

receptacle; in the Strawberry, on a swollen succulent one (fig. 154); and in the Rose (fig. 155), on a hollow one. When the fruit consists of several rows of carpels, the innermost have their margins directed to the centre, while the margins of the outer rows are arranged on the back of the inner ones. When the carpels are united, as in the Pear, Arbutus, and Chickweed, the pistil becomes syncarpous. The number of carpels in an apocarpous pistil, or the number of separate styles in a syncarpous one, is indicated in the following way:—

A flower with a simple pistil or 1 style	is Monogynous.
2 separate carpels or 2 separate styles	is Digynous.
3 carpels or 3 separate styles	is Trigynous.
4 carpels or 4 separate styles	is Tetragynous.
5 carpels or 5 separate styles	is Pentagynous.
6 carpels or 6 separate styles	is Hexagynous.
7 carpels or 7 separate styles	is Heptagynous.
8 carpels or 8 separate styles	is Octogynous.
9 carpels or 9 separate styles	is Enneagynous.
10 carpels or 10 separate styles	is Decagynous.
12 carpels or 12 separate styles	is Dodecagynous.
a greater number of carpels or styles	is Polygynous.

The union in a syncarpous pistil is not always complete; it may take place by the ovaries alone, while the styles and stigmata remain free, the pistil being then *gamogastrous* (fig. 255), and in this case, when the ovaries form apparently a single body, the organ receives the name of *compound ovary*; or the union may take place by the ovaries and styles, while the stigmata are disunited; or by the stigmata and the summit of the style only. Various intermediate states exist, such as partial union of the ovaries, as in the Rue, where they coalesce at their base; and partial union of the styles, as in Malvaceæ. The union is usually most complete at the base; but in Labiateæ the styles are united throughout their length, and in Apocynaceæ and Asclepiadaceæ the stigmata only. When the union is incomplete, the number of the parts of a compound pistil may be determined by the number of styles and stigmata; when complete, the external venation, the grooves on the surface, and the internal divisions of the ovary, indicate the number. The changes which take place in the pistil by adhesion, degeneration, and abortion, are frequently so great as to obscure its composition, and to lead to anomalies.

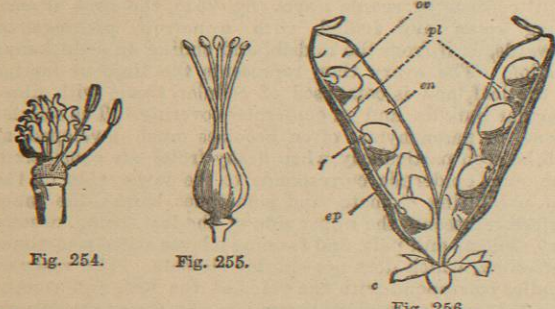


Fig. 254.—Apocarpous compound pistil of Crowfoot (*Ranunculus*), consisting of numerous separate uni-ovular carpels, arranged in spirals. The flower is polygynous. Each carpel consists of ovary, style, and stigma. Two of the stamens are left to show their insertion below the pistil in the thalamus (hypogynous).
Fig. 255.—Syncarpous pistil of Flax (*Linum*). It consists of five carpels, united by their ovaries, while their styles and stigmata are separate. Hence the flower is pentagynous.
Fig. 256.—Pistil of the Pea (*Pisum sativum*) laid open. It consists of a single carpel containing numerous ovules *ov*, which are attached to the placenta *pl*, or ventral suture, in two rows, by means of umbilical cords (funiculi) *f*. The wall of the carpel consists of three layers; the outer, *ep*, corresponding to the lower epidermis of the leaf, the inner, *en*, corresponding to the upper epidermis of the leaf. Between these two layers there is a small amount of cellular tissue like the parenchyma of the leaf. The calyx *c* is persistent. The style and stigma are marked *s*.

The pistil is more liable to changes of this kind than any other part of the flower. The carpels are usually

sessile leaves, but sometimes they are petiolate, and then are elevated above the external whorls. This elevation of the pistil may in general, however, be traced to an elongation of the axis itself, in such a way that the carpels, in place of being dispersed over it, arise only from its summit, and the pistil becomes stipitate, or supported on a stalk called a *gynophore* or *thecophore*, as in the Passion-flower and Dictamnus (fig. 177). Sometimes the axis is produced beyond the ovaries, and the styles become united to it, as in Geraniaceæ (fig. 152) and Umbelliferæ. In this case the prolongation is called a *carpopophore*. A monstrosity often occurs in the Rose (fig. 145) by which the axis is prolonged, and bears the carpels *f* in the form of alternate leaves.

The ovary contains the ovules. These are attached to the *placenta*. This, sometimes called the *trophosperm*, consists of a mass of cellular tissue, through which the vessels pass to the ovule. The placenta is usually formed on the edges of the carpellary leaf (fig. 256), and is then said to be of the *marginal* type. In many cases, however, the placentas are formations from the axis, and are not connected with the carpellary leaves; they are then said to be *axile*. Some restrict the term placenta to the point of attachment of a single ovule, and call the union of placentas, bearing several ovules, *placentaries* or *pistillary cords*. In marginal placentation the part of the carpel bearing the placenta is the *inner* or *ventral suture*, corresponding to the margin of the folded carpellary leaf, while the *outer* or *dorsal suture* corresponds to the midrib of the carpellary leaf. As the placenta is formed on each margin of the carpel it is essentially double. This is seen in cases where the margins of the carpel do not unite, but remain separate, and consequently two placentas are formed in place of one. When the pistil is formed by one carpel the inner margins unite in the axis, and form usually a common marginal placenta. This placenta may extend along the whole margin of the ovary as far as the base of the style (fig. 256), or it may be confined to the base or apex only. When the pistil is composed of several separate carpels, or, in other words, is apocarpous, there are generally separate placentas at each of their margins. In a syncarpous pistil, on the other hand, the carpels are so united that the edges of each of the contiguous ones, by their union, form a *septum*, or *dissepiment*, and the number of these septa consequently indicates the number of carpels in the compound pistil (fig. 257). It is obvious then that each dissepiment

