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XXXIII.—*Abstract of a memoir on the Embryogeny, the Anatomy and Physiology of the Simple Ascidians, &c.* By M. VAN BENEDEN, Professor in the Catholic University of Louvain, &c.\*

I HAVE the honour to present to the Academy a new memoir on some animals that inhabit our coasts. It is a sequel to those I have already communicated, and is entitled 'Recherches sur l'embryogénie, l'anatomie et la physiologie des Ascidies simples,' &c. In a short time I hope to lay before you a work on the embryogeny of the Acephala, and another on the Acarides, on which I have been occupied for several years.

To the present time I have observed four species of simple *Ascidia* on our coasts, three of which appear to be undescribed. The abundance of one of them on the oyster-beds at Ostend, and to which, because of its form, I have given the name *ampulloides*, has permitted me to study with care both its anatomy and its growth; and I have seen all the phenomena of its embryo-evolution from the first appearance of the egg and of the spermatozoa in the sexual organs. When young the *Ascidia* is nomade, as Milne Edwards stated in 1828; when adult it is fixed, and in this last stage of its existence, all the functions are reduced to those of nutrition and of reproduction.

What relates to the embryogeny has, in an especial manner, engaged my attention. It is, we may say, a new science, and yet it almost already claims its due place, for without its guidance we cannot take a step towards the solution of the highest questions in anatomy, physiology and zoological classification. Hence the reason which has induced me to give it here the same preference it has in my previous memoirs.

Cuvier and Savigny have carefully anatomized these *Ascidia*; and Sars in Norway, Dalyell in Scotland, and Milne Edwards in France have studied their genesis with equal care. The favourable circumstances in which I am placed have enabled me to add to the excellent works of these naturalists some new facts and rectifications of others. It seemed to me also that it would be not uninteresting to represent, in a continuous series, all the metamorphoses which the *Ascidia* undergo in their different ages.

The memoir is divided into four parts. The first is historical; the second contains the exposition of their anatomy; the third has the embryogeny for its subject; and the fourth comprises some reflections on the place which the Ascidians ought to have in the animal scale, and an enumeration of the species I have observed on our shores up to this date.

Hitherto no one has seen in the *Ascidia* either eyes or any

\* Extrait du tome xiii. no. 2. des Bulletins de l'Académie Royale de Belgique.

other organ of a special sense. I have ascertained the existence of eyes in one species in its adult condition, at the end and all round each of the tubes; and in its embryos, other eyes are situated upon the side of the body in the spot in which we see them in other animals of the same form. The latter disappear with its nomadic life. Milne Edwards has seen some black specks in the fry of the compound Ascidians, but he has not assigned them a function. This is the first ascertained instance of an animal having two kinds of eyes—the one for the embryonic period, the other for the adult and perfect estate\*.

In the anatomical section I have been able to complete what was known of the reproductive system. Milne Edwards had determined the existence of the male and female organ in the same individual, but the learned professor of the "Muséum" avows that he could not discover in what way the eggs and the spermatozoa were ejected. That gap I have also filled up. I have found a species, which, from the transparency of its parietes, was a favourable subject for observation; and I have seen that in it there were several outlets for the passage of the spermatic fluid into the cloacum, but one oviduct only for the exclusive passage of the eggs. The hypothesis which had been made in reference to this subject has not been confirmed.

Notwithstanding the assertions to the contrary† of the physiologist who, quite recently, has obtained such an honourable distinction from the Academy of Sciences of Paris, I more than ever persist in my belief that the spermatozoides are analogous to the globules of blood: I cannot consider them as animalcules, nor consequently as organized beings. I have not yet had an opportunity of studying the spermatozoides of the Tritons, but that cannot hinder us believing the pretended inhabitants of the spermatic liquor in the *Anodontes*, the *Ascidia*, the *Bryozoa*, and other inferior animals in which we have observed them, to be free cellules, and usually or always vibrating. It is not by inductive reasoning that I have been led to this result, as M. Pouchet thinks,

