# PART X.

## REPRODUCTIVE ORGANS IN PLANTS, AND THEIR CORRESPONDENCE WITH THOSE OF ANIMALS.

## CHAPTER XXIV.

### ORGANS OF GENERATION IN PLANTS.

From what has been already explained it will be obvious that plants, in many respects, resemble animals much more closely than is usually suspected, and this is especially so in regard to the organs of generation, and the way in which they act. There is scarcely a sexual organ found in animals that we do not find the exact analogue of in plants, and the various processes, even to the act of sexual conjugation, are identical in both.

In the lower animals propagation is effected by the parent simply dividing into two or more parts, or by sending out buds, each part or bud becoming a new being. The same process, exactly, occurs in plants,—they can propagate either by simple division or by budding, in the same way. In the higher animals there are two principles concerned in propagation, the male sperm, and the female egg, or ovum, which unite to form the new being; and it is the same in the higher plants, which propagate by the union of the male pollen and the female germ. Even the organs by which the two principles are brought together are remarkably similar in both, the hollow tube of the pistil corresponding to the female vagina, and the elongated pollen grain to the male penis. There is a real act of conjugation, or sexual union, in the one case as in the other, and as many curious modifications, both of form and mode of action, are found in the plant as in the animal.

At the present day, the fact that plants are truly sexual, male and female, is very generally known, and in many ways practically used, but it has been known only a short time.

It was not till 1716 that Vaillant, a French botanist, first clearly explained the true nature of the stamens and pistils, and showed that plants propagated sexually, like animals. This was one of the greatest discoveries ever made in botany, and also a highly suggestive fact in natural history generally, because it showed man how nature works by similar agencies in different fields. It was a long step toward a perception of the great truth of the oneness of many natural phenomena, when they are rightly understood, which are ordinarily thought to have nothing in common. Establishing the similarity of plants and animals, in the matter of propagation, led the way, at a later period, to the still more important discovery that man and all other animals are identical in the same way.

Plants, as before explained, like animals, may be either hermaphrodite—that is, have both male and female organs on the same plant; or they may be diœcious—that is, have the male organs on one plant, and the female organs on another. The hermaphrodite arrangement is the most common, so that the male and female principles being close together there is seldom any failure of fertilization.

When the male and female organs are separated, by being on different plants, which may not grow near each other, fertilization often fails, and the female plant is barren. Nature, however, has so well provided for carrying the pollen great distances, by the wind, or by insects, that the male and female may be many miles asunder and yet impregnation occur.

The date palm, on whose fruit a large number of the Arabs mainly depend for food, is diœcious, and if no male trees are near to fertilize the female ones, they are sterile, and produce no fruit. The Arabs therefore always attend to this, and if no male plant is near their plantations, they fetch branches, with the pollen on them, from a distance, and hang them in the female trees. The pollen dust is then blown about by the wind, settles on the female pistils, impregnates them, and they produce fruit. In time of war, between different tribes, it is a common practice for one tribe to destroy the male date-trees of the tribe they are contending with, and thus starve them.

The common persimmon is diœcious, and it is not unusual to find female trees producing no fruit, because no male trees happen to be near. Sometimes when the grapevine is just ready to fertilize, heavy rains occur, which wash off the pollen, so that it never rises, like dust, to fertilize the germ, and in consequence there is a failure of fruit. The same thing often happens with other plants, in unfavorable seasons, the perfect dryness of the pollen being indispensable, so that it may rise, which it will do sometimes in a perfect cloud.

