vary exceedingly; but the following are the most common:—*A raceme* is when numerous flowers are produced on an elongated simple rachis, each flower having a separate pedicel, as in the laburnum; a *thyrse* is a raceme with branched pedicels, as in the lilac; a *panicle* is a loose thyrse, with flowers on long pedicels, as in the oat; a *spike* has its flowers sessile—that is, without pedicels, on an elongated simple rachis, as in the veronica, or speed-well; a *spadix* is a spike with a thick fleshy rachis, on which the flowers grow all round, and as closely together as possible,

Fig. 58.—Raceme, Spike, Umbel, and Cyme.

as in the arum; an *amentum*, or catkin, is a spike, the flowers of which have bracts instead of floral envelopes, and the rachis of which is articulated, so as to fall when it withers, as in the walnut and the poplar; a *head* of flowers has a great many sessile florets attached to a flat or globular fleshy axis, called a receptacle, which is surrounded by an involucre, as in the daisy; an *umbel* is a head with the florets on pedicels, and the axis not fleshy, as in the parsley; a *compound umbel* has several small umbels on branched pedicels springing from a common axis; a *corymb* has some of the pedicels of the flowers longer than others, so that the flowers form a flat head, as in the yarrow; a *cyme* has the pedicels of the same length, so as to form a round

150. Explain the technicals.

head, as in the elder; and a *fascicle*, or bundle, as in the Sweet William, is a kind of compound cyme.

144. *The modes of expansion* are the different ways in which clusters of flowers open. When a spike is coiled, and unrols as the flowers open—as in the Forget-me-not—the mode of expansion is said to be *gyrate*. When clusters of flowers begin to open first at the base, or in the outer circle, their mode of expansion is said to be *centripetal;* but when the uppermost flowers, or those in the inner circle, open first, their expansion is called *centrifugal*. Sometimes the mode of expansion is irregular, but this is generally when some of the florets are abortive.

145. A FLOWER consists of a pistil, and one or more stamens, having generally one or more coverings called floral envelopes, to protect the stamens and pistil, which are destined for the production of the seed. To understand the appearance of these parts, we need only take a rose, the green covering of the bud of which is called the *calyx*, and the pink part the *corolla*. These are the two floral

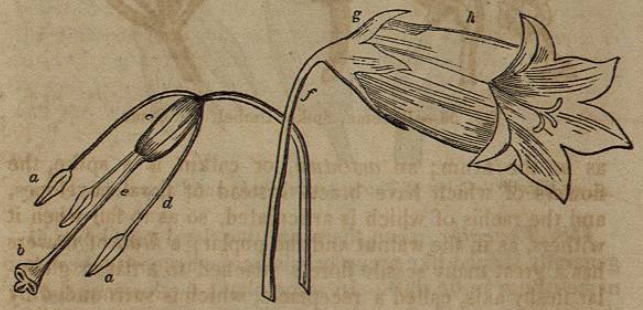

Fig. 59.—*a a*, Stamens; *b*, Stigma, or Summit; *c*, Ovary, or Seed-Bag; *d*, Filament; *e*, the Style; *f*, Peduncle; *g*, Calyx; *h*, Corolla.

envelopes. When the rose opens, it displays in the centre of its coralla a bunch of yellow thread-like substances, which are the *stamens*, and in the middle of them, though

151. Differences in mode of expansion.
152. Analyze a flower, and define.

scarcely to be perceived, is the *pistil.* Other flowers have the same parts, as shown in fig. 59.

146. *When there are two floral envelopes*, the outer one is called the *calyx*, and the inner one the *corolla;* but when there is only one, it is called the calyx. When the calyx and corolla are so mixed as to be scarcely distinguishable from each other, as in the tulip, the floral envelope is called the *perianth;* and this term is sometimes applied to the calyx and corolla, when not confounded together. When there is no floral envelope, flowers are said to be *apetalous.*

147. *The divisions of the calyx* are called *sepals*, and those of the corolla *petals;* when the calyx and corolla are confounded together, the divisions of the floral envelope are called the *segments* of the perianth. When the divisions of the corolla adhere at the margins, so as to appear united, the flower is said to be *monopetalous.*

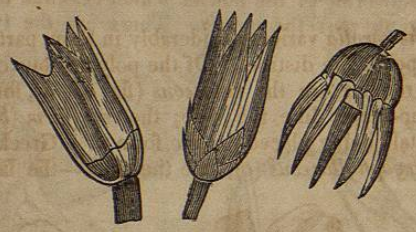

Fig. 60.—Calyx of Thorn Apple, Pink, and Campanula.

