direction. In all plants the pith consists of cellular tissue alone, and is of a light and spongy character. The cells are, in general, very regular, and hexagonal in section : in the young shoots of trees, and in herbaceous plants, these cells are filled with aqueous juices, which disappear as the plant grows older, and then they contain gas alone.

70. The pith, it is supposed, nourishes the young wood and the buds during the first year of their existence; and it has been observed that it retains its moisture for a longer period near the terminal bud, and at the parts where branches are given off.

71. Such is the structure of the stems of that very large class of plants which constitutes the third division. They are found only in Dicotyledonous plants (plants with two lobes in the seed) as the pea or lupin, and their leaves present in the veins an irregular reticulated appearance. They are called *Exogenous*, because the wood, which is the principal part of them, increases in diameter by the addition of new matter at its external surface. All the trees of this country are Exogenous. See 167–8.

72. In exogenous plants, the new matter being added externally, a bark or covering is necessary to protect it, when young and tender, from the action of the atmosphere, and from external injury from other causes: hence an important office of the bark. In endogenous plants, the new matter, being added internally, is provided with an excellent covering, formed of the main substance of the plant, and has no need of a separate protecting integument.

73. In spring there is found between the bark and the alburnum a viscid gelatinous fluid called *cambium*, which, it is supposed, is the principal agent in forming the new layers of wood and of bark. This fluid is composed of the residue of the cambium of the preceding season, enriched and renewed by the descending sap, and mixed with some of the secretions of the vegetable.

74. M. Mirbel and others are of opinion that the cambium annually forms a new layer of alburnum and a new layer of bark. This is the most simple mode of formation, and probably that which takes place.

We know tbat the cambium can repair the bark when it has been injured; and, as the new layers of wood and bark are formed where this fluid is found, it is not unreasonable to suppose tbat it acts an important part in this process.

75. M. Du Petit-Thouars advanced a singular theory, namely, that the successive formation of woody layers is caused by the development of buds, from whieh, in spring, issue numerous fibres, which deseend in the cambium between the liber and the alburnum. In gliding downwards they meet the fibres which deseend from other buds, and form a layer of greater or less thiekness, which soon becomes solid, and forms a layer of wood.

76. Each bud is regarded as a separate system of vegetation. The buds are considered so many individuals plaeed upon a common stoek, and elongating in two ways—upwards, forming new stems and branches, leaves, &e.—and downwards, forming roots; the deseending fibres being the roots whieh the buds put forth, and the cambium bearing the same relation to the roots of the bud as the soil does to a germinating seed. M. Thouars eonsiders buds as analogous in structure and mode of development to the embryo of the seed, whieh in germinating produees a young stem analogous to the seion produced by the growth of a bud. He ealls the latter a *fixed or adherent embryo*, while be denominates that within the seed a *free embryo*. Thus the wood and bark are considered as formed of the roots of the buds which are annually developed on the surfaee of the vegetable.

77. Whatever may be the mode in which the formation of the new layers takes place, it is known that the new matter which forms them *descends* from the leaf-buds or leaves, either in the innermost layers of the bark, or between it and the alburnum.

78. If all the buds or leaves be removed from the upper part of a branch, no increase in diameter will take place above those that are left. If a ring of bark be removed from a tree, the part below will not increase in thickness, and the upper lip of the wound will heal quickly, while the lower lip will not. This operation has been recommended for improving the fruit of trees; the descending sap or proper juice, confined to the upper part, increases the size of, and enriches the flowers and fruit developed above the place from which the ring has been removed. This is called ringing: care must be taken to make the ring very narrow, in order that the parts may easily reunite.

79. If a ligature be placed tightly round the bark of a tree, the part above the ligature will swell, but not the part below; and it has been observed that the rate of increase of the diameter of any part of a branch or tree is in proportion to the number of leaf-buds developed above that part.

80. From their peculiar structure, Exogenous stems readily throw out branches, and hence the form of the trees in this country is so different from that of the Palms. Figure 5 shows the general outline of an oak tree. The part of the tree where vegetation is active being near the outer surface, the buds easily penetrate

and grow into shoots, from the sides of which also buds are developed, and thus the tree is branched and sub-divided to a great extent, and from a short distance above the ground.

Fig. 5.

81. From the same cause, such trees attain a great thickness and live to a great age. The new matter being added externally, has little resistance to overcome (only that of the thin bark, which is easily distended and pushed out) and thus there is hardly any limit to its increase in diameter, while, becoming only more securely fixed as it grows, and the growth going on between the bark and the wood almost independent of the inner parts, there is as little limit to the duration of the tree. In fact each annual layer of alburnum and bark seems to have an independent existence—hence trees are often found flourishing, though quite decayed and hollow within.

82. There was, about the end of the last century, a Lime tree in the Grisons, 51 feet in circumference, that is about 17 feet in diameter. This tree was celebrated in the year 1424, so that it cannot be much under 600 years of age. There are some famous Chestnut trees at mount Etna, about twenty feet or more in diameter, and near Constantinople there is a Plane tree, hollow in the centre, and about 50 feet in diameter.

Among the most remarkable trces for age are the Baobabs, discovcred by Adanson in the Capc Verd Islands, some of which are about 30 feet in diameter and are supposed to be about 5000 years old: while it has been conjectured that some cypresses, found in Mexico, arc older still. The Oak is a long lived tree, flourishing for 600 years or more—the Olivc for 700 or 800 years—the Cbestnut for 900 years—a Dragon's blood tree in Teneriffe is supposed to be about 2000 years old. The famous Wallace Oak at Ellerslie, near Paisley, must be about 700 years old, as in the time of Wallace, it was so large as to conceal him and a number of his followers. There are some Yews in Yorkshire not less than 1000 or 1200 years old. There is a Yew at Ankerwyke, about 9 feet in diameter, and known to be considerably older than the signing of the Magna Charta by John.

V. LEAVES.

83. Leaves are flat greenish organs, of various shapes, growing from the stem or branches; at first tbey are concealed in buds, but, as the season advances, they are gradually unfolded, and come forth expanded, presenting a large surface for the action of air and light.

84. Leaves are formed by an expansion of the vessels of the stem at particular parts. Their fibres are bundles of vessels, whicb by their ramification form a net-work, or skeleton, which is filled up by cellular

tissue, continuous with the herbaceous integument of the stem. The whole is covered by the cuticle.

85. The projecting lines seen on the under surface of the leaf, and called veins or nerves, are ramifications of the vascular fibres which proceed from the stem. They terminate in the surface of the leaf by a pore or stoma.

86. Most leaves are divided into two lateral halves by a large vein extending from the base to the summit. This is a continuation of the leaf-stalk, and is called the *midrib*. From its base and sides the other veins proceed and spread in all directions.

87. In the leaves of exogenous or dicotyledonous plants (71), the veins form a kind of net-work, leaving the midrib abruptly, branching irregularly among the cellular tissue, and uniting frequently with each other.

88. In the leaves of most endogenous or monocotyledonous plants (53), the veins proceed directly from the base to the apex, or diverge gradually from the midrib, are little ramified, placed parallel to each other, and connected by simple transverse veins.

89. There are two sets of veins or vessels in the leaf; one proceeding to the upper surface from the stem, and conveying from it the sap for the purpose of being exposed to the action of air and light. This surface is, in trees and shrubs, constantly turned to the light. The other set of vessels proceeds from the lower surface of the leaf to the bark, and conveys to it the sap, now rendered fit for the nutrition of the plant. If the leaves of a branch be placed so that the upper surface be turned towards the earth, they

will gradually resume their natural position; and if prevented from doing this, they will wither and die.

90. The leaves of succulent plants, such as the Cactus and the Aloe, are provided with few pores, and evaporate very slowly, and may be considered as reservoirs of nutritious matter for the use of the plant; in great heats, and in a dry soil, preserving its existence by their power of retaining the fluids which are absorbed. Plants which grow in dry and parched situations, where supplies of rain are very scarce, have leaves of this kind. The thin small leaves of the Fir are of an opposite nature, being provided with numerous pores, and evaporating freely.

91. Thus, it will be seen that leaves are organs of great importance in the vegetable economy: they absorb nutritious matter from the vapour and other gases diffused through the atmosphere; discharge the watery part of the sap by evaporation; and expose it to the action of air and light, by which it is rendered fit for the nutrition of the vegetable. See 98. &c. Hence the virtues of plants frequently reside in their leaves. No plant can thrive if early deprived of its leaves: they are the lungs of plants.

VI. APPENDAGES.

92. Besides the parts already enumerated, there are others which occasionally are met with—Stipules, Tendrils, Spines, Prickles, Glands, and Hairs.

93. The Stipules are small leafy appendages at

the base of a leaf, like wings, found in the Pea tribe, Rose, Violet, Polygonum, &c.

94. The TENDRILS are string-like appendages, found in plants unable to support themselves, and which wind round the neighbouring bodies, and thus raise and support the plant, as in the Pea, the Vine.

95. SPINES and PRICKLES seem intended to protect the plant against injury from animals.

96. GLANDS are minute globular bodies destined to contain or secrete some particular fluid. The Ice plant is covered with them.

97. HAIRS are found chiefly on plants which grow in dry situations, and in these cases it is thought that they enlarge the absorbing surface. They are not found on aquatic plants. In some plants, the hairs are tubes for the emission of fluid from a gland beneath, as in the Nettle, the hairs of which irritate the skin by pouring in an acrid fluid, the skin pressing the tube on the gland below, and thus pressing out the liquid. When thickly set, they protect from heat or cold, as in the Great Mullein.

VII. NUTRITION IN VEGETABLES.

98. VEGETABLES consist principally of carbon (charcoal), oxygen, and hydrogen; the two latter are the ingredients which compose water: they also contain small quantities of nitrogen, lime, magnesia, &c. They derive the principal part of their nourishment from the soil. The porous extremities of the rootlets absorb

the fluids with which they come into contact. These fluids consist chiefly of water, holding in solution decayed animal and vegetable substances, and various earthy matters, as lime, alumina, magnesia, silex, potassa, and soda.