In the conservatory at Berlin there was a fine female palm-tree, which had been there for eighty years, sterile; but which was at last fertilized by some pollen sent from a distance, by post, and it then produced fruit. It was then left barren again for eighteen years, and again fertilized in the same way. Gardeners, at the present time, when they think their plants, or flowers, may not be properly fertilized naturally from any cause, take care to fertilize them artificially. This they do by taking pollen, in a proper state, and dusting it upon the pistils of the female flowers, sometimes using a fine camel's-hair brush for the purpose. By the same means they produce hybrids, or crosses, by placing the pollen of one kind upon the pistil of another kind, just as mules are produced by the union of the horse and ass. There is a limit, however, to the extent to which this can be done in plants, as there is in animals. The two parents must be related, within certain degrees, or the fertilization will not take place. Why this is we do not know. Possibly, in the case of animals, the form of the seminal animalcule may be, in some way or other, adapted to the female germ; and the same may be the case with the pollen of the plant and the future seed.

It is a curious circumstance that mules, or hybrids, both animal and vegetable, may be perfectly developed in every other way, but are never so in the sexual organs. They may even surpass the parents, generally, but cannot continue their kind by propagation.

It has been shown before that in animals, even in the human being, the female egg is formed and expelled without any intercourse with the male, but it comes to nothing if it be not impregnated. And exactly so it is with plants. The female germ is always formed in the ovarium, at the foot of the pistil, but if it be not impregnated by the male pollen it does not form a seed, but only a mass of albuminous pulp.

All germs, however, have an innate power of development, which may enable them, under peculiar circumstances, to form a new organism without the concurrence of another germ. Thus the ovum in human virgins, as before explained, may



form into an organism, to a certain extent, without any concurrence on the part of the male whatever. Such formations, however, are never perfect, and do not come to anything. They begin, but do not complete development.

In plants also, the female germ may, in some cases, develop without receiving the male pollen at all, and even reach perfection. An Australian plant which was grown in England, in the Botanic Gardens, was found to be female, and there was not another plant of the kind, of either sex, in Europe, and yet it produced perfect seeds, which germinated and grew into new plants.

The same thing has been observed in a few other cases, but must be regarded as exceptional only, and possibly when more closely observed, the occurrence may be explained satisfactorily. We know that there are some insects in which one sexual connection will impregnate several successive generations, without any other male contact, and it may be that some such phenomenon occurs in these plants.

Commonly, in hermaphrodite plants, the male and female organs are close together, forming part of the same corolla, or flower. The female organ, called the *pistil*, is in the center, and the male organs, called the *stamens*, are ranged around, within the petals of the corolla, as seen below.


FIGURE 77.—*Flower of the Lily.*

*aa* are the petals, or flower leaves. *b* the stamens, or male organs. *c* is the pistil or female organ. *d* are the six stamens separate; *e* being the anthers on the tops of the stamens. *f* is the pistil separate, with the stigma *g* on the top, and the germ *h* at the bottom.

The male pollen is formed at the top of the stamens, which usually end in a protuberance, or curiously shaped part, called the anther, which is often jointed to the stem of the stamen, and has quite a range of motion.

The female germ, or future seed, is placed at the bottom of the pistil, in what is called the ovarium, analogous to the ovary of the female animal.

The pollen, when ripe, is in the form of fine dust, which is readily blown or carried around. If a grain of this dust alight at the top of the pistil, called the stigma, a curious process takes place.

There is a very minute passage down the center of the pistil, leading to the germ, and down this passage the pollen has to be conveyed, in order to fertilize the germ. In its ordinary state the pollen grain is too large to pass down this narrow way, and it therefore undergoes a very curious change. Resting on the stigma it begins to push downward a prolongation like a root, which works its way down the passage in the pistil till it reaches the germ, and impregnates it.

This is a true act of sexual conjugation, exactly analogous to copulation in animals. As soon as it is over the flower begins to wither, the leaves, stamens and pistils dry up and fall off, and the germ develops into the seed, or fruit.

soon so reduced in numbers that the bumble bees became abundant, and the clover was perfectly fertilized! Few people would suspect any connection between cats and clover seed, and yet it is obvious enough, when the mutual dependence is traced out.

Many equally curious instances could be given, some of which particularly show the mischief which is often done, by ignorant people, in deranging the balance of nature. These people look only at one animal or plant, and observe only one event, without tracing out the connection between all beings and all events, and so learning how they mutually influence and are dependent one upon another.

