have been divided by Viallanes[5] into three divisions; i. e. the protocerebrum, deutocerebrum, and tritocerebrum; these have divisions corresponding to the supposed three preoral segments of the head. At present I do not think that there are more than two preoral segments, in the head of insects. Saint Remy shows that the brain of the Myriopods has the same divisions, and is homologous with that of insects and Crustacea. He shows, however, that the brain of Arachnids lacks the deutocerebrum, while the tritocerebrum of Insects, Crustacea, and Myriopoda is represented by the rostro-mandibular ganglion of the Arachnida.

As the brain of *Limulus* does not, contrary to that of Spiders and Scorpions, send nerves to the first pair of appendages, and has only at the most three pairs of lobes, and originally, according to Patten, three pairs of neuromeres, representing a first and second median-eye, and a third, or lateral-eye segment, it follows that no deutocerebrum or tritocerebrum is represented in its brain.

It seems to us that this lack of homology between the brain of *Limulus*, and that of Arachnids added to the other brain-characters we have pointed out, together with the different mode of grouping of the appendages, and their shape; also the absence of urinary tubes, of tracheae, and the presence of branchiae, forbid the association of Limulus and other Podostomata (Merostomata and Trilobita) with the Arachnida, but are so fundamental as to warrant their forming a class by themselves. On the other hand both embryology and morphology show that the Arachnida and Podostomata probably had a common origin, one group becoming adapted to the land, the other and older, having originated in the sea. The Insects and Myriopoda may have had a common origin, while the Crustacea probably had an independent origin.

Providence, R. I., U. S. A., Brown University, Febr. 25. 1891.

4. The Development of the American Lobster.

By F. H. Herrick, Ph. D. of Adelbert College, Cleveland, Ohio, U. S. A.

eingeg. 21. März 1891.

This paper is an abstract of researches conducted during the part of two summers (1889—1890), at the laboratory of the U. S. Fish Commission at Woods Holl, Massachusetts. It deals mainly with the early stages in the development of the egg[1]. The general statements which follow in regard to the habits of the American lobster (*Homarus ameri-*

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[5] Annales des Sc. Nat. VII. Ser. Tom. IV. 108. 1887.

[1] For a fuller preliminary statement, see the Johns Hopkins University Circulars, No. 80.

canus), are drawn entirely from the experience of two successive seasons.

Lobsters spawn at a definite period of the yar. In 1889 eggs were laid from about June 20th to July 15th; in 1890 from July 1st. to about August 20th the greatest number extruding their eggs during the latter part of July (Jl. 21 — Jl. 31.). The eggs are carried by the female throughout the fall, winter, and spring, and are not hatched under natural conditions until the following summer.

Copulation precedes oviposition by a considerable period, at least eight weeks in the case of a lobster which laid eggs while kept in an aquarium at the Station. These eggs were fertile, but were scratched off in the course of a few days so that their development was not followed. The eggs when laid are free, and enclosed by a single membrane, the chorion. A second membrane, the membrane of attachment, is added to the eggs, as in related forms, outside of the ovary. The number of eggs varies from about 3000 to upwards of 36000, depeuding largely upon the size of the lobster. A lobster 10½ inches long produces, on the average 12000 eggs. The hatching period extends from 6—8 weeks, from about May 15th to July 15th. The bulk of the eggs are hatched under natural conditions in June, and probably during the first half of this month.

The lobster does not breed annually. This is abundantly proved by the slow growth of the ovarian eggs, by the immature condition of the ovaries at the time when the young are hatched, and by the large percentage of non-egg-bearing females taken in winter and spring. In May, 1889 942 lobsters were taken at Woods Holl by Mr. Vinal N. Edwards. About ten percent of these were females with eggs. In June 2184 lobsters were caught, only about ·04 percent of which were egg-bearing females. This is explained by the fact that the eggs begin to hatch in June. These and other facts such as the excess of females over males is shown by the following table.

Table I.

Date	Total Catch.	♂	♀	♀ with eggs	% of ♀ with eggs to total catch.	♂ under 10½ in.	♀ under 10½ in.	♂ over 10½ in. with eggs	♀ over 10½ in. without eggs	% of ♀ to ♂	% of ♀ without eggs to ♀ with eggs
1889											
April 24—30	104	49	55	22	**21**	49	55	0	0	**112**	**150**
May	942	440	502	185	**10**	418	439	54	9	**114**	**171**
June	2184	1009	1175	108	**·04**	976	1099	45	31	**116**	**987**

After hatching a brood the lobster may moult, but eggs are never laid again until at least another year. Moulting also takes place in fall, and possibly at other periods. A lobster 7—12 inch. long increases its length by one inch after passing the moult. Lobsters after becoming sexually mature (length 8—9 in. in the female) probably do not moult annually. It requires 6—8 weeks after moulting to produce a fairly hard shell.

At time of hatching, the larval lobster moults, and this delicate moulted skin is often cast off together with the egg-shell. It is of considerable importance, since in artificially hatching lobsters, many die through inability to pass this moult. After 6—7 days the second moult occurs. Young lobsters swim at the surface 6—8 weeks (L. = 13—16 mm), when they attain a stage which resembles the adult in many ways, but differs from it in numerous details. After this stage the lobsters disappear entirely from the surface of the ocean. The colour variations of the first larva are very striking some individuals being bright red, others greenish blue, and others pale blue or nearly colorless. The individual color changes of older larvae are also very noticeable.

