PART XII.

DEVELOPMENT OF THE NEW BEING.

CHAPTER XXVI.

FIRST CHANGES OBSERVED IN THE OVUM AFTER FECUNDATION, AND THE WAY THE EMBRYO BECOMES CONNECTED WITH THE MOTHER.

THE description already given of the structure of the egg, unimpregnated, will make the following account of the changes it undergoes after fecundation, and the final development of the embryo from it, readily understood.

The precise way in which the sperm affects the egg, so as to cause these changes, we do not know; it is only the changes themselves that we can observe. Observations on the frog show that when fecundation takes place, the animalcules become imbedded in the gelatinous covering of the ovum, almost the moment they touch it, and pass at once into the vitellus or yelk, where all further trace of them is lost. Most probably they there combine with the vitelline material, and commence the new being. All this is accomplished by the *motion* of the animalcule, for without that it could neither reach the ovum nor enter it. When dead or rigid, they cannot impregnate.

It seems probable that when the germinal vesicle is ripe, it becomes filled, in the interior, with cells, which, when it bursts, become mixed with the cells of the vitellus, and so disappear. The germinal vesicle is therefore an egg within the egg, and it is probably one of the cells of the vesicle which the animalcules enter, and not one of the ordinary cells of the vitellus. This is why the yellow of the vesicle is often called the *germ yelk*, because it is the real point of origin of the new being, while the yellow of the ovum is called the *food yelk*, because it only supplies the nutrient material by which the new being grows. Probably the *germinal dot* is merely the ripest germ cell, and the one into which the animalcule enters. That the perfect new being is a product of the *two* principles, the male and female, there is no doubt, though a partial organism may occasionally result from one principle alone, as shown elsewhere.

When impregnation has been effected, then begins the nutrifying and growth of the embryo, some steps in the progress of which have been observed, but more in the lower animals than in the human being.

At the time when the ovum is leaving the ovary, it has somewhat the appearance shown below.

It will be seen that the cells on the outside layer or proligerous disk, as it is called, which surrounds the zona pellucida, or white, are club-shaped, their thick ends being outward, and their points all touching the surface of the ovum within. These cells remain thus, more or less, during the passage of the ovum down the Fallopian tube, and are found upon it even after it enters the womb. In other animals, however, as in the rabbit, they disappear much sooner; ultimately they disappear entirely in all cases, so far as observed. (Figure 97.)

Figure 98 shows the same ovum when these outer cells are nearly all gone.

During the passage to the womb, the ovum becomes covered with an albuminous envelope, resembling the *white* of a bird's egg, which is called the *chorion*, and which, as will be shown further on, plays quite an important part in the formation of the new being.

The first change observed in this membrane is that it becomes spongy, or covered on the surface with minute projections, like fine moss. It is probably by these that

FIGURE 97.—*Ovum from the ovary of a female dog, in heat.*

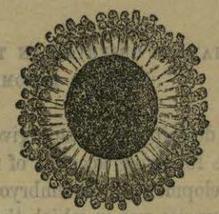


FIGURE 98.—*The same ovum as in the preceding plate, showing the disappearance of the club-shaped cells.*

the fluids of the Fallopian tube and womb are absorbed and made to contribute to its growth.

The womb itself also begins to change, as if it were preparing itself for the new visitor. All over the interior there gradually forms a fine membrane or lining, called the *decidua*, which folds inward when the ovum enters from the tube, and forms a cushion on which it lies. When there is no conception, the decidua is cast off along with the unimpregnated ovum, but when conception occurs it remains, and assists in forming the placenta, by which the child is connected with its mother.

At a later period, the decidua is found to consist of two layers, the outer one called the decidua vera, lining the interior of the uterus, and the inner one, called the decidua reflexa, covering the ovum. There are some differences of structure between these two layers in the early stages, but later on they become united so as to be indistinguishable.

The way the ovum becomes inclosed by the decidua reflexa is well shown in the following figures:

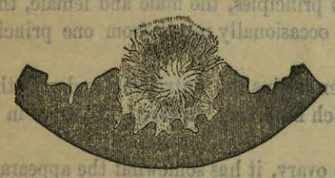


FIGURE 99.

