examination of them, owing to their being so transparent, and differing so little in density from the fluid in which they are contained. It is requisite both to have good and powerful microscopes, and to be skilled in their use. With regard to specimens of semen, a physician who sees many cases of spermatorrhœa will never be at a loss for plenty.

In the course of my own practice I have examined these interesting beings under every variety of circumstances, and from a number of different animals, besides from our own species. Nothing can well be conceived more absorbing than such a pursuit, and no discoveries are more suggestive of valuable and unlooked-for explanations, both medical and physiological.

The illustrations in the large plates will give a perfect idea of these curious organisms in various animals.

According to *Rölliker* and *Wagner* there are first formed in the semen a number of *parent cells*, filled with a white albuminous fluid, which becomes granular, and then evolves one or more seminal granules, or vesicles. Each vesicle, according to their observations, contains only one animalcule, but this does not accord with the observations of others, who have counted as many as thirty from a single vesicle. The discrepancy, however, is accounted for in this way. As each vesicle ripens it bursts open, and the animalcule escapes into the fluid semen, and if a number burst at onetime all the animalcules from them may be thought to come from the one observed. The seminal vesicles in the parent cells ripen in succession, one or more at a time, in the human being, but in birds all usually ripen at once, and then the animalcules form into bundles, or masses, and this is occasionally so in the human being. In all probability all these processes vary in different individuals, according to the strength and vigor of the organs. One man, undoubtedly, produces very many more animalcules than another, and more vigorous ones. Possibly each vesicle in one man may produce only one animalcule, and in another man several, just as one female produces more ovæ than another.

The parent cells, from which both the vesicles and their contained animalcules originate, are formed from the epithelial lining of the seminal tubes in the testicles; this peels off, and the fragments form into the parent cells. Chemical analysis shows that the composition of the semen, and of the epithelial cells of the testicular tubes is exactly the same, which is corroborative still further of their fundamental identity.

The whole process, therefore, is one of cell growth, just as is the formation of the ovæ. The cellular lining of the testicular tubes throws off small portions, just as many of the simpler organisms already described throw off parts of their structure, and these portions begin at once to develop. It is, in fact, a process of *fissiparous propagation!*

The formation of the ovum in the ovary, and of the seminal vesicle with its animalcule, in the testicle, are, therefore, both effected in the same way. Each is simply a bit of the parent cellular structure, separated from the main body, and possessing the power, under proper conditions, of continuing its development. The reproduction of man, therefore, and of all other vertebrates, is really only fissiparous in the beginning.

The animalcules will live in the human semen twenty minutes or more after a man's death, and in cold-blooded reptiles they have been found alive several days after.

In reference to their production Dr. Burnett says that the changes in the sperm

cells, which precede the development of the perfect animalcules, are exactly similar to those which occur in the ovum preceding the formation of the new being. So that both the female egg and the male seminal animalcule are produced in the same way independent of each other; and when united they together produce the new human being.

Male mules form semen, *but it very rarely contains animalcules*, which is the reason it scarcely ever impregnates. The female mule, also, only occasionally forms a perfect egg, and brings forth young, even if impregnated by a perfect male. The male mule, therefore, is more generally sterile than the female.

Spallanzani and Prevost attempted to calculate the amount of semen that would be required to fecundate a certain number of eggs, and Damas even tried to ascertain how many animalcules are needed to impregnate one egg. It was found that two grains of the semen of the male toad was sufficient to impregnate one hundred and thirteen eggs. Five grains of semen were mixed with eighteen ounces of water, and the point of a needle being dipped in this, and then made to touch an egg for an instant only, caused impregnation, The proportion of semen to egg, in this experiment, has been estimated as 1 to 1,064,000,000. The impregnation was no more complete when the amount of semen was larger, nor when the needle remained longer in contact with the egg. It was observed that in the fecundation of a given number of eggs, by a given amount of semen, the number of eggs was always less than the number of animalcules in the semen, which showed that several animalcules were taken into each egg, and endeavors were made to find how many. Experiments showed that a quantity of semen containing 225 animalcules impregnated 61 eggs, or about 3 to each. I am not aware that these experiments have ever been repeated, and it is doubtful how far their results, if correct, are applicable generally.