148. *The calyx*, when there are two floral envelopes, is generally shaped like a cup or chalice, whence it takes its name (see *g* in fig. 59). In some plants the lower part of the calyx is united into a tube, and the upper part only is divided; when this is the case, the upper part is called the *limb.* The limb of the calyx is generally said to be divided into *lobes*, or segments; but in some of the Compositæ, it is cut into a kind of fringe called *pappus*, as exhibited in the thistle, it being the part which crowns the seeds or

153. Varieties in flowers.
154. Define all the technicals.

rather pericarps, of that plant, and by means of which they are dispersed by the winds.

149. *When there is only one floral envelope*, the calyx generally takes an irregular form; and this is also the case where the petals are less conspicuous than the sepals. In the larkspur, for example, the calyx takes a *calcarate*, or spur shape; and in the monkshood, a *galeate*, or helmet shape.

Fig. 61.—Caryophyllaceous (*c*), Rosaceous (*a*), Cruciform (*b*).

150. *The corolla* varies considerably in form, particularly when the petals are distinct. Of the polypetalous corollas, the most regular are the *rosaceous* (fig. 61, *a*), forming a kind of cup-shape, like the rose; the *cruciform* (*b*), from its four petals being placed in the form of a Greek cross; and the *caryophyllaceous* (*c*), like the pink—the latter be-

Fig. 62.—Nectiferous Spurred (*b*), Lilaceous (*a*), Papilionaceous (*c*).

ing remarkable for its petals, which have a very long *unguis*, or claw, enclosed in the calyx, and a broad spreading limb

155. Names of diversified forms.

above it. The other most interesting forms of this kind of corolla, are the *lilaceous* (fig. 62, *a*), like the common lily; the *nectiferous spurred* (*b*); and the *papilionaceous* (*c*), so called from its resemblance to a butterfly. The latter corolla consists of five petals, the largest of which stands erect, and is called the *vexillum*, or standard; two smaller ones below are called the *alæ*, or wings; and the lower two,

Fig. 63.—Campanulate (*b*), Hypocratiform (*c*), Rotate (*a*).

which are united in the form of a boat, are called the *carina*, or keel. There are many other curious forms of corollas, such as those of the *calceolarias*, the *orchidaceæ*, the *aristolochias*, &c. Of the *monopetalous* corolla, there are seldom more than six regular forms; namely, *rotate* (fig. 63, *a*), or wheel-shaped, like the mezereum; *campanulate* (*b*), or bell-shaped, like the campanula; *hypocratiform* (*c*), or

Fig. 64.—Personate (*b*), Infundibuliform (*a*), Ringent (*c*).

salver-shaped, like the auricula; *infundibuliform* (fig. 64, *a*), or funnel-shaped, like the convolvulus; *urceolate*, or pitcher-shaped, like the arbutus; and *tubular*, like the blue

gentian. Of the irregular forms, the principal are the *personate* (*b* in fig. 64), or masked, like the snap dragon; the

Fig. 65.—Different Forms of Stamens.

ringent (*c*), or gaping, like the sage; and the *labiate*, like the thyme—the last two being nearly allied to each other.

151. *The use of the floral envelopes* is solely to protect the stamens and pistil from injury; and thus, though we are in the habit of considering the corolla to be the flower, it may be wanting without injury to the plant; so that a flower may be without petals, or any other floral envelope, the important parts being the stamens and pistil. In the same manner, every seed-vessel is, in the language of botanists, considered a fruit, the botanical use of the fruit being only to serve as a covering for the seed.

