In these features all the other Arthropods are like the Crustacea, but another consideration, the fact that, with few exceptions, the higher Crustacea are marine, renders the problem of their life-history much more intelligible than that of any other class of animals.

So far as the ontogenetic history of the metamorphosis of a larva is a recapitulation of ancestral stages in the evolution of the species, its retention at the present day must depend to a great degree upon the persistency of those external conditions to which the larval stages were originally adapted.

This is true at least of all free larvae, which have their own battles to fight and their own living to get, and while a larva inside an egg or within a brood pouch may possibly recapitulate obsolete ancestral stages, the survival of a free larva depends upon its adaptation to its present environment.

As compared with the ocean the inorganic environment of terrestrial or fresh-water animals is extremely variable, and changes in climate, elevation and continental configuration are accompanied by corresponding changes in enemies, competitors and food, so that the conditions which surround a modern terrestrial larva must in nearly every case be very different from those under which the remote ancestors of the species passed their life; but while this is also true to some degree of marine animals, their inorganic environment is comparatively stable, and the persistence of so many ancient marine types shows that the changes in the organic surroundings of marine animals take place much more slowly than corresponding changes on land.

This fact, joined to the definite character of the changes which make up the life history of a marine crustacean, renders these animals of exceptional value for the study of the laws of larval development, and for the analysis of the effect of secondary adaptations, as distinguished from the influence of ancestry; for while Claus has clearly proved that adaptive larval forms are much more common among the Decapods than had been supposed, his writings and those of Fritz Muller show that no other group of the animal kingdom presents an equal diversity of orders, families, genera and species, in which the relation between ontogeny and phylogeny is so well displayed, but while proving this so clearly, Claus' well known monograph also shows with equal clearness, that this ancestral history is by no means unmodified, and that the true significance of the larval history of the higher crustacea can be understood only after careful and minute and exhaustive comparison and analysis.

Greatly impressed by this fact, I begun nearly ten years ago to improve the opportunities that were afforded by the marine laboratory of the...
Johns Hopkins University, for obtaining more complete and detailed knowledge of the larval stages of a number of Macroura, and this work has been prosecuted at every opportunity, up to the present time. Some of my results have been published in my monograph on Lucifer, in the Phil. Trans. Royal Soc. for 1882, and others are incorporated in my report on the Stomatopoda collected by H. M. S. Challenger.

This memoir contains the life histories of a number of additional species, based in part upon my own studies at Beaufort, North Carolina, and at Green Turtle Cay and New Providence in the Bahama Islands, but chiefly upon the researches which one of my students, Mr. F. H. Herrick, has carried on under my general supervision. In 1886, he undertook, at my suggestion, the study of the embryology and metamorphosis of the Macroura, and devoted three years to this subject under my direction, and the results which follow are almost entirely due to his zeal and energy. He has completed the study of several subjects upon which I had previously made a beginning, so that my own unfinished notes have been incorporated with his researches, and our respective shares in the work are as follows. The chapter on Gonodaecylus is entirely based upon my own researches; the chapter entitled "Alpheus, a study in the development of the Crustacea," is entirely the work of Mr. Herrick; the one on the metamorphosis of Alpheus is based upon our combined studies, and that upon Stenopus is almost entirely the work of Mr. Herrick, as my own contributions to this life history are of minor value except so far as they supplement his work.

I shall now give a brief outline or summary of the chief results which are described in detail in each chapter.

The Life-History of Stenopus hispidus.

During the six seasons which I spent at Beaufort, North Carolina, I captured in the tow-net, at different times, some six or seven specimens of a remarkable pelagic crustacean larva: all of them well advanced and in nearly the same stage of development.

Nothing was learned of the earlier larval life, nor of the adult form of the animal, although enough was made out to show that it is one of the few Macroura which, like Peneus and the Sergestidae, have retained the primitive or ancestral metamorphosis, and that its secondary modifications are very slight as compared with those of ordinary Macrouran larvae; and also that the Beaufort larvae are new to science.

These larvae have the full number of adult somites and appendages, and in side view they are very suggestive of the Sergestidae. They are very much larger than ordinary pelagic larvae, and quite different from any known forms of Macroura.

The chief organs of locomotion are the last pair of thoracic legs, which are extremely slender, as long as the entire body of the larva, and ending in flattened elliptical paddles, which are used as "sweeps" for rowing through the water. They are stretched out in front of the body near the middle line and are then swept backwards and outwards, describing at each stroke a circle equal in diameter to about twice the length of the body. By the vigorous use of these oars, the larva swims rapidly through the water, and its movements are not unlike those of a Gerris upon the surface of a fresh-water pond.

Notwithstanding the importance of a complete knowledge of the life-history of the animal to which this sergestid-like larva belongs, I was unable to complete the study at Beaufort, although I made careful drawings of two stages and filed them away for future use.

Immediately upon our arrival at Green Turtle Key, in the Bahama Islands, early in June, 1886, our attention was at once attracted to a small, graceful, brilliantly colored prawn which was found in abundance among the coral. It proved to be Stenopus hispidus, a species which is chiefly known to naturalists through specimens from the Indian and South Pacific oceans. It has been recorded as occurring in the tropical Atlantic, but our knowledge of the adult has been very scanty and imperfect and nothing whatever has been known regarding its life-history until Mr. Herrick devoted himself to its thorough investigation.

It is an active timid animal, and is one of the most brilliantly colored of the crustaceans. As it is also one of the most widely distributed, it is noteworthy that while its color-markings are so prominent and conspicuous they are extremely well fixed and constant; so much so that the specimens from the Indian ocean and the South Pacific agree with those from the West Indies down to the most minute markings.

The adults are found in pairs, a male and a female swimming together side by side, and exhibiting evidence of strong conjugal attachment to each other.

The most noteworthy fact in its history is its world-wide distribution, and the question whether this can be a result of any peculiarity in its structure or habits at once suggests itself.

We should expect, on general principles, to find the least specialized species those most widely diffused; and one which holds its ground in so many parts of the world, and without any change of structure finds a safe and congenial home in seas so widely separated might be expected to be of indefinite or slightly specialized habits but this is not the case. In structure, in habits, in color and in external appearance, and also in its metamorphosis, Stenopus is one of the most highly specialized of the crustacea; and it owes its ability to survive in many seas to the accuracy and delicacy of its adjustment to a narrow range of conditions, rather than to indefinite and vague adaptation to many conditions.

Its antennae are unusually long and slender, and the acuteness of its senses, together with its very remarkable alertness; the quickness with which it perceives danger and the rapidity with which it escapes, have undoubtedly aided it in holding its own wherever it has gained a foothold in a suitable locality; and no crustacean, with the exception, possibly, of Gonodaecylus chiragra, is better adapted for life in a coral reef.

It is well protected from enemies by a thorax armor of hooked spines, which cover all the upper surface of its body and limbs, and as all the hooks point forwards the attempt of an enemy to swallow a Stenopus must be difficult and painful.

These facts no doubt account for its survival, and the length of its pelagic larval life is beyond question an aid to its wide dispersal, and to the discovery of new homes.

While we cannot state that the adult will not some time be found upon the Atlantic coast of our Southern States, there is no evidence that it exists there, and the larvae which were obtained at Beaufort, N. C., were undoubtedly hatched from eggs which were carried upon the abdominal appendages of parents in the West Indies or on the Florida Keys; and these larvae had therefore wandered more than six hundred miles from their birth-place. The species might therefore be diffused through a chain of coral islands six hundred miles apart, from a single starting point, in a very small number of generations.

The eggs, which are very small, are laid at night, and the segmentation, which Prof. Herrick has thoroughly studied by sections, is entirely confined to the nuclei, the yolk remaining undivided: Stenopus therefore presents a most pronounced type of centrolecythic segmentation.

The great mass of the egg consists of a homogeneous body of yolk granules, which takes no part in the process of segmentation and probably contains no protoplasm. This yolk is aggregated around a central nucleus, which divides, directly, or without karyokinetic, into two, four, eight, sixteen nuclei, and so on until the number is very great. As this process of division goes on the nucleus, each with an investing layer of protoplasm, gradually migrate to the surface of the yolk, and at last form a superficial investing layer around a central yolk out of which all the protoplasm has been withdrawn.

The yolk does not divide up into cells, although cell-outlines are faintly indicated by transitory superficial furrows.

The primitive streak is soon marked out as an area where the nuclei are densely crowded; and the position of the blastopore is indicated by a solid ingrowth which penetrates the yolk to form the inner layer of the embryo. The subsequent stages of embryonic development present nothing noteworthy.

The larva hatches in the afternoon, and during the following night the parent moults and lays another brood of eggs. The time of its escape the larva is a Protozoa, and its later history is of great interest since it unites features of resemblance to Lucifer, Sergestes, Peneus, and to the prawns in general, with individual peculiarities in which it differs from all of them.

At the time of hatching it has sessile eyes, locomotor antennae, an enormous mandible, a deeply forked telson, a long rostrum, and a complete series of appendages as far as the first peraeopod, which are essentially like the third maxillipeds. The long hind body has no appendages and is only vaguely divided into somites.
Fire or six hours after hatching it changes into a true zoea, much like that of an ordinary macrouran. The carapace becomes much enlarged; the rostrum is shortened to less than half its former length, the mandible becomes small, the forks disappear from the telson, the eyes become stalked, the antennae are shortened like those of a zoea, and the maxillipeds become the chief locomotor organs.

As these larvae could not be reared in captivity the later stages were studied from captive specimens, but Prof. Herrick has proved that the Beaufort larvae are either young Stenopel or else the larvae of some closely allied species which is at present unknown.

A specimen a little older than the oldest Beaufort specimen was captured at Nassau. It is in the Mastigopus stage, with greatly elongated eyes, and with antennae which are gradually approximating to those of the adult. The third maxillipeds are now extremely long and are the largest of all the limbs, while the huge ear-like fifth pereiopod of the preceding stage is now reduced to a rudimentary bud, and the fourth is also reduced to a two-jointed rudiment.

It thus appears that, as in the Sergestidae, the last two pairs of "walking legs" are shed after the Mysis stage to be again reconstructed in the Mastigopus stage. After several molts the Mastigopus larva gradually assumes the adult form, the principal changes being the shortening of the eyes, and the reacquisition of the fourth and fifth pereiopods.

**Alpheus.**

The genus Alpheus includes a number of small, brilliantly colored, crayfish-like crustacea, which are widely distributed, although all are essentially tropical. Two species range as far northward as the coast of Virginia, but the true home of the genus is the warm water between tide-marks or near the shore in coral seas, and they occur in the greatest abundance and variety in all the sounds and inlets along coral islands. They are well adapted, in structure, as well as in habits, for a life among the coral, and of all the crustacea which abound upon the coral reefs, the genus Alpheus is one of the most common and most thoroughly characteristic.

Nearly every mass of sponge or algae or of coral rock or living coral which is fished up from the bottom and broken to pieces contains specimens of one or more species of Alpheus, and pieces are often found which fairly swarm with these little animals.

A few of the species wander over the bottom, and wandering individuals of other species are found occasionally, but their true home is in the tubes of sponges and the holes and crannies in the porous coral limestone or under the broken shells and fragments of limestone which lie upon the bottom in shallow water. Occasionally they inhabit short vertical burrows, which they construct for themselves in the sandy mud, but most of the species pass their life hidden in the shelter which they find upon the reef.

The most conspicuous characteristic of the genus is the great enlargement of the claws of the first pair of walking legs. Both claws are large, but one of them is enormous, and serves it as a most formidable weapon of offence and defence. In some species this large claw nearly equals the body in size, and serves it as a most formidable weapon of offence and defence. In some species of Alpheus, Alpheus heterochelis, and Alpheus normassi, and it is described in detail, with ample illustrations, in the chapter on the metamorphosis of Alpheus.

As these larvae could not be reared in captivity the later stages were studied from captive specimens, but Prof. Herrick has proved that the Beaufort larvae are either young Stenopel or else the larvae of some closely allied species which is at present unknown.

A specimen a little older than the oldest Beaufort specimen was captured at Nassau. It is in the Mastigopus stage, with greatly elongated eyes, and with antennae which are gradually approximating to those of the adult. The third maxillipeds are now extremely long and are the largest of all the limbs, while the huge ear-like fifth pereiopod of the preceding stage is now reduced to a rudimentary bud, and the fourth is also reduced to a two-jointed rudiment.

It thus appears that, as in the Sergestidae, the last two pairs of "walking legs" are shed after the Mysis stage to be again reconstructed in the Mastigopus stage. After several molts the Mastigopus larva gradually assumes the adult form, the principal changes being the shortening of the eyes, and the reacquisition of the fourth and fifth pereiopods.

**The Metamorphosis of Alpheus.**

One of the most remarkable results of our study of the various species of the genus Alpheus is the discovery that, while there is such a general similarity as we might expect between the larval stages of the different species, the individuals of a single species sometimes differ more from each other, as regards their metamorphosis, than the individuals of two very distinct species.

This phenomenon has been observed by us and carefully studied in two species, *Alpheus heterochelis* and *Alpheus normassi*, and it is described in detail, with ample illustrations, in the chapter on the metamorphosis of Alpheus.

In the case of the first species the difference seems to be geographical, for while all the individuals which live in the same locality pass through the same series of larval stages, the life history of those which are found at Key West is very different from that of those which live on the coast of North Carolina, while those which we studied in the Bahamas Islands present still another life history. In the case of the second species, *Alpheus normassi*, the difference stands in direct relation to the conditions of life. The individuals of this species inhabit the tubes and chambers of two species of sponges, which are often found growing side by side upon the bottom, and the metamorphosis of those which live in one of these sponges is quite different from that of those which inhabit the other. In this species the adults also are different from each other, but as we found a perfect series of transitional forms there is no good reason for regarding them as specifically distinct, and in the case of the other species *Alpheus heterochelis* we were unable, after the most thorough and minute comparison, to find any difference whatever between adults from North Carolina and those from the Bahamas Islands, although their life histories exhibit a most surprising lack of agreement. In fact, the early stages in the life of *Alpheus heterochelis* on the Bahamas Islands differ much less from those of *Alpheus minor* or *Alpheus normani*, than do they from those of the North Carolina *Alpheus heterochelis*, and according to Packard, the Key West *heterochelis* presents still another life history.

In the summer of 1881 I received the American Naturalist with Packard's very brief abstract of his observations at Key West upon the development of *Alpheus heterochelis*, and read with great surprise his statement that this species has no metamorphosis since, while still inside the egg it has all the essential characteristics of the adult. As I had under my microscope at Beaufort the very day when I read his account, a newly hatched larva of the same species, and was engaged in making drawings to illustrate the metamorphosis of which he denies the existence, and as my experience in the study of other Crustacea had taught me that all the larvae of a species at the same age are absolute facsimiles of each other down to the smallest
hair, Packard’s account seemed absolutely incredible; and I hastily decided that, insomuch as it was without illustrations, and was written from notes made many years before, it involved some serious errors, and was unworthy of acceptance. This hasty verdict I now believe to have been unjust, since my wider acquaintance with the genus has brought to my notice other instances of equally great diversity between the larvae of different species of a single species.

The phenomenon is, however, a highly remarkable one, and worthy the most thorough examination, for it is a most surprising departure from one of the established laws of embryology: the law that the embryonic and larval stages of animals best exhibit their fundamental affinities and general resemblances, while their specific characteristics and individual peculiarities make their appearance later.

In most animals the adult life is most important, and the adults have a more diversified environment than the young, and the divergent modification which is continually taking place, to perfect the adjustment between each organism and its conditions of life, chiefly affects the adults, so that specific characters and the slight differences between varieties or races are usually confined to the adults, while the embryos and larvae are, as a rule, more generalized.

This is true of a marked degree of those animals whose young are raised or protected or cared for in any way by their parents; and while it is less true of those animals whose independent life begins very early, yet the same law holds with them also, and the chief scientific value of embryology lies in the fact that a knowledge of the early stages in the life of animals enables us to trace their broad affinities, and to distinguish them from more recently acquired differences; for the early stages of two related forms of life share in common their most fundamental characteristics, and are essentially alike, while the adults differ from each other and exhibit the divergent specializations which are of more recent acquisition.

