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MORSE, ON EARLY STAGES OF AN ASCIDIAN.

cumstances, he crossed our thresholds again, and took his wonted place in our households. Thenceforth, to the year of his death, he passed his summers in New England. He was a cherished guest under many a northern roof, but his permanent northern home was at North Wrentham, now more commonly called Norfolk. There he died among his brothers and sisters and their families, in the village where his infancy and boyhood were passed, and where he was ever regarded with the tenderest affection and respect.

Prof. Edward S. Morse read the following paper:—

NOTES ON THE EARLY STAGES OF AN ASCIDIAN (*CYNTHIA PYRIFORMIS*, RATHKE). BY EDWARD S. MORSE, PH.D.

PLATE I.

In the year 1866, Kowalevsky published a remarkable series of observations on the embryology and early stages of several Ascidians,¹ in which a structure similar, if not identical, with the type characters of the vertebrata was demonstrated.

Professor Kupffer at first doubting, then not only confirms the validity of Kowalevsky's observations, but adds additional facts showing that the nerve mass actually penetrates the tail of the embryo to a considerable length.²

The important facts revealed in these investigations have led the eminent naturalists above mentioned, as well as Hæckel, Schultze, and others, to believe that the connecting link between the Vertebrates and Invertebrates had at last been established.

Darwin, with prompt recognition has incorporated the facts in his last work on the "Descent of Man."

Since Kowalevsky's memoir above referred to was published, he has traced out the embryology of *Amphioxus*³ in which the closest resemblance is seen between this low vertebrate and similar stages of the Ascidian.

In these unsuspected relations between the Vertebrates and Ascidians through *Amphioxus*, it is interesting to remark that long ago

¹ Kowalevsky, Mem. Acad. Imp. St. Petersburg, Series VII, Tom. x, 3, 1866.

² Kupffer. Schultze's Archiv. für Mikrosk. Anatomie, Bd. 6, 1870.

³ Mem. Acad. Imp. des Sci. St. Petersbourg, VII Series, Tome XI, No 4.

Goodsir called attention to the resemblance between the phryngeal sac of the Ascidiæ, and that of Amphioxus.¹ He says "The Lancelet respire by receiving sea water into the anterior compartment of the intestinal tube—this cavity is kept dilated by the elasticity of the numerous filamentous ribs, and this dilatation may be increased by the action of the super-imposed ventral bundles of the lateral muscles. It is contracted by the action of the abdominal muscle. This is a mode of respiration similar to that which prevails in the tunicated mollusks. It is interesting to observe that the branchial membrane of the Lancelet is exactly similar in its peculiar vascularity (ramifications at right angles) to that which lines the branchial cavity of the mollusks just specified. . . . As in Ascidiæ the entrance of the intestino-respiratory canal is guarded by filaments."

In the recent removal of the Tunicates from the Mollusca, and incorporation of the same with the Vermes by Gegenbaur and others, it is interesting to recall from the memoir of Goodsir above cited, the fact that he calls attention to certain resemblances between Amphioxus and the Annulosa.

"The plan of circulation is simple and in accordance with the primitive condition of the respiratory apparatus, both functions being performed in a manner closely resembling that observed in certain annulose animals. The dorsal vessel corresponding to the heart, or branchial artery, and the abdominal vessel to the aorta of the Lancelet." Ibid., p. 260.

Any scrap of information connected with a subject so profoundly interesting justifies me in bringing forward a single observation made upon the young stages of a sessile Ascidian, *Cynthia pyriformis*, at Eastport, Maine, July, 1870.

John E. Gavit, Esq., of New York, kindly placed the larvæ in my hands for examination. The eggs were noticed in all stages, as well as free swimming larvæ in active motion. These were easily seen with the unassisted eye and looked like gigantic spermatozoa. A special series of observations in another line limited me to a single examination of these interesting forms.

Kowalevsky in the paper above referred to represents on plate II, fig. 26, a delicate membrane bordering the tail like a fin. This is represented as structureless. In the unfolded tail no traces of cartilagenous centra are shown, though he represents these parts as more

¹ Goodsir on the Anatomy of Amphioxus. Royal Society of Edinburg, Vol. xv, part I, page 259.

or less conspicuous while still enclosed in the egg. Kupffer represents the same condition of things in his figures.¹

In the many free larvæ examined by me, the axial segments were perfectly defined. Fig. 2, plate I, represents two as they rested on the slide. In these, forty segments were counted, four of these segments extending into the body proper, the anterior segment sending off three diverging processes toward the hæmal, or ventral region. Beside the persistence of these segments after the animal was freed from the egg, a remarkable structure not hitherto figured, as far as I am aware, was noticed in the caudal fin, which vividly recalled the fine diverging rays as seen in the embryo fish. These rays were extremely delicate though plainly marked. They ran off nearly parallel to the longitudinal axis of the tail, and were confined to the last five segments, reaching beyond the last caudal segment, to a distance equal to eight segments, as shown in figs. 3 and 4. Those who have seen the caudal fin of the embryo trout with its closely crowded ray lines, will bear witness to the strong similarity between the two. At the junction of the tail with the body, a series of rays of various lengths converging in pairs at the outer border of the membrane and running off at right angles to the longitudinal axis, were also marked, though of extreme tenuity. This peculiar feature is represented in fig. 2. All of the segments were nucleated, and the tail appeared of uniform length. They were enclosed in a continuous investing sheath which disappeared at the caudal tip. This latter region was granulated. The peculiar black spots, the '*sinnesorgane*,' of which nothing is known, save that they are supposed to be sense organs of some sort, were seen, but nothing definite was made out in regard to them. In fact the structure of the fin only was studied.