\* There still exists a prejudice in science,—a prejudice born of the anatomy of the superior animals,—that an animal cannot be sensible of the light without eyes, that eyes necessarily require the existence of an optic nerve, and that where this nerve exists there must also be a brain or cerebral ganglion. The study of the inferior animals has completely overturned this error. In fact, it ought to have been perceived long ago that the *Hydra* and many other inferior animals are sensitive to light, moving freely and spontaneously, and fulfilling all the functions of relative and conservative life, and that too without eyes, without nerves, without muscles and without brain. I believe that Trembley had observed, towards the middle of the last century, that *Hydræ* in a glass of water wandered to the side of the glass whence the light came.

† Journal l'Institut, 1845, p. 167.  
Ann. & Mag. N. Hist. Vol. xvii.

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but rather by an examination—mature, comparative, and based on the genesis of organization. It is four years since I studied with care the development of this product in the *Alcyonella*—nor has the delay in the publication of that work depended on me—and since then the facts in general have come to the support of my views.

It has been said that reproduction by buds in some of the *Ascidie* is a very recent discovery; and Milne Edwards assumes, for the basis of his classification, the twofold mode of reproduction by eggs and by buds. But in 1761 Bohadsch had observed the gemmiferous reproduction, and that even in a simple Ascidian, the *A. intestinalis*. Hence it was that, in the 'Encyclopédie Méthodique,' Bruguière wrote,—“It is probable that, independently of their multiplication by eggs, they enjoy also a propagation by the integuments, according to the observations of Bohadsch and Müller.”

The able Norwegian naturalist, Sars, has made some very curious observations upon the mode of formation of the compound or aggregated *Ascidie*, which perfectly explain the symmetrical arrangement of these little animals. Milne Edwards does not admit the plurality of germs to explain the aggregation, and he believes the formation by buds is sufficient to do so. Recently several important facts have appeared in support of the assertions of Sars, and it seems to me that doubt can no longer rest on the exactness of his observations. Some animals in their embryo condition, and before the adult form is reached, can divide themselves and disaggregate, by a natural fissiparous reproduction, into several other individuals, which sometimes remain grouped together and constitute a ready-made colony (*Ascidie compositæ*), and sometimes they separate to live freely (*Campanularie*, *Medusæ*, &c.). An animal of the lower classes can thus reproduce itself in its young age when it has still the embryo form: it dies in giving birth to another generation before having attained adulthood, and that second generation has not passed through the same phases of the mother that gave birth to them.

To explain the passage of the water from the respiratory cavity to the anal tube, openings or stigmata between the branchial vessels have been supposed necessary, but I rather coincide in the opinion of the naturalist who has lately denied the existence of these communications. I have always seen a thin membrane between the vessels; and the communication, in my opinion, is effected by an interruption of continuity between the parietes which separate the respiratory cavity from the cloacum.

Without having recourse to an alternating generation, as a learned Dane, Steenstrup, has lately advocated in a small but very remarkable book, it is easy, if we do not deceive ourselves,

to explain these singular embryogenic phænomena, by keeping simply in view the facts which, within these few years, have been added to science.

The class Tunicata exhibits these modes of reproduction :—  
 1. The simple *Ascidia* reproduce themselves by bud and by egg, and the embryo runs through different phases :—if it is born of an egg, it will be nomade in its youth, and its figure will be that of a tadpole ;—if, on the contrary, it proceed from a bud, the embryo will attain its adult character more quickly and by the most direct means, without ceasing to remain united to its colony, and without presenting any great external changes. 2. The compound *Ascidia*, all reproduced by buds, present nevertheless two distinct modes of embryonic evolution after their escape from the egg. Instead of undergoing simply its metamorphoses as in the preceding instance, the tadpole embryo may spontaneously divide itself into several germs which remain grouped in a determinate order. That little colony, formed at first by the reunion of several germs naturally fissured, may root itself upon a solid body, and never again leave this resting-place. Or again, 3. as in the *Pyrosomæ*, the colony may remain afloat and continue to swim freely in the bosom of the waters. 4. The *Salpæ* offer still another phænomenon : there are *Salpæ* which live in isolation and free, and there are *Salpæ* which form long chains composed of individuals joined together. We see in this peculiarity, which has been explained in different ways, nothing more than a phænomenon exactly alike to that which the *Ascidia* have shown us. Whether it is the effect of age or not, this always holds, that it is the same species which presents the phænomenon of the free and separate life and of the aggregated or combined life. The interpretation of the latter phænomenon by Chamisso, generalized by Steenstrup, appears to me inadmissible, and little at conformity with the great simplicity we everywhere observe to prevail in nature. We may from this time forward reduce to a formula the theory of embryonic development in the animal scale.