It sometimes happens, however, that the early stages of two closely related species differ greatly. This may occur when the larva of the one species leads a free, independent life, while the young of the other species are protected in some way by the parents. For example, the complicated metamorphosis which is so characteristic of star fishes, is almost totally absent in those star fishes which are provided with brood-pouches. The same relation may also be exhibited when the larvae of one species of a genus have become adapted to a mode of life very different from that of the larvae of the other species of the genus. Thus those species of Aeginidae whose larvae are parasitic, multiply sexually during the larval life and build up complex communities, while nothing of the sort occurs in those species with free larvae.

Many similar cases might be given, but we must bear in mind that they are all very different from the one now under examination. In all such cases the difference is between the larvae of two distinct species, while in Alpheus we have a similar difference between the larvae of individuals of a single species.

Among other animals it is not very unusual for certain individuals which are placed under conditions exceptionally favorable for embryonic development to be born in a more advanced stage than the normal for the species; and in such cases the larval metamorphosis is abbreviated by the omission of the earlier stages. This abbreviation of the larval life is not common, but many cases are known, and if the history of Alpheus were simply another illustration of this process of abbreviation, it would not be at all anomalous, although the existence of three well marked and fixed grades of abridgment in Alpheus heterochelis, in three widely separated localities, would still be remarkable and interesting.

The life-history of the North Carolina form of this species is more abbreviated than that of the Bahama form, and the metamorphosis of the Key West form is still more shortened; but in addition to the abbreviation the different forms also present most important differences in structure and in the order in which the appendages are developed; differences which are much more fundamental and profound than the mere length of the larval life.

The various larval forms are described with so much detail in the chapter on the Metamorphosis of Alpheus, that it is not necessary to repeat them here; but the following very brief outline will serve to call attention to a few of the most conspicuous features.

As several distinct species of the genus Alpheus pass through a long metamorphosis each stage of which is almost exactly the same in all the species, we may safely assume that this is the primitive or ancestral metamorphosis which was originally common to all the species. It has been traced in Alpheus minor by me at Beaufort, North Carolina, and by Mr. Herrick in the same species at New Providence. Mr. Herrick has also traced it at New Providence for Alpheus normani and Alpheus heterochelis. In all these forms the larva hatches from the egg in a form which is very similar to Fig. 2 of Pl. xiv, and very shortly after hatching it mouls and passes into the second larval stage. This larva has all its appendages fully developed and functional as far backwards as the third pair of maxillipeds. Following these are three bud-like rudiments to represent the first, second and fifth thoracic limbs, and posterior to these a long tapering imperfectly segmented abdomen, ending in a flat triangular telson.

The locomotor organs are the plumose antennae, and the exopodites of the three pairs of maxillipeds.

After the second moult the larva passes into the third stage. The first and fifth thoracic limbs are more functional; all the abdominal somites are distinct and movable, and the uropods or sixth abdominal appendage has appeared and its exopodite is functional and fringed with plumose hairs, while its endopodite is rudimentary. The five anterior abdominal appendages have not yet appeared.

The first thoracic leg which was represented by a bud in the preceding stages has now acquired a first basal joint and a swimming exopodite like those of the maxillipeds, but its endopodite is rudimentary.

The fifth thoracic limb is fully developed and is the most conspicuous peculiarity of the larva at this stage of development. It has no exopodite; its basal joint is not enlarged nor flattened, and its long cylindrical slender shaft is prolonged at its tip into a long lance-like hair which projects beyond the tips of the antennae.

After its third moult the larva passes into the fourth stage, which is shown in Pl. xiv, Fig. 3. The carapace now begins to extend over the eyes, and the ears make their appearance in the basal joints of the antennules. There are now five pairs of plumose locomotor exopodites belonging to the first, second and third maxillipeds, and the first and second thoracic limbs. Between the latter and the elongated fifth thoracic limb are buds to represent the third and fourth. The telson has become narrow and elongated, and the uropods are fully developed, although there is as yet no trace of the other abdominal appendages.

After the fourth moult the larva passes into the fifth larval stage, when it resembles Fig. 1 of Plate xvi, so far as concerns the anterior end of the body, from which it differs greatly as regards the telson and uropods. The eyes are now well covered by the carapace, and the swimming organs are the seven pairs of exopodites belonging to the three maxillipeds, and the first four thoracic limbs. The first five pairs of abdominal appendages are now represented by buds, but the telson and uropods are nearly like those of Fig. 3 in Pl. xiv. The telson is narrow and much elongated, and its marginal spines are very small.

During the mouls which follow, the exopodites of the abdominal appendages become fully developed, the eyes become completely covered by the carapace, the antennules develop a scale, the antennae elongate, the swimming appendages of the midbody disappear; these appendages assume their adult form, and the animal gradually becomes like a young Alpheus.

This life-history is common to Alpheus minor at Beaufort and New Providence, and Alpheus normani and Alpheus heterochelis at New Providence, although the latter species presents a totally different life-history at Beaufort. Before it hatches this form reaches a degree of development which bears a general resemblance to stages two and three of the Bahama form, with certain differences which are pointed out in the sequel.

Immediately after hatching the animal has all the somites and appendages of the adult, but all behind the maxillipeds are rudimentary, and there is little power of locomotion. The first moult occurs in a few hours, and the larva assumes the form of a young Alpheus. The eyes are almost completely covered by the carapace, the ear is well developed, the flagellum of the antennae has elongated, and the other appendages have assumed the adult form. Careful comparison will show that no exact parallel can be drawn between any larval stage of this form and a stage of the first form, and that we have to do with something much more profound than simple acceleration of development. The Bahama heterochelis has, at first, three, then four, then five, then seven fully developed and functional swimming exopodites, while the North Carolina form never has more than three. As regards the thoracic region and the first five abdominal appendages.

1 The references are to the plates accompanying the complete Memoir to be published by the National Academy of Sciences.
ages the Beaufort larva at the time of hatching is more advanced than the fourth larval stage of the Bahama form, while the uropods are like those of the Bahama form at the time of hatching.

In the latter the first and fifth thoracic limbs are the oldest, and the others appear in succession, while all five pairs appear together in the Beaufort form. In the Bahama form the uropods appear before, and in the Beaufort form after the others; and many minor differences show that we have to do with profound modification of the life history rather than with simple acceleration.

Packard’s short account of the development of those specimens of this species which occur at Key West shows that these differ from the Beaufort specimens about as these latter differ from the Bahama specimens.

The second species, Alpheus swallowi, is found in the Bahama Islands living in the tubes and chambers of two species of sponges, a green one and a brown one. Those found in the green sponges have many small eggs, while those found in the brown sponges have only a few large eggs. The eggs from the green sponge hatch with rudimentary gills, the eyes are imperfectly covered, the antennules and antennae are elongated, the thoracic limbs have the adult form, and the exopods of the three pairs of maxillipeds are the chief organs of locomotion, although all the appendages are represented. The abdominal feet are rudimentary buds however, and the uropods are covered by the cuticle of the telson.

Very soon after hatching the larva moults and assumes the form shown in Pl. xv. Fig. 2. The eyes are more completely covered, the antennules and antennae are elongated, the thoracic limbs have the adult form, and the pleopods are all functional.

In twenty-five or thirty hours after hatching it moults for the second time, and passes into the third stage, which is shown in Fig. 8. It is no longer a larva, but a young Alpheus with all the structural characteristics and pugnacious instincts of the adult.

In a few cases the development of this species is still more accelerated, and a few eggs from animals taken from the brown sponge hatched in the stage shown in Fig. 8, instead of the stage shown in Fig. 1.

 Variation in the Habits and Coloration of Alpheus.

Some of the species of Alpheus are usually or even universally found living as parasites within the water tubes of sponges, and it is extremely interesting to find that individuals of the same species, living in different species of sponges may themselves differ greatly in color and in habits.

A large brown sponge, which is not to be mistaken, grows on the shallow reefs and off the shores of all the Bahama Islands. It is found from just below low tide mark out to one-half a fathom or more of water, where its bright coloring of the tips of the claws which only are provided from the place of concealment, recall the similarly colored heads of boring annelids which abound on the reef, and may have a protective significance. This evidence, however, is not very reliable.

The colors of certain crustaceans, and also the colors of their eggs are known to vary greatly with the surroundings. In the Alpheus, parasitic in the brown sponges, these colors vary considerably where the surrounding conditions are the same. However, the color of the ovarian eggs is always the same as that of those already laid, whereas it is only in the large brown variety that any variation from these colors. In these the eggs were yellow, and the pigment on the claws more orange than red. The rostrum usually has three spines, but occasionally only two are present, the median one being lost. It is evident that these animals are perfectly protected from outside enemies, while within the tortuous mazes of the sponge, as their numbers would show. Parasites, such as Isopods however are not uncommon. There has thus been no chance or need for natural selection to act along the line of color. On the other hand, possibly, the Alpheus of the green sponge does require color protection, since the females are very sluggish during the breeding season, which extends over a good part of the year. This animal is certainly well protected against any green surface as already stated. But as will be shown, natural selection has probably nothing to do with it. The bright coloring of the tips of the claws which only are prodded from the place of concealment, recall the similarly colored heads of boring annelids which abound on the reef, and may have a protective significance. This evidence, however, is not very reliable.

The colors of certain crustaceans, and also the colors of their eggs are known to vary greatly with the surroundings. In the Alpheus, parasitic in the brown sponges, these colors vary considerably where the surrounding conditions are the same. However, the color of the ovarian eggs is always the same as that of those already laid, whereas it is only in the large brown variety that any variation from these colors.

These two forms, apparently distinct, are seen however, by closer examination, to belong to the same species, although they show very interesting variations. The Alpheus living in the brown sponges, tends to vary in several ways, chiefly in size and in the color of the body, but these experiments were not continued long enough or carefully enough to be conclusive. The species of Alpheus heterochelis are almost invariably of a dull olive color, while, in the case of the parasite of the green sponge, about one in a hundred has bright yellow eggs. In the first case at least this is probably an instance of reversion to one of the original colors from which the green was selected. In most species of Alpheus the color of the eggs is fixed and uniform, and as already suggested may have a protective significance, but in a few other cases where this is not true, the color is not only variable in different individuals, but probably also in the same individuals.

In order to explain the variations which we find in these two forms, we must assume either (1) that the parasites of the green sponge are a fixed variety with distinct habits, or (2) that they represent individuals which have migrated from the brown sponges and adapted themselves to their new surroundings, or further (3) that only those chance individuals with orange-red claws and bright green eggs, which occasionally occur in the brown sponge, find their way to the smaller green species, where they acquire great vigor and size. This last supposition is evidently untenable. If moreover the two forms, which were at first supposed to be specifically distinct, represent fixed varieties, we ought to find the young or at least adults of all sizes in both sponges, whereas it is only in the large brown variety that any small or undersized individuals occur, while a single pair of large and tolerably uniform size, is invariably found in the exhalent chambers of the green sponges.

These and other considerations render it probable that the second (2) proposition above stated is the correct one, viz., that the parasites of the green sponges were born in the brown variety, and after attaining considerable size migrated thither, where they adapted themselves at once to their slightly different surroundings, growing to three or four times their breeding season (which lasted during our stay, March to July), and at such times is well protected in her sponge or against any green surface, by the bright green ovaries which fill the whole upper part of the body, and by the mass of similarly colored eggs attached to the abdomen below. Only two pairs or four individuals out of a hundred or more which were examined showed any variation from these colors. In these the eggs were yellow, and the pigment on the claws more orange than red. The table which follows shows the variations between two large females taken respectively from the brown and green sponges, and between the size, number, and color of the eggs.

<table>
<thead>
<tr>
<th>Habitat of Alpheus</th>
<th>Length of Gen.</th>
<th>Number of Eggs</th>
<th>Diameter</th>
<th>Color</th>
<th>Color of Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown sponge</td>
<td>1/2 in.</td>
<td>19</td>
<td>3/4 in.</td>
<td>Yellow-</td>
<td>Large chela., red, blue, or brown.</td>
</tr>
<tr>
<td>Green sponge</td>
<td>1 3/8 in.</td>
<td>361</td>
<td>3/4 in.</td>
<td>(variable).</td>
<td>Usually green; in this case yellow.</td>
</tr>
</tbody>
</table>

These two forms, apparently distinct, are seen however, by closer examination, to belong to the same species, although they show very interesting variations. The Alpheus living in the brown sponges, tends to vary in several ways, chiefly in size and in the color of the body, but these experiments were not continued long enough or carefully enough to be conclusive. The species of Alpheus heterochelis are almost invariably of a dull olive color, while, in the case of the parasite of the green sponge, about one in a hundred has bright yellow eggs. In the first case at least this is probably an instance of reversion to one of the original colors from which the green was selected. In most species of Alpheus the color of the eggs is fixed and uniform, and as already suggested may have a protective significance, but in a few other cases where this is not true, the color is not only variable in different individuals, but probably also in the same individuals.

In order to explain the variations which we find in these two forms, we must assume either (1) that the parasites of the green sponge are a fixed variety with distinct habits, or (2) that they represent individuals which have migrated from the brown sponges and adapted themselves to their new surroundings, or further (3) that only those chance individuals with orange-red claws and bright green eggs, which occasionally occur in the brown sponge, find their way to the smaller green species, where they acquire great vigor and size. This last supposition is evidently untenable. If moreover the two forms, which were at first supposed to be specifically distinct, represent fixed varieties, we ought to find the young or at least adults of all sizes in both sponges, whereas it is only in the large brown variety that any small or undersized individuals occur, while a single pair of large and tolerably uniform size, is invariably found in the exhalent chambers of the green sponges.

These and other considerations render it probable that the second (2) proposition above stated is the correct one, viz., that the parasites of the green sponges were born in the brown variety, and after attaining considerable size migrated thither, where they adapted themselves at once to their slightly different surroundings, growing to three or four times their breeding season (which lasted during our stay, March to July), and at such times is well protected in her sponge or against any green surface, by the bright green ovaries which fill the whole upper part of the body, and by the mass of similarly colored eggs attached to the abdomen below. Only two pairs or four individuals out of a hundred or more which were examined showed any variation from these colors. In these the eggs were yellow, and the pigment on the claws more orange than red. The table which follows shows the variations between two large females taken respectively from the brown and green sponges, and between the size, number, and color of the eggs.
former size and the females acquiring bright green eggs, which become a source of protection in their new habitat. This view implies the greatest variability in color and in size of the individual, and in the color of the egg, which is the more remarkable from the fact that it is quite unusual in this genus.

The Embryology of Alpheus.

At my suggestion, Mr. Herrick undertook, in 1886, the study of the embryology of Alpheus, and devoted almost all of his time for three years to this subject, and while he carried on the work under my general supervision, the results which he has reached are entirely his own, and my share in the chapter which is devoted to this division of the subject is only that of an instructor. From time to time brief abstracts of the progress of the research have been written by Herrick and published in the Johns Hopkins University Circulars, and the following summary of his results contains the substance of these preliminary reports.

The work was begun at Beaufort, N. C., and the eggs of the two species of Alpheus which occur there were carefully examined and preserved for laboratory research; but much better and simpler material was afterwards obtained at the Bahamas. The early stages were much more thoroughly studied, and the development of these animals was traced in detail, step by step, from the first nucleus of the fertilized egg through all the embryonic and larval stages up to the adult condition. The eggs of each of the thirteen species which occur in the Bahamas were obtained and studied sufficiently to ascertain what are the specific differences in development, and four species were studied exhaustively in detail.

These four are Alpheus hetrocheilis, Say; A. minor, Say; A. nudus, and another form which is probably new, to which no name is now given. Unless otherwise stated the following notes on the early stages refer to the last, unknown, species. The development in the egg is the same for all, excepting A. minor, which will be referred to separately.

This prawn has proved to be a good subject in which to study the origin and rôle of certain much disputed bodies, which are met with in several Crustacea and are known as “secondary mesoderm cells.” Mr. Herrick’s studies have convinced him that the germinal layers in the early stages of development have not the significance which is usually assigned to them.