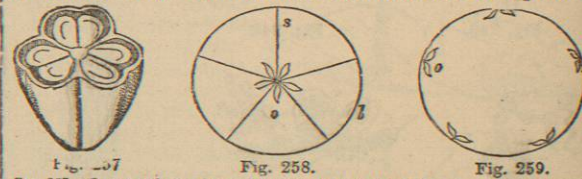


Fig. 257.—Ovary or lower part of the pistil of the Lily (*Lilium*), cut transversely. There are three loculements, indicating the union of three carpels, and the ovary is said to be trilocular. The divisions in the ovary, called septa or dissepiments, are formed by the sides of the carpellary leaves. Each septum is double and the number of septa corresponds with the number of the carpels. The ovules are placed collaterally, in pairs, in each loculement, and are attached to a central placenta, formed by the union of the three ventral sutures.
Fig. 258.—Diagrammatic section of a quincucular or pentahedral ovary, composed of five carpels, the edges of which are folded inwards, and meet in the centre. The ovules *o* are attached to a central placenta, formed by the union of the five ventral sutures. The five partitions, septa, or dissepiments, *s*, are composed of the two sides of contiguous carpels. Dorsal suture, *d*.
Fig. 259.—Diagrammatic section of a quincucular ovary, in which the edges of the carpels, bearing the placentas and ovules *o*, are not folded inwards. The compound ovary is unilocular, and the edges of its carpels are applied to each other in a valvular manner.

is formed by a double wall or two laminae; that the presence of a septum implies the presence of more than one carpel; and that, when carpels are placed side by side, true dissepiments must be vertical, and not horizontal. When the dissepiments extend to the centre or axis, the ovary is

divided into cavities, *cells*, or *loculements*, and it may be *bilocular*, *trilocular* (fig. 257), *quadrilocular*, *quincucular*, or *multilocular*, according as it is formed by two, three, four, five, or many carpels, each carpel corresponding to a single cell or loculement. In these cases the marginal placentas meet in the axis, and unite so as to form a single *central one* (figs. 257, 258), and the ovules appear in the central angle of the loculi, as in Canna, Lily (fig. 257). The number of loculements is equal to that of the dissepiments. When the carpels in a syncarpous pistil do not fold inwards completely so as to meet in the centre, but only partially, so that the dissepiments appear as projections on the walls of the ovary, then the ovary is *unilocular* (fig. 260), and the placentas are *parietal*, as in Viola (fig. 261). In

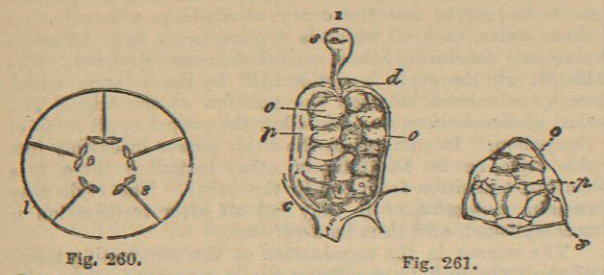


Fig. 260.—Diagrammatic section of a quincucular ovary, in which the septa *s* proceed inwards for a certain length, bearing the placentas and ovules *o*. In this case the ovary is unilocular, and the placentas are parietal. Dorsum, *d*.
Fig. 261.—Pistil of *Viola tricolor*, or Pansy. 1. Vertical section to show the ovules *o*, attached to the parietes. Two rows of ovules are seen, one in front, and the other in profile; *p*, a thickened line on the walls forming the placenta; *c*, calyx; *d*, ovary; *s*, hooded stigma terminating the short style. 2. Horizontal section of the same; *p*, placenta; *o*, ovules; *s*, suture.

these instances the placentas may be formed at the margin of the united contiguous leaves, so as to appear single, or the margins may not be united, each developing a placenta. Frequently the margins of the carpels, which fold in to the centre, split there into two lamellæ, each of which is curved outwards and projects into the loculement, dilating at the end into a placenta. This is well seen in Cucurbitaceæ (fig. 262), Pyrola, &c. From this it will be seen that dissepiments are opposite to placentas formed by the union of the margins of two contiguous carpels, but alternate with those formed by the margins of the same carpel. The carpellary leaves may fold inwards very slightly, or they may be applied in a valvate manner, merely touching at their margins, the placentas then being parietal (fig. 259), and appearing as lines or thickenings

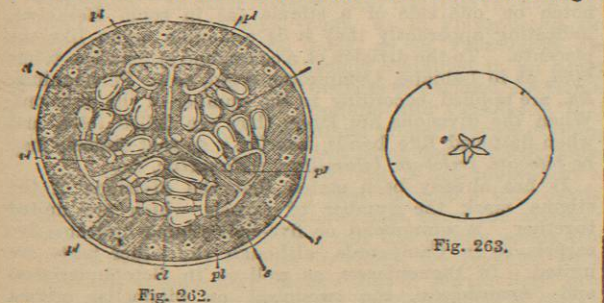


Fig. 262.—Transverse section of the fruit of the Melon (*Cucumis Melo*), showing the placentas *pl*, with the seeds attached to them. The three carpels forming the pepo are separated by partitions *cl*. From the centre, processes *s*, go to circumference *l*, ending in curved placentaries bearing the ovules.
Fig. 263.—Diagrammatic section of a compound unilocular ovary, in which there are no indications of partitions. The ovules *o* are attached to a free central placenta, which has no connection with the walls of the ovary.
 along the walls. Cases occur, however, in which the placentas are not connected with the walls of the ovary, and form what is called a *free central placenta* (fig. 263).