When on this subject I may be permitted to say a word upon that mystery of mysteries—the generation of the Aphides. It is known that these insects bring forth young throughout the summer without the concurrence of males ; that eight or nine generations in succession are exclusively composed of fruitful females ; that all these generations are viviparous, and that at the end there is born a generation composed of males and of females ; that then there is a coupling, and, instead of producing living young, the female now lays her eggs. These are facts, notwithstanding that some naturalists still disbelieve in them, and remain unconvinced by experiments conducted through years by the most celebrated observers. However inexplicable the phænomenon appears at a

first glance, it becomes easy of comprehension by a study of some of the lowest animals, and its solution might have been given long ago. The *Hydræ* are reproduced in the same way during the summer, without the assistance of males, and are viviparous during several generations which follow each other successively until the approach of winter; then, instead of buds, eggs appear, and we observe, at the same time, spermatozoides, representing the male organ, which fructify the eggs that are to preserve the species until the following spring. Is it not the same phenomenon in the Aphides? and, to give an explanation of it, is it not sufficient in fact to say that they are gemmiparous throughout the summer, and have consequently no need of the male element? All that appears to me surprising here is to see this double mode of reproduction, so common in several of the lowest animals, in animals so high in rank as the Articulata.

I have satisfied myself that in the egg of the *Ascidie*, as everywhere else, there are the two vesicles of Purkinje and of Wagner. The former only had been hitherto noted.

The manner in which the blastoderm is formed is a point of the highest interest in the history of embryonic development. At first the vitellus runs through the same phases as in other classes, viz. it divides itself into lobules which become small and smaller, and which have each a clear and transparent vesicle in their centre: we may say there are so many individual vesicles of Purkinje. This phenomenon has also escaped the notice of my predecessors. After this change in the vitellus the blastoderm appears. Is the blastoderm then formed, as in the superior animals, upon a determinate point, whence it extends slowly over the whole vitellus, or rather is it formed simultaneously upon all the points without forming a disc? I believe the latter view is the correct one, but the former is adopted by my predecessor in this matter. It has always seemed to me that the blastoderm appears at once upon every point of the surface of the vitellus; and that it constitutes, from the moment of its appearance, a continuous membrane without any aperture.

The caudal appendage of the tadpole of the *Ascidie*, instead of being formed, as has been pretended, by separation, is developed by extension, in the same way as appendages in general. We have seen nothing in these *Ascidie* that resembles the zigzag that has been figured in that caudal appendage.

Other appendages are formed on the side opposite to the tail, but these are constant neither in their number nor in their respective positions. They have been called suckers, but I have seen nothing to justify this designation. The embryo is affixed by its integuments, and these presumed suckers are often not even long enough to reach the exterior envelope.

In the last part of the memoir, consecrated exclusively to what has been called the zoological portion, as if zoology was reduced to the distinction of species, I have availed myself of the opportunity to say a word upon the general classification of animals, when discussing the place proper to be assigned to the *Ascidie*.