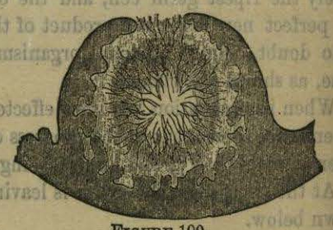


FIGURE 100.

In Figure 99, the ovum is seen pressed up against the decidua vera, lining the interior of the womb; and the decidua is beginning to push out arms around it.

Figure 100. In this illustration the two arms thrown out by the decidua vera have nearly surrounded the ovum, or have become reflected around it, thus forming the decidua reflexa.

When this stage is reached, the two deciduas are indistinguishable; the surface of the ovum, it will be seen, is quite shaggy, or covered with a hair-like growth of small vessels. These, as before explained, suck up nutriment from the surrounding fluids, and so begin the first stages of nutrition.

At a later period, these hair-like tufts become mixed with blood-vessels, which finally predominate, and by which more complete nutrition is effected. These blood-vessels communicate with the embryo through the chorion, and with the vessels of the mother's womb by the decidua, forming finally what is called the *placenta*, the organ by which mother and child are united.

The manner in which the embryo receives its nutriment from the mother, varies somewhat in different viviparous animals. In the lower types, the new being, for the most part, derives its nutriment indirectly from the surrounding fluids; and even in many of the higher types, the connection between parent and offspring is not close and intimate, but occurs at a number of scattered points. In man, however, as in all the highest types, the connective vessels between mother and child are all concentrated at one point, forming a large mass, the *placentæ*. In this organ the pure arterial blood of the mother is poured into certain cavities, from which the vessels of the fœtus absorb it, without directly connecting with the vessels of the mother. Into the same cavities also the blood of the fœtus, and its refuse material, are thrown, and taken up by the veins of the mother, to be mixed with her venous blood, and purified in her body. All animals in which this occurs are called *placental*, while those in which there is no such close connection, as in the marsupials, are called *non-placental*.

It is instructive to note here that the placental connection explains how the mother may be affected, through the child, by the father. It is certain that diseases may be transmitted from father to child, through the semen, especially syphilis, and beyond doubt the child transfers these diseases to the mother, in the impure blood which it returns to her through the placenta. Many diseases thus communicated may affect the mother ever afterward, though the child may experience little or nothing of them. And not only diseases, but physical, mental, and moral impulses may thus be given by the male to the female, through the child, which may profoundly influence her bodily and mentally as long as she lives. This is why some women, who marry again, often have children resembling their first husband, in feature, health, bodily constitution, and mental peculiarities. In fact, a woman is probably always influenced, permanently, by every man by whom she bears a child, so that her last children, if she have several husbands, may, in one sense, belong more or less to them all. This fact has long been known in regard to animals, though not practically acted upon to the extent it might be. In some future time the desirable qualities of many different males will thus be concentrated in the offspring of one female, to the great improvement of a race.

CHAPTER XXVII.

DEVELOPMENT OF THE NEW BEING FROM THE GERM.

THE first beginning of the new being, so far as our observation is able to go, is a single small cell, lying in the midst of the vitellus, or yellow of the egg. It resembles a drop of albumen, or white of egg, such as might be taken up with a pin. It is, in fact, a speck of protoplasm, such as those that form the moners, and infusoria generally.

This simple cell, the germ of a future human being, in no way differs, so far as can be traced, from the cells from which all other animals, or even plants are developed. Man, in fact, has the same origin as all other living things, animal and vegetable, down to the simple green mould which spreads over a damp wall.

Even the first steps in the process of development, up to a certain point, are the same in man as in all other vertebrate animals; and it is not possible, till that point is passed, to tell whether the germ will form a fish, reptile, bird, or mammal.

The germinal vesicle, as already stated, disappears as the egg ripens, but if fecundation occurs it is succeeded by the *embryo cell*, which we have already spoken of as lying in the substance of the vitellus. The first changes observed in the embryo cell are these: it divides first into two cells, then into four, eight, and so on, to an indefinite extent, and it is from these new cells, into which the original cell is multiplied, that all the different parts of the future embryo are formed.

