THE WONDERS OF THE EGG.—III.

[LECTURE BY PROFESSOR AGASSIZ.]

Having seen something of the great diversity among the eggs, characterizing different classes of the animal kingdom, we may now consider the functions of the egg itself—that is, the part which eggs take in the history of generation. I cannot dwell too emphatically upon the fact that eggs are produced and grow without any agency of the male animal. They are a production of the female organism. So true is this that the ovarian egg may be found in animals before they have reached maturity, before they have completed their physical growth—nay, ovarian eggs have even been observed in the embryo before birth. Neither do successive generations begin with the birth of new individuals, but with the formation of the egg from which these individuals proceed. We must look, then, upon the egg as the starting point of the complicated structure of the adult being. It is, as it were, a sieve through which the qualities transmitted by parents to their offspring are sifted. Whatever peculiarity there may be in the new being has its foundation in the egg. Within those narrow limits are circumscribed all the conditions of change; and therefore it is of paramount importance to know what the egg receives and what it transmits. We cannot investigate this part of the subject too closely. It is of vitalimportance to the question. And yet I have not seen it discussed in connection with the various explanations of the origin and diversity of life recently attempted. The egg arises in the maternal organism, without the co-operation of the other sex, and it can transmit only what it receives directly from the maternal organism, or from the paternal organism through contact with the maternal, or from ancestors through one or both. There has never yet been recorded an instance in which an egg has grown to be anything but a being similar to its parents, and yet the possibilities of modification are so numerous under these conditions, and the range of variation so great, as to make us wonder the more at the constancy of types.

MODIFICATIONS DUE TO ANCESTRY AND SEX.

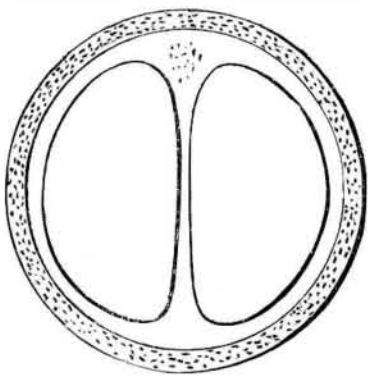
Suppose, for instance, that a male and female (I deal here with the subject in the most general way without reference to any particular species or type of animal) produce three new individuals. The three may be all males or all females, or two may be females and the third a male, or *vice versâ*. The three may all resemble the mother, have her features, her stature, her physical tendencies generally; or they may all resemble the father; one or two of the three may resemble the mother, the third may resemble the father; or only one may resemble the mother, the other two being like the father; or they may all combine the physical features of both parents; or one may present such a combination, and the others follow distinctly one or the other parent. Any one case, be the offspring more or less numerous, will show us what a variety of modifications arises merely from the contact of two beings to produce one or more new individuals. But the matter is still further complicated. These new individuals have had a grandfather and grandmother on the paternal side. You are all familiar with the singular fact, well known to us in the human family and often observed throughout the whole animal kingdom, that children may not resemble their parents at all, but be strikingly like their grandparents. Thus in the new individuals, the same combinations which might arise from their immediate progenitors may also pass to them from a previous generation, from their grandparents, or even from their great grandparents, or further back still. This reproduction of the features of nearer or more remote ancestors in their descendants is so well known and recurs so frequently that it is looked upon by naturalists as a law, and is called the law of atavism. There are historically recorded instances of the reappearance of characteristic family features after a lapse of several generations.

All these intricacies of inheritance, so frequently interrupted and seemingly so capriciously reproduced, must be connected with the egg through which influences pass to the new being. Suppose, for instance, that any features or traits, physical, moral, or intellectual, are handed down from a male grandparent through the paternal side. In such an instance the egg, which produces the new individual, does not receive the direct transmission of inherited qualities, for, as I have said, that egg arises in the maternal organism, and has a life and growth of its own before the act of fecundation takes place. Through that act of fecuntion must be made the impression by which these inherited qualities are received and transmitted to the new individual. Where the new individual reproduces the maternal features only, or features characteristic of the maternal line of descent, the case may seem at first sight more simple; but when we analyze it in all its bearings, we shall see that there is matter enough for wonder, and that we as yet know almost nothing about the mysterious problem of life. What can there be of a material nature transmitted through these bodies called eggs, themselves composed of the simplest material elements and arising in the female organism without co-operation of the male, what influence can there be, I repeat, by which all peculiarities of ancestry belonging to either sex are brought down from generation to generation?