If only one animalcule is required as the rudiment of the new being, it is evident the others are superfluous, unless they serve some subordinate purpose, which is quite possible. As the essential parts of the nervous system are all double, it may need always two to form them.

Spallanzani demonstrated the fact that contact of the semen with the ovæ was all that was needed to impregnate. He kept a slut carefully confined, and when she was in heat injected the semen from a dog into her vagina; the result was, that she had a litter of puppies like the dog from whom the semen was taken. This operation, as will be shown farther on, is often resorted to, successfully, in human beings, when some impediment prevents impregnation in the usual way.

Impregnation is, therefore, essentially a *material act*, and not the result of any mysterious agency, or unknown spiritual power, as was formerly thought. It is simply the union of two different kinds of cells, or masses of protoplasm, each more or less specialized, or differentiated; the result of the union being the development of a new organism, made up of a mass of cells, propagated from these two primary ones.

Although not formed perfectly, till the age of puberty, semen is yet produced sometimes in children, and accompanied by strong sexual excitement: a fact which should not be forgotten. Probably in most cases semen which will *excite*, is formed long before it is perfect enough to impregnate. There is no doubt, however, that quite young boys are often capable of impregnating, as women have sometimes discovered to their shame.

The state of the mind, and the direction given to the feelings and emotions, has much to do with this. There is, perhaps, no function of the body more influenced

PLATE VIII.

SEMINAL FLUID OF A MAN.

Figure 1 is a parent cell, containing three seminal vesicles.

Figure 2 is a seminal vesicle enlarged, showing its granular structure.

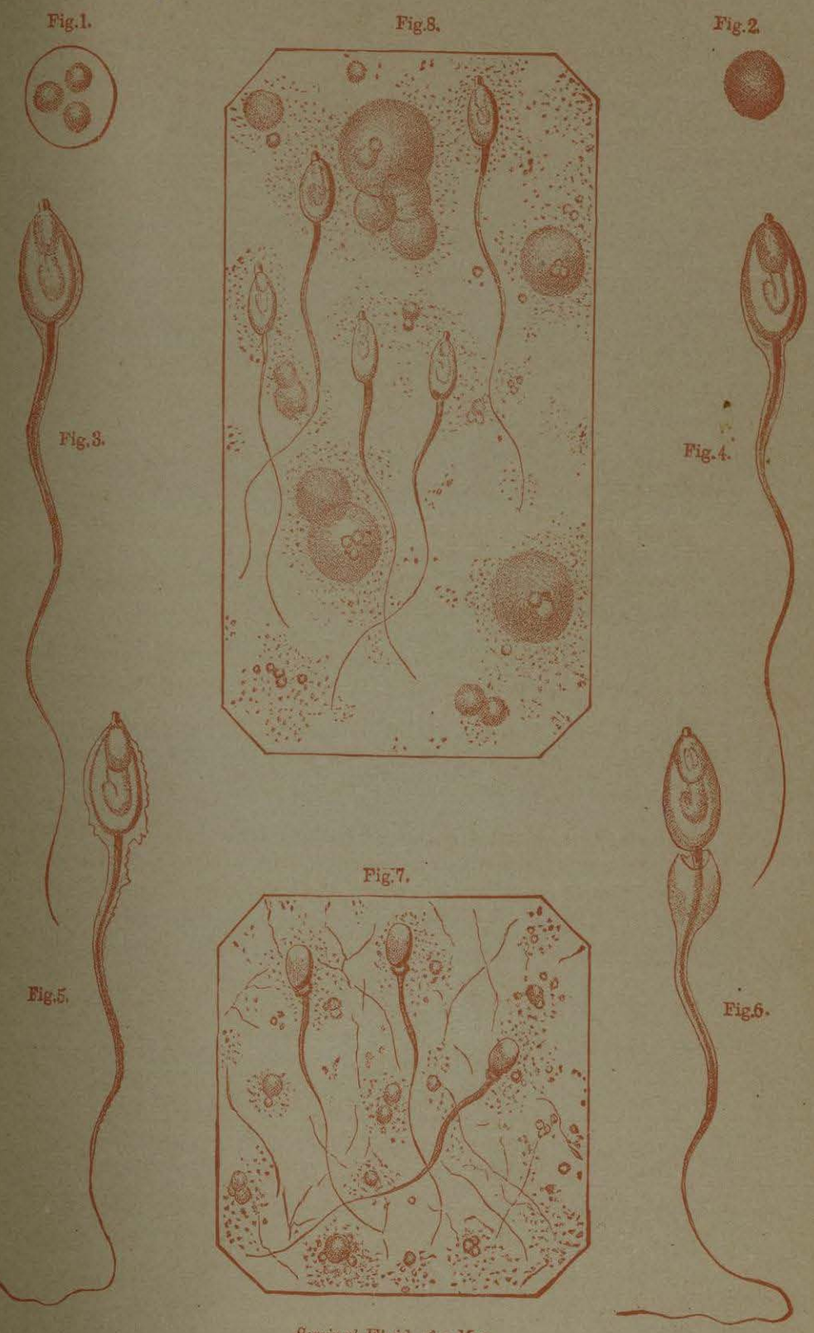
Figures 3 and 4 are two of the animalcules much magnified, showing the mouth with the (probable) stomach and intestines in the interior.