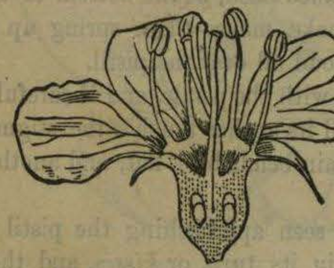

FIGURE 82.

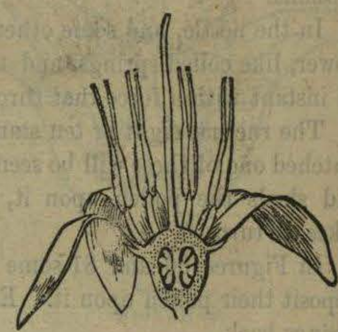

FIGURE 83.

Figure 82 and Figure 83 show different arrangements of the sexual organs. In Figure 82 the stamens are placed on the lower part of the petals, while in Figure 83 they are on the germ cell itself. The pistil is in the midst of them in both cases, and connected with the germ below. In Figure 82 one of the stamens is just touching the stigma, on the pistil.

Mr. Darwin, in his wonderful book on the fertilization of plants, gives a vast amount of interesting information on this subject, which is well worth study. Among other important facts, his experiments have shown that the pistil, in regard to the pollen, has a power of selection; for when the pollen of different varieties is mixed and applied to the stigma, it will always take one particular kind, and that only, though it will take one of the others if that be not present.

FIGURE 84.—*Pistil of the Poppy.*

FIGURE 85.—*Pistil of the Madder-plant.*

Figure 84 shows the seed capsule, or pistil, of the poppy, with two of the stamens.
Figure 85 shows the double pistil of the madder-plant, with all the stamens removed.

It is quite possible also even in animals, when they mix promiscuously, that the semen of some males may always be absorbed in preference to that of others, so that their descendants will preponderate over the others, and thus become a special breed.

Another curious fact may also be noticed. It is chiefly those plants that need insects to fertilize them which produce honey, while those in which the pollen is blown about by the wind are nearly always without it. In such plants also the stamens generally project beyond the corolla, or else there are no flower petals at all, so that the pollen is freely exposed to the action of the wind.



There is a curious water-plant, called the *Vallisneria Spiralis,* which grows at