99. The animal and vegetable matters are essential, forming the main substance of the food of the plant. The action of the earthy matters on the plant is not so well ascertained. It is most probable that they act as a stimulus to the absorbing fibres of the root; and within the plant, as a condiment, by their stimulating properties assisting to keep up the action of the solids in elaborating the food, and also forming an important part of the secretions.

100. The food of vegetables must always be taken in a fluid form, as the spongioles are incapable of absorbing solid matter. Hence there is no need of teeth for the purpose of masticating the food. The spongioles cannot continue long to absorb a thick or viscid fluid, as they would be clogged up by it, and hence a plentiful supply of water is necessary.

101. Four kinds of earth are generally found in soils: alumina, argil, or clay; sand or silex; lime or calcareous earth; and magnesia. These constitute two principal kinds of soils; stiff, from an excess of clay, or what is called argillaceous; or dry, loose, and sandy, from an excess of siliceous matter.

102. "The silica in soils is usually combined with alumina and oxide of iron, or with alumina, lime, magnesia, and oxide of iron, forming gravel and sand of different degrees of fineness. The carbonate of lime

is usually in an impalpable form, but sometimes in the state of calcareous sand. The magnesia, if not combined with the gravel and sand of soil, is in a fine powder, united to carbonic acid. The impalpable part of the soil, which is usually called clay or loam, consists of silica, alumina, lime, and magnesia."—" The vegetable and animal matters are sometimes fibrous, sometimes entirely broken down and mixed with the soil."—*Davy's Agricultural Chemistry.*

103. A stiff argillaceous soil opposes the entrance of air to the seed, the free growth and penetration of the roots, and retains a great deal of moisture, which enfeebles the root, and renders the crops which grow in it insipid, watery, or dropsical. It requires to be mixed with a light dry earth, and to be frequently turned up by the plough that the clods may be broken down and pulverised.

104. A loose sandy soil does not retain the moisture afforded by the rain, which is so essential to the growth of the plant; and, owing to its want of cohesion, cannot fix the plant, so that when young it is liable to be rooted up by the winds. A soil such as this must be improved by the admixture of argillaceous and calcareous earth, and must be well manured, or have a crop of some light vegetable ploughed in with it, before it can be considered as fit for the production of a good crop.

105. Besides these, there are many other circumstances which affect the productiveness of soils; such as, the facility with which they are heated by the rays of the sun; the length of time they retain their heat;

their power of absorbing moisture from the air; the degree of evaporation from their surface; their power in acting upon, combining with, and retaining the organized matter in the soil, which is greatest in rich soils, those which contain much alumina and carbonate of lime, and least in sandy soils, in which the organic matters, not being attracted by the soil, are decomposed by the air, or dissolved and removed by water; the nature of the subsoil; and many others, upon which it would be out of place to insist here.

106. Lime is of great value in the improvement of soils. By its caustic nature, or its affinity for carbonic acid and water, it assists in decomposing the various organic matters in the soil: it acts as a stimulus to the absorbents of the root; and, by its firmness and cohesive properties, while at the same time it is not stiff and tenacious, forms an excellent addition to either a sandy or an argillaceous soil. It is particularly adapted to thin marshy soils, which are unable to retain the organic matters which are decomposed.

107. Ploughing breaks down the earth; exposes it and the various organic substances in the soil to the action of the atmosphere, the oxygen in which aids in the decomposition of any organized matter which may be present; and mixes thoroughly the different ingredients in the soil.

108. Manure enriches the soil by supplying the most essential matter for the nutrition of vegetables, decayed animal and vegetable matter. Soils which have become exhausted, that is, which have been deprived of their organic ingredients by a succession of

crops, require to be invigorated by the admixture of more organic substances. This is done by means of manure, which is composed of the necessary material, —carbon, oxygen, and hydrogen, &c., and in which the putrefactive process has made such progress, that it is in an apt state for having its cohesion destroyed, and being reduced to its pristine elements. It is rendered soluble in water, in which state it is ready for being assimilated to the vegetable tissue.

109. It has been observed that many plants excrete from their roots a peculiar matter, which varies in the different kinds of plants. This matter, it is probable, consists of those parts of the sap which are not adapted for the nourishment of the vegetable, and which have been absorbed along with the nutritious particles, as the spongioles, it is supposed, have not the power of distinguishing between the different substances that are presented to them, but absorb promiscuously all fluids with which they come into contact.

110. This matter, being rejected by the vegetable, is therefore injurious to a vegetable of the same kind; and hence a succession of crops of the same plant, or even of the same family of plants, become gradually degenerated and of an inferior quality; while, on the other hand, any crop or succession of crops is followed with advantage by a crop of another family, as it is found that it can make a good use of the exudation from the roots of the former.

111. This excretion from the roots may be considered a natural manure. calculated, however, to be beneficial only to plants of a family different from that

which produced it; and this is a principle capable of a most important and extensive application in agriculture, as, by a judicious succession of crops, we are enabled to provide from each crop a sort of manure for that which is to succeed it.

112. The fluids thus absorbed undergo some modification in their course from the fibrils of the root to the stem, being most probably acted upon by the secretions of the plant which they meet. They then become what is called *sap*, a watery sweetish fluid, containing various salts, the organic matter which has been absorbed transformed into mucilage and sugar, and a large proportion of water.

113. The sap is found in the woody part of the stem, through which it begins to ascend towards the branches early in spring. At this period it may be easily collected by piercing the woody parts in the Vine, Birch, or Maple, when it will flow out in great abundance.

114. Heat, by promoting the flow of the sap, is favourable to the growth of plants, and their vegetation is often accelerated by the application of artificial heat, which is called *forcing*. The greater size, and quicker and more vigorous growth of vegetables in tropical climates, is owing chiefly to this cause.

115. When the buds are developed and have put forth their leaves, they cause the sap to flow more equally and steadily, by constantly consuming what is presented to them; and if the wood be now pierced, little or no effusion of sap takes place, the leaves drawing it towards them as it is required, and

removing large quantities of the watery part by evaporation.

116. The greater part of the sap ascends through the alburnum to the full grown leaves, which afford it an outlet by evaporating part of it, and sending the rest through the proper vessels to the bark, thus consuming rapidly what they receive.

117. The sap, when it arrives at the leaves, is deprived of its watery part by exhalation or evaporation. This takes place principally under the influence of light and heat. Hot and dry weather greatly facilitates this operation, as Hales ascertained by experiments on the Sunflower (*Helianthus annuus*), which was found in such weather to transpire thirty ounces daily; being one-half more than its average quantity. The watery part of the sap, having performed its office of dissolving the solid matter necessary for the nutrition of the plant, thus rendering it fit to be absorbed by the spongioles, is discharged as of no further use.

118. An important operation, it is supposed, is carried on by the leaves when under the influence of light. They exhale oxygen gas, derived from the carbonic acid in the atmosphere, and from that conveyed to them in the sap. The carbon is retained, being an important element in the composition of vegetables. Light, then, it is generally believed, causes the accumulation of carbon, and the expulsion of oxygen.

119. During the absence of light, in the night-time, a very different process is carried on : the leaves absorb oxygen, and give out carbonic acid.

120. The action of the leaves of plants on the atmosphere is a subject which is still involved in considerable obscurity. It would appear, if we attempt to draw any conclusion from the experiments at present known, that, in clear sunshine, plants decompose carbonic acid derived from the sap or from that in the air, retain the carbon, and give out the oxygen; that in diffuse day-light or cloudy weather, they sometimes perform this process, and sometimes give out carbonic acid, by eliminating carbon which unites with the oxygen of the air; and that during the complete absence of light, they mostly perform the latter process. And it is considered at present, that the general effect of vegetation on the air is to purify it, decomposing the carbonic acid, retaining the carbon, and restoring the oxygen.

121. Carbon, it is known, is absolutely necessary for the support and growth of vegetables, and, when this element is not to be found in the soil, they *can* extract it from the atmosphere, and assimilate it to their substance.

122. Saussure made plants vegetate in water and in an atmosphere, both of which were completely deprived of carbonic acid, and found that they did not thrive; but if carbonic acid were in the atmosphere, they flourished and arrived at maturity. Plants have been made to grow in dried earth, in flowers of sulphur, in a soil made of pounded glass and quartz, in all of which they could procure no carbon, which must consequently have been derived from the atmosphere. When a newly-formed or barren soil is first beginning

to be clothed with vegetation, the oxygen, hydrogen, and carbon, must be derived solely from the atmosphere; and it is only by drawing largely from this source, through the medium of the vegetables growing upon them, that such soils can at last become able to support the growth of more perfect vegetables.

123. Light, it is also known, is absolutely necessary for the healthy existence of the plant; and its operation, when it is in full power, seems to consist in causing carbon to be deposited, as plants grown in the dark are tender, feeble, and insipid, wanting many of those properties which, it is probable, must depend on the presence of carbon. If a plant be kept in the dark or etiolated, the green parts become of a sickly white colour, and indeed the whole plant becomes soft and feeble. There is a deficiency of carbon, which is necessary to the firmness and stability of the plant and the development of the green colour. This is well seen in the Garden or Heading Cabbage, the internal leaves of which are white and tender, while the external ones are strong and fibrous, and have the green colour properly developed. When vegetation proceeds in the dark, the plant loses its peculiar virtues, and all the fluids are nearly alike, possessing a mild sweetish taste. Thus Celery, a deleterious plant in its natural state, becomes mild and wholesome when blanched. Light tends to heighten the colours, and give the secretions their proper qualities.

124. We are still much in the dark regarding the nature and uses of the action which takes place in the

leaf, aud the influence of external agents upon it. It is not unreasonable to suppose that the leaf is not regulated in its action entirely by the degrce of light present. It must be borne in mind, that a plant is a being endowed with life, and capable, to a certain extent, of adapting the exercise of its functions to the circumstances in which it may be placed; and we may fairly presume, that the amount of carbon taken in by the leaf, or given out by this organ, will vary much according to the quantity in the sap derived from the soil, which, it is evident, must be very differcnt in different situations.