The mass of cells which results from gastrulation, some of which are poured into the yolk, is an unclassified, indifferently layered, and cannot be regarded as mesoderm and endoderm in the sense in which these terms are used. It is potentially both epithelium, muscle, and gland, since all these structures may be formed from it. The endoderm on the other hand, by its position and function, is more clearly defined from the start. The development in general is characterized by great secondary modification.

Segmentation of the Nucleus and of the Yolk.

The egg when laid, is enveloped by a single membrane, the chorion or shell, which functions as an egg sac. If the nucleus is unfertilized, it is not able to initiate the process of segmentation. The fertile nucleus divides, and its products pass towards the surface, until a synecytium of eight nuclei is formed. Either just before or after the division of these, the yolk undergoes segmentation simultaneously over the whole surface into a similar number of partial pyramids. Each yolk cell or pyramid has a large nucleus at its base, while its apex fuses with the common yolk mass in the interior of the egg. The process is now a regular one until 128 to 256 small segments are formed. The rate of cell multiplication is then retarded over one-half of the egg, while it still continues and perhaps is accelerated over the remaining portion of it. The egg thus loses its radial symmetry and becomes two-sided. It is important to notice that no products of the segmentation nucleus are left in the interior of the yolk. The superficial pyramidal structure is lost; the primitive blastoderm is established, and there now takes place a general migration of nuclei from the surface to the yolk within, but principally as would be expected from that part of the egg where the blastoderm cells are most numerous, corresponding to the future embryo. This is followed by a partial secondary segmentation of the food yolk into balls. The yolk-ball is apparently formed about the migrating nucleus, but as the latter is moving, this segmentation is irregular.

Mr. Herrick has been able to follow very closely the entire process of segmentation in Stenopus, where it is substantially the same as that just described, except that there is no general migration of cells from the surface prior to gastrulation. This is true also of Pontonia domestica, and it is quite probable that the majority of macronus pass through the same phases in their early development.

Alpheus minor is anomalous from the fact that the products of the first nucleus, instead of multiplying by regular binary division, appear to multiply by endogenous cell formation, and to give rise to numerous spores or nuclei, before the blastoderm is formed.

The Egg Gastrula.

A slight invagination occurs where the superficial cells are thickest, and the egg becomes a modified gastrula. The depression is shallow, and does not form an enclosed cleft within the yolk. The included cells multiply rapidly, and form a mass of similar elements, some of which pass into the yolk. The protoplasm surrounding the nuclei of these cells is prolonged into a reticulum, which encloses myriads of small yolk fragments, and probably digests them by an intracellular process, after the manner of feeding amoebe. The thickening in front of and surrounding the blastopore, which is now obscured, is the rudiment of the abdomen. Anteriorly the protoplasmic lobes are more properly the optic discs, make their appearance on either side of the long axis of the embryo, as circular patches of endoderm. Meanwhile, nuclei wander from the cell mass below the abdominal plate to all parts of the egg. Some pass to the opposite side, and take up a position beside the flattened epithelial cells, of what was the primitive blastoderm. The majority, however, pass forward and upward in two divergent lines from the sides of the abdominal plate, and eventually large numbers of these wandering cells settle down over the dorsal surface of the embryo.

Secondary Mesoderm Cells.

At the beginning of the egg-naupe period, when numerous yolk cells have passed forward and joined the inner surface of the embryonic ectoderm, certain new bodies begin to appear in great numbers. They vary in size from small refringent particles to spores nearly as large as ordinary nuclei. The latter stain deeply and uniformly, and with high powers it is possible to demonstrate a clearer zone about them, which is evidently the first trace of a cell body proper. How do these bodies, the “secondary mesoderm cells,” originate, and what is their function? As to their origin Mr. Herrick believes there can be no doubt whatever. They arise by a process of endogenous growth from the embryonic cells or nuclei, chiefly from those wandering cells just described. Many of the latter may be seen to be swollen out, and their chromatin divided into coarse grains and balls of various sizes. The wall of the cell probably breaks down and thus sets the spores free.

The fate of these bodies is not so easily determined, but Mr. Herrick is disposed to believe that some of them become ordinary mesoderm cells, while there is some evidence that others are converted directly into blood corpuscles. These spores are most marked in the fully developed egg-naupus, where there is a large accumulation of them around the oesophagus and at the bases of the rudimentary appendages. After this stage they generally disappear from these regions. Somewhat later, however, when there is a well-developed nervous system and six pairs of post-nauplius appendages, a patch of ectoderm cells on the surface of the egg opposite to the embryo becomes noticeable. It remnants of a median unpaired dorsal organ. A slight invagination apparently takes place at this point, but at any rate a number of cells pass into the surrounding yolk, and these give rise in the way described to a swarm of minute spores.

By the time that pigment is deposited in the eyes, it is easy to demonstrate the presence of blood corpuscles in the stream of plasma which bathes the nervous system. They have the adult characteristics, that is to say, they possess a deeply staining nucleus, and a clear irregular body. In the nauplius stage, moreover, some of the larger “secondary mesoderm cells” have a similar appearance, and are therefore possibly primitive blood cells. Mr. Herrick’s study of these bodies has convinced him that Reichenbach’s views on the origin of the secondary mesoderm cells of Asterias, although adversely criticized, are the true ones. According to this naturalist they arise from the nuclei of the endoderm cells, forming the ventral wall of the primitive stomach.

The Germinal Layers.

The plasticity of the embryonic cells and layers and the comparative tardiness with which they are clearly differentiated cannot fail to impress anyone who follows closely the early stages of development. The cell-mass developed around the blastopore, forming the abdominal process, cannot be
ARTIFICIALLY DIVIDED INTO LAYERS. IT CERTAINLY REPRESENTS VERY LARGELY THE PRIMITIVE MESODERM, BUT SOME OF ITS ELEMENTS PASS TO THE OPPOSITE POLE OF THE EGG AND BECOME INDISTINGUISHABLE FROM THE SUPERFICIAL ECTODERM. A PART OF THIS MASS REMAINS AS THE MESODERM OF THE Rudimentary abdomen, while many of the cells which migrate from it give rise to spores, which are undoubtedly mesodermic in function.

The endoderm does not appear as a definite layer until comparatively late. It arises from yolk cells which assume a peripheral position, and joining the cells of the hind-gut form the walls of the mesenteron.

THE EYE.

The optic discs appear as patches of ectoderm, one cell thick, on either side of the long axis of the embryo in front of the rudimentary abdomen. Before the appendages are definitely formed, these have become thickened ectodermal discs. This thickening is due, (1) to delamination, or to a division of cells in a plane parallel with the surface; (2) to emigration of cells from the surface, due to crowding or to a division of superficial cells in a plane at right angles to the surface. A disc of cells is thus formed which gives rise chiefly to the eye and its ganglion. The cord of cells uniting the two optic discs represents mainly the future brain. The eye proper is due to the differentiation of the outer layer of the cells of this disc, while the ganglion is developed from the inner layer.

GONODACTYLUUS CHIZAGRA.

There are few orders of animals which we are more ignorant than we are of the Stomatopods. They are well known as museum specimens, and every natural history cabinet contains one or two which have been brought home as rare curiosities from distant seas, but we know hardly any thing of the habits of the living animals. They are abundant and widely distributed, but like most rapacious animals they are very alert, taking alarm at the slightest disturbance, and retreating to the depths of their burrows at the bottom of the ocean, where they are so completely hidden from observation that their capture is difficult, and any attempt to study them in their homes is almost out of the question.

The habits of Squilla are tolerably well known, and in my report on the Stomatopoda collected by H. M. S. Challenger I have given an account of the habits of Lysiosquillula based upon observations made at Beaufort, North Carolina, but except for a few scattered and fragmentary notes in the various descriptive papers this is the whole of our knowledge of the order. During the seasons of 1886 and 1887 I was so fortunate as to find, in the Bahama Islands, Gonodactylus chiragra living in localities which were peculiarly favorable for observing its habits, and I am now able to supplement my report upon the Challenger collections, by an account of this interesting species, of which little had hitherto been known except the fact that it is the most cosmopolitan of the Macoura, abounding on the shores and inlets of all tropical and sub-tropical seas.

I also obtained its eggs in abundance and succeeded in rearing the young from them in aquaria, and am now able to make a contribution to a subject upon which there were hitherto no direct observations, for it is a noteworthy fact that while the older larvae of Stomatopodes have long been known, and while many genera and species of them were carefully figured and described and named by the older naturalists before their relationship to the adult Stomatopods was suspected, not a single species in the whole order has, so far as I am aware, been reared from the egg and in this way identified with its specific adult.

While the adults usually inhabit burrows in the bottom, the larvae swim at the surface of the ocean, and as none of the animals which are captured in the surface net exceed them in beauty and grace, these glass-like pelagic larvae are familiar to all naturalists who have had an opportunity to study the surface fauna of the ocean. Their perfect transparency, which permits the whole of their complicated structure to be studied in the living animal, their great size and rapidity, the graceful beauty of their constant and rapid movements, cannot fail to fascinate the naturalist. Unfortunately they are as difficult to study as they are beautiful and interesting, and notwithstanding their great abundance and variety only two or three of them have been traced to their adult form.

Unlike most Malacostraca, the Stomatopods, instead of carrying their developing eggs about with them, deposit them in their deep mind inaccessible as difficult to study as they are beautiful and interesting, and notwithstanding movements, cannot fail to fascinate time natoralist. Unfortunately thmey are larvae are familiar to all naturalists who have had an opportunity to study its specific adult.

Far as I am aware, been reared from while many genera and species of them were carefully figured and described upon whicim there were hitlmerto no direct observations, for it is a noteworthy fact that while the older larvae of Stomatopods have long been known, and are of the Stomatopods.

The attemupt to unravel the tangled thread of the larval history of the Stomatopods is therefore attended with very exceptional difficulties, and the earlier writers were content to rest after the bestowal of generic and specific names upon the larvae. As I found after the Challenger collection was placed in my hands, that it was very rich in larvae, I attempted to determine, by comparison, the larval series for each genus, and the methods which I employed for making the comparison are fully stated in my report.

As one of the results of this comparison I ventured to describe the general characteristics of the larva of the genus Gonodactylus (p. 113); and in Pl. xii, Fig. 5 of that report I figured a larva which I ventured to call the larva of Gonodactylus. A comparison of that figure with this memoir will show that this determination was correct, as the larva of Gonodactylus chiragra, which is here described, is so much like the one figured in the Challenger report that they belong in all probability to the same species.

ON REPRODUCTION BY BUDDING IN THE DISCOMEDAUS.

By R. P. Bigelow.

In 1841 Sars described a process of budding in the scyphistoma larvae of either Aurelia or Cyanea. The buds may grow directly out from the main part of the body of the larva or they may be produced on stolons extending outward from the foot. In either case several buds may apparently be formed in various positions on the scyphistoma at one time. His figures show the buds still attached to the parent and with a well developed crown of tentacles at the distal end. Goette (1887) has confirmed these observations as to the formation of a stolon and has also found that the larvae of Cystobrachis tuberulata produce buds. In this species the process, as described by Goette, is quite peculiar. A bud is formed as an outgrowth from the body of the scyphistoma and as this grows it gradually approaches the shape of its parent, but its relative position is just the reverse of what Sars found, for the distal end forms the stem and the proximal end begins to flatten out into a circular disk. In this condition the bud is set free and swims about, rotating on its long axis with the stem forward. The mouth is formed at the point where the construction finally separated the bud from its parent and the larva fixes itself by the opposite end.

In all the above cases this process of budding appears to be merely an incident in the life history of the individual. On the other hand, in the Cassiopea Xamachana that I obtained during the past summer while at our Marine Laboratory in Jamaica and of which a description will be published soon, the process of budding is an important if not the chief factor in the perpetuation of the species.
The bud first appears as a slight swelling on the body of the scyphistoma near the stem. It involves all three layers of the body-wall. At an early stage in the growth of the bud the four septal muscles may be found embedded in the jelly and apparently growing out from a thickened area of the ectoderm at the apex of the bud. At this point the supporting jelly is very thin, so that the entoderm and ectoderm are almost in contact. As the bud increases in size the opening between it and the coelenteric cavity of the scyphistoma is gradually closed by a contraction, the constriction increases in depth until, finally, the bud is set free as a pear or spindle-shaped ciliated body rotating on its longitudinal axis as it swims about. It very soon loses all trace of its former connection with the older larva and becomes somewhat flattened. Later, during this free swimming stage, the mouth first appears as a minute opening in the hinder end of the larva. Whether this point is identical with the distal or with the proximal end of the bud it is difficult to say. The evidence points in both directions.

That this point was the distal apex of the bud seems probable when we observe, in the first place, that in the completed bud it is generally the distal end that is the more acute. This is also true of the posterior end of the swimming larva and the mouth always arises at this end. Better evidence is furnished in the second place by the position of the septal muscles. It is known that in larvae produced from eggs the septal muscles arise as ingrowths from the ectoderm of the circumoral disk. In the buds of Cassiopeia the septal muscles when first observed have the appearance of ingrowths from the ectoderm of the distal end of the bud and it is impossible to trace them to the proximal end. The earliest stage after the formation of the mouth of which I have sections has the septal muscles continuous with the ectoderm of the circumoral disk in the same way. This seems conclusive, but on the other hand the fact must not be overlooked, that in the stage last mentioned the septal muscles are also well developed at the oral end of the larva. Moreover, in the bud when about to be set free, while the entoderm cells in the proximal part are somewhat granular, those in the distal end are clear and larger than the others and thus come to be more like the entoderm in the stem of the scyphistoma. This is directly opposed to what is indicated by the origin of the muscles and makes it possible, therefore, that the distal end of the bud may after all be oral as Goette says it is in Cotylorhiza, and we should expect the two species to agree in this particular.

At about the time that the larva is ready to assume a sedentary mode of life it becomes top-shaped by the narrowing of the anterior end and by the formation of a shoulder at a little distance from the posterior end. This shoulder is the beginning of the circumoral disk and the part of the animal posterior to it is the proboscis. There has been no invagination during the formation of the mouth, but it is possible that this proboscis arises by an outgrowth of the ectoderm of the mouth and the origins of the septal muscles. This seems the more probable when we remember that one of the few points on which Claus and Goette agree is in regarding the lining of the proboscis in the species studied by them as being of entodermal origin.

With the increase in diameter of the circumoral disk the entoderm pushes out towards the periphery of the disk as four shallow gastric pouches separated by four gelatinous septa, each enclosing a septal muscle. These septa very soon become perforated on the distal side of the muscle so that the entoderm of adjacent pouches comes into contact at this point. In this way the four columnellae ("Septalknoten") are formed. The disk becomes octagonal and each of the angles soon grows out into a tentacle containing a solid axis of entoderm cells. Four of these tentacles are in the radii of the septa. The tentacles appear to arise in cycles of eight, there being at first eight, then sixteen, twenty-four, and at last thirty-two. Very often, however, additional tentacles are interpolated.

The septal muscles remain solid structures until after strobilization begins, when four very slight funnel-shaped depressions appear in the circumoral disk, or subumbrella, each extending a short distance into the upper end of one of the septal muscles. These septal funnels remain rudimentary and disappear soon after the medusa is set free.

Several interesting questions naturally suggest themselves, such as,—the origin of budding in the scyphomedusae, which of the known methods is nearer the primitive one, whether this has any relation to strobilization, and the like; but until much more evidence has been collected than we at present possess it will be impossible to give to them conclusive answers. It seems to me to be highly probable, however, that the mode of budding that occurs in Cassiopea will be found to be the most highly specialized of those so far known. It seems to be an especial adaptation to overcome the unfavorable effect on the distribution of the species caused by the sedentary mode of life of the adult, a mode of life so unusual with medusae. Dwelling as it does on the bottom in quiet lagoons and bays, its eggs stand little chance of wide distribution and the planulae would not probably swim very far from their mother before becoming fixed. The individual buds probably do not swim very far either, but the last one of a series of generations of buds may be at a great distance from the parental, sexually produced scyphistoma.