Figures 5 and 6 are two others, equally magnified, showing the outer thin skin torn off, and in shreds, as it often is from their active movements and mutual struggles.

Figure 7 shows dried semen, such as is often found on the linen, and which frequently is the certain evidence of onanism, or of rape. The three animalcules contained in it are stiff and dead. This is under the microscope.

Figure 8. This shows a spot of fresh semen, as seen under the microscope; the animalcules are living and moving, among a mass of mucous globules, and seminal vesicles. Compare these living ones with the dead ones.

PLATE VIII.



Seminal Fluid of a Man.

by mental and moral conditions than that of seminal secretion. It may be increased by dwelling upon sexual matters with the thoughts, or it may be decreased by forcing the mind away from them.

Emotions of various kinds may be powerful enough to utterly suppress sexual excitement, or to raise it to a pitch utterly beyond all control.

There is so much that is curious and wonderful about the seminal animalcules, that it is not surprising they should have formed the basis of many strange theories. That they are necessary to the beginning of life in all the higher beings is beyond question, and that they are living themselves is equally certain. Whether they really propagate, like other beings, we do not certainly know, though many physiologists are convinced, from close observation, that they do. If they do not, then they must be generated *spontaneously!* In either case they must be regarded as necessary to the formation of *the human being in its first stage!*

Those who have doubted their vitality can scarcely have seen much of them. No one who has watched their fantastic and active movements, and observed their gradual development, like that of any other similar being, from a cell, or egg, and seen them stupefied, or even killed, by drugs, can well conceive of them as not living. If they are not living creatures, then thousands of others are not that we always regard as such. For my own part, I have no doubt of their vitality, and I believe them to be spontaneously generated from the epithelial cells of the tubes of the testicles.

In different beings, as before observed, the animalcules vary very much in form, and we will presently give delineations of some of the most remarkable of them.

To those who wish to examine them microscopically, it will be useful to know that they can be best seen in the semen of the male of the common fowl, especially in the spring. They are always most numerous, most active, and largest, at the time of breeding, in all animals. In fact, at other times, they are often almost entirely absent, or only the vesicles are found.

The semen of the male *frog* also shows them very well.