125. The sap, having in the leaf been rendered fit for the nutrition of the plant, descends in the innermost layer of the bark, being here called *proper juice*, assist in preparing the cambium, which acts such an important part in the formation of the new layers of wood and bark, is diffused horizontally through the medullary rays, and produces the different secretions which are found in the vegetable.

126. The animal creation in respiration, and several chemical operations going on largely at the surface of the earth, remove the oxygen and substitute carbonic acid, thus tending to render the air unfit for the support of animal existence, from the want of oxygen and the increase in the proportion of carbonic acid. But the vegetable kingdom, producing the opposite effect on the air, namely, that of extracting the carbon from the carbonic acid and restoring the oxygen, counteracts the effect of animal life on the air; *and thus these two great kingdoms of nature, mutually adapt the air*

for each other, by their opposite wants, and their opposite action on air.

127. We have already seen (9, 122) that vegetables can live on inorganic matter alone—but that animals cannot—hence another important office which vegetables perform for the animal creation—they convert inorganic matter into fit food for the latter, for animals live on vegetables, or other animals, and these have derived their subsistence either directly or indirectly from the vegetable creation. Vegetables are thus in more ways than one, purveyors of food for the animal kingdom.

VIII. THE FLOWER.

128. When we examine what, in common language, is termed a flower, we find that it is of a very complex structure, consisting of a number of parts which differ very much from each other, as well as from the other parts of the plant. Some of them are very curiously formed; they undergo various changes from the time when they first emerge from the bud to their final disappearance; and each part has a distinct office to perform in bringing about these changes. These parts also vary much in the different kinds of plants, in size, form, structure, and colour.

129. First, there is the corolla, the beautiful and often richly coloured leaf, the part which most attracts our attention, and to which the term flower is usually applied. This part is well seen in the rose, the

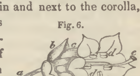
anemone, the poppy, the buttercup, the blue-bell, the violet.

130. Next, surrounding closely the lower part of the *corolla*, there are a few small leaves, generally green, though different in form from the ordinary leaves of the plant, and having the appearance of a cup in which the corolla rests. This is called the flower-cup or CALYX.

131. Then, within the corolla, we perceive a number of slender bodies, of which so many are set *next to* the corolla, and the others (sometimes only one) differing from the first in both appearance and structure, occupy the centre of the flower.

132. These various parts are seen in Fig. 6, the flower of deadly nightshade (Atropa Belladonna); *a* is the PEDUNCLE or flower-stalk which supports the flower, and connects it with the plant;—*b* the CALYX or flower-cup;—*c* the COROLLA;—*d d* the first series of slender bodies, placed within and next to the corolla, and five in number in this flower; they are called STAMENS;—and *e* the next, of which there is only one in this flower, and called the PISTIL.

Fig. 6.



133. In the deadly nightshade the calyx is like a cup, but deeply divided into five segments or lobes, of which three are seen in the figure; the corolla is shaped like a bell, of one piece, but separating into five lobes at the margin. In Fig. 7, the flower of the apple tree (Pyrus Malus), the big leaves, five in num-

ber, are the *corolla*, each leaf being quite separate from the rest; the *calyx* (also in five separate leaves) is seen projecting between the separate pieces of the corolla; next to the corolla are seen the *stamens*, of which there are a great number; and in the centre may be observed five black points, the extremities of the *pistils*.

Fig. 7.

134. In the large figure, page 18, which represents the whole plant of *Saxifraga granulata*, a view is given of the flower as it appears on the plant, and also detached and in separate pieces. The corolla is in five separate leaves, of which one is seen at the side (*b*): the calyx is seen below (*a*): and at *c* the ten stamens and the pistil with its two beaks are shown, apart from calyx and corolla. It will be observed that the peduncle or flower-stalk arises between the stem and a leaf, at the angle formed by their meeting. This situation is called the *axil* of the leaf, and it is there that buds and flowers are found. The leaves of the corolla are termed *Petals*, those of the calyx *Sepals*.

135. *Calyx and Corolla.* The calyx and corolla are found in a great many different forms. Fig. 8 shows the calyx and corolla of the common cowslip (*Primula veris.*) The corolla is a tube, expanded at

its orifice, where the stamens are seen. Fig. 7 gives an example of the general form of the calyx and corolla in a great tribe of plants called *Rosaceous*, the rose being one of them. The corolla is in five petals. This extensive family embraces the apple, the rose, the bramble, the cherry, the hawthorn, the strawberry, &c. Fig. 9 shows the calyx and corolla of the tobacco plant (Nicotiana tabacum); and Fig. 10 is a representation of the corolla of the Fuller's teazle (***Dipsacus Fullonum***) split up longitudinally to show the stamens arising from the interior of the corolla. The corolla generally has the stamens inserted upon it in this manner, when it is of one piece.

Fig. 8.

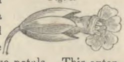
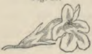


Fig. 9.

Fig. 10.

Fig. 12.

Fig. 11.



136. Fig. 11 shows the calyx and corolla of ground ivy (*Glechoma hederacea*), and Fig. 12 shows the corolla of the lavender plant (***Lavandula spica***) split up and folded back to bring into view the stamens

arising from it. These two plants belong to a tribe or family of plants called *Labiatæ*, from the form of the mouth of the corolla, which resembles an animal with a gaping mouth. This is a very numerous family, and besides the character of the corolla just mentioned, they are distinguished by having (with very few exceptions) four stamens in each flower, of which two are longer than the other two, and four seeds at the bottom of the tube of the corolla. Mint, sage, rosemary, balm, dead-nettle are examples.

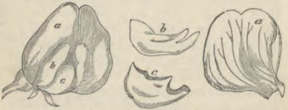
137. In Fig. 13, the peduncle, calyx, and corolla of charlock (*Raphanus Raphanistrum*) are shown. The calyx consists of four sepals, three of which are seen in the figure. The corolla also consists of four separate leaves, set in the form of a cross, from which, plants having this form of corolla, are called

Fig.13.

CRUCIFORM. The form of the petals is seen at the left—narrow and tapering below—broad and expanded above. There is a very numerous tribe of plants, the flowers of which are formed in this manner. They have six stamens in each flower, and one pistil. Of the stamens four are longer than the other two, and each of the latter is placed apart from the other, one on each side of the pistil, while the other four are in pairs. The fruit is a pod, somewhat like the pod of the pea, but differing from it in being divided into two cavities by a partition extending the whole length of the pod. See Figs. 33 and 34, par. 163, the pods of this tribe. Cabbage, turnip, radish, mustard, cress, cuckoo-flower, wall-flower, stock, shepherd's purse, are examples of this extensive family.

138. In Fig. 14 is seen a very singular form of corolla, found in an extensive family, called LEGUMINOUS OF PAPILIONACEOUS.

Fig. 14.



The corolla has somewhat of the appearance of a butterfly, whence the term *papilionaceous*. It consists of four pieces, a large broad leaf (*a*) called the *vexillum* or standard, two small and narrow leaves (*b*) called *alae* or wings, and the fourth (*c*) resembles a boat or the keel of a boat, whence it is termed the *carina* or keel. This is often in two pieces, or only slightly united at their lower edge, so that this corolla is sometimes said to consist of five leaves. The stamens are not seen in the figure; they are enclosed in the carina or keel, great care being taken in this tribe to protect these delicate organs. The stamens are of a very peculiar form here—See Fig. 21; and the pistil is surrounded and protected by the stamens. The fruit in all this tribe is a pod, such as that of the pea, with no partition— See Fig. 32, par. 162. The laburnum, the broom, furze, lupin, clover, bean, and sweet-pea, belong to this tribe of plants,

139. The calyx and corolla enclose and protect the interior parts, more especially when they are young and tender, like the outer scales of buds; and, folding inwards during rain or towards evening, secure the stamens and pistils from cold and moisture. It is probable, also, that the corolla, exposing the sap (the blood of plants) to the air, performs some important function in the nutrition of the stamens and pistils similar to what the leaves do for the other parts of the plant, and that it has some peculiar action connected with light and heat: as we know that the colours of bodies have a considerable influence on their relations to these agents, it is likely that the varied colours of the corolla have all some definite object in modifying in each different plant the influence of light and heat on this organ, and, of course, on the interior organs which it surrounds.

140. The corolla in most plants soon fades and withers. The calyx is more permanent, often remaining as a protection to the fruit and seeds, rising when the corolla has faded, and clasping them so as to form a sort of covering, and falling away when they are ripe, or at least folding back to allow the seeds to escape.

141. The calyx and corolla are not always present, and, botanically speaking, the term flower is applied solely to the stamens and pistils, though, in common

language, it is applied only to the corolla which surrounds them. In a very curious plant found in watery places, called mare's tail (*Hippuris vulgaris*), there is neither calyx nor corolla, but in the axil of each leaf a solitary stamen and one pistil are found.

142. *The Stamens.* The little bodies next to the corolla are the stamens. They consist of slender stalks, supporting an oblong somewhat rounded body at the upper extremity. The number of the stamens differs in different flowers, there being only one in some flowers, in others a great number, as the poppy, anemone, rose, ranunculus. When the stamens are few, their number is generally the same as, or some multiple of—the divisions in the other parts of the flower.

143. The slender stalk of the stamen is called the *filament;* the term *anther* is applied to the rounded body which it supports. In Fig. 15, *a* is the filament, *b* the anther.