In addition to their special researches the members of the Johns Hopkins Marine Station accumulated during the summer of 1891, from May 28 to September 1, a number of general observations upon the fauna of Jamaica, made more or less incidentally, yet of use as a preliminary view of the material there accessible. These notes are now brought together and recorded, in connection with the accompanying sketches, for the use of future workers in the marine zoology of Jamaica.

First the general nature of the fauna in various parts of Kingston Harbor is indicated for the localities 1-41 on the map, starting from the location of the Laboratory at Port Henderson (1).

Then a general account of the animals observed, with special reference to their breeding habits, is given for Port Henderson and other regions visited. And finally a few observations upon the nature of the preliminary collecting that was done at more distant points and the general character of the marine life there is appended.

In connection with this the outline sketch of Jamaica gives the names of towns visited by various members of the Laboratory and, by the dotted line, the various excursions from Port Henderson to distant parts of the sea shore and the interior.

---

The shore in front of the Laboratory at Port Henderson furnishes 3 or 4 species of chiton, small octopus, several gastropods, aplsia, planarians and black nemertines, large sabellas, several crabs and isopods, the white land crab, Gomodactylus chiragra in holes in the rock, numerous boring molluscs, madrepores, millepores and several species of zoanthids besides anemones of several kinds.

(2). A small pool opening from the Salt Pond towards the sea beach has its bottom covered by cassiopeas, "Guinea-corn blubbers," while numerous gelatinous masses of annelid and gastropod eggs are to be found about the edge with several alge.

(3). Dredging in 2-3 fathoms off the "wood wharf" yields innumerable echinids, coeptocystes, and a rare astron, a small branching madrepore, seapharca in clusters, single ascidians and fine masses of serpent tubes.

(4). Dredging in 2-3 fathoms off the Fishermen's Houses yields the same as (3). In addition there are here long reefs of rock, nearer shore, covered by only 2-3 feet of water, on which large star fish may be easily taken in abundance.

(5). Dredging off Fort Augusta in 3-4 fathoms yields abundance of the seapharca and branching madrepore.

(6). Dredging off Green Bay in 3 fathoms yields small stag-horn corals.
Balangoglossus occurs in the sand, under water, at the south end of the sandspit.

22. Drunkenman’s Cay is overgrown by mangroves that afford roosting places for pelicans and frigate birds. Though not very good collecting for corals the surrounding water yields many anemones, amongst these a fine cerianthus in sand amongst stones along shore on the southeast end. Many small blue and white star fish abound; large spatangoids were dredged in quantity in the sandy shoals immediately north of the Cay. Small squid and large octopus occur as well as chetiferous chitons. Large blue-spotted flounders, changing color, lie on the bottom under the mangroves. Balangoglossus of large size may be dug rather abundantly in sand near the north shore, near the flagstaff, where also a peculiar annelid occurs. Sixty yards further out small balangoglossus with many young echinoderms abound under small stones.

23. This small Cay is composed of sand and coral debris, thrown up 3—4 feet, and furnishing breeding ground for terns and gulls. The water near by yields good stag-horn corals.

24. The large South Cay is occupied at times by fishermen, is inhabited by termites, lizards and hermit crabs (young Cenobita Diogenes). Except corals little of interest was found here.

25. Lime Cay has a small pool of brackish water and mangroves supporting a large colony of termites. The ground lizard occurs as well as a small gecko, laying its eggs under stones. Young hermit crabs also occur. On the south the coral rock is exposed, and off the southwest end most perfect algyconarians may be dived up, this being the best locality for “sea fans.”

26. Maiden Cay is but a sand bank with one young cocanut tree.

27. Southeast Cay supports many mangroves about a salt pool. The collecting is not so good as at South Cay to judge from our single visit.

28. In the central parts of the mangrove swamps, white and blue herons nest in large numbers.

29. Along the shore leading towards Passage Port little besides innumerable fiddler crabs and herons is to be collected.

30. The south end of the Salt Pond is partly overgrown by mangroves and offers little of interest, fiddler crabs are quite abundant.

31. The middle division of the Salt Ponds is open, July 13, for a boat, though at times only stinking mud remains, it is said. Many small crocodiles are found along the edges of the mangroves.

32. The innermost Salt Pond is a morass of mangroves and mud, yielding no life.

33. The Ferry River is passable for light row boats up to a morass that abounds in birds. This is the chief haunt of the crocodile.
(34). On the Salt Pond Hills the adult hermit crab Ocypoda Diogenes may be taken with eggs, moving about amongst the bushes along the path to Rodney's Lookout, especially in the evening, and to be found also here and there along the ridge.

(35). After certain winds large euryophores collect along the south side of the "Slashes" and the tow-net catches small ephym, ostracods and porcellane. Oysters are common upon the mangroves to the west of this beach.

(36). Dredging across all the deeper parts of the Salt Pond shows that the bottom is sinking mud with dead shells and a few live lamellibranchs. No amphioxus to be found. Surface collecting shows the presence of a few zoeas and the pelagic eggs of numerous fish living in the densely saline and luminously phosphorescent water.

(37). Dredging for Amphioxus across Hunt's Bay from Fort Augusta towards Greenwich proved fruitless. The sandy mud yields many sponges, luidia and toxopneustes, while near the north shore clear sand without life was all that the dredge brought up.

(38). In calm weather a reef off the Laboratory yields excellent sponges, millopores, stag-horn, brain and "curry" corals, which may be taken by diving in 4—9 feet water.

(39). Close to the shore by the fishermen's houses in water 3—6 feet deep, plenty of large pentagonal star-fish may be seen and picked up, while toxopneustes abounds over the sandy bottom amidst the sparse eel-grass.

(40). Dredging off Fort Augusta, in the mouth of Hunt's Bay, yields broken shells and a few very large living spatangoids.

(41). Near the Fort the bottom is sand, with eel-grass, from which the dredge brings abundance of toxopneustes, with some yellow sponge and luidia.

GENERAL ACCOUNT OF ANIMALS OBSERVED.

Mammals.

The Indian Cony, or short tailed Uitza (Oryzomys brachyurus Hill) does not now occur near the Laboratory, though reported to have been common on the Salt Pond Hills a few years ago. It would seem, however, that some remain in the John Crow Mountains and in parts of Manchester. Rabbits and Guinea pigs are stated, on the authority of hunters, to be feral on Goat Island, Old Harbour, where also, as over the Heathshire Hills, generally, feral goats and hogs still abound with a few Guineas fowl. Rats and mice abound everywhere in spite of the check put upon them by the introduction of the Mongose, and so great is the destruction of fruit, caused by the climbing rats, that coconut trees in certain districts along the north coast are protected by sheet iron bands some feet above the ground.

The Mongose (Hempestes musius), of which only nine individuals were introduced from India in 1872, by Mr. W. B. Espent, is now seen crossing the roads boldly or running through the woods in all parts of the island, at least near all the roads following the coast. All the accounts agree that it has exterminated the snakes and ground lizards as well as put a check upon the rats and the poultry also, besides changing some of the habits of birds and indirectly increasing the number of ticks, formerly kept down by the snakes and lizards.

It may readily be trapped at the Laboratory and kept captive; seizing rats by the back of the neck and eating their viscera first. During the night it sleeps coiled up, being active only during broad daylight.

Innumerable individuals of numerous species of bats abound in the caves near the Laboratory. Late in June advanced embryos in utero were taken. Almost nothing is seen or heard along shore of either seals or whales, though some porpoises come into Kingston Harbor. The Manatee however still lingers in Jamaica a few miles from the Laboratory towards the west, where they are seen at intervals of a few years by turtle hunters and fishermen who take them in their nets at times. On the North coast also Manatee flesh was sold at four pence per pound, at Montego Bay, within the memory of young children.

Of the domestic animals the hogs present traits in shape of head, length of limb and tail and size of tusk, recalling the wild-hog of Europe. Among the various mongrel dogs a small lap-dog with long white hair and diminutive head is to be met with occasionally in many parts of the island, as at Port Royal, Sav la Mar and points on the North coast and may be supposed to represent either a marked climatral variety or, possibly, a remnant of the aboriginal Aloe, or lap-dog of the Caribs.

Birds.

The peculiarly dry region immediately surrounding the Laboratory is remarkably well supplied with many species of birds all noticeably tame or bold. Most of the smaller birds nest during June while the larger ones, as Cathartes aura and the larger herons, nest about two months earlier. Eggs of various gulls are sold as "booby" eggs in Kingston markets, brought from distant Cayes, some being also found upon Fort Royal and Old Harbor Cayes. Near Cave, a few miles west of Blue Field large numbers of grotesque young pelicans were observed still upon the nest, August 14th, though able to fly. An extended notice of the various species observed, nesting habits, etc., may be published elsewhere by Mr. Field. As bearing upon the question of biological environment and adaptation it may be here mentioned that the ground doves (Chamapetes passerinus) now nest in the cactus trees, dillidoes, having apparently adapted themselves to the habits of that introduced carnivore, the mongoose.

Reptiles.

Crocodiles (Crocodilus acutus) still abound in many regions along the South coast though extinct on the North. At the Salt Pond many were shot by the nid of a dark-lantern, the eye shining in the dark as does that of the alligator. Others were found in the "Slashes" or mangrove swamp along Hunt's Bay, while in the murrays on the Ferry River they attacked and severely injured washwomen, late in the summer. At Black River and Sav la Mar they occur in great numbers, in the fresh water swamps. A nest was found near Fort Augusta, July 1; the embryos being then far advanced. The nest is an excavation in the sand without any collection of debris such as is made by the alligator in Florida.

Several old nests observed in the Salt Pond have the same character, and show that the young may, from the first, live in water even more salt than the ocean. Near one nest many young, 30 cm. long, were taken by a wire noose July 14th, while the mother, still remaining with them, measured 10 feet 9 inches. Their food consists of fish and small crabs, judging from the contents of the stomachs of the specimens from the Salt Ponds.

The edible Igunna is still found occasionally upon the hills back of the Laboratory, while many anoles, geckoes and other climbing lizards, abound in and about the building, as everywhere else in Jamaica. The ground lizard (Ameiva doralis) is, however, rarely seen except upon the small Cayes, having been elsewhere destroyed by the mongoose. The beautifully colored large Venus (Droctees Edwaldsii) was taken in the Bog Walk and at Antonio. In the latter region a blind subterranean lizard is reported as common in gardens. On the Cayes off Port Royal, as well as upon the mainland from the shore to the very summit of Blue Mountain Peak, 7,289 feet, minute, spherical, white lizard eggs may be found under stones, etc., in various stages of development during July, while larger eggs of a gecko (Thecodactylus testis) can be had at any time, from May to September, by searching in the hollow stems of dead cactus, mangrove and other trees near the Laboratory. These eggs have a thin, brittle shell, but are evidently soft when deposited as they adhere in clusters, and are often compressed out of a spheroidal shape. Moreover, any cluster presents various stages of development, from young blastodermms to perfect lizards ready to hatch. A peculiarly corrugated, soft shelled egg is found in clusters under the moist "trash" in banana plantations near Bog Walk Station and Port Antonio.

A land tortoise, the "turtle," is reported by turtle hunters as occurring upon Goat Island, Old Harbor; possibly this is one of the introduced forms so often reported by the older explorers as indigenous. Several kinds of pond and marsh turtles were observed. Marine turtles abound all along the coast, being sold in the markets at the same price as beef, but the eggs are not readily got owing to the few localities presenting large areas of sandy beach. They do, however, lay between Old Harbor and the Laboratory, large individuals depositing as many as 12 to 19 dozen eggs, young ones only 7 dozen, as stated by Jennings, an expert turtle hunter. An interesting method of catching them during the breeding season, early Summer, illustrates their lack of discrimination then. Wooden decoys, floating on the surface and attached to nets, lure the males, till they eventually become entangled in the coarse meshes of the floating, vertical net. These "cooting" nets are used on the North coast also.

No snakes were found or heard of, though so abundant before the introduction of the mongoose.
Amphibia.

The huge South American toad (Bufo awo) has fulfilled Gosse's prophecy made in 1851, for it now abounds in all parts of the island though only two dozen individuals were brought from Barbadoes to Kingston in 1844. This dispersal has been independent of man's interference, while in the case of the Mongooses, introduced for the same purpose, large prices were at first paid by planters for specimens to turn loose in their estates. The negroes know them as "bull frogs" and state that the breeding time is October, the eggs being then deposited in long strings in fresh water pools. ovarian eggs examined in July are black and large, which would support the above statement as would also the accounts of the prodigious noise made by the toads in the autumn. Their habits are much the same as those of the common toad of the Eastern States, and their vitality great, as indicated by the fact that one remained in a glass jar for more than two months without food, without discoverable injury.

Several noisy tree-toads abound throughout the moist regions of the island. One deposits its eggs in a mass in the water collecting amidst the bases of the leaves of epiphytic bromelias, being observed in early stages of development at the end of May in the region of Mandeville. Another lays clear pelucid eggs of great size under logs, etc., in moist localities, being found on the summit of Blue Mountain Peak in early and late stages of development July 9th and at Bog Walk Station soon after. These tree-frogs are found all over the island: at Port Antonio the breeding season seemed to be past July 20, while at Manchioneal specimens with very large ovarian eggs were taken July 24. The egg has a large amount of yolk and hatches as a frog, without metamorphosis or aquatic life.

No tailed amphibia were found or heard of.

Fish.

Pelagic fish eggs were taken in the surface net during the summer both in the Harbor and in the land locked "Salt Ponds" where great numbers of mullet and two other species abound. The peculiar bamboo fish-traps with casting nets and lines used amongst the Cays supply large variety of edible fish for market, but as no seines were drawn, excepting in the "Stashes" near the Laboratory, sharks could not be obtained for embryological work, nor were any seen till late in August where several large ones were shot in front of the Laboratory. The mountain streams contain several small fish and the larger "mountain mullet."

Amphioxus in young stages was taken in the tow-net on Port Royal Beech early in June, but no adults could be found in Hunt's Bay or the Salt Ponds, by dredging and digging.

Crustacea.

The spiny lobster is taken in the bamboo fish-traps near Port Henderson and furnished eggs in an advanced stage July 24, June and July being its breeding period according to the statement of the fishermen.

Throughout June and July the white land crab, geacarcin, carried eggs in and about the Laboratory, for the most part in a late stage of development, the zoas being nearly ready to hatch, as they sometimes did in salt water aquaria, as on June 14. At this season the crabs, both female and male, may be taken at night close to the shore edge, apparently ready to discharge the zoas.

The black land crab was not seen at the Laboratory during our stay, unless one late in May, but young individuals were found in the mountains both on the North and South coasts.

The hermit crab, Coenobita Diogenes, is abundant upon the hills over the Laboratory, and carries eggs, in early stages, during July and August. In the same period the active grapsus on the Laboratory wharf may be taken with eggs, while dredging off Port Augusta yielded panoplos and dromia with eggs.

A large red "sea crab," Ilitias, taken in a fish pot off Old Harbor Cays, Aug. 3, still bore a few eggs, while at the same season small black sesarmas on Pelican Cay carried large numbers of minute eggs.

A peculiar sesaroma-like crab is found in the fresh water rills running into the Wag Water River, at least 12 miles from the sea, and was also taken near the Moneague, on trees, where it lives amid the moist bases of the leaves of bromelias. Some still kept in Baltimore show evident adaptation in habit to this mode of life.

All the summer alpheus and gonodactylus were taken with eggs both on the Cays and along shore by the Laboratory. The surface net in June yielded lucifer, copepods and ostracods bearing eggs.

Numerous shrimps, 6 or 7 kinds, are found in the fresh water rivers, as in the Wag Water and the streams near Port Antonio, where they carry eggs in August. The very large prawn, Palemon Jamaicensis is taken in very small rivulets near Port Antonio by means of a trap resembling an eel pot, baited with burnt coconut or meat—which attracts the shrimp also. It is commonly known as the Cray-fish or more expressively as the "John go."