This is seen in many of the Caryophyllaceæ and Primulaceæ (figs. 264, 265). In Caryophyllaceæ, however, while the placenta is free in the centre, there are often traces found at the base of the ovary of the remains of septa, as if rupture had taken place, and, in rare instances, ovules are found on the margins of the carpels. But in Primulaceæ, Myrsinaceæ, and Santalaceæ, no vestiges of septa or marginal ovules can be perceived at any period of growth; the placenta is always free, and rises in the centre of the ovary, and the part uncovered by ovules gradually extends into the style. Free central placentation, therefore, has been accounted for in two ways; either by supposing that the placentas in the early state were formed on the margins of carpellary leaves, and that in the progress of development these leaves separated from them, leaving the placentas and ovules free in the centre; or by supposing that the placentas are not *marginal* but *axile* formations, produced by an elongation of the axis, the ovules being lateral buds, and the carpels verticillate leaves, united together around the axis. The first of these views would apply well to Caryophyllaceæ, the second to Primulaceæ. The latter case has also been explained, on the marginal hypothesis, by considering the placentas as formed from the carpels by a process of chorisis, and united together in the centre.

Some consider the axile view of placentation as applicable to all cases, the axis in some instances remaining free and independent, at other times sending prolongations along the margins of the carpellary leaves, and thus forming the *marginal placentas*. Occasionally, divisions take place in ovaries which are not formed by the edges of contiguous carpels. These are called *spurious dissepiments*. They are often horizontal, and are then called *phragmata*, as in Cathartocarpus Fistula, where they consist of transverse cellular prolongations from the walls of the ovary, only developed after fertilization, and therefore more properly noticed under fruit. At other times they are vertical, as in Datura, where the ovary, in place of being two-celled, becomes four-celled; in Crucifereæ, where the prolongation of the placentas forms a *replum* or partition; in Astragalus and Thespesia, where the dorsal suture is folded inwards, in Oxytropis, where the ventral suture is folded inwards; and in Diplopractum, where the inner margin of the carpels is inflexed. In Cucurbitaceæ divisions are formed in the ovary apparently by peculiar projections inwards from curved parietal placentas. In some cases horizontal dissepiments are supposed to be formed by the union of carpels situated at different heights, so that the base of one becomes united to the apex of another. In such cases the divisions are true dissepiments formed by carpellary leaves. The anomalous divisions in the ovary of the Pomegranate have been thus explained.

The ovary is usually of a more or less spherical or curved form, sometimes smooth and uniform on its surface, at other times hairy and grooved. The grooves usually indicate the divisions between the carpels, and correspond to the dissepiments. The dorsal suture may be marked by a slight projection, or by a superficial groove. When the ovary is situated on the centre of the receptacle, free from the other whorls, so that its base is above the insertion of the stamens, it is

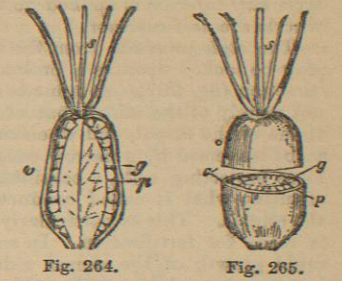


Fig. 264.—Pistil of *Corydalis hirsutum* cut vertically. *o*, unilocular or monothecal ovary; *p*, free central placenta; *g*, ovules; *s*, style.
Fig. 265.—The same cut horizontally, and the halves separated so as to show the interior of the cavity of the ovary *o*, with the free central placenta *p*, covered with ovules *g*.

termed *superior*, as in *Lychnis*, *Primula*, and *Geranium* (fig. 215). When the margin of the receptacle is prolonged upwards, carrying with it the floral envelopes and staminal leaves, the basal portion of the ovary being formed by the receptacle, and the carpellary leaves alone closing in the apex, the ovary is *inferior*, as in *Pomegranate*, *Apple*, *Fear*, *Gooseberry*, and *Fuchsia*. In some plants, as many *Saxifragaceae*, there are intermediate forms, in which the term *half-inferior* is applied to the ovary, whilst the floral whorls are *half-superior*.

The *style* proceeds from the summit of the carpel, and may be looked upon as a prolongation of it in an upward direction (fig. 267). It is hence called *apical*. It consists not merely of the midrib but of the vascular and cellular tissue of the carpel, and when carefully examined is found to be traversed by a narrow canal, in which there are some loose projecting cells, a continuation of the placenta, constituting what is called conducting tissue, which ends in the stigma. This is particularly abundant when the pistil is ready for fertilization. In some cases, owing to more rapid growth of the dorsal side of the ovary, the style becomes *lateral* (fig. 266); this may so increase that the style appears to arise from near the base, as in the *Strawberry*, or from the base, as in *Chrysobalanus Icaco*, when it is called *basilar*. In all these cases the style still indicates the organic apex of the ovary, although it may not be the apparent apex. When in a compound pistil the style of each carpel is thus displaced, it appears as if the ovary were depressed in the centre, and the style rising from the depression in the midst of the carpels seems to come from the torus. Such a style is *gynobasic*, and is well seen in *Boraginaceae* and *Ochnaceae*. The form of the style is usually cylindrical, more or less filiform and simple; sometimes it is grooved on one side, at other times it is flat, thick, angular, compressed, and even petaloid, as in *Iris* and *Canna*. In *Goodeniaceae* it ends in a cup-like expansion, enclosing the stigma. It may be smooth and covered with glands and hairs. These hairs occasionally aid in the application of the pollen to the stigma; and are called *collecting hairs*, as in *Goldfussia*, in *Campanula*, where they appear double and retractile, and also in *Aster* and other *Compositae*. These hairs, during the upward development of the style, come into contact with the already