Fig. 15

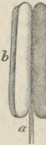


Fig. 18

144. If the anther be examined, it will be found (in most cases) to consist of two cavities or *cells*, containing a fine powder called *pollen.* This powder is generally yellow—but white in Azalea and a species of Amaryllis—green in Amaryllis aulica. When the pollen is matured, the cells open or burst, to let it out—opening (*dehiscing* is the term) by splits, or pores, or

valves.—See Fig. 15, in which each cell opens by a longitudinal slit at the margin to allow the pollen to escape. See Fig. 16, in which there are valves (doors or lids) at the sides of the cells, which become elevated, the pollen escaping at the openings; and Fig. 17, in which the pollen escapes by pores at the summit. The first method (Fig. 15) is the most common. It may be seen very distinctly in the lily tribe. The second mode is observed in the barberry and the laurels. In the heaths, rhododendrons, and solanums (potato tribe) the third mode of the escape of the pollen is found. In pyrola the pores are at the lower part of the anther.

Fig. 16.

Fig. 17.

Fig. 19.

145. The mode of arrangement and number of the stamens vary much. In figures 6, 8, 9, 10, 11, 12, we see that the stamens are few in number and enclosed in the tube of the corolla. In Figs. 7 and 18, the stamens are more exposed and very numerous. In Figs. 12 and 19, there are four stamens, of which two are longer than the other two. This is the number and arrangement in the labiate tribe (136).

146. In Fig. 20, a curious structure is shown : all the filaments of the stamens are united into a cylinder or tube, which encloses the pistil; the column composed of the united filaments splits at the upper end

into many branches, on which the anthers are set—the whole having much of the appearance of a tree and its branches. This is the form of the stamens in mallow and holly-hock.

Fig. 20.

Fig. 21.

147. See the account of the stamens in the cruciferous flowers, paragraph 137.

148. In Fig. 21 a very peculiar structure is illustrated. There are ten stamens, of which nine are united by the filaments, while the tenth is separate. The ten filaments together form a flattened tube, completely surrounding the pistil in the early stage of its growth, the single filament lying close to, but not being united to the others. This is the structure of the stamens in the papilionaceous tribe (par. 138).

149. There is another family of plants, the compound or syngenesious tribe, which have the stamens formed in a very remarkable manner. There are *five* stamens in each flower, and their *anthers are united*, forming a tube or cylinder, which surrounds the pistil, while the filaments, arising from the tube of the corolla, are quite separate from each other, like the filaments in Fig. 10: the whole flower is very minute. The

dandelion, the daisy, the china-aster, the marygold, the sun-flower, belong to this tribe. *In the daisy or sun-flower each of the little yellow bodies in the centre is a complete flower, having stamens, pistil, and corolla.* In the dandelion *each* of the yellow leaves will be found to be a complete flower, if traced to the lower extremity, and carefully detached. The examination of a flower of one of this tribe, with the help of a magnifying glass, will be found exceedingly curious and interesting. Each flower is so minute, so delicate, and yet so complete in all its parts, that it may be called a *Lilliputian* flower, such as Gulliver would find in his travels through the kingdom of Lilliput. See (223).

150. *The Pistil.* The next part of the flower is that which occupies the centre—the pistils. They are variable in number and appearance—in most cases fewer in number than the stamens—frequently there is only one.

151. In general the pistil consists of a rounded body at the lower extremity, called *germen* or *ovary*, and a slender stalk proceeding upwards from this, called *style*, which is somewhat expanded at its upper extremity, and there receives the name of *stigma*. See Fig. 22, in which the flower of deadly nightshade is seen, the corolla and stamens being removed; *a* is

Fig. 23.

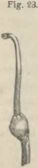
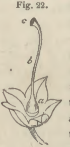


Fig. 22.



the germen, *b* the style, *c* the stigma. In Fig. 18, par. 143, are seen the pistils in the dog rose, rising in the centre. Fig. 23 shows the pistil of snapdragon. In Fig. 20 are seen the pistils of the mallow rising in the midst of the round bodies, which are the anthers. In Fig. 21 is seen the pistil of the papilionaceous tribe (*a*) partly enclosed in the case formed by the united filaments. In Fig. 24 the pistil of the

Fig. 24.

Fig. 25.

lily is shown. In Fig. 25 we see the pistil of the grass of Parnassus, the large rounded body in the centre.

152. Examine the *germen* or lower part of the pistil: it will be found that it is hollow, and that it contains a number of small round bodies. These are called *ovules*, from a latin word signifying *eggs*, as these are, in fact, the eggs of the plant, from which the new plants are to arise, and the growth and perfection of which is the ultimate object of the compli-

cated apparatus we have been describing. These are seen in Fig. 26, in the centre

153. This figure is a representation of a horizontal section of a flower, giving a general view of the relative situation of the different parts. The external thick black lines represent the *calyx;* the open lines within—the corolla; next are seen the stamens; lastly, in the centre is seen the germen, consisting of several cells, with the ovules in the narrow and inner end of each cell, in the centre. This, in general, is the position of the ovules. There is generally a relation in the number of the different parts of the flower, as seen in the figure.

Fig. 26.

154. Each cell resembles a leaf folded so that it is united at the edges, these edges being in the very centre of the flower, and the ovules being developed at the inner edges, one row along each margin. This arrangement of the ovules is well seen in digitalis, in which there are two cells, in tulip, iris, lily, hyacinth, in which there are three cells in each germen; and in the pea, and common celandine, in which there is only one cell in the germen. The cell being analogous to a folded leaf, the ovules resemble buds, which are found growing at the margins of some leaves, as the Bryophyllum calycinum, and Malaxis paludosa.

155. In all flowers the ovules occupy the centre, carefully protected by the germen or case which

surrounds them. These ovules are various in number in different plants. In each flower in the compound of syngenesious tribe (par. 149) there is only one ovule —in the germen of the labiate tribe there are only four ovules. Most plants have a number of ovules in the germen, as the poppy.

156. It is an opinion now generally entertained by Botanists, that all the parts of the flower are formed from leaves, modified by folding, adhesion, abortion (deficient growth at some part), and increased development at other parts. The flower is considered to consist of a series of whorls (circular rows) of these modified leaves, the calyx being the outer whorl —the cells of the germen the inner whorl. The parts of each whorl are *alternate* with the parts of the adjoining external and internal whorl—that is, the middle of each part is opposite to the edges of the corresponding parts in the adjoining whorls. See Fig. 26.

157. The above view of the origin of the parts of the flower (154 and 156) is supported by examination of the flower in its earliest stage; by a general resemblance in structure between the leaf and the calyx and corolla; by the form of the *bracts*, or floral leaves, situated between the leaves and the flower, and intermediate between them in form; by the readiness with which, as in double flowers, the stamens and pistils become petals; by the resemblance between petals and sepals (134) which in many cases are hardly different, as in the lily tribe, the tulip, the hyacinth, and many other flowers, and which pass gradually into each other in some plants, as the paeony rose,

and others of the Ranunculus tribe; and by the strong analogy between leaves and sepals, the latter of which are found growing into leaves, as in roses, water avens, &c. the sepals of which are often expanded and divided into leaflets, like the regular leaves of the plant. This view of the flower was first developed by the German poet, GOETHE.

IX. FRUIT AND SEED.

158. A month or two afterwards, on looking at the same flower, a great change will be perceived; the corolla has decayed and disappeared, or at least is so shrunk and withered that it can hardly be recognised; the calyx perhaps remains, forming a protection to the germen, but not so fresh and full; the stamens have faded away, and the style and stigma have fallen off. These, having performed their parts, decay and fall off. Sometimes the remains of the withered corolla adhere for a while, as may be seen in the gooseberry and apple. Nothing is left but the *germen*, enlarged, *and its contents, grown into seeds;* and it is the enlarged germen which is generally called the fruit, as in the apple, gooseberry, or orange. The term *pericarp* is applied to the enlarged seed-case.

159. These pericarps or seed-vessels are of very various forms. The figures below illustrate some of the leading varieties, and in some of them is seen also the manner in which they dehisce (open) to let out the seeds. In some seeds, as those of the

syngenesious tribe, the pericarp remains, a covering to the seed, and descends to the ground along with it.

Fig. 27.

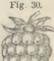
Fig. 28.

Fig. 29.

160. Fig. 27 shows the seed-vessel of the hazel (*corylus*). Fig. 28 shows the fruit of the cherry (*prunus*), the pericarp being soft and juicy externally, while the seed is closely enveloped by a hard bony shell, commonly called a *stone*. The fruit of the apple and pear tribe is shown in Fig. 29, the ovary being enlarged and thickened, and very fleshy, containing five cells, each cell having two seeds.

161. In general the soft and juicy fruits which are eaten are the enlarged ovaries. In some cases, however, this is not the case, as in the strawberry (*Fragaria*), Fig. 30, in which the sweet fleshy part which is eaten is not the germen, but an enlargement of the part on which the germens are placed. The little yellow hard bodies on the outer surface of the fruit of the strawberry are the pericarps (enlarged germens), quite external to the juicy substance.

Fig. 30.



162. The figures below will illustrate the opening (dehiscence) of the pericarp to let out the seed. Fig. 31 shows the thin dry pericarp (called a capsule) of catchfly

(*lychnis*). This dehisces by the folding back of the teeth which close it in the early stage. The dehiscence of the capsule is very distinctly seen in fox-glove (*Digitalis*), and poppy (*Papaver*), the former of which splits up longitudinally at several points, while the latter dehisces by pores at the upper part. In Fig. 32 is seen the pod of the pea, a pericarp of one cell, which splits along its two margins into two pieces, and thus allows the seed to escape. The dehiscence is frequently at the situations corresponding to the margins and midrib of the folded leaf, as in the pea, in which dehiscence takes place at both places.

Fig. 31.

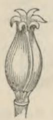
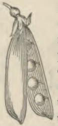


Fig. 32.



163. The two adjoining figures represent the fruit of the cruciferous tribe (par. 137). These plants have two forms of pericarp, the *silicula* or pouch (Fig. 33) and the *siliqua* or long pod (Fig. 34). This is a pericarp of two cells, dehiscing longitudinally into three pieces, the central one being the partition which divides the cavity into two. Wall-flower, stock, and shepherd's purse have pericarps of this structure.

Fig. 33.

Fig. 34.

The Seed

164. The seed is carefully enclosed in several

coverings which protect it: every one knows the coverings of the seed in the pea and bean.