Terrestrial isopods are very numerous, while a large amphipod was found amidst moist leaves, etc., on the ground, on the summit of Blue Mountain Peak. Hippa is common in sandy beaches near Lucea.

Goose-barnacles grow to a length of one inch, in two weeks.

Arachnida.

Many spiders and phalangiums abound throughout the island. Solfuga is to be found here and there near the Laboratory lying concealed in the dry deserted parts of termite's nests, under stones and dry wood or in hollows of dead cactus. Phrynus may be taken in the same localities, and was found abundantly under logs along the road down Mt. Diabolo to the Moneague, together with many pseudo scorpions. Phrynus also occurred in the old church yard at Port Antonio, where the young were abundant at the end of July. Two species of scorpion carry young in July and August, and are common under stones and wood near the Laboratory, while a much larger form occurs in the cane fields of Camannas Estate.

Insecta.

Peripatus was searched for at Blue Fields and elsewhere, but with no success. But few have ever been taken in Jamaica; and as it is unknown to the negroes it is probably excessively rare.

Very many kinds of myriapods are found in all moist regions. A small polydesmus lays eggs under leaves, bark and trash at Bog Walk Station July 16, while recently hatched larvae were found in the churchyard at Port Antonio a week later.

The "duck ants," termites, build their large nests on trees, rocks, fences and houses throughout Jamaica and have even established large colonies in the mangrove trees upon the small Cays off Port Royal and Old Harbor. Their eggs and larvae may be taken in the nests all summer.

Along with the numerous smaller fire-flies the brilliant elater, Pyrophorus notithesis, can be taken in the grass lands near the Laboratory by night or under bark of trees, by day, but is much more abundant at Port Antonio where it flies for a short period immediately after sunset.

Lepidoptera seemed especially numerous about the Laboratory, while other groups were best represented by musquitoes and various species of cockroaches. The singular moth, erebus, was frequently observed in the Laboratory during the latter part of August. About the only insect commonly attracted to the lamps was the "soldier bug" that feeds in innumerable clusters upon the seeds of the silk-cotton trees near Halfway-Tree Pen, Aug. 7, when various stages of the young as well as conjugating adults were taken.

Worms.

In the fresh water of Hope River at Gordontown small planarians were found under stones in great numbers, July 20, while a land planarian was taken under logs on the road to the Moneague, coming down Mt. Diabolo. Planarian larvae were common in the surface collections during June. Several adult forms, including Leptophaena and Thyasomone, were taken on corals, etc. No leeches were found. Several brightly-colored, banded, nemertean occur on wharves back of the palisadoes and in front of the Laboratory under stones. Some of these carry eggs in August.

A peculiarly marked new species of Balanoglossus, having alternating half-rings of red across the body, attains a large size in the clear sand on the north of Drunkenman's Cay and is also found at the west end of Raekum Cay. The body is full of nearly ripe eggs, Aug. 5.

Sipunculids were unexpectedly rare, but occurred here and there under stones and in coral rock.

Annellids also are difficult of access and do not present the excess of Eunicidae to be expected, which is partly due to the dearth of sponges as
dwelling places. Tube-dwelling sabellias and serpulas abound everywhere: of these the large *Sabella melanina*, called the "Sei Hen" on the north coast, is exceedingly common all around the island upon mangrove roots as well as under edges of corals and rocks.

Many Amphionimidae are conspicuous about coral reefs, crawling fully exposed, but protected by their calcareous setae and recognized by their marked colors.

The large clusters of eggs in jelly so common in the salt ponds and mangrove swamps appear to belong to the Capitellidae that are exceedingly abundant in the foetal mud.

No pelagic forms were found!

Earth worms are common, a singular form occurring on the trees at the Moneague.

Mollusca.

Small octopods are common at the Cays and squids were sometimes seen.

The shells of *spirula* are very common along the beach at Green Bay.

Many species of chiton abound along the shores or on the Cays. The eggs were obtained and fertilized, May 29 and June 11, from animals taken in front of the Laboratory.

A few pteropods and heteropods were taken at the surface in front of the Laboratory late in August.

Lamellibranchs, excepting the "true" and "false" oysters everywhere common on mangrove roots and the scapharca dredged between Fort Augusta and the Laboratory, are small and to be found chiefly under and amongst the coral rocks.

Large conchs are not found near Kingston, but further east and on the north coast near Montego Bay. Smaller gasteropods are very abundant.

The small white capsuls of one of these cover the rocks in front of the "Upper Houses."

The eggs of the remarkably variegated gasteropod of several varieties, occurring both in the densely saline water of the salt ponds and in the fresh water rivulet at Port Antonio may be easily got, in aquaria, in August. This gasteropod can be kept in salt or fresh water for months and fresh water rivulet at Port Antonio may be easily got, in aquaria, in August. Yet, spatangoid plutei were found in various stages of development in front of the Laboratory late in August.

No salpas were seen or heard of.

Many species of chiton abundance along the shores or on the Cays. The eggs were obtained and fertilized, May 29 and June 11, from animals taken in front of the Laboratory.

A few pteropods and heteropods were taken at the surface in front of the Laboratory late in August.

Lamellibranchs, excepting the “true” and “false” oysters everywhere common on mangrove roots and the scapharca dredged between Fort Augusta and the Laboratory, are small and to be found chiefly under and amongst the coral rocks.

Large conchs are not found near Kingston, but further east and on the north coast near Montego Bay. Smaller gasteropods are very abundant.

Of the dozen species observed in June, July, August, though apparently ripe eggs were found, August 6th, in a fine cirrhentus taken at Drunkenman’s Cay.

Many kinds of zoanthus forming large, conspicuous masses are very common near the Laboratory as well as at the Cays.

Corals of considerable variety and in innumerable numbers may be readily got at the Cays or found by diving in much perfection a few rods from the Laboratory. Aleyonarias of many forms occur near all the Cays but may most readily be procured at Lime Cay. Large eggs were found in aleyonaria and plexaura, June 25, but they were not discharged in aquaria.

Small physialis abounded in the harbor in June and early part of July, with certain winds.

A few species of discomedus came into the harbor occasionally and were also seen at Montego Bay in August. Of these aurelia was taken with eggs in all stages of cleavage and gastrulation, July 17, near the Laboratory.

Polyclonia occurs of large size in the narrow passages back of the Palisadoes, lying on the bottom in shallow water. It has ripe sperm July 25. At Port Antonio also the same form occurs back of the reef.

The Salt Pond harbors great numbers of cassoapeas which cover the bottom of a small bay projecting towards the beach near Pt. Clarence. No sexual reproduction was observed, but rapid increase by a process of budding in the large Syphistomus.

Several very large ctenophores abobd in the harbor throughout the season, especially in June and July.

Though large sponges were not found many small ones occur at the Cays and on the mangrove roots.

Colonies of vorticella and radiolarians abound in the surface material.

**MARINE COLLECTING DISTANT FROM PORT HENDERSON.**

An expedition to Old Harbor showed that there is abundant dredging ground near the Cays with pure calcareous sand and coral formation equal to that off Port Royal.

Pelican Cay is a large mass of pure calcareous sand, not influenced by detritus from Hope river, raised 3—5 feet, level and covered by a dense growth of bushes and low trees but with a grassy region at the west end and a narrow white beach about the whole. Pigeons and terns abound but are not nesting, August 2. Ground lizards and several species of crabs abound.

Pigeon Island presents a large central lagoon of opaque, green, frothy water separated on the east by a sea-wall of coral debris 4—5 feet high. On the main sandy part of the island, ternites, crabs and lizards are abundant as well as mosquitoes.

Dead Man’s Cay is scarcely above the water and densely overgrown with mangroves and other trees. Pelican and frigate birds no longer nest there: indications are evident of its use as a burying-ground for cookies. The growth of mangroves would seem to preclude good collecting along the shores of most of the harbor.

Much to the west Black river and Sav la Mar being without protected harbors and influenced by the large rivers do not offer good facilities for marine work. All along the coast, however, as at Gosses’s Bluefields, corals and sandy beaches would doubtless furnish many things of interest, though the land fauna is here more attractive.
On the northwest coast Lucea, with a well protected harbor, furnished very fair surface-collecting in the middle of August and about the same shore-collecting as at Port Henderson. Owing, however, to the abruptness of the coast no coral is accessible at the surface and mangrove swamps do not furnish the wealth of life found at Port Royal.

Montego Bay from its situation is completely protected from the prevailing winds and offers unusual advantages for surface-collecting, the calm water being of remarkable clearness yet swarming in peculiar marine forms. The extensive sand beaches, rocks and sunken coral reefs yield abundance of echinoderm, crustacea and coelenterates and mollusces more numerous than elsewhere in Jamaica. Here also the mangrove fauna approaches that of Port Royal in its character and diversity. The conditions are nearer those of the Bahamas than at any other part of Jamaica.

Falmouth, with its exposed harbor and fresh water, yields algae not observed elsewhere but is not rich in its marine fauna. The same is true of the remaining ports in the north as far as Port Antonio, excepting perhaps Port Maria where the occurrence of crystalline rocks along with the limestone in prominent bluffs affords somewhat unusual conditions seized upon by algae, and perhaps to be recognized in the character of the fauna.

At Port Antonio the fauna seems identical with that at Port Henderson as far as seen in a week or so of exploration. Yet the reefs are less varied and not as rich in animal forms nor are there any of the peculiar mangrove "Zoological Gardens" so remarkable at Port Royal. On the other hand the land and fresh water fauna is rich and accessible while the nature of the coast allows of most easy access to the pelagic fauna, which seems and not as rich in animal forms nor are there any of the peculiar mangrove by algae, and perhaps to be recognized in the character of the fauna.

The following list of Crustacea collected for the most part near the Lab-}

latory at Port Henderson by Dr. T. H. MORGAN, but in some cases obtained from Port Antonio, has been prepared by JAMES E. BENEDICT, of the United States National Museum.

**Brachyura.**

1. Pericera cornuta (Herbst).
2. Macracoloma trispinosum (Latreille).
4. Othonia hiruminieri Schramm.
5. Othonia, sp. One small female. The species cannot be accurately determined.
7. Mithrax hispidus (Herbst).
8. Mithrax cinetimnus (Stimpson).
9. Mithrax sculptus (Lamarck).
10. Mithrax coromatus (Herbst).
11. Thoe puella Stimpson.
13. Menippe rumphii (Fabricius).
15. Panopeus areolatus Benedict and Rathbun.
17. Lupa forcaes (Fabricius).
18. Acheolus spinimanus (Latreille).
19. Encratoctes sp. nov. The species cannot be accurately determined.
22. Gonopiopus orientatus (Latreille).
25. Pachygrapsus gracilis (Saussure).
26. Areograpsus jamaicensis, gen. et sp. nov.
27. Ocypoda arenaria Say.
28. Sesarma angustipes Dana.
29. Sesarma bidendata sp. nov.
31. Leiolophus planissimus (Herbst).
32. Dromidia antillensis Stimpson.
33. Petrolistes sexspinosus (Gibbes).
34. Petrolises armatus (Gibbes).
35. Petrolises, sp.
36. Megalobrachium granuhiferum Stimpson.
37. Porcellana ocellata Gibbes.
38. Palemon fustinus Saussure.
The Anatomy and Development of the Eyes and Sub-Neural Gland in Salpa. A Preliminary Note. By

MAYNARD M. METCALF.

[At Professor Brooke's suggestion I have undertaken a comparative study of the eye and sub-neural gland in Salpa, as part of his more general study of the genus; and this paper is a brief outline of some of my results.

M. M. M.]

The Anatomy of the eye of Salpa pinnata, solitary form.

On the dorsal surface of the ganglion in the solitary form of Salpa pinnata there is a ridge shaped like a horse-shoe, with the open part of the horse-shoe anterior. The ridge, like the ganglion, is composed of a cellular peripheral portion and a non-cellular core: the cellular portion of the one being continuous with that of the other, while the fibrous core of the ridge is continuous with the central, non-cellular part of the ganglion. The width of the ridge is about equal to its height above the ganglion. On the anterior face of its posterior portion and on the inner faces of its two anterior limbs the cells are modified to form the eye. This eye, then, in every part faces toward the mid-dorsal point of the brain. The cells of the posterior and outer faces of the ridge are not modified, but closely resemble the cells of the ganglion. A cross section of the ridge at any point would show the same structure. Take for description a section in the longitudinal vertical plane of the body. It would cut the posterior part of the ridge at right angles. On the posterior side the unmodified, nerve cells are seen; then comes the central, non-cellular core and anteriorly the retina of the eye. This latter is composed of three layers of cells: (1) the pigment cells equal in size to the unmodified, nerve cells, but so closely massed together and so full of fine, pigment granules, that no details of structure can be made out; (2) a layer of cells, which closely resemble the unmodified nerve cells of the ganglion. Anterior to these, again, is (3) the layer of rod cells. These rod cells each show the characteristic division into (a) a deeply staining, thick-walled portion abutting on the next posterior layer (2), and (b) a lightly staining, thin-walled, anterior portion containing clear protoplasm and a large nucleus with very apparent, chromatin network. The delicate membrane, which covers the brain and the optic ridge, covers the anterior face of the rods.

The form and structure of the eye of the solitary form in Salpa runcina—
formicis, S. ventigera-confederata, S. hexagona, S. cylindrica, S. costata-Tillanwski and S. democratica-merocrinata, agree closely with the description given for Salpa pinnata. In the solitary form of Salpa cordiformis-zonaria there are certain differences in the form of the eye, but the structure of the retina is the same.

The development of the eye of Salpa pinnata, solitary form.

In a young embryo, at a time when the ganglion shows no central, non-cellular portion, a ridge of cells pushes up from the dorsal surface of the ganglion. This ridge has, from the first, the characteristic, horse-shoe shape, the open part of the horse-shoe being anterior. The ridge increases in size as the ganglion grows. When the central cells of the ganglion degenerate, the cells in the core of the ridge degenerate, the two areas of degeneration not being separate, but being, from the first, continuous with each other. At a considerably later period, the retina cells begin to assume characteristic appearance. The most peripheral layer of cells over that portion of the ridge destined to form the retina become larger; their cell boundaries become distinct,* and their nuclei increase in size. As these cells grow, they become columnar, with their long axes horizontal. The cells of the posterior part of the retina remain unmodified for a longer period. In cross section about six of these cells appear, two-thirds of which will become pigmented, while the other third remain unmodified to form layer (2) of the retina. At about the time pigmentation begins, the inner ends [toward the core of the ridge] of the rod cells begin to become thick-walled and, so, stain more deeply than the distal ends. The adult condition is reached by an increase in the size of the rod cells, a greater thickening of the walls of their inner ends, and by a greater deposit of pigment granules in the posterior cells of the retina.

The anatomy of the eyes of Salpa pinnata, chain form.

The histological structure of the retina of the chain form of Salpa pinnata agrees closely with that of the solitary form, but the shape of the eye is quite different. It also may be called a horse-shoe with its open part posterior, but only the posterior extremities of the limbs of the horse-shoe abut on the ganglion. A double fold of ectoderm lies between the ganglion and the anterior portion of the eye. In this anterior curved part of the eye there lies a second mass of retinal tissue, elongated from right to left, resting on the lower limb of the eye to the other. This is bound to the rest of the eye by elongated, spindle-shaped cells, connecting the anterior face of the second mass to the posterior face of the anterior portion of the main body of the eye. It is impossible, without figures, to describe intelligibly the details of form.

There are some peculiarities in the arrangement of the histological elements. In the posterior limbs of the eye the rod cells point dorswards, while the pigment layer lies on the side toward the ganglion. In the anterior portion of the eye this arrangement is nearly reversed. The rod cells point ventrally and anteriorly, and the pigment layer is on the dorsal and posterior faces of the optic ridge. In the second, smaller portion of the eye, mentioned above, the rod cells point toward the open side of the horse-shoe, and the pigment cells are anterior, lying close to the pigment layer of the anterior portion of the eye ridge.