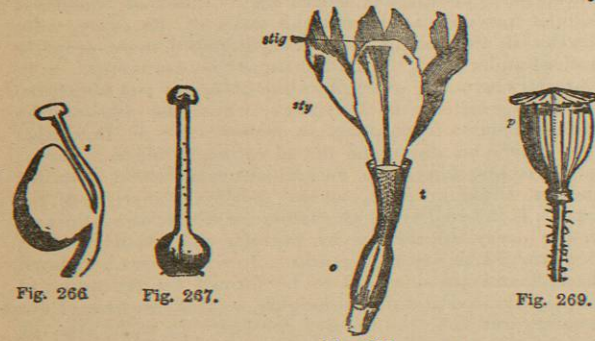


Fig. 266

Fig. 267.

Fig. 269.

Fig. 268.

Fig. 266.—Uniovular carpel of *Lady's-mantle* (*Alchemilla*) with the style arising laterally near the apparent base. It is called a lateral or semi-basilar style, although it arises from the organic apex, which is here turned round. The stigma at the summit of the style is capitate.

Fig. 267.—Compound syncarpous pistil of *Primula*. The five carpels of which it is composed are completely consolidated so as to appear one. The ovaries *o*, the styles *s*, and stigmata *s* are united. The flower is called monogynous, although in reality there are five parts of the pistil.

Fig. 268.—Gynaeceum of the *Flower-de-Luce* (*Iris*), consisting of an ovary *o* adherent to the perianth, and a style *sty*, which divides into three petaloid segments bearing stigmata *stig*. The ovary is inferior, the perianth superior.

Fig. 269.—Capsule of *Poppy*, opening by pores *p*, under the radiating peltate stigma

ripened pollen, and carry it up along with them, ready to be applied by insects to the mature stigma of other flowers.

In *Vicia* and *Lobelia* the hairs frequently form a tuft below the stigma. The styles of a syncarpous pistil may be either separate or united; when separate, they alternate with the septa. When united completely, it is usual to call the style *simple* (fig. 267); when the union is partial, then the style is said to be *bifid*, *trifid*, *multifid*, according as it is two-cleft, three-cleft, many-cleft; or, to speak more correctly, according to the mode and extent of the union of two, three, or many styles. The style is said to be *bipartite*, *tripartite*, or *multipartite*, when the union of two, three, or many styles only extends a short way above the apex of the ovary. The style of a single carpel, or of each carpel of a compound pistil, may also be divided. Each division of the tricarpellary ovary of *Jatropha Curcas* has a *bifurcate* or forked style, and the ovary of *Emblia officinalis* has three styles, each of which is divided twice in a bifurcate manner, exhibiting thus a dichotomous division. The length of the style is determined by the relation which ought to subsist between the position of the stigma and that of the anthers, so as to allow the proper application of the pollen. In some cases the ovary passes insensibly into the style, as in *Digitalis*, in other instances there is a marked transition from one to the other. The style may remain *persistent*, or it may fall off after fertilization is accomplished, and thus be *deciduous*.

The *stigma* is the termination of the conducting tissue of the style, and is usually in direct communication with the placenta. It may, therefore, in most instances, be considered as the placental portion of the carpel, prolonged upwards. In *Armeria*, and some other plants, this connection with the placenta cannot be traced. The stigma consists of loose cellular tissue, and secretes a viscid matter which detains the pollen and causes it to protrude tubes. This secreting portion is, strictly speaking, the true stigma, but the name is generally applied to all the divisions of the style on which the stigmatic apparatus is situated. The stigma alternates with the dissepiments of a syncarpous pistil, or, in other words, corresponds with the back of the loculaments; but in some cases it would appear that half the stigma of one carpel unites with half that of the contiguous carpel, and thus the stigma is opposite the dissepiments, that is, alternates with the loculaments, as in the *Poppy*. If the stigma is viewed as essentially a prolongation of the placenta, then there is no necessary alternation between it and the placenta, both being formed by the margins of carpellary leaves, which in the one case are ovuliferous, in the other stigmatiferous. There is often a notch on one side of a stigma (as in some *Rosaceae*), indicating apparently that it is a double organ like the placenta. To the division of a compound stigma the terms *bifid*, as in *Labiatae*, *Compositae*, *trifid*, as in *Polemonium*, &c., are applied, according to the number of the divisions. When the divisions are large, they are called *lobes*, and when flattened like bands, *lamellae*; so that stigmas may be *bilobate*, *trilobate*, *bilamellar*, *trijamellar*, &c.