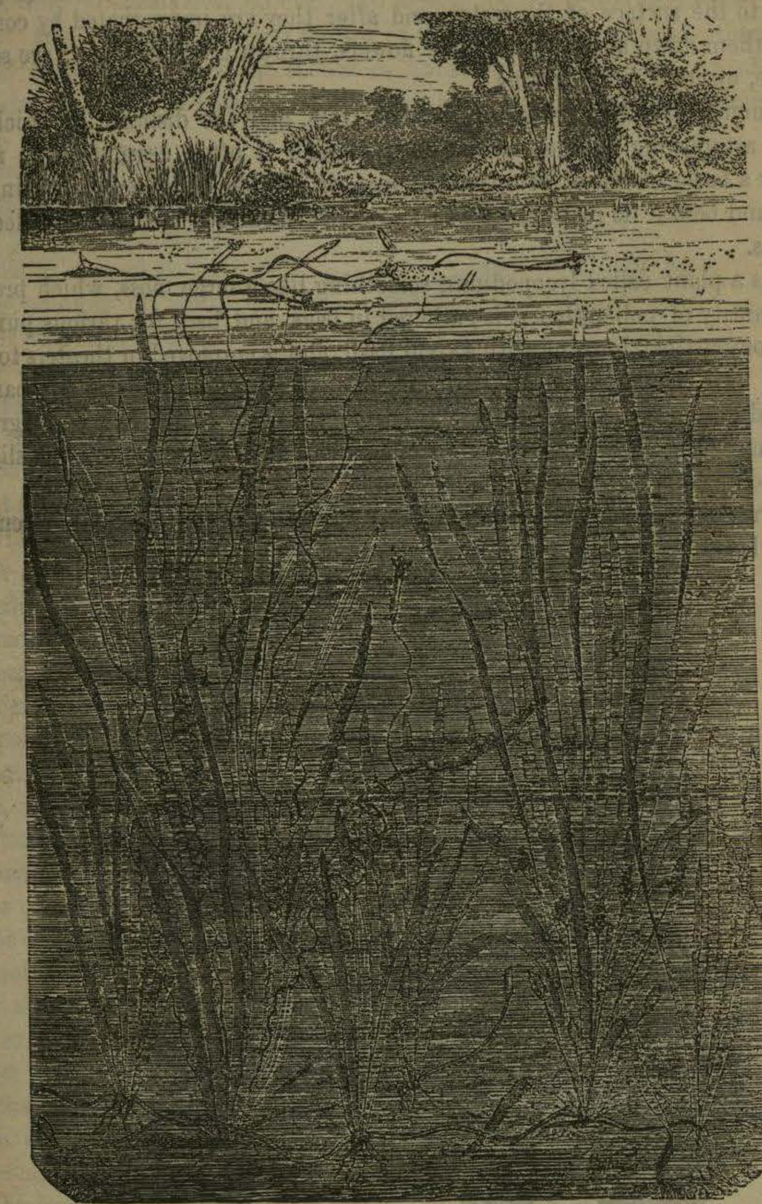

FIGURE 86.—*The Vallisneria Spiralis.*

the bottoms of ponds, in which the contrivances for assuring fertilization are well worth studying. It is diœcious, but the male and female flower stalks usually grow very near each other. At the time of fertilization, the female stem lengthens so that the flower is carried to the surface of the water, where it expands. The male flowers grow on short stems, at the bottom of the water, but at this time they become detached, in some unknown manner, and float up to the top where they too expand, and are drawn toward the female flowers, so that the pollen is shed upon the stigma, and the germ is fertilized. The male flowers then wither and die, while the female descends again to the bottom, and there the seed is perfected.

The spiral stems of the female flowers, as shown above, by expanding, project the flower to the surface of the water, and after they are impregnated by contracting, draw them down again. The male flowers, thrown up from below, are seen on the surface, ejecting pollen grains.

The amount of pollen produced by some trees, and the distance to which it is carried, is astonishing. Where pine forests abound it often descends, like rain or mists, over a large extent of country. Indeed, it is often called sulphur rain, from its color, and before its real nature was known, very curious notions prevailed as to what it was.

There is a plant called lycopodium, something like a large moss, which produces such a quantity of pollen that it is gathered in bags, and used for various purposes. It is very combustible, burning with a vivid flash, and is employed in theaters to make lightning. If a handful be scattered in the air, and a light applied to any part, the whole cloud flashes into a bright flame at once. It is easy to see how conflagrations in forests may be accelerated, or even originated, by this substance, for the slightest spark would be sufficient to cause its ignition.

The forms of the pollen grains are very varied and often peculiar, resembling closely the lower protozoa in animals, as seen in the following illustration:

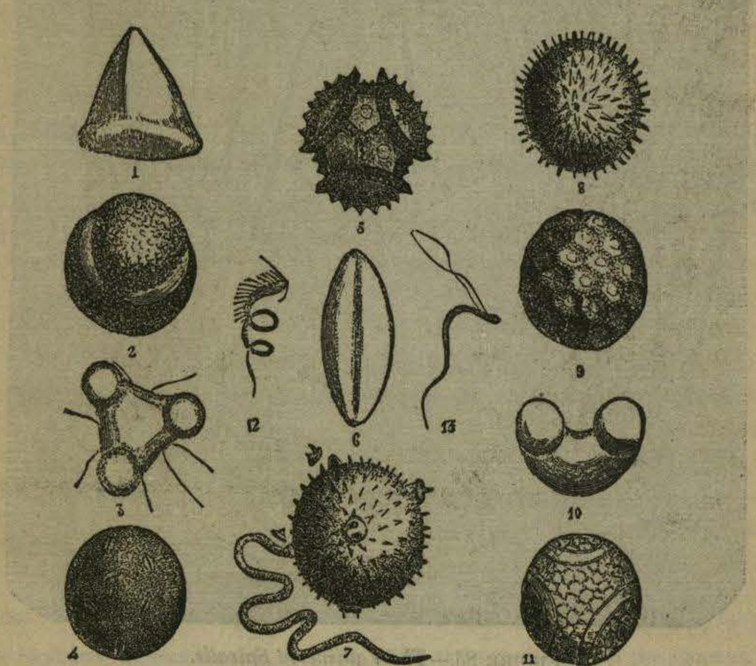

FIGURE 87.—*Various forms of Pollen Grains.*

There are also other phenomena connected with the inflorescence of plants, not less suggestive than those already given. In many of them the temperature rises to a most remarkable extent, so that the flower becomes actually *hot*. In some arums, in fact, the temperature rises as high as 143°, a heat sufficient, under some conditions, to make it wither up. Touching one of these flowers is like touching hot iron. Probably most flowers, at the time of fertilization, develop heat as well as motion, as a consequence of the activity of the sexual organs, which is strictly analogous to the erotic fever in animals at the corresponding period.



But not only do plants develop heat, and motion, at the period of greatest sexual exaltation. Many of them give out flashes of light at such times, and others again currents of electricity, like what occurs in animals. Reproduction, in short, is nature's supreme effort, and both in plants and animals it brings all her forces into active play.

The countless millions of germs produced by some of the lower plants has already been referred to, as well as the astonishing amount of male pollen; but even in the higher plants the quantity of seeds produced seems almost fabulous. A single poppy-plant has been found to contain 32,000 seeds, and a tobacco-plant 40,000, while an elm-tree may produce in one season half a million seeds. Of course, only a small fraction of all these seeds can form new plants, while but a still smaller fraction of the male pollen is needed in fertilization. And this superabundance, it must be remembered, is not occasional, but constant, season after season. Nature has provided, in every way, all the elements of reproduction, not only in abundance, but apparently in extravagant excess.

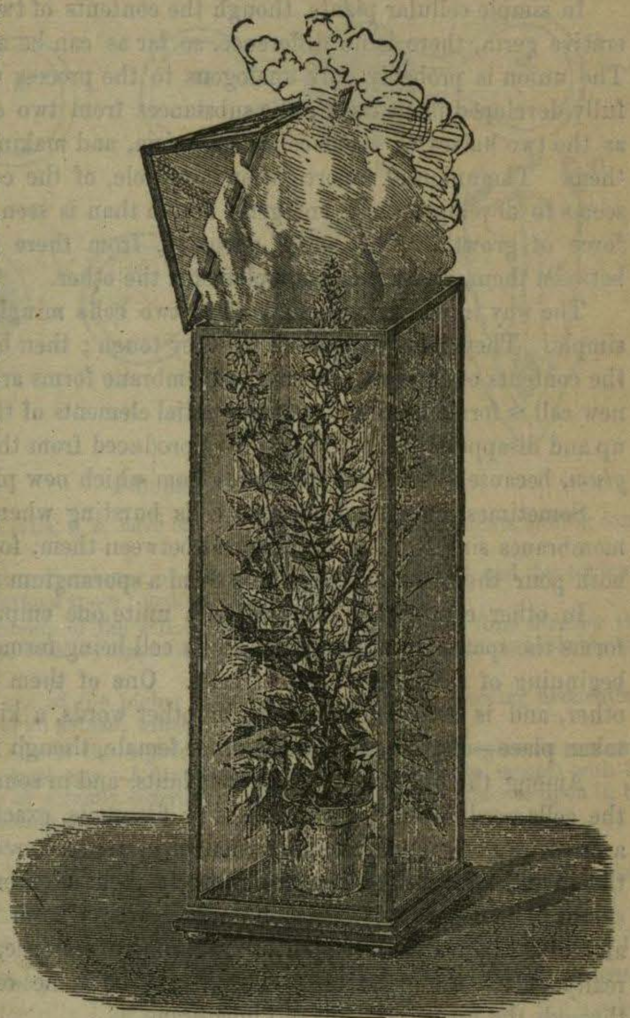

FIGURE 88.