165. The seed consists chiefly of the *embryo*, the rudiment of the young plant, and the *cotyledons* or seed lobes, which contain a store of nourishment ready to supply the young and tender plant in the first stage of its existence, before the roots are formed, and before the plant is sufficiently matured to depend on the root for support.

166. The embryo consists of the *radicle*, which, when the seed germinates, descends and becomes the root, and the GEMMULE or PLUMULE which ascends and gives rise to the stem and leaves. See Figs. 35 and 36, the seed of the bean, the covering being removed; *c c* are the cotyledons (the bean being split up), *a* the *gemmule*, and *b* the *radicle*. In Fig. 36, the gemmule and radicle are shown as they appear after germination has made some progress.

Fig. 35.

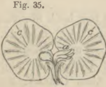


Fig. 36.

167. There are other plants which, having their seeds formed by distinct flowers, have only one cotyledon or lobe in the seed. Plants with two cotyledons in the seed are termed *Dicotyledonous*—those with only one cotyledon, *Monocotyledonous.*

The following peculiarities are found in each of these great tribes of Plants:—

DICOTYLEDONS.	MONOCOTYLEDONS.
Stems Exogenous.	Stems Endogenous.
Leaves with their veins or nerves much and irregularly ramified, so that they tear with a ragged edge.	Leaves having paralle veins or nerves, so tha they tear with a straight edge.
Parts of the Flower consist each of 2 or 5 pieces, or some multiple of these—generally 5.	Parts of the Flower consist each of 3 pieces, or some simple multiple of 3.
Distinct Calyx and Corolla.	Calyx and Corolla one—see Tulip or Lily

168. All the figures in this book illustrate Dicotyledonous plants, excepting Figs. 2, 3, and 24. Onion, Tulip, Lily, Hyacinth, Water Plantain, Star of Bethlehem, Imperial Lily, Lily of the Valley, Crocus, Iris, Daffodil, Palm, Aloe, Grasses, Rushes, are examples of the Monocotyledonous structure.

169. There is a class of plants destitute of stamens and pistils, and having simple homogeneous seeds, without radicle, gemmule, and cotyledons. They are called ***Flowerless***, ***Cryptogamic*** (206, 218), ***Acotyledonous*** (without cotyledons) ***Cellular***, and ***Acrogenous*** (46). Mushrooms, Lichens, Mosses, are

examples: and the Ferns, though not cellular, are included in this class, resembling it in other respects.

X. PROPAGATION OF PLANTS.

170. There is a very large assemblage of plants which produce their seeds by stamens and pistils, and they are called *flowering* or *phænogamic* plants. In most cases the stamen and pistil are together (in the same flower), the flower being then called *perfect*.

171. In some plants the stamen and pistil, though on one plant, are not together, as on the oak and the nettle. The flowers are then said to be *monoecious* (par. 216), and in these cases the pollen either falls on the stigma, or is conveyed to it by the wind, or by insects.

172. In other plants, as the willow, the hop, one plant has stamens only, while another has pistils only. The flowers in this case are called *Dioecious*, and the same means serve to convey the pollen as in the last case. A flower with pistils only is called *Pistilliferous;* one with stamens only is called *Antheriferous.*

173. In the flowering tribe of plants the pollen must reach the stigma in order that the ovules may ripen and become seeds, and there are many different ways in which this is brought about.

174. In a great number of cases the flower is erect, the stamens are longer than the style, so that the anthers are above the level of the stigma; and when the cells of the anther open, the ripe pollen neces-

sarily falls upon the stigma. In other cases, where the pistil is longer than the stamens, the flower is inverted or drooping, so that the pollen still falls upon the stigma, (as in the *Fuschia*). In other cases of this kind, where the flower is not drooping but erect, there is a nectary (a honey store) at the bottom of the flower, which attracts insects: these, agitating the stamens as they enter, and receiving a quantity of the pollen on their bodies, necessarily deposit a portion of it on the stigma as they fly out. In many plants, as rue, barberry, rock-rose, pellitory of the wall, kalmia, grass of parnassus, the stamens are formed with an elastic spring, by which they throw the pollen on the stigma, or have a moving power by which they approach the stigma and deposit the pollen upon it. In monoecious plants, the antheriferous flowers generally occupy the upper part, so that the pollen falls upon the other flowers. In these, in dioecious, and indeed in all plants, the wind is a leading agent in bringing the pollen (which is a very light powder) to the stigma. In a dioecious plant which grows under water (*Valisneria spiralis*), the antheriferous flowers become detached, rise to the surfaee, and float about, while the pistilliferous flower, which retains its connection with the plant, has a spiral stalk, which unfolds and lengthens out so as to elevate the flower above the surface of the water—there the two kinds of flowers meet, and insects or the wind apply the pollen to the stigma, an *operation which does not go on effectively under water* Then the stalk of the pistilliferous flower resumes its spiral form and draws the flower under water, there to perfect the seeds. The Utricularia, a plant which grows under water, and has *perfect flowers*, (par. 170), has bladders attached to its roots, which become filled with gaseous matter, so as to cause the plant to ascend to the surface when the pollen is ripe, and effect the application of the pollen in the air. When this is done, the bladders lose their aerial fluid, and the plant again becoming specifically heavier, descends to ripen the seeds.

175. The pollen of the stamens, which falls upon the stigma, being conveyed through the style to the *ovules* in the *germen*, vivifies them, causes in them a new and more vigorous growth, so that they enlarge and grow into *seeds*, bodies which are capable of becoming plants similar to those which produced them.

176. When the seeds are ripe, the seed-case or pericarp opens (*dehisces*) to let them escape. They fall to the ground, and, under the influence of heat, air, and moisture, take root, grow, produce the same kinds of organs, and pass through their various stages of existence in the same way as the plants which produced them.

177. The dehiscence of the pericarp is beautifully seen in willow-herb, violet, broom, and many other well known plants.

178. Most plants produce a considerable number of seeds, and in a great many cases there is some peculiar construction in the pericarp or seed, by which the seeds are not allowed to fall down and accumulate on the spot where they grew, but are scattered and conveyed to a distance (*disseminated*) from the

parent plant. In most plants which do not drop their seeds around themselves, the wind is the leading agent in dispersing the seeds, being often assisted by the great lightness of the seed, by some appendage, such as wings or feathers (as in willow-herb, in dandelion, and thistle, and the rest of the syngenesious tribe) which aid the wind in wafting the seed to a distance, or by the pericarp dehiscing at the upper part and sides, so that the seeds do not fall out, but are shaken or blown out by the wind. In other cases, as in the broom (*Cytisus*), the balsam (*Impatiens*), the Oxalis, there is a mechanical contrivance in the pericarp or seed, which has the effect of a spring, in projecting the seed, when ripe, to a distance from the parent plant.

179. The use of these contrivances for dispersing seeds is obvious. They would choke each other in germinating close together, if they simply fell to the ground, and be thus lost or wasted. When the parent plant remains (as in trees), they would be superfluous at the spot where there is already a plant of the same kind; but by being dispersed, the seeds are cast abroad and get room to germinate—they grow up and fertilize other places, and thus perpetuate the species, and increase the useful products which the plant may yield to the animal creation.

180. Animals are frequently the means of the dispersion of seeds. Rivers and even seas also aid in spreading seeds.

181. New plants arise from three sources. 1st, From seeds, which, when placed in a fit situation,

become new plants, of the same species as that which produced them, though frequently of a different variety.* The commencement of the growth of the seed is called *germination.* 2nd, From buds, which are also capable of producing new plants. In this case, it is always the same variety that is produced. 3d, From slips or branches, which, when treated in a particular manner, are capable of becoming entire and independent plants, when separated from the parent. This is called propagation by slips or layers; and in this case also, we always obtain the same variety. This latter mode might be included along with the second, thus making two principal sources of vegetation—seeds and buds.

Germination.

182. A perfectly formed seed may be considered a young plant, the vital energies of which are in a dormant or latent state, but ready to be excited to action when the appropriate stimuli are applied; and containing a quantity of matter in a state to be easily formed into proper nutriment, and applied to its support before it is able to provide for itself.

183. Seeds possess a large quantity of carbon. This substance, by its antiputrescent qualities and hardness, prevents the seed from undergoing putre-

* Plants are divided into Genera, Species, and Varieties. Each genus includes many species, and each species many varieties. The varieties of any species differ in particulars which are not deemed of much importance, such as colour, size, &c., and a seed always produces a plant of the same genus and species as that of the parent, but frequently of a different variety.

faction, and thus preserves it for a great length of time. All that is necessary for preserving seeds, is, to prevent germination or putrefaction. For this purpose, they must be carefully excluded from the action of heat and moisture, and other chemical agents. Seeds retain their vitality for a very long period—for hundreds, or even thousands of years. Seeds which have been proved to be not less than 1800 years old, have germinated and produced thriving plants; and plants have appeared, on turning up the ground in some situations—the seeds of which are conjectured to have been buried in the soil for a still longer period.

184. Four conditions are necessary for the process of germination,—the presence of water, of heat, and of air, and the exclusion of light.

185. *Water* softens the integuments, and renders them capable of being burst by the swollen embryo; dissolves the nutritive matter contained in the seed, thus reducing it to a fit state for being absorbed for the nutrition of the embryo; conveys in solution nutritive particles from other sources; and furnishes two important ingredients in the composition of vegetables.

186. The *air*, by means of the oxygen which it contains, effects a chemical change on the farina of the seed. The oxygen combines with the carbon, and forms carbonic acid, which escapes; thus the proportion of oxygen and hydrogen being increased by the expulsion of the carbon, the farina is converted into a semi-fluid substance, of a saccharine or mucilaginous

nature, consisting of starch, gum, and sugar, well adapted for the nutrition of the plant in its infant state.