The zoospermes were first positively discovered by Ham, in 1677, at Leyden, and afterwards more thoroughly examined by Leeuwenhock, who announced the fact of their existence to the Royal Society of England. Immediately all the savants then living became interested, and the microscope was brought into general use for their examination. King Charles himself had them displayed before him, and his whole court followed suit. In fact, the whole learned world was much excited, and the most curious speculations and theories were based upon the remarkable discovery.

The zoospermes were first discovered in the human semen, but examination soon showed that they existed in that of all beings, down to insects.

The form of the zoosperm varies not only in the different classes of animals, but even in the species, so much so, in fact, that some physiologists have thought the different species could be distinguished by them; some of these differences are noted elsewhere, both pictorially and by description, but only those which have been thoroughly identified. The older physiologists, who worked with imperfect microscopes, gave very erroneous representations of them, but the more perfect instruments we now possess enable us to observe them plainly, and to portray them accurately.

The great controversy has been as to their nature, many being loath to admit that they are real living beings. A careful examination of them, however, can scarcely leave a doubt on this point. If they are not living creatures, then neither are large

PLATE IX.

SEMINAL ANIMALCULES OF THE FROG.

Figure 1 shows an animalcule with the granular globule still attached to the lower end. It is nearly straight.

Figure 2. It is seen beginning to bend, and it goes on bending more and more, as seen in Figures 2, 3, 4, 5.

In Figure 6 the two ends cross.

Figure 7. The two parts begin to twist.

Figures 7, 8. The twisting has proceeded still farther.

In Figure 9 it is seen with the two parts firmly twisted into one, the loop at the top seeming to form a head.

Figure 10 shows a seminal vesicle bursting, and the animalcules escaping in a bundle, each one with a small yellow granular globule attached to one end.

Figure 11 shows the bundle beginning to break up, so that each becomes separate.

Figure 12. Semen of the frog in water, showing the animalcules, the mucous globules, and seminal vesicles.

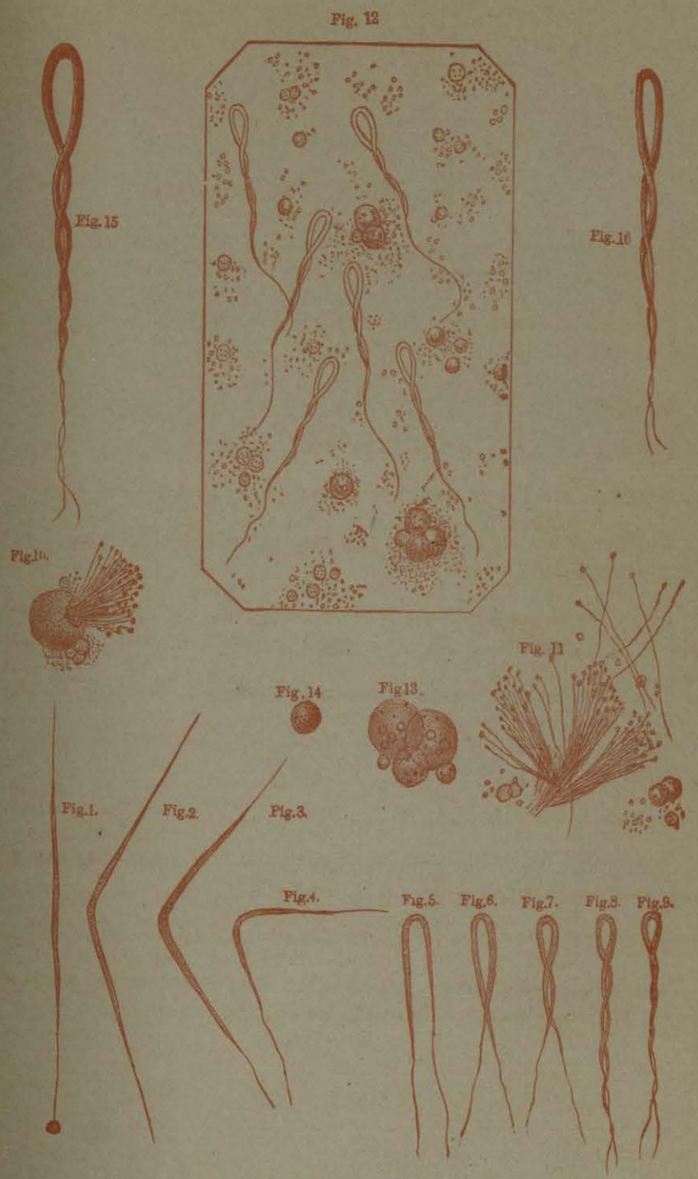
Figure 13. Mucous globules.