152. *The stamens*, when perfect, consist of a stalk or filament (*a*), supporting a roundish or oblong body called the *anther* (*b*), the cells of which are filled with a fine dust called the *pollen* (*c*, see fig. 65). The filaments are generally long and slender, like threads; but they are sometimes broad and leaf-like, as in the water-lily; and sometimes they are wanting. The anthers are of various shapes, but are always hollow, and commonly in two cells, united by a part called the *connective*. When the pollen is ripe, the cells open generally by a kind of slit; but sometimes, as in the barberry, by a valve, which becomes detached at the base, and curls upward. All the heath-tribe have a small hole or pore in the upper part of each cell, through which the pollen rises when it is quite ripe. There are

156. What is the function of the envelope?
157. What of the stamens, anther, and pollen?

three kinds of anthers, namely, *adnate* (*d*), in which the filament is attached to the back of the connective, from one end to the other; *innate* (*e*), in which the filament is inserted in the lower part of the connective; and *versatile* (*f*), when the filament is inserted in the middle of the connective, but so slightly, that the anther moves with every breeze. The connective is sometimes drawn out into one or two spur-like bodies called *appendages*, as in the whortleberry and the violet. The pollen, though to the naked eye apparently only a fine dust, will be found, when examined by a powerful microscope, to consist of a number of curiously formed grains, each of which is filled with fluid. The shape of all the pollen grains of one genus is the same; as, for example, in all the species of the evening primrose, they are triangular; those of the spider wort are cylindrical and curved, and those of the bladder senna are square. Each grain has two distinct coverings, and the fluid which it contains is crowded with a multitude of minute particles all in active motion, and generally quite distinct from each other, though the largest is not more than the five-thousandth part of an inch in length. In most cases the grains of pollen are also quite distinct; but in the evening primrose they are connected by slender threads, and in some other genera they adhere in clusters. In the orchidaceæ and the asclepedaceæ the grains of the pollen form solid and wax-like masses. When the pollen falls upon the

Fig. 66.—Pistils.

158. What varieties of anthers?
159. How is the pollen shaped?
160. Describe the varieties.

stigma, each grain sends down a long slender tube, through which the fluid it contains, and all its minute particles, are carried downwards to the ovary.

153. *The pistil* consists of a hollow part called the *ovary*, or seed-vessel (*a* in fig. 66), which is generally surmounted by a hollow tube called the *style* (*b*), supporting a porous substance termed the *stigma* (*c*), which is not covered by any epidermis. The stigma is of various shapes, and sometimes it is even leafy, as shown in fig. 66 at *d*. It is most commonly, however, divided into several lobes, sometimes called *stigmata*, as shown at *c*. Fig. 67 shows some

Fig. 67—Forms of Pistillum.

remarkable forms of the pistil, one of which has the ovary (*e*) with a very small sessile stigma at the tip, at the extremity of a long stipes or stalk, called a *gynophore*, which looks like a style, the part which looks like an ovary below, at *f*, being the receptacle which bears the stamens. The caper has this kind of pistil. The ovary, when young, will generally be found, if cut open, to be divided into cells by partitions, which are called *dissepiments*, or *septa*; but these partitions frequently disappear altogether, or at least become imperfect in the ripe fruit. In all ovaries there is a kind of string or nerve called the *placenta*, to which the incipient seeds, or ovules, are attached; and which, when it adheres to the sides or walls of the ovary, is called *parietal*; but when it forms a column in the centre, is said to

161. Of what parts does the pistil consist?
162. Define all the technicals italicised.

be *free central.* The ovary is generally sessile, but it is sometimes placed on a short thick stalk, called a *stipe.* When there are several ovaries in one pistil, they are called *carpels.* Enclosed in the ovary are the rudiments of the future seed, which are called *ovules.* When these are first formed they are quite soft; but if closely examined, they will be found to consist of two or more skins with a little pulp inside, each having a very small opening which is imperceptible to the naked eye, called the *foramen.* When the tube of the pollen descends into the ovary, it enters this little opening, and thus the fertilizing fluid is conveyed into the ovule.