It has already been stated that the divisions of the stigma mark the number of carpels which are united together. A quinquefid or five-cleft stigma indicates five carpels, as in *Campanula*, although the other parts are united. In *Bignoniaceae*, as well as in *Scrophulariaceae* and *Acanthaceae*, the two-lobed or bilamellar stigma indicates a bilocular ovary. Sometimes, however, as in the case of the styles, the stigma of a single carpel may divide. It is probable that in many instances what is called bifurcation of the style is only the division of the stigma. In *Gramineae* and *Compositae* there is a bifid stigma, and only one cavity in the ovary. This, however, may be probably traced to subsequent abortion in the ovary of one of the carpels. Its position may be terminal or lateral; either on one side of the style, uni-

lateral, as in *Asimina*, or on both sides, *bilateral*, as in *Plantago*. Occasionally, as in *Tasmannia*, it is prolonged along the inner surface of the style. In *Iris* it is situated on a cleft on the back of the petaloid divisions of the style (fig. 268). Some stigmata, as those of the *Mimulus*, present sensitive flattened laminae, which close when touched. The stigma presents various forms. It may be globular, as in *Mirabilis Jalapa*; orbicular, as in *Arbutus Andrachne*; umbrella-like, as in *Sarracenia*, where, however, the proper stigmatic surface is beneath the angles of the large expansion of the apex of the style; ovoid, as in *Fuchsia*; hemispherical; polyhedral; radiating, as in the *Poppy* (fig. 269), where the true stigmatic rays are attached to a sort of peltate or shield-like body, which may represent depressed or flattened styles; *cucullate*, i.e., covered by a hood, in *Calabar Bean*, where it is situated on the apex of a declinate style, bearded (hairy) on its concave surface. The lobes of a stigma may be flat and pointed, as in *Mimulus* and *Bignonia*, fleshy and blunt, smooth or granular, or they may be feathery, as in many *Grasses* (fig. 213). In *Orchidaceae* the stigma is situated on the anterior surface of the column formed by the union of the styles and filaments,—the point where it occurs being called *gynisus*. In *Asclepiadaceae* the stigmas are united to the face of the anthers, and along with them form a solid mass (fig. 229).

Transformations of the pistil are of frequent occurrence, and depend generally on abortion of a certain number of carpels, and on adhesions of various kinds. In the apocarpous pistils of *Aconite*, *Nigella*, *Larkspur*, and *Pæony*, we find on the same plant pistils composed of two, three, four, five, and six carpels. In some of the *Brambles*, all the carpels except one have been observed to disappear, thus making the fruit resemble that of the *Plum*. In the case of *Leguminous* plants there is usually only a single carpel, although the flower is pentamerous; this state has been traced to abortion of carpels, and the view is confirmed by finding plants in the same natural order with more than one carpel. Pistils of a succulent nature, such as those of the *Sloe* and *Bird-cherry*, sometimes assume the form of a pod, like that of the *Pea*. Occasionally stamens are changed into carpels, and at other times the carpels are transformed into stamens, and bear pollen.

The ovule is the body attached to the placenta, and destined to become the seed. Ovules are most usually produced on the margins of the carpellary leaves, but are also formed over the whole surface of the leaf, as in *Cupressus*. In other instances they rise from the floral axis itself, either as terminal buds, as in *Polygonaceae* and *Piperaceae*, or as lateral buds, as in *Primulaceae* and *Compositae*. The ovule is usually contained in an ovary, and all plants in which the ovule is so enclosed are termed *angiospermous*; but in *Coniferae* and *Cycadaceae* it is generally considered as having no proper ovarian covering, and is called *naked*, these orders being denominated *gymnospermous*. The *gymnospermal* view is not adopted by all botanists some maintaining that there is a true ovarian covering. In *Cycas* the altered leaf, upon the margin of which the ovule is produced, and the peltate scales, from which they are pendulous in *Zamia*, are regarded by all botanists as carpellary leaves. But in the *Coniferae* great discussion has arisen regarding the morphology of parts in many genera; some considering the scales at the base of the scaly bracts of the cone as a placental process growing from the bract, which is thus a carpellary leaf opened out and bearing a sessile ovule, the whole cone representing a single flower, while others, again, regard the scale as an ovarian integument, and the ovule as being destitute of ovary, the outer scales being bracts, and the cone therefore being an inflorescence. The carpellary leaves are sometimes

united in such a way as to leave an opening at the apex of the pistil, so that the ovules are exposed or *seminude*, as in *Mignonette*. In *Leontice thalictroides* (*Blue Cohosh*), species of *Ophiopogon*, *Peliosanthes*, and *Stateria*, the ovary ruptures immediately after flowering, and the ovules are exposed; and in species of *Cuphea* the placenta ultimately bursts through the ovary and corolla, and becomes erect, bearing the exposed ovules. The ovule is attached to the placenta either directly, when it is called *sessile*, or by means of a prolongation called a *funiculus*, *umbilical cord*, or *podosperm* (fig. 270a, f). This cord sometimes becomes much elongated after fertilization. The part by which the ovule is attached to the placenta or cord is its *base* or *hilum*, the opposite extremity being its *apex*. The latter is frequently turned round in such a way as to approach the base. The ovule is sometimes embedded in the placenta, as in *Hydnora*.

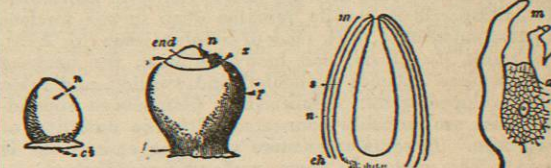


Fig. 270.

Fig. 270a.

Fig. 271.

Fig. 272.

Fig. 270.—Young ovule of *Celandine* (*Chelidonium majus*) before its coverings are developed. It consists of the nucleus *n*, which at this stage of growth is naked. The base of the nucleus, where the nourishing vessels enter, is marked *ch*. This point is called the *chalaza*.

Fig. 270a.—The ovule of *Polygonum*, with its nucleus *n*, covered by the inner coat *s*, or the secundine, and the outer coat *p*, or the primine. The opening in the secundine, *end*, is called the endostome, that in the primine, *ex*, is the exostome. The point of the nucleus is seen projecting at the foramen. The end by which the ovule is attached to the placenta is marked *f*.

Fig. 271.—Orthotropic or orthotropal ovule of *Polygonum*, showing the embryo-sac *s*, in the nucleus *n*, the different ovular coverings, the base of the nucleus or chalaza *ch*, and the apex of the ovule with its foramen *m*.