The yelk of the egg also undergoes a similar change at the same time, dividing first into two portions, and then into four, and so on, till it forms just as many separate parts as there are new cells formed from the primary embryo cell.

Each cell absorbs to itself one of these portions of the yelk, which forms its share of the primary nutritive material; for the purpose the yelk serves is to provide material by which the new being first begins to grow.

In the mammalia, these changes occur while the egg is passing down the Fallopian tube to the womb, and by the time it reaches there the subdivision, of both cells and yelk, has proceeded so far that the whole mass seems made up of numerous minute grains, which occupy nearly all the original space of the *zona pellucida*, or white.

These changes are very clearly shown below.

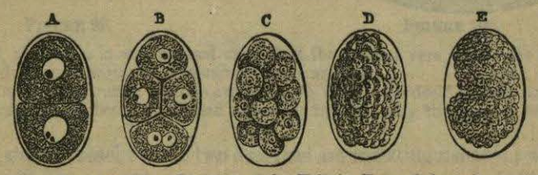


FIGURE 101.—*Division of the Yelk in Eggs of Ascaris.*

This shows the yelk dividing first into two, as in A, then into four at B, and so on up to E.

The next figure shows the corresponding changes of the ovum of a dog.

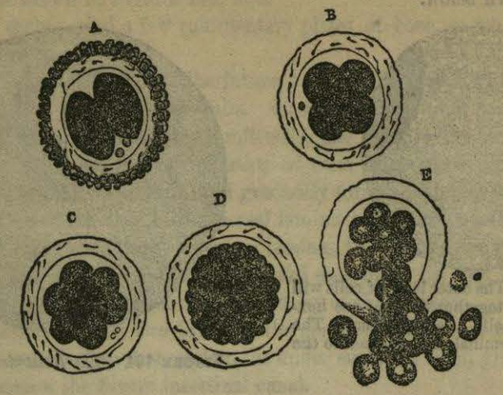


FIGURE 102.—*Division of the Yelk in Egg of the Dog.*

A, shows the ovum with the yellow first divided into two. The white contains several seminal animalcules. This is from the Fallopian tube about half an inch from the womb. B, shows the further division of the yelk into four parts, and the gradual disappearance of the outer projections. This was taken just at the entrance of the womb. C. A still later stage, with the division carried still farther. D. An ovum from the womb. The subdivision of the yelk has now gone so far that it is a mere mass of granules. E. This represents an ovum burst, by compressing it, to show the yelk segments, each containing a transparent vesicle, or cell, in its interior.

It is not possible, for obvious reasons, to obtain the ovæ at every corresponding known stage in the human being, but we know them to undergo similar changes.

Up to this stage, the separate yelk grains, with their cells, are all loosely aggregated together, each one distinct, but with no definite investing membrane. One soon forms, however, around each, converting it into a cell, of which the yelk is the contents, and the vesicle the nucleus.

The outer layers of these cells adhere together, forming an investment for the whole, which binds them together into a globular mass.

When this process is fully completed, the interior of the mass is found to be hollow, and to contain a clear fluid. It is then called, by some physiologists, the *blastodermic* vesicle.

Gradually this globular mass or vesicle becomes larger, and a darker colored roundish spot is seen upon it, called the *germinal area*. It seems to be formed by the gathering together of a number of the original small cells which have become opaque.

The wall or outer membrane of the vesicle, called the *germinal membrane*, now thickens, and gradually divides into two layers, which at first seem both alike, but eventually differ very much, and fulfill very different purposes in the future development.

The outer one, called the *serous layer*, or sometimes the *animal layer*, forms the foundation of the future spinal column and nervous system; the inner one, called the *mucous layer*, or *vegetative* layer, forms the foundation of the future nutritive organs. This division first begins in the germinative area, but soon extends over the whole germinal membrane.

The germinative area, at first roundish, gradually becomes oval, and then pear-shaped, as shown below.