154. *The disk* is a solid fleshy part at the base of a flower, which appears to serve as a foundation for the other parts. When the disk supports numerous florets or carpels, it is called a receptacle, as the receptacle of the daisy, the teazel, &c. (*c* in fig. 68). In some plants, the recep-

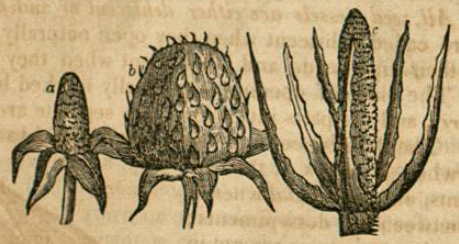

Fig. 68.—Receptacles of Raspberry (*a*); Strawberry (*b*); Teazel (*c*).

tacle becomes detached from the carpels when they ripen, as in the raspberry (*a*), and in others it becomes distended and juicy with the ripe carpels still upon it, as in the strawberry (*b*). In other cases, the receptacle lines the calyx which surrounds the ovary, and becomes the fleshy part of the fruit, as in the apple and pear, the peach, &c.; and sometimes the receptacle, turned inside out, encloses the flowers and seeds, as in the fig.

163. What of the disk, and its variety of function?

155. *Appendages of a flower* are those parts the use and nature of which have not been exactly defined, and which Linnæus called by the general name of *nectaries*, from the fact that most of them secrete the saccharine fluid or honey found in many flowers. Of these appendages or supernumerary parts are the rays of the passion-flower, the trumpet-shaped cup of the narcissus (*b* in fig. 62), the scale at the base of the petals of the butter-cup, the indusium of the Lechenaultia, &c. These appear, however, to be abortive organs; as, for example, the rays of the passion-flower are imperfect stamens, and the corona of the narcissus consists of the filaments of imperfect stamens grown together. This tendency of the parts of a plant to change their form by growing together, is frequently exemplified in the leaves and bracts.

156. A FRUIT, in botanical language, is simply a seed-vessel, which is sometimes enveloped in a hard and dry, and sometimes in a fleshy covering, or *pericarp.*

157. *All seed vessels are either dehiscent or indehiscent.* They are called dehiscent when they open naturally to discharge their ripe seeds, and indehiscent when they do not do so. The place of opening is generally marked by lines or *sutures*, and the parts into which they separate are called *valves.* The dehiscence of a seed-vessel is said to be *septicidal* when it opens at the dissepiments, and *loculicidal* when it opens between the dessepiments; but these last two terms are not in general use.

158. *The most common kinds of seed-vessels* are the following:—The *follicle* (see fig. 69), a dehiscent many-seeded carpel, with one valve and one suture, generally growing two or three together; and the *legume* (*a* in fig. 70), a

Fig. 69.—Follicles.

164. Name the appendages, and their character.
165. Define fruit and pericarp.
166. What seed-vessels are dehiscent and indehiscent?
167. Name the varieties most common.

dehiscent many-seeded carpel, with two valves and two sutures, the placenta bearing the seeds being attached to the *dorsal* or back suture. The *capsule*, which is dehis-

Fig. 70.—A Legume and a Pome.

cent, dry, and many-seeded, is composed of several carpels joined together, which either form one large cell, as in the poppy, or are divided into several cells, by the dissepiments. The *silique*, which is long and narrow, and the *sillicle*, which is short and broad, are formed of two carpels, joined together with a central membranous placenta; they are dehiscent, and open into two valves. The *nut* is dry, bony, one-celled, and indehiscent. Nuts are of various kinds, from the hazel-nut (*c* in fig. 71) to the hard bony seed of

Fig. 71.—Raspberry and Nut.

the rose and cratægus. The seed of the acer, which is a nut, is enclosed in a thin membrane, and called a *samara*, and the acorn is a nut of a peculiar kind, called a *gland*. The loose covering of the filbert, and the cup of the acorn,

168. Define the technicals.

are both different states of the *involucre*. The *achenium* is a dry, bony, indehiscent, one-celled carpel, the pericarp of which drops with the seed, but does not adhere to it; the *caryopsis*, on the contrary, is an indehiscent one-seeded membranous carpel, the covering of which not only drops with the seed, but adheres to it firmly, as in wheat, the covering of which is only separated after grinding in the form of bran. Of the other kinds of seed-vessels, the *pyxis* or *pyxidium*, is a capsule which opens transversely, as in the anagallis; the *etærio* (a term not in common use) is a collection of one-seeded berries adhering together, as in the raspberry (*d*); and the *berry*, when ripe, has numerous loose seeds buried in pulp, the seeds when unripe adhering to *parietal placentas*, as in the gooseberry. The *pome* (*b* in fig. 70) is what is called a kerneled fruit; that is, it consists of two or more cartilaginous or bony carpels, joined together, and enclosing the kernels or seeds; the whole being surrounded by the fleshy lining of the tubular part of the calyx, the leafy limb of which remains on when the fruit is ripe, and is called the *eye*, as in the apple and pear. The *drupe* (see fig. 72) is a stone fruit; that is to say, its seed or kernel is enclosed in a bony nut, called the *endocarp;* over this is the fleshy lining of the calyx, which becomes a juicy pulp, and is called the *sarcocarp;* and this is covered with a thick downy skin, or *epicarp*. It will be observed, that all the fruits hitherto mentioned have each sprung from one flower, part of one of the floral envelopes of which (the calyx) has become the pericarp of the seeds; in the fig, however, a great number of flowers are found in one fruit, which consists of the dilated receptacle of the florets; and in the pine apple and bread fruit, the eatable part consists of the thickened bracts