Figure 88 shows a plant of the Bastard Dittany (Dictamnus Fraxinella), inclosed in a glass case to confine the inflammable vapors which arise from it. On opening the case and applying a light, the vapors at once burst into flame. Many plants, during the period of flowering, give out these inflammable vapors, as well as flashes of light, heat, and currents of electricity; all resulting from sexual activity.

It must be remembered, however, that both germs and pollen are essentially protoplasmic, and very possibly they may be important agents in the reproduction of that natural protoplasm, before referred to, which abounds in the air and in the water. When not used in their quality of germs, pollen, or seeds, they may simply disintegrate into that impalpable, universally diffused organic dust which the air everywhere contains, and which constitutes what experimenters call the floating atmospheric germ. The vitality of some seeds is very remarkable. They will endure the greatest extremes of both heat and cold, and may be kept for hundreds of years, and yet germinate when placed under proper conditions. Certain seeds, which often come to Europe in wool, imported from Brazil, may be *boiled* for four hours, and yet afterward grow if planted. Many others will stand boiling for a shorter time. Some raspberry seeds taken from an old Celtic tomb, seventeen hundred years old, were sown in the Horticultural Garden, London, and grew, and the bushes from them may still be seen there.

In simple cellular plants, though the contents of two cells unite to form the generative germ, there is no difference, so far as can be ascertained, between the two. The union is probably only analogous to the process of fission, or division, in the fully-developed plant itself; the substances from two cells uniting in the same way as the two halves of a one-celled organism, and making one complete cell between them. The union of a portion, or the whole, of the contents of two different cells, seems to develop a more energetic action than is seen in either cell alone, or more force of growth. This arises, probably, from there being some small difference between them, and the one complements the other.

The way in which the contents of two cells mingle to form a new one is very simple. They merely approach till they touch; then burst at the point of contact, the contents of the two intermix, a membrane forms around the intermixture, and a new cell is formed containing the essential elements of the original two, which shrivel up and disappear. The new cell thus produced from this union is called the *sporangium,* because it produces the spores from which new plants arise.

Sometimes, instead of the two cells bursting when they touch, their investing membranes simply unite, and expand between them, forming a new cell, into which both pour their contents, and thus form a sporangium as before.

In other cases, when the two cells unite one empties into the other, and thus forms the sporangium, instead of a new cell being formed. Probably this is the first beginning of a differentiation of cells. One of them varies in some way from the other, and is attracted to it; or, in other words, a kind of sexual difference has taken place—one is male and the other female, though imperfectly.

Among the higher cryptogamous plants, and in some of the sea-weeds, certain of the cells produce thread-like bodies or filaments, exactly resembling the spermatic animalcules of animals, which, when ripe, are scattered around by the bursting of the investing membrane, and move freely about of themselves. When one of these sperm filaments merely comes in contact with a germ cell, it seems to stimulate it, and cause increased development by its mere presence, but it is uncertain if it ever really enters the germ cell. There may be some osmotic absorption, however, through the investing germ cell membrane.

The cell which grows and develops the new organism is always called the female, or germ cell, analogous to the egg in animals, and the filamentous one which stimulates it is called the male or sperm cell. They may either be formed on the same plant (hermaphrodite) or on different plants (diœcious).

In the simpler forms, where two of the same kinds of cells unite, the new one (embryo) is perfect from the first, and is at once cast off to commence life on its own account. But when we come to the actual union of two different kinds, a sperm cell and a germ cell, by the sperm filament penetrating the germ cell, and uniting with it,



or by osmotic action through the membrane, the case is different. The sperm cell is usually small and imperfect, while the germ cell is provided with a large amount of nutritious material, like the yelk and white of a bird's egg, by which the sperm embryo is nutrified and developed to a much more perfect stage before it is cast off. In other words, it is retained till it is formed into a perfect embryo, ovum, or *seed,* which is different from either the sperm cell, or the germ cell, from which it is derived.