Figure 14. The yellow granular globule, which is attached to one end of each animalcule when it first comes out of the vesicle.

Figures 15 and 16 show two of the animalcules much enlarged.

These changes in form are very curious to observe, and are well worth close attention. The semen should be taken at spawning time, in the spring

PLATE IX.



Seminal Fluid and Animalcules of the Frog.

numbers of insects and infusoria, for the zoospermes have all the vital properties of these in perfection.

In fact, the investigations of Pouchet and others prove that they have internal organs—presumably digestive—and also *fins*, by which they swim, as fishes do: they also develop from eggs, just like many other animalcules.

The manner in which the zoospermes move is different in those of different animals; some move simply by lashing with the tail, while others progress by means of a fin on the back, and others again revolve in circles, so that they vary in this respect as much as the different kinds of infusoria.

In the human zoosperm, the motion is always straight forward, and it seems to be effected partly by the undulations of the tail, and partly by the motion of a real fin, on one of the edges, which can be readily seen when the animalcule is examined in profile. It is also covered by a kind of membrane, or skin, which is sometimes cast off—as snakes cast their skin—and is then seen to hang about them in shreds, as seen in some of the illustrations we give.

Schwan even asserts that the human zoosperm possesses a sucker, by which it can attach itself firmly to any part with which it may come in contact; and Ehrenberg asserts the same. Gerber goes so far as to tell us that he clearly detected organs of generation in some that he examined.

Close observation proves that the zoospermes in all animals, develop in vesicles, or cells, as shown in the human being. In many persons suffering from wasting diseases these vesicles are often absent, or very small, and they consequently have no animalcules or very imperfect ones.

Lallemand has demonstrated that the zoospermes exist at first as small globules, and that they grow and develop into a larger and more perfect form gradually, as other animals do. It is, probably, this growth of the zoospermes which causes the testes, in certain animals, to increase so remarkably in size at the season of coupling. In the drake, for instance, they then become three times as large as at other seasons.

It is conjectured, with good reason, that when the testes of these animals are at the smallest, they do not contain animalcules at all, but only their ovæ. After a time these become ripe, break open, and emit the animalcules, which then perfect their development, and by their increase of size, cause the enlargement of the testes.

That the animalcules usually decrease in size in old age, or during certain diseases, is well established, and they are also dull and slow in their movements in such cases.

Henle assures us that the power of locomotion, in a healthy zoosperm, is such that it will traverse the distance of an inch in seven minutes and a half; which is considerable, when its minute size is considered.

When moving, they will turn aside to avoid any object, or to pass by one another, just as other animals do, indicating even will, or choice. Prussic acid kills them instantly, and so does strychnine, after throwing them into convulsions. A slight shock of electricity deprives them of life as certainly as a stroke of lightning does a man.

Meyer and Werneck even assert that the pollen of plants consists essentially of animalcules, having all the characteristics above described; and certainly, as elsewhere shown, the resemblance between them is very close, both in form and action.

PLATE X.

SEMINAL ANIMALCULES; AND EGG, OF A RABBIT.

Figure 1 shows some of the mucus, mixed with semen, taken from the organs of a female rabbit, twenty hours after connection with the male. The animalcules are still living, in the midst of blood corpuscles and mucous globules.

Figure 1*a*. A mucous globule much magnified.