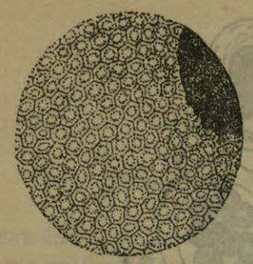


FIGURE 103.—The outer layer of cells will be seen squeezed together till they are hexagonal, like the cells of a honeycomb. The dark spot, or germinal area is seen to the left, at the top.

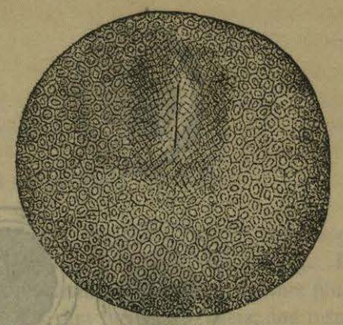


FIGURE 104.—*The Blastodermic Vesicle.*

In the center of the pear-shaped area, Figure 104, is seen a clear white space, called the area pellucida, bounded by a dark ring, which is afterward called the *area vesiculosa*. Down the center of the area pellucida is seen a thin dark line, called *the primitive trace!* which appears to be formed from the serous layer only,—this line or primitive trace, is *the actual beginning of the future human being!*

The outer dark pear-shaped ring, is in two portions, or separate rings, united together, called the *dorsal laminæ*. They play a very important part in the further development, as will be shown.

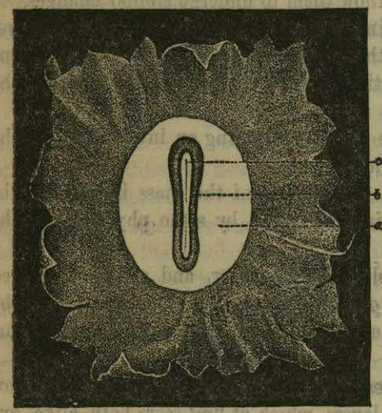


FIGURE 105.—*First changes in the Germinative Area.*

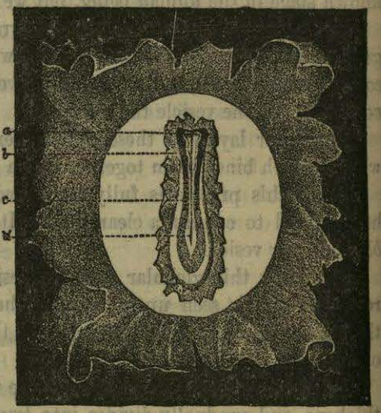


FIGURE 106.—*Ovum more advanced, showing the beginning of the Brain and Spinal Column.*

These rings, as will be seen in the above illustration, assume finally a shape like a guitar, and gradually swell up all round, so that the shallow groove, called the primitive trace, becomes buried deeper and deeper between them. This goes on till the edges of the two rings fold over, come together, and so form a tube. At the same time the upper part of the groove (the primitive trace) divides into three separate parts or vesicles, which are the beginnings of the three principal parts of the future

skull and brain, and the lower part of the groove becomes the future backbone and spinal marrow, as shown in Figures 105, 106.

Even at this early period a few rudimentary plates of bone, or what will become bone, may often be traced.

In birds and fishes, the bones of the future spine are indicated by a straight cord of round cells, called the *chorda dorsalis*. In some of the lower fishes these never become bony, but always remain simple soft cells, like those in the human embryo.

While this is going on, an accumulation of cells takes place between the two laminæ of the germinal membrane, and gradually form themselves into the future blood-vessels. From each side of the dorsal laminæ also a prolongation is sent out, which forms what are called the two ventral laminæ, from which are formed the ribs on each side. These gradually bend over toward each other till they finally join, on the future breast-bone, and thus shut in the cavity of the chest.

The outer portions of the two layers of the germinal membrane fold over under the abdomen, so as to inclose that, and on the under surface a small groove gradually forms, which becomes the future intestinal canal.