These different processes are clearly shown in the following illustration:

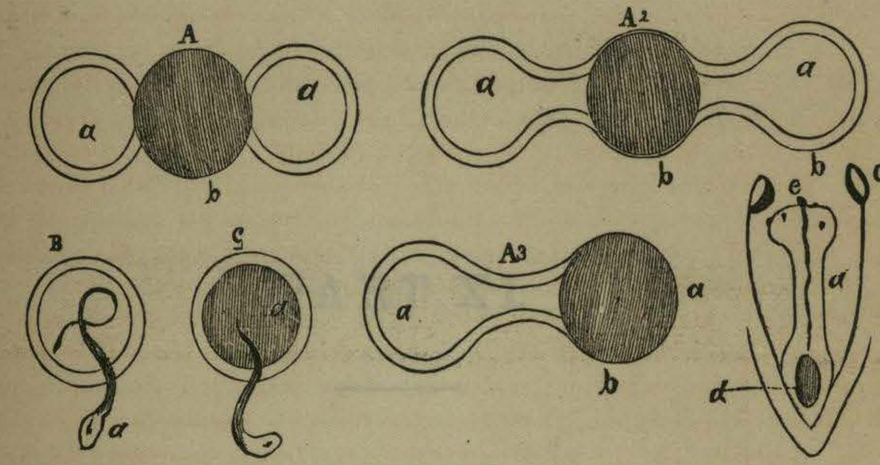


FIGURE 89.

Figure A shows how the two cells, *a, a,* have burst on contact, and their contents uniting form the sporangium, *b.*

Figure A 2 shows the investing membrane of the two cells, *a, a,* expanded, and the contents of both intermixed in the new-formed space; making the sporangium, *b.*

Figure A 3. In this the contents of the cell *a* have passed bodily into *a**, thus forming the sporangium in one of the original cells, by the union of the contents of both. This is probably the first commencement of sexuality.

B is a sperm cell (male) of one of the higher cryptogams; it contains a moving filamentous body, resembling the zoosperm of an animal, which is just escaping from it.

C is a germ cell (female) of one of the higher cryptogams, filled with protoplasmic material analogous to the yelk of the animal egg. A filamentous male germ is seen in contact with it, effecting its impregnation either by actually entering it, or by exerting some influence upon it, by osmotic action, through the investing membrane.

In perfect plants, which produce seeds, as before shown, the sperm cell, or pollen grain, in like manner, pushes out a long tube, which forces its way down what is called the style, or pistil, of the flower, till it reaches the germ cell, and fertilizes it, so that it can develop into the perfect embryonic germ or seed. This curious process, as before observed, is wonderfully like the act of *copulation* in animals, the pollen tube acting the part of a penis, and conveying the fertilizing male principle to the female germ.

This is shown in the last figure. *a* is the pistil of a flower, with the seed *d* at the bottom. *c* is one of the stamens, there being one also on the opposite side. *e* is one of the male pollen germs lengthening itself out like a thread, down the tube of the pistil, to reach the germ *d.*

Much more that is exceedingly interesting could be said on this matter, but this is sufficient to show the remarkable correspondence between animals and plants in the process of reproduction. It will also show that the old poetic dream of the *loves of flowers* is probably a reality! Any one who has studied the curious ways in which the male and female organs of flowers unite, how they bend, and turn, and twist, to come together for a short embrace, and the close union they form, can scarcely help thinking that pleasurable sensation, of some kind, must accompany the process. It is, perhaps, really the same in kind as love in animals, only different in degree.

# PART XI.

## PARTHENOGENESIS, OR VIRGIN GENERATION; AND THE ALTERNATION OF GENERATIONS.