Figure 2. The same fluid taken thirty hours after. The animalcules are seen to be dead, and more or less broken up.

Figures 3 and 4 show animalcules much magnified, seen in different ways.

Figure 5. The bodies of dead animalcules.

Figure 6. A separate body magnified. There is apparently no trace of internal organs.

Figure 8. Smaller animalcules.

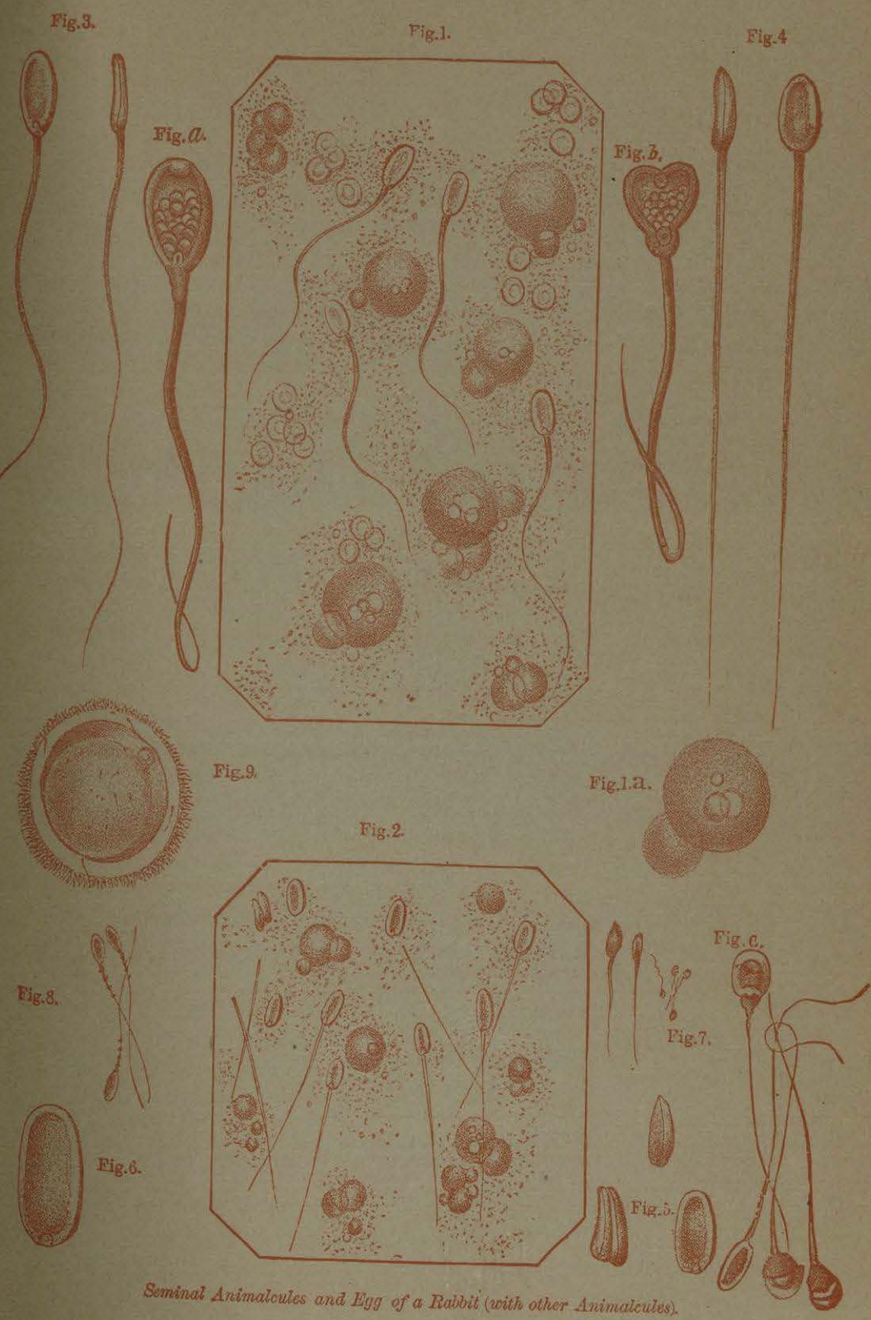
Figure 9. Egg of the rabbit, fifteen hours after connection with the male.