Up to this point, the embryo has been nourished directly by the matter of the original vitellus, or yelk, with which it was in contact, but its increased size and complexity of structure now require a more perfect distribution, and a different mode of assimilation. This is effected by the formation of the blood-vessels, which are gradually evolved from the nuclei of the cells, the cavities of which have become connected. The first function of the new-formed vessels is to absorb all the nutritious matter of the yelk, and convey it to all parts of the embryo by circulation, so that each part receives what it needs. This continues till the yelk material has been entirely absorbed and appropriated. The first movement of nutritive fluid being *toward* the embryo from the outside, before any *heart* can be detected.

At quite an early period, in mammalia, the yelk sac is gradually separated from the embryo by that portion next the body becoming contracted. The connecting link, however, always remains, forming what is afterward called the umbilical vesicle.

The heart is formed from a cluster of cells, beneath the upper part of the spinal column. It begins to pulsate even before it has lost its cellular character, and becomes muscular by degrees. In the chicken, it may be distinctly perceived in 27 hours after incubation has begun. The different parts of the heart are developed successively, and the circulation is at first carried on just as it is always in fishes, the true mammalian heart coming afterward. Thus all mammalia, man included, at a certain stage, are fishes, in the circulating apparatus as well as in other respects.

The allantois in birds is the organ by which the embryo breathes, or is brought in contact with the air which comes through the shell. The human embryo, however, uses the mother's lungs, as explained elsewhere, and in it the allantois is merely the medium of connection between the embryo and the chorion, at the placenta. It is the same in all other mammalia, and in some it extends around the whole embryo. Ultimately, as the connection between mother and child becomes more direct, through the blood-vessels of the uterus and placenta, the allantois shrivels up, and almost disappears, being no longer needed. The same thing also occurs in regard to the umbilical vesicle, which disappears in the same way, excepting a small portion which develops into the *urinary bladder*. The duct by which it was connected with the abdomen also shrivels up in the same way, all but a small

PLATE XXI.

THE WOMB AFTER IMPREGNATION.

Figure 1. *a.* Walls of the uterus, cut through, showing their spongy structure. *b.* Mucous deposit, which afterward forms the lining membrane, or decidua vera. *c.* Inner mouth of the womb, or *os uteri internum.* *d.* Mucous deposit in the neck of the uterus. *e.* Outer mouth of the womb, or *os uteri externum,* or *os tincæ.* *f.* Base of the womb, or fundus of the womb. *g.* Uterine end of the Fallopian tube.

Figure 2. Longitudinal section of the uterus. *a.* The decidua vera. *b.* The decidua reflexa, hanging like a sac in the cavity of the womb.

Figure 3. Shows the formation of the decidua reflexa, by the gradual entrance of the ovum. *a.* The ovum, pushing its way into the womb, and carrying the decidua before it. The different rings show the decidua reflexa at different stages, till it is pushed against the decidua vera.

PLATE XXI.

Fig. 1.

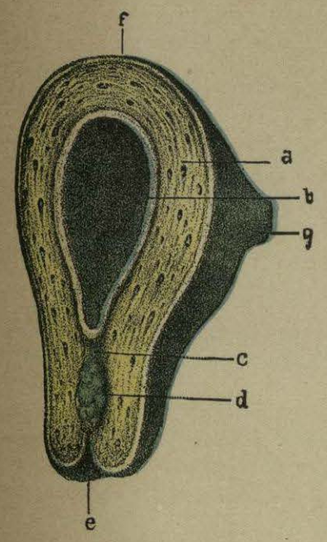


Fig. 2.