The eye is innervated by two optic nerves, which appear to be prolongations of the central, non-cellular area of the ganglion. The fibres run over the dorsal face of the posterior limbs of the eye, of some of them here entering the outer clear ends of the rod cells. Further back, at the point where the relative position of rod cells and pigment cells is reversed, the fibres divide into two bundles on each side, one bundle going directly to the clear ends of the rod cells of the second, smaller portion of the eye, the other bundle passing around the inner side of the eye to innervate, in the same way, the rod cells of the anterior portion of the eye. The delicate membrane which covers the brain is continued over the whole eye.

In addition to the median dorsal eye, there are, in the chain form of Salpa pinnata, two pairs of much smaller eyes. One pair is placed, one on each side of the middle point of the posterior face of the brain, in the mid-point of the ganglion cells just dorsal to the point of origin of the posterior nerves. The structure of the rod cells is practically identical with that found in the median, dorsal eye. The rod cells are arranged in a hemisphere, their clear ends posterior, on the rear face of the ganglion. In the specimens studied, all of which had been hardened in acid reagents, no pigment could be found. The cells at the base of the rods resemble in all particulars the indifferent, ganglion cells, and can not be distinguished from them. The other pair of smaller eyes lie on the dorsal surface of the brain, one on each side. The right one lies at the base of the right optic nerve, on the right side of and a little in front of it. The left is situated in a corresponding position on the left side. This pair of eyes resemble exactly in size, shape and structure those just described. Instead, however, of the clear ends of their rod cells being toward the periphery of the brain, they are directed toward its centre. The thick-walled, dorsal ends of the cells abut on the pigment layer of the large, dorsal eye, but the intervening, delicate, neural membrane shows that they form no part of the latter structure.

The development of the eyes of Salpa pinnata, chain form.

The early stages of development in the chain form are almost identical with those of the solitary form. There is a horse-shoe shaped up growth of unmodified ganglion cells. The central cells of the ganglion and the cells of the core of the ridge degenerate at the same time. But very soon the horse-shoe shaped arrangement of the eye cells is lost. They are, from the first, close pressed to the ectoderm. Very soon after the appearance of the optic ridge, the ectoderm arches up over the ganglion, carrying with it the cells of the ridge, till they lose their connection with the ganglion, except that the core of the ridge is pulled out into long fibres, that bind the eye cells to the ganglion. The cells destined to form the eye are now close pressed to the ectoderm in the form of a thickened disc, the fibres connecting the centre of its ventral face with the non-cellular core of the brain.

* The cell boundaries of the cells of the ganglion and of the rest of the ridge can not readily be made out. In the ganglion of the adult Salpa cell boundaries can seldom be seen.
The changes in form and histological structure, that produce the adult condition, proceed simultaneously. The development of the histological elements proceeds in the same manner as in the solitary Salpa pinnata. The anterior edge of the disc just described approaches the brain till it comes in contact with it, the ectoderm in front of the disc touching now the brain as well. The posterior edge of the disc retains its original position. In this way the developing eye is for a time perpendicular to the brain. The nerve fibers which, from the first, connected the center of the disc with the non-cellular core of the brain, now, of course, lie along the posterior face of the ciliated funnel. The dorsal portion of the disc now curls over backward, forming the first sign of the second, smaller portion of the eye, that lies in the anterior part of the horse-shoe, in the adult condition. The disc now bends more and more forwards, the contact of its originally anterior edge with the brain being retained. The originally posterior edge of the disc in this way becomes anterior and its originally anterior edge posterior, while its originally ventral surface becomes dorso-ventral. By this shifting the ectoderm, which lies against the originally dorsal surface of the disc, is brought into contact with the ectoderm covering the brain, the brain and developing eye being now separated, except at the back of the eye, by a double layer of ectoderm. This condition is retained in the adult. During the final shifting of the developing, optic disc from its perpendicular position to the horizontal, the differentiation of the histological elements occurs. The adult form is reached by the greater separation of the second, smaller portion of the eye from the anterior part of the disc and by the division of the posterior portion of the disc into two, antero-posterior limbs, connecting the anterior part of the disc with the dorsal surface of the brain.

The two pairs of smaller eyes develop later than the larger eye by the histological differentiation of certain of the ganglion cells situated in the positions where the smaller eyes are found in the adult.

The development of the sub-neural gland in Salpa pinnata.

The adult structures, which are probably homologous with different portions of the sub-neural gland and dorsal tube of Ascidians, are the same in both the solitary and chain form of Salpa pinnata. They are best described after tracing their development. The Salpas differ from the Ascidians in having the cavity of the central nervous system, which is present only in the early development, continuous with the lumen of the ciliated funnel. In an early stage of the development of the nervous system of the chain form of Salpa pinnata, long before any trace of the eye appears, the cavity of the brain and the lumen of the funnel open freely into each other by a wide duct so short and wide as to hardly deserve the name duct. The anterior edge of the disc just described approaches the brain till it comes in contact with it, the ectoderm in front of the disc touching now the brain as well. The posterior edge of the disc retains its original position. In this way the developing eye is for a time perpendicular to the brain. The nerve fibers which, from the first, connected the center of the disc with the non-cellular core of the brain, now, of course, lie along the posterior face of the ciliated funnel. The dorsal portion of the disc now curls over backward, forming the first sign of the second, smaller portion of the eye, that lies in the anterior part of the horse-shoe, in the adult condition. The disc now bends more and more forwards, the contact of its originally anterior edge with the brain being retained. The originally posterior edge of the disc in this way becomes anterior and its originally anterior edge posterior, while its originally ventral surface becomes dorso-ventral. By this shifting the ectoderm, which lies against the originally dorsal surface of the disc, is brought into contact with the ectoderm covering the brain, the brain and developing eye being now separated, except at the back of the eye, by a double layer of ectoderm. This condition is retained in the adult. During the final shifting of the developing, optic disc from its perpendicular position to the horizontal, the differentiation of the histological elements occurs. The adult form is reached by the greater separation of the second, smaller portion of the eye from the anterior part of the disc and by the division of the posterior portion of the disc into two, antero-posterior limbs, connecting the anterior part of the disc with the dorsal surface of the brain.

The two pairs of smaller eyes develop later than the larger eye by the histological differentiation of certain of the ganglion cells situated in the positions where the smaller eyes are found in the adult.

Preliminary Notes upon the Embryology of Chiton. By Maynard M. Metcalf.

The investigations, the first results of which are here recorded, were carried on at the Biological Laboratory of the Johns Hopkins University, during the summer and fall of 1891. The material was collected and the early stages observed at the summer session of the laboratory at Jamaica, W.I., in 1891.

Chiton squamosus, L., the species studied, are exclusively littoral. Chiton squamosus, the most common, abounds under the stones near low water line, as many as twenty individuals having been found under one stone. A smaller number are found crawling upon the surface of the wave-washed, coral rocks of the shore, between tides. In this latter situation alone was Chiton marmoratus to be found. This species is not so plentiful, a search of an hour's time bringing to light not more than thirty individuals.

Of the many hundreds of individuals of eight different species* observed during June and the early part of July, none were found bearing bunches of eggs in the mantle chamber. Males of most species, containing mature spermatozooa, were abundant. On the contrary, but two females, one Chiton marmoratus and one Chiton squamosus, laid eggs in the aquarium, though many were collected at different times and kept for several days.

Just before ovulation commenced, the female began to crawl rapidly about the floor and sides of the aquarium. The male showed evidence of sexual excitement, being even more active than the female. Before the deposition by the latter of the first eggs the semen was observed to pour as a white, cloudy stream from beneath the posterior part of the mantle of the male, in the region of the orifice of the vas deferens. About a minute or a half later, the minute pea-green eggs commenced to be ejected from the corresponding point of the mantle chamber of the female. During the ordinary respiration of the Chitons, at one anterior point and at a posterior point on the opposite side, a small tube is formed by the arching up of the mantle edge, the bottom of the tube being formed by whatever surface the mollusc is resting upon. A constant stream of water passes into the anterior tube, through the mantle chamber and out of the posterior tube. During the discharge of the sexual products, instead of one there are two posterior tubes, one on each side, in the region of the orifice of the oviduct, or vas deferens, as the case may be. The eggs, or spermatozooa, are carried out of the mantle chamber through these tubes by the ordinary respiratory current. Neither during the period of sexual excitement preceding the ejection of the sexual products by the two individuals, nor during the time the eggs were being fertilized, did the male and female come into contact with each other, or approach nearer than usual. Whatever exciting influence passed from one to the other was conveyed a considerable distance through the sea water of the aquarium. The extrusion of eggs by the female and of spermatozooa by the male, in each case observed, continued for two hours or more. This fact, probably, in part, accounts for the different stages of development noted in any pipetteful of eggs collected.

The eggs are small, one-fifth of a millimetre in diameter, exclusive of the chitinous envelope. They are very opaque; those of Chiton squamosus more so than those of Chiton marmoratus. Each have a light pea-green color, which is of great assistance in manipulating them, rendering them easily visible and distinguishing them from particles of dirt. The chitinous envelope has a pattern peculiar to each species.

My work was confined to six weeks' observation in Jamaica of the developing embryos and larvae during June and July of 1891, and two months' study last fall of the preserved embryos. The work, so far, has mostly confirmed Kowalevsky's observations,† and has added little to them.

The egg when laid has a central nucleus; the formation of the pole bodies was observed; the number is variable. In certain cases one was found—more often two; and in one case three: one of normal size, one a third smaller, and another two-thirds smaller. The last two were probably the result of an unequal division of one of an original pair, while those eggs in which but one pole body was found were, perhaps, not fertilized.

The unsegmented egg ready for segmentation is round, with usually two pole bodies. The first external phenomenon observable is the flattening of the egg beneath the pole bodies. This occurs about fifteen minutes after the egg is laid. Almost immediately a slight furrow appears across this flattened surface, while as yet the vegetative pole shows no sign of segmentation. The furrow deepens, at the same time running clear around the egg. By further constriction the egg is divided into two portions as nearly spherical as the limited space within the egg envelope allows. After a little these two cells approach one another more closely till the embryo is again nearly spherical. (The cells do not fuse). Before the flattening of the animal pole of the egg its nucleus moves toward the pole bodies. During the first division its position is in this way eccentric. Whether the ensuing division by a meridional furrow into four cells commences at the animal pole I am unable to say, but from analogy with the first furrow one would judge that it does. The four cells, completely formed at about thirty minutes, are not spherical, but are elongated in the direction of the principal axis.

The eight cell stage corresponds to Kowalevsky's description for "Chiton Polii," having four large vegetative pole cells, and four slightly smaller animal pole cells. No twelve cell stage was found, either in watching the development of the egg, or among the preserved embryos. I do not think it occurs, either in Chiton marmoratus, or Chiton squamosus. Serial sections of one embryo in the eight cell stage showed the nuclei of the four larger cells and of one of the animal pole cells in the same stage, an early stage, of division, the chromatin threads not yet separated from the equator of the spindle. The nuclei of the three other animal pole cells showed no traces of division. A considerable blastostoele is present at this time, and is not wholly obliterated during the later development. The animal pole cells are so placed that two of them meet at the centre in an elongated line (Rabl's "direction furrow,") while the two others do not come into contact across the middle line. The vegetative pole cells are similarly arranged with their direction furrow at right angles to that of the animal pole cells.

The sixteen cell stage, as found by Kowalevsky in "Chiton Polii," consists of two layers of large cells, four in each layer, and, between them, two layers of small cells, four in each layer. No twenty-two cell stage occurs.* By a division of each of the sixteen cells thirty-two cells are obtained. The thirty-six cell stage exactly resembles that figured by Kowalevsky for "Chiton Polii," but the pattern which Kowalevsky represents for the animal pole is, in Chiton marmoratus and Chiton squamosus, the pattern of the vegetative pole, while his figure of the vegetative pole of "Chiton Polii" corresponds to the pattern of the animal pole of Chiton marmoratus and Chiton squamosus. This is shown very plainly, both in surface view and in wax reconstructions made from serial sections. As the flattening of the vegetative pole, or gastrulation, proceeds, a division of one layer of the smaller cells in the animal half of the embryo gives forty cells. This, because of the opacity and minute size of the embryos, is the latest stage of segmentation observed. I hope, however, to carry the observation of segmentation up to the time of the completion of gastrulation.

Gastrulation and the formation of the mesoderm occur as described by Kowalevsky for "Chiton Polii," also the shifting of the blastopore from a posterior position to the ventral surface, just behind the velum, where it persists as the mouth. At four and one-half hours gastrulation is complete. The velum shows at five and one-half hours. At eight hours the veliger larva emerges from the egg envelope. I can add only minute points to Kowalevsky's description of the surface features of the larval development, and these I will reserve till a later paper. I have not carried the study of sections beyond the end of the embryonic period.

Some Notes from a Study in the Morphology of the Lamellibranchia. By J. L. Kellogg.

During the summers of 1890 and 1891 I was engaged, at the direction of Professor McDonald, United States Fish Commissioner, in a comparative study of the anatomy of the Lamellibranchia found near the Commission station at Woods Hole, Mass. Upon my return to the Johns Hopkins University I continued the work for some little time, devoting my attention principally to a study of the gills of a number of forms.

* Such a stage, if found, would be an anomalous break in the regular sequence of segmentation as found in Chiton marmoratus and Chiton squamosus. It seems possible that Kowalevsky's observation was made upon an abnormal embryo.

The result of my work has been given to the Fish Commission in a paper containing about one hundred figures, which will shortly appear in one of their publications.

In beginning the work, it was pointed out to me by Professor W. K. Brooks, of this institution, that the anatomy of Lamellibranchs had most frequently been studied by means of dissections, which were hard to make or to figure satisfactorily; and that little use had been made of sections, especially in a comparative study of different forms. Following this and other suggestions which were frequently made to me by Professor Brooks, I hope that I may show this method to be the best one for such a study which can be made use of.

Since the completion of my work, a valuable paper has appeared on the anatomy of Lamellibranchs, by Paul Pelseneer (Archives de Biologie, Tome XI, Fas. II, 1891), who had a very large amount of material at his disposal for comparative work. In my paper I have had occasion to refer frequently to this author's observations.

In this preliminary note I can say little of the comparisons in the anatomy of the forms examined, but will merely mention a few points of interest taken up here and there, which do not need illustration.

The adductor muscles and striated fibres. The adductors of many forms are made up of two kinds of fibres, one part being of a darker shade than the other. It has been observed in a few forms that the darker fibres are striated, but it is always stated that this striation is not at all comparable to that of Arthropods or Vertebrates. The functions of these different parts of the adductors are not understood. Pelseneer thinks that the dark area of striated fibres is for rapid contraction, and that the lighter area exerts its function later.

I have come to the opposite conclusion, from observations made upon Poten irroraud. If one valve of the shell be carefully removed, the smaller, darker area of the great adductor will be seen to preserve an extremely contracted condition, while the larger white area, also slightly contracted, now appears free to hreak away from their attachment and to fasten in new positions. I have not yet had time to study the histology of these muscles, and it is reasonable to suppose that it is probably the case in other forms.

Striated fibres, so far as I know, have only been described in this group as occurring in the adductor muscles. Observers generally seem afraid to call it a striation, and it is spoken of indefinitely as "an appearance of striation."

I have found, however, muscle fibres possessing a very distinct cross striation in the auricles of the heart of the oyster (Ostrea virginianus). These striations are so large that in my preparations there were but twenty of them to .03 mm. I have not yet had time to study the histology of these muscles in detail. In the auricles of this heart also are many scattered pigment cells, and the muscle fibres are surrounded in many places by elongated cells possessing large vacuolated ends, almost exactly similar to the cells of the excretory epithelium in the kidney.