Figure *a*. Seminal animalcule of the bat.

Figure *b*. Seminal animalcule of the bear. In this there are seen two openings, the one at the top supposed to be the mouth, and the other the anus.

Figure *c*. Seminal animalcules of the Guinea-pig.

PLATE X.



Seminal Animalcules and Egg of a Rabbit (with other Animalcules).

And this accords perfectly with what is shown elsewhere, that plants and animals are, essentially, in the primitive form, identical with each other.

It may be stated as an absolute fact that living animalcules, variable in form, are found in the semen of all animals, and that they are the real vivifying, or impregnating principle of the semen. If they be filtered out, the remaining part of the seminal fluid has no effect on the female egg whatever. They are not found before puberty, and in those animals which propagate only at certain seasons, the animalcules are found in the semen only at those seasons.

In the *polecat*, the head of the animalcule is round, large, and flat, so that when they are laid sideways, only the head and tail can be seen. They much resemble tadpoles, and have similar movements, effected entirely by the bending and straightening of the tail. The movement is always forward, and never backward, as is the case, indeed, with those of most animals.

The animalcules of the *dog* are much like those of the polecat, but are not so large.

Those of the *rabbit*, shown in the illustrations, are longer than those of the dog, and they are the most active and the most varied in their motions of all the animals yet examined, which makes them very valuable for observation.

The animalcules of the *Guinea-pig* are longer than any of the others above named, and much resemble those of the polecat, excepting that on the head is noticed a circular semi-transparent mark.

In the *field mouse* they are very long, and shaped like eels, which they also resemble in their mode of swimming. Their heads are marked by several transparent dots, similar to the one observed in the polecat, which give them a very peculiar appearance. The *rat* and *common mouse* are very similar to the field mouse.

The animalcules of the *horse* are not large in proportion to the animal, and have round heads, in the center of which is a clear, bright, globular point.

Those of the common *fowl* and the *pigeon* are very much alike, having an oblong head, with the usual long tapering tail. Those of the *duck* are shorter and thicker, and are only found in the spring and beginning of summer. In fact, in all birds that have a pairing season, we find the animalcules only at that season.

The largest animalcules, not only in proportion to the animal, but absolutely, are found in *snails*, which seem to have been unusually favored by nature, in regard to sexual development.

In whatever light they may be regarded, these beings possess great interest. They are undoubtedly the beginning, in some way or other, of all animals, but we know very little of the way in which they begin.

CHAPTER XIX.

IMPREGNATION, EXTERNAL AND INTERNAL.

POUCHET'S TEN FUNDAMENTAL LAWS WHICH GOVERN THE PROCESS OF FECUNDATION.

1*st Law.* Generation is essentially the same in all beings, mankind not excepted.

2*d Law.* In all beings, the female eggs exist before and independent of conception, the same as the male semen does.

3*d Law.* The egg is never impregnated in the ovary or organ that produces it.

4*th Law.* The egg must always have attained a certain development before it can be impregnated, and must also have left the ovary.

5*th Law.* In all beings the egg leaves the ovary independent of impregnation.

6*th Law.* In all animals the eggs are emitted at certain regular periods, peculiar to each, at which times there also occurs a peculiar excitement of the female organs.

7*th Law.* Conception can occur only when the semen is present at the same time with the perfectly developed egg.

8*th Law.* The menstruation of the human female is strictly analogous to the periodical erotic excitement of other animals, sometimes termed the rut or heat.

9*th Law.* Consequently, conception is necessarily connected with menstruation, and there is, therefore, in human females, a period when impregnation can occur, and one when it cannot, *and those periods can be pointed out.*

10*th Law.* In the human being, impregnation always takes place either in the womb, or in the very end of the tube next to the womb.