Fig. 272.—Vertical section of the ovule of the *Austrian Pine* (*Pinus austriaca*), showing the nucleus *n*, consisting of delicate cellular tissue containing deep in its substance an embryo-sac *b*, formed before impregnation by the coalescence of a vertical series of a few cells. The micropyle *m* is very wide, and through it the pollen-grains come into contact with the summit of the nucleus, into the substance of which they send their tubes.

The ovule appears at first as a small cellular projection from the placenta. The cells multiply until they assume a more or less enlarged ovate form, constituting what has been called the *nucleus* (fig. 270, *n*), or central cellular mass of the ovule. The nucleus may remain naked, and alone form the ovule, as in *Balanophoraceae*, *Santalaceae*, &c.; but in most plants it becomes surrounded by certain coverings or integuments during its development. These appear first in the form of cellular rings at the base of the nucleus, which gradually spread over its surface. In some cases only one covering is formed, especially amongst gamopetalous Dicotyledons, as in *Compositae*, *Campanulaceae*, also in *Walnut*, &c. But usually besides the single covering (fig. 270a, *s*) another is developed subsequently (fig. 270a, *p*), which gradually extends over that first formed, and ultimately covers it completely, except at the apex. There are thus two integuments to the nucleus, an outer and an inner, called respectively *primine*, *p*, and *secundine*, *s*,—the terms having reference to their position as regards the nucleus and not indicating the order of development. The name *tercine* has been given to the outer layer of cells of the nucleus. The integuments do not completely invest the apex of the nucleus, but an opening termed the *foramen* or *micropyle* is left. This foramen in most ovules extends through both coats, the opening in the primine (fig. 270a, *ex*) being the *exostome*; that in the secundine (fig. 270a, *end*) being the *endostome*. But in many Monocotyledons the exostome has no share in the formation of the micropyle. The micropyle indicates the organic apex of the ovule. The term micropyle is sometimes restricted to the foramen in the perfect seed. The size

of the micropyle depends on the development of the nucleus, as well as on the thickness of the integuments. Where the integument is very thick and the nucleus small, the micropyle is a long canal, as in Hippuris; but more usually the nucleus is large, and the integuments reduced to a few layers of cells, and in this case the micropyle is correspondingly reduced. The nucleus alters in the progress of growth so as to be prepared for the development of the embryo in its interior. A single cell of the nucleus near its centre enlarges greatly until it forms a hollow cavity surrounded by the smaller cells of the nucleus. This cavity is the *embryo-sac* (fig. 274, *e*), and the protoplasmic contents have been termed the *amnios*. This embryo-sac increases in size, gradually supplanting the surrounding cellular tissue of the nucleus until it remains surrounded only by a thin layer of it; or it may actually extend at the apex beyond it, as in Phaseolus and Alsine media; or it may pass into the micropyle, as in Santalum. In Gymnosperms it usually remains deep in the nucleus and surrounded by a thick mass of cellular tissue (fig. 272). In Veronica, Euphrasia, and many Labiatae, the neck of the embryo-sac becomes elongated and swollen, and from it are developed certain vermiform or filamentous appendages, which are probably connected with the nutrition of the embryo. In some cases more than one embryo-sac is formed. This occurs in some gymnospermous plants, as the Yew, and it is also seen in Cruciferae. In the Mistletoe several sacs are formed, but it is doubtful whether in this case several ovules have not coalesced. Usually only one becomes fully developed. When the embryo-sac has reached a certain stage of growth, a development of cellular tissue takes place within it by free cell formation. This occurs in all gymnospermous plants, and constitutes what is known as the *endosperm* (fig. 280, *b*). In angiospermous plants the endosperm is not formed until after fertilization, and it is rare to find any special development of cellular tissue within the embryo-sac before fertilization. But in some cases at the base of the embryo-sac a few cells are formed, which have been termed *antipodal cells*, and are frequently afterwards absorbed, or may be incorporated in the true endosperm when it is formed. The further processes of growth in gymnospermous ovules on the one hand, and angiospermous ovules on the other, differ so much that they must be noted separately.

At the apex of the embryo-sac in gymnosperms, two or more cells of the endosperm enlarge so as to form what have been termed *corpuscles* (fig. 273). Each of these divides so as to form a large lower terminal or *central cell*, and an

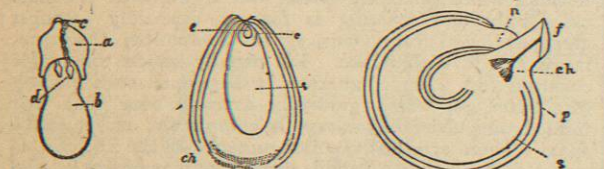


Fig. 273.—Vertical section of the embryo-sac *b*, and of part of the nucleus *a*, of the ovule of the Weymouth Pine (*Pinus Strobus*). At the micropylar end of the embryo-sac two cells, called corpuscles, *d*, have made their appearance. Each of these is at first separated from the inner surface of the micropylar end of the sac by a single cell, which afterwards divides into four, leaving a passage from the surface of the sac down to the corpuscle. The pollen-grain *c* on the summit of the nucleus, then sends down a tube which perforates the embryo-sac, and reaches the corpuscle through the intercellular canal.
 Fig. 274.—Diagram of ovule of Polygonum, showing the nucleus *n*, and the embryo-sac *e*, containing a vesicle or germinal cell *g* formed before impregnation. This cell, after fertilization, develops the first cell *e* of the embryo. The dark shading at the base marks the chalazae, and the outer lines are the integument, the micropyle being opposite the chalazae.
 Fig. 275.—Campylotropous or campylotropous ovule of Wallflower (*Cheiranthus*), showing the funiculus *f*, which attaches the ovule to the placenta; *p*, the primine, *a*, the secundine, *n*, the nucleus, *ch*, the chalazae. The ovule is curved upon itself, so that the foramen is near the funiculus.