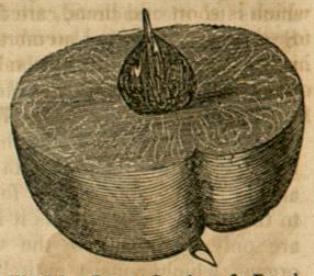

Fig. 72.—Drupe (Section of a Peach)

169. Explain the technicals in italics.

of a number of flowers, which have grown together, and become pulpy.

159. THE SEED contains the *embryo* or germ of the future plant, which is generally surrounded by a nutritious substance termed the *albumen*. The whole seed is covered with a thick skin or outer integument called the *testa*, one end of which has a strongly-marked round scar or *hilum*, which shows where the seed was attached to the placenta. Sometimes the seed is sessile; but at others it has a little *funicle* or footstalk growing out of the hilum, or a thick fleshy skin called an *axil*, by which it hangs to the placenta. Within this testa is a second or inner integument, which is scarcely discernible from the first, and within this is the *nucleus* of the seed, containing the embryo. Near the radicle point of the embryo, and generally at the end opposite to the hilum, is a small opening through both the integuments to the nucleus, called the *microphyle* or *foramen*. Sometimes there is also on the testa, as in the orange, a mark where the skins of the outer and inner integuments join, which is called the *chalaza;* and a kind of nerve, called a *raphe*, which runs from it to the hilum.

160. *The chalaza* marks the point of union between the two membranes of the testa and the nucleus, and it is always exactly opposite the foramen. Sometimes it is close to the hilum, but at others it is distant from it, and the two are only connected by the vessels of the raphe. These organs, which consist entirely of spiral vessels and ducts, without any woody fibre, are sometimes collected into a projecting cord, and sometimes beautifully spread over the testa, as in the seeds of the orange and lemon. In those seeds where the hilum is exactly opposite the foramen, there is no chalaza, and of course no raphe, as the one cannot exist without the other.

161. *The axil* is a fleshy substance, which envelopes the seed, covering the testa. It is only found in some plants;

170. What are the contents of the seed?
171. The analogy between animals and plants in their organs and process of reproduction, and names.
172. Define the italicised words.

as, for example, in the nutmeg, of which it forms the mace; and in the seed of the enonymus, or spindle-tree, in which it is unusually large. It serves as a kind of funicle, and is, in fact, an enlargement of the placenta.

162. *The nucleus* of the ovule consists of a soft pulpy matter, which in the ripe seed becomes changed into the embryo and the albumen; or the embryo only, if there should be no albumen.

163. *The albumen* is the store of nourishment which nature has laid up for the support of the young plant, before its organs are sufficiently matured to allow of its supporting itself. In most cases this matter surrounds the embryo; but sometimes it forms part of the cotyledons, and at others it is wanting altogether. Even where it exists, it varies very much in quantity, sometimes being much smaller than the embryo; while in other cases, as, for example, in the cocoanut, the albumen weighs as many, or more ounces, than the embryo does grains. The albumen varies in quality as much as it does in quantity. It is generally fleshy, as in the pea and bean; but sometimes it is farinaceous or floury, as in the wheat and in the marvel of Peru; at other times it is oily, as in linseed; horny, as in the coffee; or even stony, as in the kind of palm whose seed forms the substance called vegetable ivory. In the nutmeg and the custard apple tribes, it appears to be perforated in every direction by a mass of dry cellular tissue; and an embryo of this kind is said to be *ruminated*.