It has already been shown by the previous explanations, that the two generative principles, the *sperm cell* and the *germ cell*, must be brought together before they can originate a new being by their joint action. This union is called *impregnation*, or *fecundation*, and it is effected in many different ways; sometimes it occurs in the body of the female, and at other times without. When it occurs within the female body it is effected by the act of *copulation*, for which special organs exist, which will be described farther on; when it occurs without the body, the process is much more simple, no act analogous to copulation then taking place.

The actual process of impregnation, or that union of the two principles from which the new being originates, has always been a physiological mystery, and a fruitful theme for philosophical speculation. It is evident, however, that the only way to clear up such a mystery, is to examine the generative organs, and their products, under every possible variety of circumstances, and to do this with care and patience for a length of time, so that a sufficient number of observations may be made. This task has only been undertaken very recently, and consequently our knowledge of this mysterious process, until lately, has been altogether incomplete and imperfect. The investigations already referred to, and others which will be men-

tioned farther on, have developed the laws of fecundation, and removed that process altogether from the field of mere speculation. M. Pouchet was undoubtedly the first who clearly enunciated these laws in any publication, though others had arrived at them independently; we will, therefore, state them as he has done, and then make whatever comments and further statements may be necessary.

The First of these Laws has been already well illustrated in our first articles, where it has been shown that the generative process is essentially the same in man as in all other beings, though it was formerly thought to be different. All animals, it was there explained, are developed from eggs, formed in the female's body, only in some these eggs are impregnated and developed internally, and in others externally; and in some, as the human being, for instance, they are very minute, and, therefore, difficult to discover.

There are four different varieties of the generative process; the *viviparous*, or that in which the eggs are impregnated and developed into the new being within the body, as in the human being; the *oviparous*, or that in which the eggs are impregnated within the body, but expelled and hatched without, as in birds; the *ovoviviparous*, or that in which the eggs are impregnated within the body, and hatched while they are passing out, as in some insects and reptiles; and lastly, the *marsupial* variety, or that in which the young are half-formed within the body and complete their growth without, as in the kangaroo. To one or the other of these varieties the generation of every animal can be referred, though in some there may be unimportant peculiarities in the process.

An example of ovoviviparous generation may be seen in the common *meat-fly*, which does not lay eggs upon the meat, but little larvæ, or maggots, perfectly formed, the eggs being hatched while passing down the canal from its body. In some species, the young have even developed into perfect insects, and are ready to undergo their metamorphosis when they pass from the body of the mother. The young *scorpion* is perfect, and begins to walk immediately it is born, having been hatched and developed within the parental body, and the same thing is observed in the common *aphis*, or green plant-louse. Some insects can even generate both ways, and produce sometimes eggs, and sometimes perfect young, or even both together, in immense numbers. The structure of the egg is always the same, but in the oviparous animals it has added to it a quantity of extraneous nutriment by which the new being is nourished while in the shell, or outer covering. The eggs of the viviparous have nothing of the kind, because they are attached, from the first moment of conception, to the mother's body, and derive their nutriment from it. The large portion of vitellus, or yellow, which we see in the egg of the chicken, is only intended to supply nutriment to the young, and so is the albumen, or white, which, with the shell, form no part of the egg, properly speaking, but are formed around it, *after it leaves the ovary*, and while passing from the body.

An examination of the ovarium of the bird will make many of these statements readily understood, and will be found a very useful study. It consists, during the laying period, of a large number of ova, of various sizes, all fastened by ligaments, or small stems, to a central point, which is the true ovarium, and from which they all originate. Some of the ova, or eggs, are very minute, like mustard-seeds, while others are larger, and a few are nearly as large as when expelled from the body, but none of these have either white or shell while they remain connected with the ovary. As the egg enlarges, the ligament which holds it becomes less, and eventually, when