In my opinion we ought to return to the classification of Linnæus in the distribution of the animal kingdom. In invertebrate animals there are only two types, viz. insects and worms, and the mollusca and radiata of Cuvier, which properly make one branch only. It is not the organization which ought exclusively to serve as a basis for the primary divisions, but rather the embryogeny. There are in nature animals in which the vitellus enters inwards by the belly; others in which it enters by the back; and again, others in which it enters neither by one nor the other way. The first are the vertebrated, or the Hypo-cotyledones; the second are the articulated, or the Epi-cotyledones; and the third embrace the mollusca and radiata, or the Allo-cotyledones.

It is very remarkable that in botany the three great divisions of plants into dicotyledons, monocotyledons and acotyledons has been more and more corroborated by every subsequent investigation; and there should be, if I do not deceive myself, in the two kingdoms of organic beings, the same divisions based upon the same embryogenic organs.

Many almost insurmountable difficulties disappear in a great measure when we admit the conjunction of the mollusca and radiata of Cuvier in one section, as Linnæus has done.

The Allo-cotyledones embrace several classes, just as the vertebrated and articulated animals do. We may arrange them in the following order: Mollusca, Polypes, Vermes, Echinodermata, Rhizopodes, Infusoria and Sponges. In the class Mollusca we may preserve the established divisions, with the exception of the Cirrhipedes, which are Epi-cotyledones. The Tunicata form a distinct order of the same value as the Acephala, the Gasteropoda and the Cephalopoda.

The class Polypi embraces the *Bryozoa*, the *Medusæ*, the *Anthozoa* and the *Alcyonians*.

In the class Vermes there remain the *Nematoidea*, the *Acanthotheca*, &c. In the Echinodermata there are no changes required excepting for some doubtful genera. The Rhizopodes, embracing the greater part of the microscopic Cephalopoda, in my opinion should constitute a distinct class, having, at its head, the *Noctiluca miliaria*, which seems to be a naked Rhizopoda. Lastly, the classes of Infusoria and of the Sponges.

Some zoologists consider the Cirrhipedes as crustaceans, because in their early age they have all the characteristics of these;

but this is not sufficient, it seems to me, to justify the association; and the true place for the Cirrhipedes is, as a distinct class, between the Myriapoda and the Annelides. The *Campanularia* are not *Acalephæ*, because that, in their embryo state, they have their characters and aspect; nor are the *Acalephæ* members of the order *Anthozoa*, because the young Medusans resemble that order. Such facts indicate an affinity, but do not call for a coalition in one order.

The *Medusæ* are Anthozoans in their young age, and many *Anthozoa* are at first Medusans; hence they necessarily belong to the same class, in which they constitute distinct orders.

The *Hydræ* are not Anthozoans, but rather freshwater *Medusæ*, as I have along ago published. They cannot be separated from each other by any character of importance.

The *Tunicata*, which more especially occupy our present attention, are very closely connected with the Bryozoa and the *Acephala*. I have thought it proper to leave them in the class *Mollusca*, because of the presence more especially of a heart. If they had not that organ, there would have been no more reason to place them amongst the *Mollusca* than amongst the polypes. In the branch or tribe of the *Allo-cotyledones*, the first class only, that of the *mollusca*, possesses a true heart.

#### XXXIV.—On the Development of Chara. By C. MÜLLER\*.

[With three Plates.]

##### § 1. Introduction.

ALTHOUGH this subject has occupied the attention of many observers from an early period, and notwithstanding great light has been thrown upon it by these numerous investigations, still a history of its development combining the diffused observations has hitherto been wanting. My object has been to effect this, and its accomplishment appeared to me the more requisite, inasmuch as this family, which is characterized by so many important structural peculiarities above all other cryptogamic families, nevertheless holds a doubtful position in systematic arrangement. Although from these investigations I do not venture to decide upon its systematic affinities, still, by describing the production of the spores to which so much importance is attached, I hope at least to adduce facts which may bring us nearer the truth. I would willingly have added the development of the anthers at the same time, on which numerous but not conclusive observations have been made; but as the time has arrived at which these

\* Translated from the *Botanische Zeitung* for June 12 and 19, 1845.