187. *Heat* always promotes chemical combination and decomposition, and thus assists the action of the water in dissolving the hard parts of the seed, and that of the air in its part of the process. Most probably heat also acts as a general stimulus to the absorbents in the seed. Seeds cannot be made to germinate in very cold weather, except by the application of artificial heat. Too great heat also checks germination, and destroys the vitality of the seed.

188. *Light* is unfavourable to germination, because it disposes to an accumulation of carbon in the seed, and a consequent hardening of the parts, or rather prevents the expulsion of carbon, and consequent softening of the parts, which is necessary that they may be taken up and applied to the use of the plant. The seeds of red poppy and charlock remain in the ground and retain their vitality for a long period; hence they are frequent on new banks or newly upturned ground.

189. From the operation of these causes, it will be seen why seeds planted too deeply in the earth do not germinate. The air has not access to them, and therefore, from the want of this important stimulus, they remain torpid. Hence it is that earth newly dug up frequently becomes covered with weeds, the seeds of which soon germinate when exposed to the air.

190. Placing seeds at a certain depth in the earth

excludes them from the access of light which is so injurious to germination; insures a supply of moisture which would not remain with them were they placed at the surface; protects them from the wind, and from the attacks of animals, and enables the roots to take a firm footing in the soil.

191. When germination has commenced, the seed becomes soft, and swells; oxygen is absorbed and carbonic acid disengaged; the particles of the covering of the seed lose their cohesion, and it is burst to make way for the elongation of the embryo; the radicle elongates and descends, often attaining a considerable length before the gemmule has made any progress, and soon exercising its function of absorbing food; the cotyledons expand and become seminal leaves, which afford nourishment to the young plant in the first stages of its existence, by elaborating the sap, and wither when the proper leaves of the plant have unfolded—or remain under the surface, are gradually absorbed, and disappear; the gemmule or first bud gradually unfolds and enlarges; the leaves and stem appear, and we now have a young plant—a living being, able to provide its own sustenance, to elaborate that sustenance, and to apply it to its increase, and to the formation of seeds to perpetuate the species.

192. In the operation of malting, the object is to convert the farina of the seed into sugar. For this purpose the seed is made to germinate, and this process is stopped (by heating) at that point at which it has been found there is the greatest quantity of saccharine matter in the seed. Were germination

allowed to procced further, the saccharine matter would be taken up for the nutrition of the young plant, and its nature completely altered.

Propagation by Buds.

193. Plants are propagated by buds in four different ways. 1, By means of the bulbs which grow at the base of the scales in the bulbous root, as in the Snowdrop or Lily; these bulbs are soon detached from the parent bulb, and become independent plants. 2, By means of the bulbils which grow upon the stem in the axilla of the leaves, as in the Coral-root (*Dentaria bulbifera*), and in the Orange Lily (*Lilium bulbiferum*), or in the place of the flowers, as in the Mountain Garlic (*Allium carinatum*); these become detached, and form new plants. 3, By means of the buds or small bulbs which grow at the margins of the leaves in the *Bryophyllum*, and the Bog Orchis (*Malaxis paludosa*); and, 4, By means of the minute buds or eyes found in the tubercles of various plants, as the potato (*Solanum tuberosum*).

194. In Viviparous Alpine Bistort (*Polygonum Viviparum*) the pistil of the lowermost flowers generally becomes a bulb (bud) which begins to grow and throw out leaves before it falls off, and being detached, strikes root and forms a new plant. The seeds in this plant are seldom ripened. Sheep's Fescue Grass (*Festuca ovina*) frequently produces, in place of the flowers, buds, which fall off as bulbs, and vegetate; this is also the case with Alpine Meadowgrass (*Poa alpina*) and Sand Garlic (*Allium

arenarium). Plants which form buds or bulbs which they throw off, and which then vegetate independently, are called *Viviparous.*

195. All these buds resemble seeds in this, that when detached from the parent, and placed in the earth, they produce new plants. They differ from seeds, in not being formed by flowers; in not being able to preserve their vitality for such a length of time; in not having distinct parts such as radicle, gemmule, and cotyledons, being merely extensions of the substance of the parent; and in always producing the same variety. Hence one advantage of propagating the Potato by buds; we have found a variety well adapted for use as an article of food, and we can ensure its reproduction. If grown from a seed, a very different variety might be produced, which would not have the same nutritious properties. In fact, *plants arising from buds, are regarded as a continuation of the same individual*—hence they in time become exhausted and deteriorated.

Propagation by Slips and Layers.

196. *Propagation by layers* consists in surrounding a young branch with moist earth, in which case it throws out roots, and very soon becomes an independent plant. It is customary to make a small incision at the part placed in the earth, or to pass a ligature round it. This intercepts the descending sap, which, by being accumulated, *excites the latent buds*, and these being developed in the earth, become roots.

197. Sometimes the branch is bent downwards and fastened in the earth, as in the Vine, which is always propagated in this way: and many plants propagate themselves naturally in this way, the stems or branches lying on the earth, and taking root where they come immediately into contact with it, as the Currant-bush and Laurel. At other times the branch is surrounded with earth in its natural position, and detached when it has taken root.

198. *Propagation by Slips* much resembles the preceding mode. The only difference is, that the branch or slip is detached from the parent before being made to put out roots. The slips or cuttings of most trees that have a light white wood, as the Willow, the Ash, or the Poplar, easily take root when placed in the earth; and indeed the Willow is reproduced chiefly in this way. It is difficult to propagate by slips woods which are very dense and contain much resin, as the Fir and Oak.

199. These processes for the propagation of plants are, in many cases, preferred to multiplying by seed. Propagation by slips or layers always produces the same variety as that from which the slip is taken; so that if we have a plant which produces good fruit, by propagation in either of these modes, several may bo raised bearing fruit equally good. The tree is always more speedy in bearing fruit when formed in this way, than when grown from a seed.

200. It is an interesting fact, and one which is turned to good account in the cultivation of fruit trees, that, when the tree is raised in this way, the number of

seeds in the fruit is almost always less than when produced from a seed, so that more of the juices and strength of the plant are expended in perfecting this fruit. The Vine, when raised by seed, has four seeds in each grape; but frequently only two when propagated by layers. The Sugar-cane, which is propagated nearly in a similar manner, bears no seed at all, but the other parts of the plant are richly developed. Thus, also, the seeds of the plants mentioned in par. 194, are rarely ripened; and in common Solomon's Seal (*Convallaria multiflora*), the berries are seldom ripened, the plant increasing much by root. The perpetuation of the individual (195) is thus unfavourable to the production of seed.

XI. VIEW OF THE LINNÆAN METHOD OF ARRANGING PLANTS.

201. The object of the Linnæan Classification of Plants is to enable a beginner, from a few simple characters, to find out, in a work of reference, *the name* of any plant which may be new to him, and thus ascertain its history. It resembles an alphabetical index to a description of plants, which, when we know the name of the plant, informs us in what page we shall find it described. In like manner, when we know one or two characters of a plant, we can find its name and place in the Linnæan System, and thus, in any work containing a description of plants arranged according to this method, get access to an account of it.

202. For this purpose, plants are arranged in divisions, all those in each division possessing some feature in common, which distinguishes them from those in the other divisions; so that, upon looking at a plant, we can easily see to which division it belongs. The plants in each division are arranged in subdivisions or sections, each also possessing some well-marked character, which distinguishes the plants which it includes from those in the other subdivisions, and so on. The first or great divisions are called CLASSES. The plants which each class contains are arranged in divisions called *orders*. These again, are divided into sections, each of which is called a *genus* or family, chiefly characterized by the form of calyx, corolla, and seed-vessel; and lastly, the genus is subdivided into *species*, each distinguished by the form and other appearances of the root, stem, leaves, &c. Every plant has two names, the name of the *genus* (its generic name) and that of the *species* (its specific name) to which it belongs: just as every man has two names—a surname to tell his family, and a christian name to distinguish him from the other members of the same family—the surname being analogous to the generic name of a plant, and the Christian name to its specific name. In naming a plant, the generic name is placed first: thus, Veronica hederifolia (Ivy-leaved speedwell.) Veronica (speedwell), is the generic name, and the specific name, hederifolia (ivy-leaved), is added to distinguish this plant from other kinds of speedwell. See page 18.

203. The mode by which a beginner finds out the

name of a plant is very simple indeed. He has a book containing a description of all known plants. He is supposed to retain in his memory what is the distinguishing feature of each of the classes, and he examines the plant to ascertain which of these features it presents. This being found out, he knows that the plant is one of those included in the corresponding class. There are twenty-four classes—he has fixed it in one of them, and has thus already made some progress. The plants which the class contains are arranged in divisions (called *orders*), each of which, like the classes, possesses some easily discovered and well marked character. He again examines the plant to find to which of these divisions or orders it belongs. This being ascertained, he has now found in which of the twenty-four classes his plant is described, and in which order of the class, the number of plants through which he has to search for it being now reduced very much. On looking at the descriptions of plants belonging to this order, it will be found that these are subdivided in various ways, and by comparing his plant with the characters of the subdivisions, he contracts the boundaries within which the plant is contained, gradually descending from class to order, genus, and species, fixing its genus by comparing the calyx, corolla, and other parts of the flower with those of the plants in the text book in the same class and order, and the species by examining the leaves, stem, root, &c. When he first began his inquiry, as far as he knew, the plant might be *any one* in his text-book—the first step showed him that it was one out of a certain number; the next step reduced the number, and so on.

204. This is a general view, then, of the method for discovering the name of a plant, and such is the beauty and wonderful simplicity of the Linnæan Method, that, though developed about one hundred years ago, and at a time when our knowledge of plants was very imperfect, it is still decidedly the best (and indeed the only system) for the beginner. We shall now explain it in detail.

205. In this arrangement there are 24 classes. The first 23 include the FLOWERING OF PHÆNOGAMIC plants. They have, in general, a calyx and corolla, and produce their seeds by stamens and pistils. And these seeds consist of the distinct parts mentioned in 165–6.

206. The 24th class consists of the FLOWERLESS or CRYPTOGAMIC plants (par. 169), destitute of calyx, corolla, stamens, and pistils.