The egg, as we have seen, is, in its incipient condition, only an organic granule arising between the structural cells of the ovary. It grows there and acquires a remarkable complication before it has completed its successive phases as an egg. Not until it has reached the state which I have described as that of the perfect egg does it receive the contact of the spermatic cells from which dates the formation of a new being, either male or female. This in itself is a strange thing—that a mother produces, not necessarily a being like herself, but quite as often beings so unlike herself in structure as to be endowed with all the peculiarities of the male sex. In the origination of a new species, this double series of influences must be included and combined in the proportions necessary to produce a being differing from all foregone species, and capable of maintaining its pattern generation after generation.

There is one feature in the growth of the egg of which I have as yet said nothing. The yolk, that homogenous substance, which fills the vitelline membrane, in which swim the germinative vesicle and germinative dot, must undergo a very remarkable change before it can give rise to the new individual. It is self-kneading, broken by the process of its own growth into a smaller or larger number of distinct fragments.

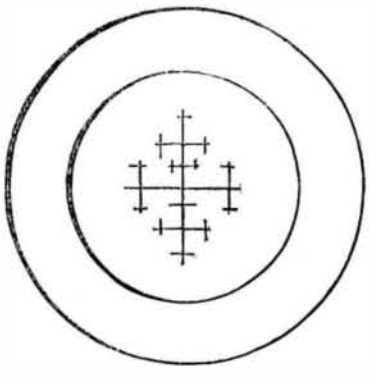
This breaking up of the whole substance which simulates disintegration ends in a recementation; these fragments reunite to form the mass out of which the new germ is to be developed. This process is knowr. as segmentation, and has been observed in the eggs of all animals. The process of segmentation has been studied in the mammalia, in birds, in reptiles, in fishes, among articulates, among mollusks and radiates. This process may or may not be initiated by fecundation. There are some animals in which the first appearance of segmentation may precede fecundation; others in which it is always subsequent to fecundation; in no animal is the process known to be completed without fecundation. Neither does it take place in all animals in the same manner,



EGG OF MAMMAL DURING SEGMENTATION INTO TWO PARTS.

Within the vitelline membrane, occasionally it would seem that the whole yolk is not taken in; there are sometimes little fragments left out from the larger masses. Whether these separate balls of yolk have envelopes of their own is a question difficult to decide. The most skillful naturalists differ about it. The original yolk being thus divided in to 4, the same process goes on till the 4 are divided into 8, the into 16, the 16 into 32, the 32 into 64.

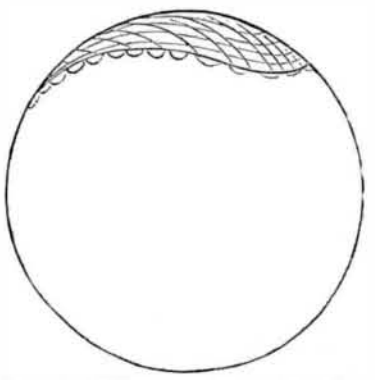
Beyond this it is almost impossible to track them individually; it is difficult to bring the whole yolk under the microscope, so that each fragment can be counted; and if it is pressed, however slightly, the whole mass then runs together, so that no division whatever can be traced. Occassionally, however, the self-division has been followed even beyond sixty-four. By this time, the yolk is transformed into a body which has much the appearance of a mulberry, and this condition of the yolk has been called the mulberry stage. When it has become so far subdivided that every separate particle, owing to its diminutive size, is difficult of microscopic observation, even under very high power, each such particle seems like a cell, and may indeed be considered as a cell. This self-division of the yolk mass ends in an accumulation of cells which differ from those of the initiative yolk, and are the basis for the formation of the new being, the material in fact out of which the new being is to be built.



EGG OF TURTLE DURING SEGMENTATION.