Since the above lines were written, Mr. Gavit has placed in my hands for examination a number of embryos, from the same lot studied, which he preserved in a saturated solution of salt and water. These he has since mounted in cells with the same preservative fluid, and though a year and a half has elapsed since these specimens were immersed in the fluid, they are remarkably preserved and reveal certain features not recognized in the living specimens.

Fig. 6 represents one of these preserved specimens. All traces of segments have disappeared, the segments being irregularly broken

¹Ibid., Taf. IX, fig. 16.

in a series of short, cylindrical masses. Löwig and Kölliker¹ represent the tail of a larval Botryllus with the segments divided in a median line, making a double row of segments running parallel, as well as a double row of smaller cells representing the investing membranes. This condition may represent a later stage, though all the specimens preserved by Mr. Gavit present this peculiar appearance.

With the breaking up of the segments, a contraction of the axis has taken place at the tail, leaving a distinct cavity, this is more plainly shown in fig. 5, where double transverse lines are faintly seen indicating the former presence and position of the segments. The fin is seen as a continuous membrane bordering the entire outline of the animal. The fin rays are very conspicuous and commence just at the junction of the tail with the body and start off at right angles with the longitudinal axis. At the tail they rapidly diverge and finally run parallel with the axis. The wider marks of the fin rays correspond nearly in number to the number of segments in the axis. As these were invisible in the living specimens it is impossible to say whether they agree as to number and position with the segments.

In conclusion it is interesting to add that Savigny, Milne Edwards, Van Beneden, Sars, Kölliker, Dalyell, Agassiz and many others have added their testimony in regard to the existence in many genera of Ascidians of active tailed larvæ, till it was supposed that this appearance of the embryo was characteristic of all Ascidians.

Lacaze Duthiers,² however, describes the young of *Molgula* as presenting a remarkable exception; the young not having a tail, nor showing any signs of activity, but escaping from the egg with the appearance of *Amœba*, by flowing out of the egg, a rounded plastic fluid mass, and remaining sedentary at the bottom of the vessel. Albany Hancock³ on the contrary has observed the embryos of two species of *Molgula* in which they present all the features of the usual active tailed larvæ, and questions whether Lacaze Duthiers had *Molgula* at all; for certain reasons, which he presents, he thinks Duthiers, had another genus, *Eugyra*, under examination. Prof. A. E. Verrill however, in a series of valuable papers on the Ascidians of New England,⁴ states in regard to *Lissoclinum tenerum* V. (gen. et sp. nov.) that "the eggs are few and relatively very large. The develop-

¹ *Annales des Sciences Naturelle*, III Series, Tome v, pl. 7.

² *Comptes Rendus*, Tome LXX, p. 1154.

³ *Annals and Magazine Nat. Hist.* IV Series, No. XXXV, p. 353.

⁴ *American Jour. Science and Arts*, Jan. to June 1871, p. 445.

ment of such eggs is direct, without passing through a tadpole-shaped larval state," with the following note, "with the alcoholic specimens it is not possible to trace completely the early stages of this development, or to be perfectly certain that these egg-like bodies are genuine eggs, although some of them appear to contain at first, a germinal vesicle."

Further investigation will probably show that eggs passing through such an anomalous development are different in their nature, and it is not improbable that the simple Ascidian *Eugyra* and the compound Ascidian *Lissoclinum* will also present a kind of egg which passes through that course of development supposed to be typical of the class. Prof. Verrill, with his usual caution, expresses a doubt whether the egg-like bodies he observed, were genuine eggs, in the note just quoted.

EXPLANATION OF PLATE I.

The embryos from which these were drawn were about eight one-hundredths of an inch in length.

Fig. 1. Showing body of embryo and anterior end of axial, cartilaginous rod.

Fig. 2. Two embryos showing fin rays at the junction of the tail with the body.

Figs. 3, 4. Showing caudal fin.

Fig. 5. Tail of preserved specimen showing contraction of axial rod, leaving cavity.

Fig. 6. Entire drawing from preserved specimen, showing breaking up of axial rod with fin rays.

Prof. Agassiz said that he studied the embryology of the Ascidians nearly twenty-five years ago, but that the appearances described by Prof. Morse were new to him and of great interest. He failed, however, to see more than a certain analogy between the embryo Ascidian and Vertebrate. He thought that if the Vertebrates had descended from the Ascidians there ought to be some traces of the process in the geological record but there was no evidence of this.

Dr. Chas. Pickering remarked that the position of *Amphioxus* among the vertebrates seemed doubtful to him.

Mr. F. W. Putnam said he thought there was no reason for regarding *Amphioxus* as an adult vertebrate. We