207. The leading or diagnostic character of the first eleven classes is taken from the NUMBER OF THE STAMENS; and the names applied to them, as well as to all the classes and orders in the Linnæan system, are compounded of two Greek words, so as to express precisely the peculiar character of each.

208. The first class, MONANDRIA, includes those plants which have but one stamen in each flower, and the term is made up from the Greek words *monos* (one) and *aner* (applied to the stamen); and all the other names are formed in a similar manner.

209. The termination *andria* is used where the word *stamen* or *stamens* is meant to be expressed.

210. And the following Greek names for numbers are used for the first eleven classes, and in one or two other cases. *Monos* (one), *di* (two), *treis* (three), *tetras* (four), *pente* (five), *hex* (six), *hepta* (seven), *okto* (eight), *ennea* (nine), *deka* (ten), *dodeka* (twelve).

I. Monandria, with *one* stamen. Mare's Tail (Hippuris).

II. Diandria. *Two* stamens. Speedwell (Veronica).

III. Triandria. *Three* stamens. Crocus. Iris. Grasses.

IV. Tetrandria. *Four* stamens. Holly (Ilex) Woodruff (Asperula). See Fig. 10.

V. Pentandria. *Five* stamens. See Fig. 6.

VI. Hexandria. *Six* stamens. Tulip. Lily.

VII. Heptandria. *Seven* stamens. Horse chesnut (Æsculus).

VIII. Octandria. *Eight* stamens. Maple (Acer), Heath (Erica), Evening-primrose (Œnothera).

IX. Enneandria. *Nine* stamens. Flowering-rush, (Butomus), Laurel (Laurus).

X. Decandria. *Ten* stamens. Saxifrage, Pink (Dianthus), Catchfly (Lychnis). See Fig. 1.

XI. Dodecandria. *Eleven to Nineteen* stamens. House leek (Sempervivum), Rocket and Mignonette (Reseda).

211. The next two classes are characterized partly by the situation, and partly by the number of the stamens, a new character (situation) being here taken into account.

XII. Icosandria. *Twenty or more* stamens, *inserted upon the calyx.* See Figs. 7 and 18. Haw thorn (Cratægus), Rose, Apple (Pyrus), Bramble (Rubus).

XIII. Polyandria. *Twenty or more* stamens inserted upon the receptacle, that is, arising from under the germen.* Poppy, Larkspur (Delphinium), Ranunculus, Anemone.

212. In the next two classes the stamens are of the same number as in two of the previous classes, (tetrandria and hexandria), but they *are of unequal length in each flower*, hence the names *di* (two), *dynamia* (superior), *tetra* (four), *dynamia* (superior), from the Greek numerals already explained, and the Greek word *dunamis*, power.

XIV. Didynamia. *Four* stamens, of which *two* are longer than the other two. See Figs. 12 and 19. Foxglove (Digitalis), Snap-dragon (Antirrhinum), Lavender (Lavandula), and all the flowers mentioned in par. 136.

XV. Tetradynamia. *Six* stamens, *four* being longer than the other *two*. Wall-flower (Cheiranthus), Stock (Matthiola). This is the cruciform tribe. See par. 137.

213. In the next three classes a new character is introduced—the union of the stamens by the filaments, expressed by the termination *delphia*, derived from the Greek word *adelphos*, a brother.

XVI. Monadelphia. Stamens united in *one* fasci-

* The names of those two classes do not express their peculiar character so precisely as could be wished: they are from *eikosi* (twenty), and *polus* (many). In both cases there are twenty or more stamens. The situation constitutes the distinction.

culus or tube. Geranium, Mallow (Malva). See Fig. 20.

XVII. Diadelphia. Stamens united in two fasciculi. See Fig. 21. Clover (Trifolium), Pea (Pisum), Broom (Spartium), Laburnum. This is the *papilionaceous* tribe (138.)

XVIII. Polyadelphia. Stamens in three or more fasciculi. St. John's Wort (Hypericum).

214. The next class includes those plants described in par. 149, and is named from two Greek words, *sun* (together), and *genesis* (growth or generation), intended to indicate the union of the anthers. The term *synantheræ* (anthers together) would be more expressive.

XIX. Syngenesia. Stamens united by the anthers (filaments are free, arising from the tube of the corolla.) Daisy (Bellis), Sun-flower (Helianthus), Dandelion (Leontodon), Thistle, Ragweed, Sow-thistle, China-aster.

215. The next class embraces a tribe of plants in which the anther is united with the style of the pistil, and hence called *Gynandria*, from the Greek words *gune* (applied in botany to the style) and *aner* already explained.

XX. Gynandria. Anther and style united. Orchis, Lady's Slipper (Cypripedium).

216. In the next two classes, the stamens and pistils are not found in the same flower (171–2). The names of the 21st and 22d classes are from the numerals already explained, and the Greek word *oikesis*, (a dwelling). In Monoecia (*monos* one, and

oikesis), the stamens and pistils, though apart from each other, are on one plant (*one* dwelling). Iu Dioecia (*di* two, and *oikesis*), they are on two separate plants (dwellings).

XXI. Monoecia. Each plant in this class bears both antheriferous and pistilliferous (172) flowers. Bur-reed (Sparganium), Oak (Quercus), Nettle (Urtica), Beech (Betula).

XXII. Dioecia. Each plant in this class has antheriferous flowers only, or pistilliferous flowers only. Willow (Salix), Misletoe (Viscum), Hop (Humulus), Poplar (Populus).

217. XXIII. Polygamia. This class embraces those kinds which have on one plant *antheriferous*, *pistilliferous*, and *perfect* flowers, or only one or two of these kinds. Fig (Ficus), Atriplex.

218. XXIV. Cryptogamia. Flowerless Plants. Plants which do not produce their seeds by stamens and pistils. Mosses, Ferns, Lichens, Mushrooms, Sea-weeds. The names of the two latter classes are from the Greek words *gamos*, applied in botany to express the manner in which the seeds are produced, *polus* (many), and *kruptos* (hid or concealed).

The Orders.

219. In the first thirteen classes the orders or subdivisions depend on the number of the styles or distinct stigmas. They are as follows: the termination *gynia* being from the Greek word *gune*, applied to the style.

Monogynia,...... 1 style.	Heptagynia,..... 7 styles.
Digynia,......... 2 styles.	Octogynia,...... 8 —
Trigynia,......... 3 —	Enneagynia, ... 9 —
Tetragynia,...... 4 —	Decagynia, ... 10 —
Pentagynia,..... 5 —	Dodecagynia,. 12 —
Hexagynia,...... 6 —	Polygynia, ...many —

The whole of these orders do not occur in each class; sometimes only two or three.

220. In the 14th class, Didynamia, there are two orders:

1. *Gymnospermia*, in which there are four naked seeds (ovarv thin, deeply 4-lobed), from the Greek words *gumnos* (naked) and *sperma* (seed) See the seed of Lavender, Fig. 12, Dead-nettle (Lamium). This is the *Labiate* tribe (136).

2. *Angiospermia*, in which the seeds are enclosed in a distinct seed-vessel or ovary, from *aggos* (a vessel), and *sperma* (seed). Fox-glove, Snap-dragon. See the seed-vessel of Snap-dragon in Fig 23.

221. In the 15th class, Tetradynamia, there are two orders:

1. *Siliculosa*, with the seed-vessel a *silicula*, pouch, or short pod. Shepherd's purse (Capsella). See Fig. 33.

2. *Siliquosa*, with the seed-vessel a *siliqua*, or long pod. Wall-flower (Cheiranthus). See Fig. 34.

222. In the 16th, 17th, and 18th classes, Monadelphia, Diadelphia, and Polyadelphia, the orders are determined by the *number of the stamens*, the same characters as the first 13 classes.

223. In the 19th class, Syngenesia, there are five orders.

1 *Polygamia Æqualis.* Here all the florets are perfect, each having stamens and an ovary bearing seed. Dandelion (Leontodon), Thistle (Cnicus).

2. *Polygamia superflua.* Here the central florets are provided with stamens and pistil, while those at the margin have only a pistil, both bearing seed. Daisy (Bellis).

3. *Polygamia frustranea.* Here the central florets have both stamens and pistil, those at the margin have neither stamens nor pistil, or an abortive pistil (neuter). Blue-bottle (Centaurea).

4. *Polygamia Necessaria.* Here the central florets have only stamens, those at the margin only pistils. Marygold (Calendula).

5. *Polygamia Segregata.* In this order the common calyx or involucre encloses several smaller calyces or cups, which separate and surround the florets. Globe-thistle (Echinops).

224. In the 20th, 21st, and 22d classes, Gynandria, Monoecia, and Dioecia, the orders are founded on the characters of several of the preceding classes, generally on the number of the stamens.

225. In the 23d class, Polygamia, there are three orders:—1. *Monoecia.* 2. *Dioecia.* 3. *Trioecia.*

226. In the 24th class, Cryptogamia, the orders have been modified since the time of Linnæus: see the Tabular view, page 99.

227. It will be seen from the foregoing account of the Linnæan system, that the leading divisions, *the classes*, are themselves arranged in sets, being determined by a variety of characters.

228. First, there are two great divisions, FLOWERING PLANTS (with stamens and pistils), and FLOWERLESS PLANTS (without stamens and pistils). The first 23 classes include the Flowering plants, the 24th the Flowerless.

229. The *twenty-three classes* of Flowering plants are divided into *two sets,—three classes* (21st, 22d, and 23d) which have the stamens and pistils separate from each other; and *twenty classes* (1st to 20th) in which the stamens and pistils are together.

230. These *twenty classes* are also in *two sets,— one class* (the 20th) having the anther and style *united*, while in the other *nineteen classes* these organs are separate.

231. These *nineteen classes* are in *two sets,—four classes*, (16th, 17th, 18th, 19th) in which the stamens are united to each other, and *fifteen classes* (1st to 15th) in which they are separate.