The byssus. The byssus organ of Cardita borealis, situated in a groove on the ventral side of the foot, was found to be simple enough for easy study, and in the paper referred to above, I have illustrated its structure by two figures. The secretory epithelium is made of two distinct kinds of cells. Those most numerous are cuboidal and are apparently ciliated. It is probable, however, that the cells are covered by a very regular layer of a striated secretion, which gives this appearance of ciliation, and that no cilia exist. Outside this layer is another layer of undoubted byssus secretion. At the inner angles of the deep secreting folds are numerous large, clear, unstained masses, which are probably those of the individual examined, which have lodged in this position. Perhaps they have been fertilized by spermatzoa from the same hemaphrodite gland, but the spermatzoa seem always to reach maturity before the ovum. Fertilization may take place by spermatozoa from other individuals, taken into the kidney with water from without. It thus happens that the spermatocytes become a brood chamber. This condition may be an accidental one, but I am inclined to believe that the advantage to the species thus gained by the protection of so many embryos, for so long a time in their development, is considerable, and that, by the operation of natural selection, the kidneys may have become especially adapted for this function.

The nephridium of Ostrea virginianus. In the spring and early summer, I have always found that the kidneys of Poten irroraud contained eggs in various stages of development, often in very great numbers. Garner has shown that the sexual glands here open into the kidney, and these eggs are probably those of the individual examined, which have lodged in this position. Perhaps they have been fertilized by spermatzoa from the same hemaphrodite gland, but the spermatzoa seem always to reach maturity before the ovum. Fertilization may take place by spermatozoa from other individuals, taken into the kidney with water from without. It thus happens that the spermatocytes become a brood chamber. This condition may be an accidental one, but I am inclined to believe that the advantage to the species thus gained by the protection of so many embryos, for so long a time in their development, is considerable, and that, by the operation of natural selection, the kidneys may have become especially adapted for this function.

Conclusions of the gills of Yoldia, and the collection of food. The gills of certain Lamellibranchs which are composed of plates instead of filaments, made known in Nucula and Yoldia by Misukuri, have not previously been thoroughly studied in any form but Nucula. I have made a careful examination of their structure in Yoldia. Certain facts in regard to the living gill of this form are of interest. They are able to contract themselves in a variety of ways, first by shortening to a considerable extent from before, backward, and like all the movements of this form, this is done very rapidly. A contraction may also take place in such a way as to greatly reduce the gills' surface—figure B—then, and from above, downward. A wave contraction may often be noticed on the ventral side of the gills. A single plate, or at most two plates, is affected at one time. It bends a certain region of its ventral surface forward or backward so as to separate this region from one of the neighboring plates, and bring it close to the plate on the other side, either before or behind, as the case may be. This latter plate quickly bends in the same way, the first assuming its original position, and then the succeeding plates, thus causing a wave of bending to run along the gill. Single plates may contract slightly independently.

The result of my work has been given to the Fish Commission in a paper containing about one hundred figures, which will shortly appear in one of their publications.

In beginning the work, it was pointed out to me by Professor W. K. Brooks, of this institution, that the anatomy of Lamellibranchs had most frequently been studied by means of dissections, which were hard to make or to figure satisfactorily; and that little use had been made of sections, especially in a comparative study of different forms. Following this and other suggestions which were frequently made to me by Professor Brooks, I hope that I may show this method to be the best one for such a study which can be made use of.

Since the completion of my work, a valuable paper has appeared on the anatomy of Lamellibranchs, by Paul Pelseneer (Archives de Biologie, Tome XI, Fas. II, 1891), who had a very large amount of material at his disposal for comparative work. In my paper I have had occasion to refer frequently to this author's observations.

In this preliminary note I can say little of the comparisons in the anatomy of the forms examined, but will merely mention a few points of interest taken up here and there, which do not need illustration.

The adductor muscles and striated fibres. The adductors of many forms are made up of two kinds of fibres, one part being of a darker shade than the other. It has been observed in a few forms that the darker fibres are striated, but it is always stated that this striation is not at all comparable to that of Arthropods or Vertebrates. The functions of these different parts of the adductors are not understood. Pelseneer thinks that the dark area of striated fibres is for rapid contraction, and that the lighter area exerts its function later.

I have come to the opposite conclusion, from observations made upon Poten irroraud. If one valve of the shell be carefully removed, the smaller, darker area of the great adductor will be seen to preserve an extremely contracted condition, while the larger white area, also slightly contracted, now appears free to hreak away from their attachment and to fasten in new positions. I have not yet had time to study the histology of these muscles, and it is reasonable to suppose that it is probably the case in other forms.

Striated fibres, so far as I know, have only been described in this group as occurring in the adductor muscles. Observers generally seem afraid to call it a striation, and it is spoken of indefinitely as "an appearance of striation."

I have found, however, muscle fibres possessing a very distinct cross striation in the auricles of the heart of the oyster (Ostrea virginianus). These striations are so large that in my preparations there were but twenty of them to .03 mm. I have not yet had time to study the histology of these muscles in detail. In the auricles of this heart also are many scattered pigment cells, and the muscle fibres are surrounded in many places by elongated cells possessing large vacuolated ends, almost exactly similar to the cells of the excretory epithelium in the kidney.

The byssus. The byssus organ of Cardita borealis, situated in a groove on the ventral side of the foot, was found to be simple enough for easy study, and in the paper referred to above, I have illustrated its structure by two figures. The secretory epithelium is made of two distinct kinds of cells. Those most numerous are cuboidal and are apparently ciliated. It is probable, however, that the cells are covered by a very regular layer of a striated secretion, which gives this appearance of ciliation, and that no cilia exist. Outside this layer is another layer of undoubted byssus secretion. At the inner angles of the deep secreting folds are numerous large, clear, unstained masses, which are probably those of the individual examined, which have lodged in this position. Perhaps they have been fertilized by spermatzoa from the same hemaphrodite gland, but the spermatzoa seem always to reach maturity before the ovum. Fertilization may take place by spermatozoa from other individuals, taken into the kidney with water from without. It thus happens that the spermatocytes become a brood chamber. This condition may be an accidental one, but I am inclined to believe that the advantage to the species thus gained by the protection of so many embryos, for so long a time in their development, is considerable, and that, by the operation of natural selection, the kidneys may have become especially adapted for this function.

Conclusions of the gills of Yoldia, and the collection of food. The gills of certain Lamellibranchs which are composed of plates instead of filaments, made known in Nucula and Yoldia by Misukuri, have not previously been thoroughly studied in any form but Nucula. I have made a careful examination of their structure in Yoldia. Certain facts in regard to the living gill of this form are of interest. They are able to contract themselves in a variety of ways, first by shortening to a considerable extent from before, backward, and like all the movements of this form, this is done very rapidly. A contraction may also take place in such a way as to greatly reduce the gills' surface—figure B—then, and from above, downward. A wave contraction may often be noticed on the ventral side of the gills. A single plate, or at most two plates, is affected at one time. It bends a certain region of its ventral surface forward or backward so as to separate this region from one of the neighboring plates, and bring it close to the plate on the other side, either before or behind, as the case may be. This latter plate quickly bends in the same way, the first assuming its original position, and then the succeeding plates, thus causing a wave of bending to run along the gill. Single plates may contract slightly independently.
Mitsukuri came to the conclusion that this primitive form of gill was concerned only in the aeration of the blood, and that it probably had nothing to do with the collection of food. I was able to observe, however, in Yoldia, that not only is its function possessed by the gills, but that it was performed with amazing rapidity. Carmine grains on coming in contact with the ventral surface, were hurried toward the median groove, into which they were thrown, in the meantime being cemented into masses by the secretion of the gland cells of the plate, and then passed forward onto the palps.

The structure of the gill plates of Yoldia. This cannot be described here in any detail. My sections differed greatly from that figured by Mitsukuri. The thickened ventral edge is sharply marked off from the plate. The cells of its frontal region possess very great cilia. On the sides, in from the frontal region, are two rows, each made of many ciliated cells. These are similar to Peck's latero-frontal cells in the gill of Anodonta, &c., but instead of being a single row of cells as in those cases, each shows five or six cells in cross section. The same condition exists in many other Lamellibranchs which I have examined. These cilia do not serve to join contiguous plates or filaments, but I believe serve to keep foreign bodies in the water currents from entering between them, thus confining these particles to the outer edges where they may be passed on toward the palps.

Gill plates of Solenomya. The thickened (morphologically ventral) edge differs greatly from that in Nucula and Yoldia, in that all its outer cells are almost exactly alike, being columnar, ciliated, and having a dense, deeply staining outer border. At the sides of the frontal region, are gland cells. Pelseneer figures sections of these plates, but in a very unsatisfactory way. He represents a large cell on either side of the frontal region bearing long cilia—probably supposing them to correspond to Peck's latero-frontal cells. I am confident that such cells do not exist in S. velum or S. borealis. Pelseneer may have mistaken a gland cell of this region—which he did not observe as such—for a large nucleus, and supposed it to indicate a large cell.

No muscular fibres, as described in Yoldia, were found in the plates, and their walls were never convoluted.

Other gills. A number of gills were examined and figured, but I cannot here attempt a description of them. A new method of inter-filamentar junction was demonstrated for Peten. There are no ciliated discs as in the Arca, but from the inner edge of the filament (next the water tube between the gill lamellae) springs a large conical projection, which is longer than a cross section of the filament. A continuous row of these stretches along filament to filament. The cells of their walls bear cilia which interlock with those of neighboring filaments, as in the ciliated discs. I have designated these projections as ciliated spurs.

Pelseneer figures large cells, with long cilia, in the filament of Peten opercularis, corresponding to Peck's latero-frontal cells. These do not exist in Peten irritatus. At a little distance interior to this region on either side, is a row made up of four or five ciliated cells in a section. These cells are large, and the cilia are very long. In all cases of this kind these large cells are closely crowded together. I have, called these ciliated lines, the compound straining lines, on account of the function of their cilia of straining the water which passes in between the filaments, and to distinguish them from the single rows of latero-frontal cells. I believe that the cilia from this single line also act as a strain.

A very noticeable peculiarity of the gills of Venus mercenaria is that in certain regions, great blood sinuses proceed into the water tubes from the walls of the inter-lamellar partitions, and almost completely fill them. In other regions, the blood sinuses are little developed, and great sinuses of the same kind are formed by the swelling of the inner edges of the filaments at the salient angles of Gill folds.

Without saying more as to the structure of the gills which I have examined and described elsewhere, I may state a few conclusions which I have reached in regard to the structure of Lamellibranch gills.

1. The single row of latero-frontal cells, described by Peck in Anodonta and the two single rows of Dreissenus, are not present in any of the marine forms which I have been able to examine, with the exception of Mytilus. Here there is an outer single row on either side, and an inner compound row of lateral straining cells. This latter arrangement will, I believe, be found to be the most usual one in Lamellibranch gills.

2. Gland cells are present at the sides—seldom, if ever, in the middle—of the frontal region, from one to three appearing in section on either side. They were seen in this position in Solenomya, Arca, Mytilus, Peten, Anodonta, Venus, Mya, Anomia and Ostrea. I was not positive about Yoldia but believe I have seen them in this form also. Gland cells at times exist in other regions of the filament.

3. I believe that an endothelial lining of the blood cavity of the filament or plate, between the chitinous layers, will be demonstrated in the majority of the Lamellibranchiata. I am certain of having observed it in Yoldia, Peten, Mytilus, Anodonta, Venus, and probably in Arca and Ostrea.

General considerations. I have attempted to show in a few forms, structures which have suffered a change from an earlier condition, having been brought about by the degeneration of the foot.

It is well known that the mantle, in forms like Anodonta, plays the part of a reservoir for blood used in protruding the foot, when that organ is retracted. The oyster, for instance, has no foot, though its ancestors must have possessed one, and the mantle, being part of this mechanism for protruding and retracting the foot, has lost its great blood spaces, and has become firm by the substitution of compact tissue, and in Mytilus and other forms, by the reproductive glands.

In fact, there seems to be an almost constant correlation between the aborted or absent foot, and a thick mantle with no large blood spaces, and also between a fully developed, locomotor foot, and a mantle consisting mainly of immense blood spaces.

A comparison of the branchial chambers. Figures of cross sections show at a glance the comparative size and conditions of the branchial chambers in different forms. The very large mantle chambers seem to be characteristic of those forms which are most active, as Yoldia, Venus and many others. In Mytilus, where the foot is much reduced in the adult, the surface of union of the mantle to the visceral mass is much greater, thus reducing the size of the branchial chamber. In the oyster, where the foot has entirely disappeared, the branchial chamber is so small as to be completely filled by the gills.

In an active locomotor form, like Venus for example, there would be much oxidation going on in the tissues, and this would necessitate correspondingly great facilities for the aeration of the blood; consequently we find the gills greatly developed, and a large branchical cavity in which they may hang. More of the mantle with its great blood spaces, is also exposed to the water.

Suppose the power of locomotion to have been lost, and the animal to have become fixed by a byssus, as in the adult Mytilus. Oxidation is lessened, the gills become smaller; the mantle lobes lose the blood spaces, and are filled with the sexual gland, and the branchial chamber is lessened in size. In the oyster the breaking down of tissues and the need of aeration is reduced to a minimum. As a result, we find a very small branchial chamber.

The phylogeny of the gills. It is generally considered that the anatomy of those forms with plate gills shows them to be the most primitive forms of the group. But there is a very great gap between these plate gills and the strictly filamentous type. In his Challenger report on the Mollusca, Pelseneer attempts to show by a series of diagrams the phylogenetic development of the gills. From Mallembe he derives Nucula. He now, however, regards Nucula as most primitive. Following this, he interposes a hypothetical gill, with plates prolonged ventrally, but having no sign of an ascending limb. The next stage is represented by the gill of Arca, in which there is a fully formed ascending limb, and neither limb shows anything platelike in shape, being more nearly cylindrical. We know that the rudiments of filaments in Mytilus and a few other forms are cylindrical, and not at all platelike. The gap here between plate and filament, even supposing the second to be derived from the first, is very great. We might more easily suppose a priori, that the former had been developed from the latter by the degeneration of the ascending limb of its filament. But as other facts go to
show the plate gill forms to be the more primitive, they must be removed for some distance from all other Lamellibranchs. The ascending limb, how-
ever, may be a new structure, suddenly developed in forms nearest those with the plate gills. If not, it seems to me we ought to regard the plate as being homologous, not alone to the descending limb of a filament, as Mitsu-
kuri believes, but to both ascending and descending limbs, as the latter is merely a continuation onward from the end of the former.

There are many points in the completed paper to which reference has not here been made.

**Notes on the Echinoderms of Kingston Harbor, Jamaica, W. I., By George W. Field.**

We found the Echinoderm fauna of Kingston Harbor rich beyond expectation, both in the number of species represented, and more especially in the number of individuals of many of these species. Through the courtesy of Dr. Plaxton, of Kingston, we were enabled early to get a preliminary survey of the nature of the upper end of Kingston harbor, and of the more prominent species of Holothurians and Echinids.

The number of species of Echinoderms which were found in Kingston Harbor and about the Cays at its mouth was about twenty-eight. A longer residence and dredging in the deeper waters would probably have increased this number considerably. Much difficulty has been experienced in properly identifying many of the specimens, particularly several of the Holothurians and Asterids. The systematist will find a rich field for work among the West Indian Echinoderms, particularly in the group of the Holothurians.

The difficulties of dredging were very considerable, arising in part from the nature of the bottom, from the unmanageableness of the boat, and chiefly from the wind. There always seemed to be a perfect calm or a gale; the calm periods between exceedingly short. However considerable dredging was done by various members of the party. The general result was a very rapid clogging of the dredge by the great quantities of the common “sea h’egg,” *Toxopaeus varius* (A. Ag.) in all the various sizes.

The surface tow net showed a wonderful richness of the larval Echinoderms in the pelagic fauna, chiefly however, during our stay, confined to Oph- iurid, Echinid and Spatangid pluteus, the relative abundance being in the order named. During the month of June they were abundant, but in early July they were extremely numerous. They were found in greatest numbers in tows made about sunrise. In the evening towing they were invariably absent. These larvae appear to come to and remain at the surface from midnight until about sunrise; after that to gradually disappear until three hours after sunrise, when they are rarely found at the surface. Their appearance seemed to be little or not at all influenced by the tide, but did depend very much upon the quantity of flood water poured into the harbor by the various rivers.

In its general aspect the Echinoderm fauna shows no very considerable variation from that of the Bahamas and Southern Floridas, though apparently richer in species and in individuals.