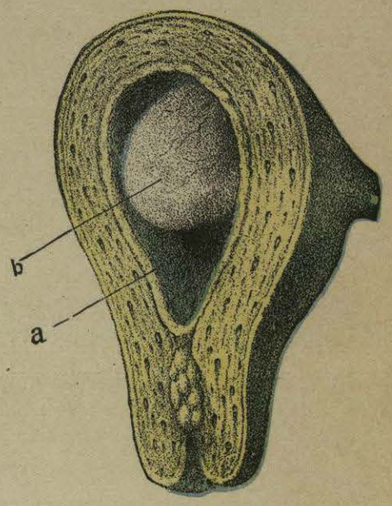
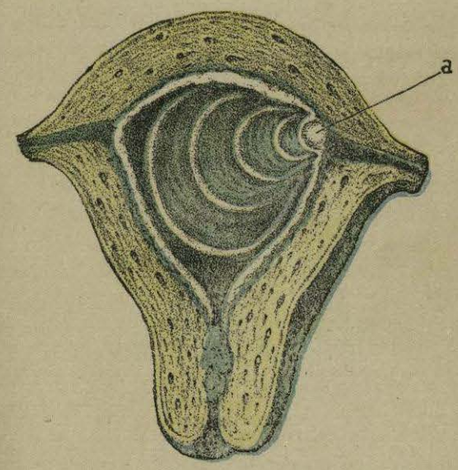


Fig. 3.



Section of the Womb.

part, which remains and forms the ligament called the *urachus*, by which the bladder is suspended to the navel, or umbilicus.

The amnion contains a peculiar fluid, called the *liquor* amnii, which in composition is similar to the serum of the blood. The embryo floats in this liquor, and probably absorbs it as nutriment. During the first two months, the space between the amnion and the inner membrane of the chorion is also filled with a peculiar gelatinous substance, which probably likewise assists in the nutrition, before the formation of the placenta and blood circulation.

The umbilical cord, by which the child is connected with the mother, when fully formed, is composed of a portion of the amnion, the umbilical vesicle, the vessels by which the yelk was absorbed into the embryo, the urachus, and the blood-vessels which pass from the mother to the child. At a later period, the cord is composed mainly of these blood-vessels, which in man consist of two *arteries* going from the mother, and one *vein* going from the child.

The plan of the circulation of the blood is the same in the embryos of all kinds of vertebrates, at an early period, and gradually changes in each till it attains the form peculiar to that type. In man it resembles them all in succession.

The liver, in the human being, begins to be formed about the third week, and it is from the first very large, being at the fifth week one half the weight of the whole embryo. About the third month it reaches nearly to the pelvis, and almost fills the abdomen. After this it begins to gradually decline, but remains very large, in proportion to the body, up to the period of birth. During fœtal life, the liver appears to perform a very important part in the purification of the blood.

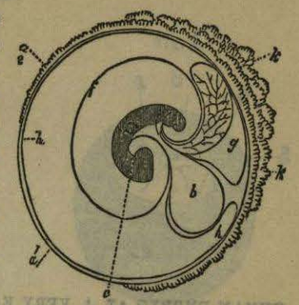


FIGURE 107.—*Diagram of the human Ovum at about the second month of Embryonic Life.*

a 1. Smooth part of the chorion, or outer membrane. *a* 2. The portion of the chorion called the villous, from the formation of numerous small vessels, like roots. *k k*, shows these vessels much enlarged, and beginning to collect into the mass called the placenta, through which the embryo is nourished by the mother's blood. *b*. The umbilical vesicle, or remains of the yelk sac. *c*. The young embryo. *f*. The inner layer of the investing membrane, called the amnion. *g*. The allantois. *h*. The outer layer of the amnion, which unites with the chorion.

The lungs first appear as two buds, at the upper part of the alimentary canal, and progress very slowly, because they are not needed during fœtal life.

The urinary organs present some very interesting features in the course of their development, representing, as they do in their early stages, the permanent forms of these organs in all the lower types. In the chicken, the first sign of a urinary apparatus is discernible on the third day; it is then in the form of two tubes, one extending down each side of the spinal column, from the heart downward toward the allantois. On the fourth day, there are formed, in connection with these tubes, certain bodies called the *corpora Wolffiana*, or Wolffian bodies. These are evidently secreting bodies, and the fluid they secrete is poured into the cloaca, or end of the large intestine. These Wolffian bodies, and certain clusters of convoluted vessels which form with them, are the only urinary organs of fishes; but in the bird they develop further, and in the higher vertebrata finally become true kidneys.

In the human embryo, the Wolffian bodies appear about the end of the first month, and about the seventh week the true kidneys begin to be seen, as if growing from