232. The *four classes* in which the stamens are united are in two divisions,—*one class* (19th) in which the stamens are joined by the anthers, the filaments being free, and *three classes* (16th, 17th, 18th) in which the stamens are joined by the filaments, the anthers being free.

233. The *fifteen classes* in which the stamens are separate from each other are in two sets, *two classes* (14th and 15th) in which the stamens are of unequal length in each flower; and *thirteen classes* in which the stamens in each flower are equal in length, or, at least, there is no very marked difference.

234. These *thirteen classes* are in two sets—*eleven*

classes (1st to 11th) in which the number of the stamens in each flower is *less than twenty*, and *two classes* (12th and 13th) in which the number of stamens in each flower is *more than twenty*.

235. In these *two classes* the situation of the stamens is taken into account in determining the class; the stamens being placed upon the calyx in the 12th class, upon the *receptacle* (under the ovary) in the 13th class.

236. The first *eleven classes* are distinguished from each other solely by the number of the stamens.

237. Thus, in determining the Linnæan class of a plant, the student examines it to see, *first*, if it have or have not stamens and pistils; if it have these organs, he, *secondly*, looks if the stamens and pistils are in the same flower, or separate; if they are together, he, *thirdly*, looks if the stamens and pistil are free or united to each other; if free, he looks, in the *fourth* place if the stamens are united to each other or separate; and so on, as will be understood from the arrangement of the classes in brackets in the following tabular view of the Linnæan system.

					CLASSES.
STAMENS AND PISTILS PRESENT.	FLOWERS have both STAMENS and PISTILS.	*Stamens distinct from the pistil.*	Stamens distinct from each other.	1 stamen, . .	1. MONANDRIA, ...
				2 stamens, . .	2. DIANDRIA, ...
				3 ——— . .	3. TRIANDRIA,.......
				4 ——— . .	4. TETRANDRIA, ...
				5 ——— . .	5. PENTANDRIA, ...
				6 ——— . .	6. HEXANDRIA,......
				7 ——— . .	7. HEPTANDRIA,....
				8 ——— . .	8. OCTANDRIA,......
				9 ——— . .	9. ENNEANDRIA,....
				10 ——— . .	10. DECANDRIA,......
				11 to 19 . .	11. DODECANDRIA, ..
				20 or more on the calyx,	12. ICOSANDRIA,......
				——— receptacle,	13. POLYANDRIA, ...
				2 long and 2 short,	14. DIDYNAMIA,......
				4 long and 2 short,	15. TETRADYNAMIA,
			Stamens united to each other. By the filaments.	In 1 fasciculus,	16. MONADELPHIA,..
				In 2 fasciculi,	17. DIADELPHIA,.....
				In several do.	18. POLYADELPHIA,
				By the anthers, .	19. SYNGENESIA,....
		Stamens united to the pistil, .			20. GYNANDRIA,......
	FLOWERS have STAMENS only, or PISTILS only	Both kinds of flowers on each plant,			21. MONŒCIA,........
		One kind of flower on each plant,			22. DIŒCIA,...........
		Perfect flowers, or with stamens only, or pistils only, on the same or on different plants,			23. POLYGAMIA,......
STAMENS and PISTILS ABSENT OR NOT VISIBLE,					24. CRYPTOGAMIA,.

ORDERS.

1. Monogynia, Digynia.
2. Monogynia, Digynia, Trigynia.
3. Monogynia, Digynia, Trigynia.
4. Monogynia, Digynia, Tetragynia.
5. Monogynia, Digynia, Tri-, Tetra-, Penta-, Hexa-, Poly-gynia.
6. Monogynia, Digynia, Trigynia, Tetra-, Hexa-, Poly-gynia.
7. Monogynia, Digynia, Tetragynia, Heptagynia.
8. Monogynia, Digynia, Trigynia, Tetragynia.
9. Monogynia, Trigynia, Hexagynia.
10. Monogynia, Digynia, Trigynia, Pentagynia, Decagynia.
11. Monogynia, Digynia, Tri-, Tetra-, Penta-gynia, Dodecagynia
12. Monogynia, Digynia, Pentagynia, Polygynia.
13. Monogynia, Digynia, Tri-, Tetra-, Penta-, Hexa-, Poly-gynia.
14.
    1. Gymnospermia, seeds naked.
    2. Angiospermia, seeds in a seed-vessel.
15.
    1. Siliculosa, pericarp a silicula, or short and round pod.
    2. Siliquosa, pericarp a siliqua, or long and narrow pod.
16. Triandria, Pentandria, Hept-, Oct-, Dec-, Dodec-, Poly-andria.
17. Pentandria, Hexandria, Octandria, Decandria.
18. Decandria, Dodecandria, Icosandria, Polyandria.
19.
    1. Polygamia Æqualis, all the florets perfect.
    2. P. Superflua, florets of the disk perfect, ray with pistils only.
    3. P. Frustranea, florets of the disk perfect, of the ray having neither stamens nor pistils.
    4. P. Necessaria; florets of disk, stamens only; of ray, pistils only
    5. P. Segregata, each floret with a separate flower-cup, or calyx.
20. Monandria, Diandria, Hexandria.
21. Monandria, Diandria, Triandria, Tetrandria, Pentandria, Hex-, Poly-andria, Monadelphia, Syngenesia, Gynandria.
22. Monandria, to Dodecandria, Poly-, Gyn-andria, Monadelphia.
23. Monœcia, Diœcia, Triœcia.
24. Fungi, Lichenes, Algæ, Characeæ, Hepaticæ, Musci, Marsileaceæ, Lycopodiaceæ, Filices, Equisetaceæ.

XII. NATURAL SYSTEM FOR THE CLASSIFICATION OF PLANTS

238. There is another way of arranging plants called the *Natural System*, or *Method* of *Natural Families*—the only system entitled to the name of a CLASSIFICATION. The principles of this system were first developed in 1789, in a work entitled *Genera Plantarum*, by a celebrated French Botanist, ANTOINE LAURENT DE JUSSIEU.

239. In this arrangement those plants are grouped together which have the greatest number of points of resemblance in structure—the greatest number of characters in common; thus differing from the Linnæan or Artificial System, which selects only one character, and groups together plants which are similar in that point, however dissimilar in other respects. An example will best explain the difference.

240. Sage (*Salvia*) evidently belongs to the Labiate tribe (136). It has all the characters which distinguish that tribe except one. It has the corolla of one piece and with a gaping mouth, the calyx two-lipped, the seeds four, the leaves opposite and corrugated, the stem quadrangular, and the plant presents the same aromatic properties which characterise the Labiate tribe. For these reasons, in a system where plants are arranged according to their natural affinities, Sage is included in the order *Labiatae*; but it has only *two* stamens, while the generality of the Labiatae have *four*; therefore, in the Linnæan system, where the situation of plants is determined

by that one character, the number of the stamens—Sage is placed in DIANDRIA, far removed from its allies, the rest of the Labiatae in DIDYNAMIA, and classed, and in the same order with Duckweed (*Lemna*) and the Ash (*Fraxinus*), which have just about as much resemblance to Sage and to each other, as a horse to a serpent, or a bird to a fish. In like manner, Lady's Mantle (*Alchemilla*), a rosaceous plant (135) in all its more important characters and properties, is removed from the rosaceous tribe in ICOSANDRIA, and placed far away in TETRANDRIA, because its stamens are only four.

241. Now, the Linnæan method is admirable for the purpose for which it was intended (201)—for assisting the *beginner* in learning the *names* of plants. But it is of no other use, and that use is only as an introduction to the *study of plants:* it conveys little knowledge of the structure and none of the properties of plants.

242. The Natural System, however, has higher pretensions. The plants in each Order (Family) are united there, because they have more points of resemblance with each other, than with any other plants. The order implies a *number* of characters, and hence, when the characters of an order are known, much valuable information is already acquired regarding all the plants whose names are under that order—with respect both to their structure, and their properties; for it is found that plants similar in many points of structure, have also many properties in common.

243. Cruciform, Rosaceous, Labiate, Papilionaceous,

Umbellate plants (with the Flower-stalks radiating from a central point—as, Hemlock) illustrate natural Families. Few are so clearly defined as these; but in all there are affinities, more or less marked and numerous, which serve to unite the plants in each Family. And, not only are the plants likest to each other joined in one family—the Families are arranged so that the adjoining ones are always the most similar, and are divided into classes: these are divided into sets, and arranged so that the adjacent classes are the most nearly related. In pars. 167-8-9 will be seen the great and primary natural divisions of plants. Thus when we know the situation of a Family in a natural scheme—we already know some leading points in the structure of the plants of that Family.

244. The Natural System is the Grammar of Botany, and the natural arrangement of plants may be compared to the classification of words, as nouns, adjectives, verbs, &c., these into subdivisions, as verbs into tenses—these into moods, and so on. And it is called "Natural," because it endeavours to follow the analogies and differences chalked out by nature, which has grouped vegetables, as well as animals, in Families, differing from each other in several particulars, but in each of which families, all the species agree in many important external characters, and, more or less, in their internal structure and properties.

245. Linnæus himself was sensible that the perfection of the natural method was the great end of Botanical science, and he published what he called *Fragments of a Natural Method.* There were not

materials, however, in his time, for establishing the proper distinctive characters, and collecting the Families into a system. He observes, however, that the natural system is no chimera, as all plants, of what order soever, show an affinity to others; and hence, if this affinity, or the links of this natural chain could once be made out and connected, not only the virtues of a great number of species may be ascertained, but we may know with certainty how to find a proper succedaneum for plants which cannot easily be had. Jussieu brought to light this chain, the existence of which Linnæus had wished for and anticipated, while succeeding botanists, Brown, Decandolle, and others, have done much towards bringing the extremities of it into sight, rendering our view of some obscure parts more clear, and demonstrating the complete connection of the various links. This natural system of classification, which is now begining to be studied in this country, we may probably take another opportunity of developing more fully. With the preceding brief sketch of its nature and objects, we here conclude the *Science of Botany.*

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