upper neck of smaller cells (*stigmatic cells*), appearing as four when viewed from above, enclosing a canal. From

the upper part of the central cell at the bottom of the neck, a small portion is separated—the *canal cell*. It is from a portion of the central cell that, after fertilization, the embryo is formed. Those parts all have great physiological importance in connection with fertilization. In angiosperms from the protoplasmic mass at the apex of the embryo-sac by free cell formation two (rarely one) elongated ovoid cells are produced. These are the *germinal vesicles* (fig. 274). In some angiosperms as Crocus, Maize, &c., the vesicles placed side by side are both equally elongated; to a considerable extent their lower ends are rounded, and there it is that the nucleus is found. The upper end projects into the micropyle, and is marked by distinct striae longitudinally. This portion has been distinguished as the *filiform apparatus*. From the germinal vesicles after impregnation the embryo is formed, only one vesicle developing. This filiform apparatus is considered as corresponding to the canal cell formed from the corpuscula in gymnosperms, and it seems to serve for conducting the impregnating influence to the lower part of the central cell. In most angiosperms the germinal vesicles are placed obliquely over each other—one attached to the apex of the sac, the other lower down, and there is no filiform apparatus. Of these two vesicles the lower one alone forms an embryo, the upper one performing the same function as the filiform apparatus of other angiosperms, and the canal cell of gymnosperms. The point where the integuments are united to the base of the nucleus is called the *chalazae* (fig. 278, *ch*). This is often coloured, is of a denser texture than the surrounding tissue, and is traversed by fibro-vascular bundles, which pass from the placenta to nourish the ovule.

When the ovule is so developed that the point of union between the integuments and nucleus (the chalazae) is at the hilum (next the placenta), and the micropyle is at the opposite extremity, there being a short funiculus, the ovule is *orthotropal*, *orthotropous*, or *atropous*. This form is well seen in Polygonaceae (fig. 271), Cistaceae, and most gymnosperms. In such an ovule a straight line drawn from the hilum to the micropyle passes along the axis of the ovule. Where, by more rapid growth on one side than on the other, the nucleus, together with the integuments, is curved upon itself, so that the micropyle approaches the hilum, and ultimately is placed close to it, while the chalazae is at the hilum, the ovule is *campylotropal* or *campylotropous* (fig. 275) when the portions on the two sides of the line bisecting the angle of curvature are unequal, or *campitropal* when they are equal. Curved ovules are found in Leguminosae, Cruciferae, and Caryophyllaceae. Usually the opposite faces of the concavity of curvature of such ovules coalesce, and outwardly no indication of curvature is visible; but in some cases there is no coalition and the ovule is *lecotropal*, or

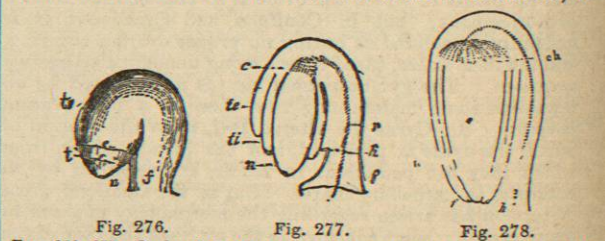


Fig. 276, 277.—Ovule of *Chelidonium majus* (cut longitudinally in fig. 277 to show the relation of its different parts). *A*, hilum or umbilicus; *c*, chalazae; *f*, funiculus or umbilical cord; *r*, raphe; *n*, nucleus; *ti*, secundine; *te*, primine; *ed*, endostome; *ex*, exostome.
 Fig. 278.—Anatropous or anatropous ovule of Dandelion (*Leontodon Taraxacum*), showing the coats of the ovule surrounding the nucleus *n*, which is inverted, so that its base *ch*, where the chalazae exists, is removed from the base or hilum of the ovule *b*, while the foramen *f* is near the base. The connection between the base of the ovule and the base of the nucleus at *s* is kept up by means of the raphe *r*.

horse-shoe shaped. The inverted, *anatropal*, or *anatropous* ovule (figs. 276, 277, 278) is the commonest form amongst

angiosperms. In this ovule the apex with the micropyle is turned towards the point of attachment of the funiculus to the placenta, the chalazae being situated at the opposite extremity; and the funiculus, which runs along the side usually next the placenta, coalesces with the ovule and constitutes the *raphe* (*r*), which often forms a ridge. The anatropous ovule arises from the placenta as a straight or only slightly curved cellular process, and as it grows, gradually becomes inverted, curving from the point of origin of the integuments. As the first integument (secundine) grows round it, the amount of inversion increases, and the funiculus becomes adherent to the side of the nucleus. Then if a primine be formed it covers all the free part of the ovule, but does not form on the side to which the raphe is adherent. Some anatropous ovules, however, seem to be formed in a different manner, the nucleus arising as a lateral bud from the apex of the funiculus, as in some Compositae. These may be taken as the three types of ovule in the vegetable kingdom; but there are various intermediate forms, such as *semi-anatropal*, *amphitropal*, and *heterotropal* (transverse) ovules, where the funiculus is only, as it were, partially attached along one side, becoming free in the middle.