164. *The outer integument* of the seed consists of two parts, the outer one of which is called the *primine*, and is merely a cellular coating traversed with veins; the inner one, which is called the *secundine*, sometimes adheres so closely to the outer one, that it is difficult to separate them, unless the ovule be examined at a very early period of its growth. The outer of these coverings being intended to protect the seed from injury, is frequently of a hard, bony, or leathery texture, and its surface is generally smooth and polished. Sometimes, however, the surface of the seed is

173. Varieties of albumen.
174. Describe the integuments or membranes.

rough, and it is either winged, or covered with tufts of hair, called *coma*, which are intended by nature to aid in the dispersion of the plant. The seed of plants belonging to the asclepiadaceæ is covered with a fine silky down, and that of the cotton plant with cotton. The seeds of the Black Italian poplars are also buried in a cottony substance. Occasionally the outer integument is furnished with veins, so as to form a kind of network; and in other cases it forms a membranous covering, as in the seed of the orange. The inner membrane is generally white, and so thin, that it looks like a lining to the other. When the ovule first forms, a portion of the inner membrane frequently projects at the foramen, having the appearance of a little cup-shaped stigma, but this part disappears as soon as the pollen tube has entered the foramen. Occasionally there are three coverings to the ovule; but when this is the case, the inner one adheres closely to the pulpy part of the seed. Sometimes there is a protuberance on the testa, called a *caruncle*.

165. *The embryo of an exogenous plant* is said to consist of three parts; the radicle or root, the cotyledons or seed-lobes, and the plumule or ascending shoot; but to these may be added a fourth, the collar or neck. Of these, every embryo must have a radicle and a plumule, with the connecting point or collar between them; but the cotyledons are not so essential; and in some cases—as, for example, in the cyclamen and the dodder—they are wanting altogether. It is generally supposed that every exogenous plant has two cotyledons, and hence these plants are called *dicotyledonous;* but the sycamore has three cotyledons; the forget-me-not, and other plants of the same tribe, four; and the pine and fir-tribe from two to twelve; while in the horse-chestnut and the oak, the cotyledons grow together, so as to appear but one. In other plants—as, for example, in the marvel of Peru—the cotyledons are unequal in size, one being nearly twice as large as the other. The cotyledons of this plant, and those of the sycamore, are strongly veined, like leaves, in the seed; and the latter, which are very long, are curiously wrapped up in the bud.

175. What of the parts of the embryo?

166. *The position of the embryo* in the seed varies in different plants; but the root always points towards the foramen, as the root is the first part that makes its appearance, and it is always through this opening that the young plant emerges from the seed. The little hole that marks the foramen is so very small in the ripe side, that it would escape the attention of any but a botanist; but when there is no chalaza, it is always opposite the hilum, which is generally very conspicuous; and when there is a chalaza, its position is marked by the projecting cord or raphe. The embryo is said to be straight when its radicle points towards the hilum, as in the apple and the pear, the cotyledons of which fill the whole seed, and are enclosed in the broadest end. In other cases the cotyledons point towards the hilum, and when this is the case, there is no raphe, as the chalaza is always close to the hilum. In the primrose tribe, the embryo lies across the seed; and in the convolvulus, it is coiled up in a spiral manner. It is also often

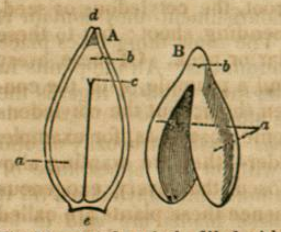

Fig. 73.—Seed entirely filled with the Embryo.

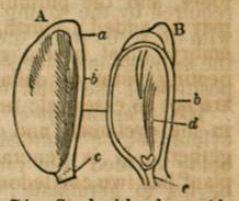

Fig. 74.—Seed with a large Albumen and small Embryo.

curved when the hilum is half way between the foramen and the chalaza. The embryo is always in the same position in every plant of the same genus, and even of the same order. In fig. 73, A shows a seed of the candleberry myrtle, which is entirely filled with the embryo, cut in two. In this *a* is one of the cotyledons, *b* the radicle, and *c* the place between the cotyledons from which the plumule

176. Varied positions of the embryo.