Though sadly incomplete, it is hoped that these notes may be of some value in introducing the visiting student to some of the more prominent species.

It is my intention at some early day to give a full description of the various Holothurians, particularly the Synaptidae collected.

**Holothurids.**

*Synapta* — A small brown Synapta is common among the bunches of algae, molluscs and tunicates which hang from the roots of the mangroves in the lagoon back of Port Royal.

*Synapta* — A monster Synapta is found under the flat slabs of coral about the Cays. Its body is much pigmented with brownish patches in adaptation to its mode of life. It is probable that more than one species was found.

*Holothuria* — A large holothurian, nearly colorless, living in the sand, was found at Drunkenman Cay.

*Holothuria* — Two or more species were abundant everywhere in the harbor.

**Mulleria Agassizii.** Common in various parts of the harbor, particularly near its head and in the lagoon back of Port Royal.

**ECHINIDS.**

*Taxopaeus varius* (A. Ag.). By far the most abundant of all the Echinoderms. Found over almost the entire bottom of the harbor. Its habits are exclusively wandering, never remaining permanently in holes of rock, as do some other species. Its favorite habitat is the smooth, hard areas covered with algae. Here they are found in immense numbers, and the dredge very quickly fills up with them. About midway between Port Hend- derson and Kingston are extensive sand flats, in many places not more than eighteen inches below the surface. These flats are thickly dotted with these urchins, concealed, however, to the casual observer by the bits of sea weed, small pebbles, bits of shell, or more often by a bunch of a certain calcareous alga very abundant in these waters. This debris is held in place upon the dorsal surface of the creature by the ambulacular feet. This mode of protective concealment is as effective as it is interesting.

Sexually ripe individuals were most readily found in early June, but so abundant is this species that no difficulty was experienced in finding indi-

viduals in condition suitable for artificial fertilization during the three following months. The eggs are beautiful objects for study, the most favorable of any I have ever seen. The development proceeds very rapidly and the larvae can be reared with remarkable ease. The entire metamor-phosis is completed in about five weeks. A very complete series of speci-

mens in all stages of development were obtained. The fragile tests of this species denuded of spines are found on every beach; they often show very pretty markings of white and green in all degrees of contrast.

*Echinometra subangulata* is found in great number among the rocks along the shores of the Salt Pond Hills. Well-nigh every hole and crevice in and under the rocks shelters one or more of these long spined urchins. In no case did I find evidence that the rock had been excavated to form sheltering depressions, as is done by *Strongylocentrotus* in many parts of the world. The urchin appears when small to have entered the hole or crevice, and in growing has come to conform more or less to the shape of the hole. It is only rarely that one is found outside the protection of some crevice. This habit has probably been acquired as a safeguard against being washed away by the breakers which the trade wind drives upon these shores. This species ranges through a great variety of colors—many shades of green, red, and brown to black. The eggs are small, with a great quantity of red pigment, and therefore unfavorable for study. The larvae seem to be less hardy, and are more difficult to rear.

*Hypnopodium excelsum* (A. Ag.). This very large urchin with short, white, thickly set spines, is found in great numbers among the reefs and about the cays at the mouth of the harbor. This species, like *T. varius*, though to a less degree, has acquired the ability to hide itself under a load of debris which it holds upon its back by means of the rows of dorsally projecting feet. The eggs obtained in June are not very favorable for study.

*Diadema scissum*. The most strikingly conspicuous of all the creatures about the coral reefs. As one approaches the cay, far down in the water are seen numerous irregularly shaped black patches of varying extent. As the water becomes shallow, a huge yellow head of coral, *Madrepora palmaeata*, is distinguished, and around and under its branches are crowded together great numbers of this large black urchin. Furnished with apparently ample protection when taken singly, what formidable defence against attack they present when crowded so closely together. The long, extremely delicate, needle-like spines are a constant menace to the wading collector, since ordinary boots furnish little protection. The spines, though sharp as needles and very brittle, yet have two redeeming features: for the minute barbs which beset its surface all point towards its shell, and hence are easily withdrawn from the wound; and their location is rendered easy by the crimson pigment which marks the place of entrance. They are, however, to be guarded against, as all of us can testify.

A small urchin which I took to be the young of this species has the spines marked with alternate bands of black and white.

The eggs are very small, and extremely unfavorable for study on account of the quantity of red pigment. I did not succeed in artificially fertilizing them.

*Cidaris tribuloides*. The least common of the regular urchins. It is to be found in small numbers about the cays. The eggs were not examined.
SPATANIDS.

*Meeoa ventricosa* (Lütk.). Obtained in abundance by dredging in the sand just outside the belt of Gorgonias around Drunkenman Cay. Many specimens were examined about July 15, but no sexually ripe individuals were found.

*Echinaster semilibraria* (Lam.). This small and delicate shelled spatangid was found at various times in small numbers at Racum and at Lime Cay in the sand in shallow water. So few were found that I did not attempt to get the eggs.

*Echinaster roseus* (Gr.) was not seen alive, but the bleached tests are common objects.

Clayaster subdrapitus was taken in the dredge off Fort Augusta.

OPHIUIDS.

*Ophioecus archips*. This large dark-colored ophirrid was rare near Port Henderson, though very common under the slabs of broken coral about all the cays.

Sexually ripe individuals were abundant during June. The eggs are much pigmented.

*Ophiolepis reticulata*, common in similar localities as was also *Ophioloma antiquarium*.

*Ampiaura* — not common: a single specimen was found at Racum Cay.

*Ophiactis* (*Oxteri*)?. The common ophirrid at Port Henderson, fairly swarming under the loose stones near the shore. Its marking shows many beautiful combinations of coloring. The sexually ripe individuals may be readily recognized by the swollen gonads showing through the skin of the ventral surface. The females show a purplish tint; the males appear whitish at these points. The eggs were artificially fertilized late in June and early in July. They are much pigmented.

ASTERIDS.

The asterids, though represented by a good number of species, have relatively the smallest number of individuals.

*As Routing — A single individual was brought to the laboratory in a mutilated condition by a fisherman who found it in his fish pot.

*Astropentax variabilis* (Lütk.). A single specimen was dredged off Fort Augusta.

— — —. Two specimens of an Asterias-like star-fish were found which I am unable to identify. It is apparently not common. Upon removal from the water it immediately performed many astonishing feats of autotomy with neatness and despatch. It would be a remarkably good species for study of this interesting phenomenon.

*Leidia* (*elatreta*)?, common in the deep water of the harbor as well as outside. A very widely distributed genus.

*Leidia saccoplasma*. Two specimens of what I am pretty certain is this species were dredged off Fort Augusta. But as they did not fall into my hands, I was unable to identify them with certainty.

*Leidia* — A single large specimen was found by Dr. Andrews wrapped around the base of an Alcyonarian colony: in color and external markings it showed a remarkable protective resemblance to the Alcyonarian stock. I afterwards found great numbers of what appear to be young individuals of this species in shallow water at Drunkenman Cay. The remarkable fact about these was that nearly every specimen showed evidence of being in process of reproducing lost parts; and two specimens were found where apparently a single detached arm had begun to form the disc and the other arms.

— On the underside of the loose rocks at Drunkenman Cay we found great numbers of a beautiful little asteris. Its aboral surface ranged in color from white through yellow to red: many specimens also were a bright blue. The oral surface was white. Although brightly colored they were very inconspicuous, and only by careful searching of the lower surfaces of the rocks were many specimens procured. So far as I am aware this species is as yet undescribed. I made a colored sketch from the living animal, and have many preserved specimens.

The eggs are much pigmented, and the orange colored gonads are seen through the thin body wall.

*Echinaster spinosus*. This brilliantly red star-fish is found in large numbers in the mangrove enclosed salt water lagoon back of Port Royal. I failed to examine the eggs.

*Oreaster reticulata* (Lütk.). This largest and most conspicuous of the asterids is found upon the smooth sandy bottoms; it is particularly numerous on the deeper portions of the sand flats between Fort Augusta and Port Royal.

I examined many specimens during June and July, but did not find any at all approaching sexual ripeness.

PREPARATION OF SPECIMENS.

The large stars (*Oreaster*) are difficult of preparation. But very satisfactory results may be obtained by the following method. Kill, by immersion in fresh water, preferably at about 35°–40° C. for an hour or two. Then remove as much of the soft parts as can easily be cut away by spreading open the mouth and ambulacral grooves. Immerse for any convenient time in alcohol, in which corrosive sublimate is dissolved. Then dry very quickly in the hot sun. Unmutilated specimens may be made by following the longer immersion in fresh water, with weak alcohol for one or two hours, and then for several days in ten per cent. solution of corrosive sublimate in strong alcohol. Then quickly dry in the sun. After thorough drying, the normal colors can be reproduced by means of water colors with very good and permanent results.

Satisfactory specimens of *Didactena setosa* are particularly difficult to obtain, and even more so to preserve, on account of the delicacy and fragility of the spines. The best results may be obtained by the following: thrust a stout sharpened wire through the aboral disc as the creature lies in its natural position in the water. This will detach him from the bottom, and by pushing the wire through and putting a loop at both ends the animal can be readily handled by means of the wire. Suspend ventral side down for fifteen minutes in warm fresh water, or in one-tenth per cent. chromic acid solution in a large vessel: if the chromic acid solution be used follow it by washing in several changes of fresh water for an hour or two; then for an hour or two in weak alcohol, then for a day or two in the ten per cent. solution of corrosive sublimate in strong alcohol. Then dry rapidly in the sun, hanging by the wire, ventral side up. If the drying be quickly done, the spines will retain nearly their normal position. The same process with the modifications which will readily suggest themselves can be applied to the other echinoids.

Alcoholic specimens should be killed by immersion for a short time in 1 per cent. chromic acid solution, or in warm fresh water, if for museum purposes. Then place in weak spirits and finally in eighty per cent. alcohol. For histological purposes, Fleming's chrom-os-acetic solution gives good results. After hardening, decalcify in seventy per cent. alcohol to which a few drops of H. Cl. or of picric acid has been added. Should bubbles of gas be found in the tissue as the result of the decalcifying process, they can be removed by placing the dish under a bell jar in which there is a partial vacuum. The specimen is then ready for staining and embedding.


In my work on the Marginal Sense Organs in the Pelagidae* I was able to trace back the development of the rhopalia only to the ephyra stage. Agassiz and Claus had stated that these organs are developed in the basal portions of the larval tentacles, but I was inclined to accept the statement made by Goette and confirmed by his figures, that the rhopalia are formed as evaginations from the under surface of the marginal part of the umbrella entirely independently of the larval tentacles, which totally disappear. It has been a surprise to me, therefore, to find this view to be erroneous, at least so far as Cassiopea Xamachana is concerned.

A completely developed scyphistoma of this species is provided with at least thirty-two tentacles, often with a greater number. A small pocket from the general digestive cavity penetrates each tentacle for a very short distance. Beyond this it has a solid axis of entodermal cells that are large and vacuolated, and have been compared to the cells of the chorda dorsalis in the vertebrate. External to the entoderm is a thin supporting membrane, upon this is a layer of muscle fibres, and the whole is covered by a columnar epithelium of small cells with thickly scattered batteries of nettle cells.

*University Circulars, No. 80, April, 1890.*
The tentacles may be divided into two series of an equal number of members arranged alternately on the margin of the circumoral disk. The tentacles of one series are held always more nearly erect—that is, more nearly parallel with the longitudinal axis of the larva than those of the other series.

After the scyphistoma has reached a diameter of about two millimetres a change in shape occurs at the base of each tentacle of the more erect series. This may be regarded either as the outgrowth of a conical lobe from the margin of the circumoral disk bearing the tentacles at its tip, or as a conical widening of the basal portion of the tentacle. The former view is probably the better.

At the time when the constriction that is finally to divide the strobila becomes first perceptible, the marginal lobes have acquired a semicircular outline, and a slight elevation is noticeable on the aboral side of each rhopalial tentacle immediately external to the mass of concretions. The epithelium at this point is pigmented and forms the first rudiment of the eye. Gradually as the marginal lobe grows, two processes are formed, one on each side of the tentacle, and a ridge is formed on the aboral side of its base connecting them. These processes finally form the rhopalial lobes of the umbrella ("Flugellappen"), and the connecting ridge grows out over the rhopalium as the hood ("Deckplat"). Exactly similar growths of the processes occur in the marginal lobes of the other series.

As the marginal lobe grows, the injuries to the oral side become apparent, and a ridge is formed on the aboral side of its base connecting them. These processes finally form the rhopalial lobes of the umbrella ("Flugellappen"), and the connecting ridge grows out over the rhopalium as the hood ("Deckplat"). Exactly similar growths of the processes occur in the marginal lobes of the other series.

The change to the adult condition is chiefly one of growth. The layer of otolith cells loses its columnar character and becomes many cells thick, and the ocellus degenerates slightly into a flat pigment spot. The adult rhopalium is, with the exception of this pigmented area essentially like the rhopalium of Pelagia.
THE JOHNS HOPKINS PRESS.

A MEMOIR ON THE GENUS SALPA.

By WILLIAM K. BROOKS, Ph. D.

The Johns Hopkins Press announces for early publication a Memoir on the Genus Salpa by Professor W. K. Brooks. It will contain about two hundred pages, quarto, with fifty colored plates. The Memoir is based for the most part on material collected by the United States Fish Commission.

The following subjects are treated:

- The General Natural History of Salpa and its Allies.
- Descriptions of North American Species of Salpa and Doliolum.
- The Embryology of Salpa.
- The Development of the Salpa Chain, and the History of the Process of Budding in Salpa and Doliolum.
- The Phylogeny of Salpa, the Evolution of the Proliferous Stolon, and the Significance of the Polymorphism of Salpa.
- The Geographical Distribution of the Species of Salpa considered in their relation to the circulation of the surface water of the ocean.

Advance orders will now be received. The edition will be limited. The price is fixed at $5.00 net.

SELECTED MORPHOLOGICAL MONOGRAPHS,

VOLUME I.

BY MEMBERS OF THE JOHNS HOPKINS UNIVERSITY.

EDITED BY W. K. BROOKS, Ph. D.

370 pages and 50 plates, 4o. Cloth. $7.50. 1887.

CONTENTS.

   (Reprinted from the Philosophical Transactions of the Royal Society of London, 1882, Part I.)

II. The Development of Renilla, with 16 plates. By E. B. Wilson.
   (Reprinted from the Philosophical Transactions of the Royal Society of London, 1883, Part III.)

   (Reprinted from the Memoirs of the Boston Society of Natural History, 1886; Volume III, Number XII.)

   (Reprinted from the Report on the Scientific Results of the Voyage of H. M. S. Challenger, during the years 1873-76: Zoology: Volume XVI, Part XLI, 1886.)

OBservations on the embryology of insects and arachnids.

By ADAM T. BRUCE, Ph. D.

50 pages. 7 plates. Cloth. $3.00.

Orders and remittances for any of the above volumes should be addressed to The Johns Hopkins Press, Baltimore.

STUDIES FROM THE BIOLOGICAL LABORATORY.

H. NEWELL MARTIN, Ph. D., M. D., Professor of Biology, Editor; W. K. BROOKS, Ph. D., Professor of Animal Morphology, Associate Editor.

Four volumes have already been issued, and Vol. V. is in progress. Each volume contains about 500 octavo pages, and numerous plates. The subscription per volume is $5.00: separate numbers may be purchased at a price varying with their size and the number of plates they contain. The first three volumes are now out of print.

The latest paper issued in this series is:


THE OYSTER.

A POPULAR SUMMARY OF A SCIENTIFIC STUDY.

By WILLIAM K. BROOKS, Ph. D.

The subjects specially discussed are:

- The Possibilities of Oyster Culture.
- The Anatomy of the Oyster.
- The Artificial Cultivation of Oysters.
- The Cause of the Decline of the Oyster Industry and the Protection of the Natural Beds.

The volume contains 240 pages, 120, and 14 lithographic plates, and is bound in cloth. The price is one dollar net.

Orders and remittances for any of the above volumes should be addressed to The Johns Hopkins Press, Baltimore.