The position of the ovule relative to the ovary varies. When there is a single ovule, with its axis vertical, it may be attached to the placenta at the base of the ovary (*basal placenta*), and it is then *erect*, as in Polygonaceae and Compositae; or it may be inserted a little above the base, on a parietal placenta, with its apex upwards, and then is *ascending*, as in Parietaria. It may hang from an apical placenta at the summit of the ovary, its apex being directed downwards, and is *inverted* or *pendulous*, as in Hippuris vulgaris; or from a parietal placenta near the summit, and then is *suspended*, as in Daphne Mezereum, Polygalaceae, and Euphorbiaceae. Sometimes a long funiculus arises from a basal placenta, reaches the summit of the ovary, and there bending over suspends the ovule, as in Armeria (Sea-pink); at other times the hilum appears to be in the middle, and the ovule becomes *horizontal*, *pellate*, or *peritropous*. When there are two ovules in the same cell, they may be either *collateral*, that is, placed side by side (fig. 257), or the one may be erect and the other inverted, as in some species of Spiraea and Æsculus; or they may be placed one above another, each directed similarly, as is the case in ovaries containing a moderate or definite number of ovules. Thus, in the ovary of Leguminous plants (fig. 256), the ovules *o*, are attached to the extended marginal placenta, one above the other, forming usually two parallel rows corresponding to each margin of the carpel. When the ovules are *definite* (i.e., are uniform, and can be counted), it is usual to find their attachment so constant as to afford good characters for classification. When the ovules are very numerous (*indefinite*), while at the same time the placenta is not much developed, their position exhibits great variation, some being directed upwards, others downwards, others transversely; and their form is altered by pressure into various polyhedral shapes. In such cases it frequently happens that some of the ovules are arrested in their development and become abortive.

The homology of the ovule is by no means the same in all plants. In such cases as Polygonum and Piperaceae, it represents the termination of the floral axis, and therefore is of the nature of a caulome. Again, in such plants as Primulaceae and Compositae, it is produced laterally upon the axis, and therefore represents a leaf, the integuments representing the lamina, and the funiculus the petiole,—the nucleus being an outgrowth from them. In some instances of malformation a transformation into these parts actually takes place. In cases where they are produced on the margin of the carpillary leaves (the usual mode), the ovules represent lobes of a leaf, and in some cases of monstrosity,

as in Delphinium elatum, they appear as lobes of the carpillary leaf, whilst in Cupressus they are evidently outgrowths of the leaf. Further, the ovules in Orchidaceae must be considered as mere trichomes, as they have no fibro-vascular bundles, and are developed from superficial cells of the placenta.

When the pistil has reached a certain stage in growth it becomes ready for fertilization. Pollination having been effected, and the pollen-grain having reached the stigma in angiosperms, the summit of the nucleus in gymnosperms, it is detained there, and the viscid secretion from the glands of the stigma in the former case, and the moisture from the ovule in the latter, induce the protrusion of the intine as a pollen-tube through the pores or points of perforation of the grain, many or few tubes being formed according to the number of pores. The pollen-tube or tubes pass down the canal (fig. 279), through the conducting tissue of the style when present, and reach the interior of the ovary in angiosperms, and then pass to the micropyle of the ovule, one pollen-tube going to each ovule. Sometimes the micropyle lies close to the base of the style, and then the pollen-tube enters it at once, but frequently it has to pass

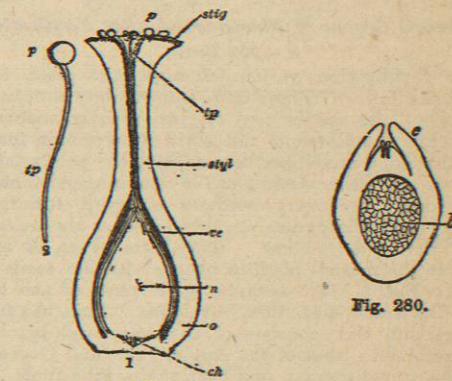


Fig. 279.—Pistil and pollen of Polygonum. 1 Stigma, *stip*, with pollen-grains *p* adherent to it, sending tubes *tp* down the conducting tissue of the style *st*; the ovary *o* containing the ovule with its covering and central cellular mass or nucleus *n*, containing a rudimentary embryo-sac *ee*, in which ultimately the embryo is developed. The base of the ovule attached to the placenta is marked by the chalazae *ch*. 2. Pollen-grain *p*, separated, with pollen-tube *tp*.
 Fig. 280.—Vertical section of the ovule of the Scotch Fir (*Pinus sylvestris*) in May of the second year, showing the enlarged embryo-sac *b*, full of endospermial cells, and pollen-tubes *c*, penetrating the summit of the nucleus after the pollen has entered the large micropyle of the ovule.

some distance into the ovary, being guided in its direction by various contrivances, as hairs, grooves, &c. In gymnosperms the pollen-grain resting on the apex of the nucleus sends out its pollen-tubes, which at once penetrate the nucleus of the ovule (fig. 280). In angiosperms when the pollen-tube reaches the micropyle it passes down into the canal, and this portion of it increases considerably in size. Where, as in Santalum album, Crocus, &c., there is a filiform apparatus, the pollen-tube comes in contact with it. In most cases, however, it reaches the apex of the embryo-sac, sometimes slightly indenting it, as in Narcissus poeticus and Digitalis purpurea, or even perforating it, as in Canna. The granular protoplasmic matter in the pollen (fovilla) is then transmitted to the embryonal vesicle and fertilization is effected. Consequent upon this, after a longer or shorter period, those changes commence in the embryonal vesicle which result in the formation of the embryo plant, the ovule also undergoing changes which convert it into the seed, and fit it for a protective covering, and a store of nutriment for the embryo. Nor are the effects of fertilization confined to the ovule; they extend to other parts of the plant. The ovary enlarges, and, with the seeds enclosed, constitutes