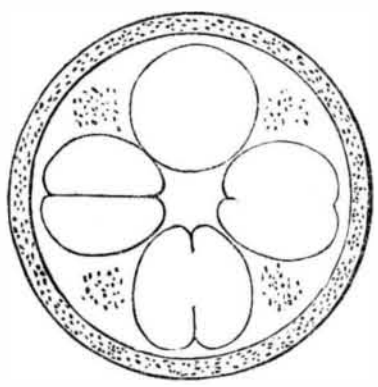
If we now compare the egg of a reptile, that of our common snapping turtle for instance, with the mammalian egg, we find that the process of segmentation differs somewhat, and does not penetrate the whole substance in the same manner. A portion of the surface of the yolk becomes plowed, as it were, by furrows at right angles with each other. These furrows do not extend over the whole surface but encroach upon it only for a certain circumscribed area, the remainder of the yolk remaining in its original condition of yolk cells, while the furrowed area rests upon it as a skin or layer. There is now a difference between above and below, marked by the distinct character of the upper and lower portions of the yolk. We shall presently perceive a difference between right and left, between front and back also.

Take, for instance, the highly magnified yolk of a mammalian egg, with the germinative dots already formed on the the side. The vitelline membrane surrounding such a yolk is rather thicker than in a bird's egg, and forms a sort of transparent zone outside of the yolk. When the process of segmentation begins, the yolk shrinks slightly upon itself and no longer fills the vitelline membrane completely. Presently a slight indentation becomes visible on one side of the yolk, and another corresponding to it on the opposite side. This indentation grows deeper and deeper until it cuts the yolk through, and ends its total division in two halves,



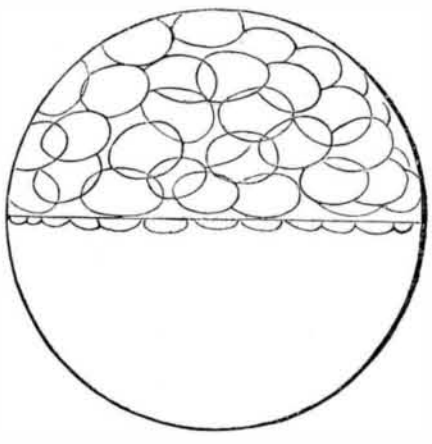
EGG OF TURTLE IN MORE ADVANCED STAGE OF DEVELOPMENT.

the two halves remaining, however, in close contact. While this process goes on, the germinative vesicle vanishes, if indeed it has not disappeared before. In some animals this vesicle is dissolved before the segmentation begins: in others, during the process. This division of the yolk in halves being completed, the same change begins now in the two halves. Indentations are seen on either side of each half, and these indentations deepen till they meet and sever the two masses of yolk; and now, where we had one yolk mass, we have four distinct lumps side by side; they become rounded in form, and look like four soft balls.



EGG OF MAMMAL UNDERGOING SEGMENTATION INTO EIGHT PARTS.

In the eggs of the frogs and toads, there is still another mode of segmentation. The yolk divides, as in the mammalian egg, into halves. But only one of these halves proceeds with the self-division and multiplies itself into an indefinite number of cell-like particles. The other half of the yolk remains unchanged.



EGG OF BATRACHIAN.

You will easily understand how difficult it has been for embryologists to put together in their true sequence these phases of development. Not only must the exceeding difficulty of the microscopic observation be considered, but also the fact that, in order to find every single link in the chain, to obtain, for instance, a sight of the mammalian egg just at the process of self-division or at any one point of it, the mother must be killed at a given moment of the segmentation. Suppose a naturalist to be investigating the process in some of the higher mammalia, for instance, such as produce but one young only at a time; it is evident that he must meet extraordinary, almost insuperable, difficulties at every step. No one has ever seen the segmentation of the egg in a mare or a cow, or even in a sow. These are too expensive to be sacrificed for the study of embryology. Professor Vischoff made his investigations upon the rabbit, and that one investigation cost him ten years of his life. Science must be conquered; and these conquests bespeak the high intellectual culture of those who make them. It is easy to fling theories into the world broadcast, based upon a few imperfect and shallow observations, and palm them upon those more ignorant than their originators; but it is one thing to theorize about what nature may do, another to know, by virtue of patient and intense study, what she does.

C. E. says: "I have taken your paper during the past two months; but if I could not get another, I would not take $10 for the balance of the year's subscription."