The structure of the mature ovary is characterized by the presence of gland like organs which possibly represent rudimentary yolk-glands. The gland forms a kind of egg-tube, abutting upon, and partly enclosing the growing egg. The columnar cells, of its walls stop short at the sides of the egg so that this glandular coecum resembles a narrow bag, with an egg pushed into its mouth. These gland-like bodies are present for two or three weeks after oviposition, in the peripheral parts of the ovary. They are then gradually absorbed. The germinal vesicle of the ovarian ovum is the direct descendant of the nuclei of the ovarian stroma. Yolk appears to be formed at first, in close relation with the protoplasm of the egg, possibly also by the glands, and from degenerate nuclei in various parts of the ovary.

A portion of the vas deferens is very glandular, and gives rise to a viscous secretion which is probably expelled with the sperm, and possibly serves to fasten the spermatozoa to the under surface of the female during copulation.

Segmentation of the Nucleus and Yolk.

The time occupied by the segmentation processes, and by the progressive changes in development during the summer, fall and winter months is shown in Tables II and III. There is great irregularity in the segmentation, and lack of uniformity in the rate at which this process proceeds in perfectly normal eggs. Some eggs which afterwards develop remain with yolk unsegmented until the third or fourth day after fertilization. The first segmentations affect only the protoplasm, and take place near the centre of the yolk. The cells thus formed pass out toward the periphery of the egg, and some of them — 3—4 in number — outstripping the rest, reach a part of the surface first, where they initiate the segmentation of the yolk (Fig. 1). The

Fig. 1.

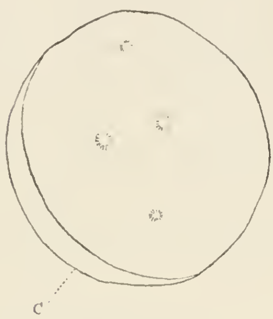

Fig. 2.

Fig. 1. Egg with unsegmented yolk. Nuclei of four cells migrating to one part of the surface, can be seen just below the surface. C = chorion.

Fig. 2. Profile view of egg as the beginning of yolk segmentation 20 nuclei visible at surface: the yolk on one side is raised into hilloks about the nuclei just under the free portion of the chorion (C), while that of the opposite side is unsegmented and free of protoplasm.

nuclei, though not quite at the surface, appear to be so, and the yolk amasses itself about them in the form of hillocks. These constitute the first yolk segments or pyramids. A profile view of the egg shows a perfectly regular contour on one side, while on the other it is thrown into undulations which correspond to the segments just noticed (Fig. 2.). The lobster's egg at this stage strongly recalls the meroblastic type, and would seem to represent a transition between this and the ordinary superficial segmentation of Decapods. This, however, is not quite true, as will be presently seen.

Cells not only spread over the surface by division but others also reach it by independent migration from the yolk, until, about forty hours after fertilization, the superficial yolk is entirely segmented. About thirty segments are now present. The cells over one half of the egg (those which have reached the surface first) are often preparing to divide by the time the yolk over the opposite side is completely segmented. This handicapping of certain cells by others still further tends to produce irregularities in the early phases. This irregularity however soon disappears, so that individual eggs have their yolk nearly uniformly divided (Fig. 3). Nucleus division arises by karyokinesis, periods of rest alternating with periods of activity.

Irregularities of segmentation are very numerous. One often finds eggs composed of sereval hundred segments, some very small,

Fig. 3.

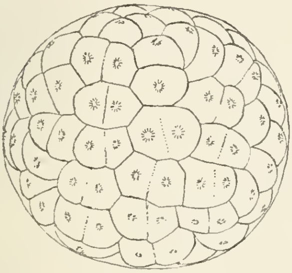

Fig. 4.

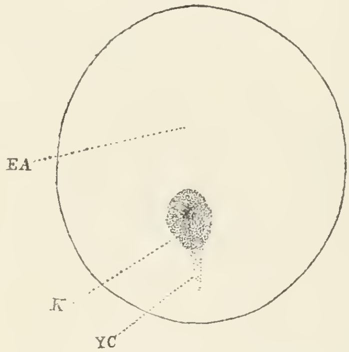

Fig. 3. Egg in which yolk segmentation has become nearly regular: about 130 yolk segments: dotted limes show the uncompleted cleavage of the yolk in many of the segments.

Fig. 4. Keel-stage of egg. The wedge-shaped mass of cells (*K*) forming the keel only is represented. In the midst of it is a conspicuous pit, and behind the keel a train of cells (*YC*) extends into the yolk below the surface. In front of the keel is the embryonic area (unrepresented), consisting of a single layer of rapidly dividing cells. *K* = Keel. *EA* = embryonic area. *YC* = Yolk cells.

others very large, and of various intermediate sizes. Again, eggs otherwise regularly segmented, may contain a large superficial mass of unsegmented yolk. Then one meets with eggs with yolk quite unsegmented, with the exception of 2—6 small segments on one part of the surface.

The segmentation stages occupy about three days under the conditions shown in Table II. By the end of the 4th day the invagination stage is reached. This is followed by the keel-stage (Fig. 4.), which lasts about 4 days. By the beginning of the 10th day the nauplius appendages begin to bud forth, — first the 1st pair of antennae and mandibles — and a little later the 2d pair of antennae. On the 27 th to 30 th day eye pigment can be detected at the surface.

(Schluß folgt.)