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No. 1. — *Report on the Brachiopoda obtained by the United States Coast Survey Expedition, in Charge of* L. F. de Pourtalès, *with a Revision of the* Craniidæ *and* Discinidæ *by* W. H. Dall.

(Communicated by Professor Benj. Peirce, Superintendent U. S. Coast Survey.)

In the preparation of this paper I have been indebted to the Smithsonian Institution, under the direction of Professor Joseph Henry, for the use of their library and collection of recent brachiopods; to J. Gwyn Jeffreys, Esq., F. R. S., for kindly lending specimens of the brachiopods obtained by the English Deep-Sea Dredging Expedition, for comparison; and to Thomas Davidson, Esq., F. G. S., for many favors.

The animals which compose this class are of peculiar interest to the naturalist and geologist, as being represented in rocks of very early ages, and continuously through the various formations up to the present period. Their position in the natural system of classification being still a matter of discussion, all facts bearing on their anatomy and embryology are of the highest interest. I have endeavored, therefore, instead of compiling a mere list of species and descriptions, to enter as thoroughly into the details of anatomy as the means at hand would allow, and have considered the present a fit opportunity for rectifying the synonymy of some groups which, from the confusion in which they have been involved, have long been avoided by naturalists as stumbling-blocks.

It is hardly necessary to add, that I am indebted for the opportunity of doing this work to the kindness of Professor Agassiz, who placed the materials in my hands for examination, with the kind concurrence of M. de Pourtalès and Dr. William Stimpson

Class BRACHIOPODA Cuvier.

Animals provided with two shelly valves, each of which, normally, is bilaterally symmetrical. Valves united by three or more pairs of muscles, which, with all the other soft parts (except occasionally the intestine) are arranged in bilateral symmetry with relation to the longitudinal axis of the valves, respectively. Organs consisting essentially of a mantle composed of two lobes, which have their anterior edges always disconnected, and which correspond to the valves of the shell; a disk of membrane, variously modified, with its edges fringed with a series of tubular brachia; a mouth situated within the posterior edge of this disk; a stomach with a more or less differentiated and anteriorly recurved intestine; a circulatory system more or less contained within a series of vessels and an atrial system of sinuses or lacunes; with a unilocular heart and usually one or two pairs of accessory pulsatile vesicles; with the genitalia usually suspended in the vascular sinuses and expelling their products through one or two pairs of oviducts opening externally; nervous ganglia in a ring surrounding the œsophagus; respiring oxygen by absorption through contact of the sea water with the surface of the tissues of the mantle and brachia; diœcious, and exclusively marine.

This diagnosis comprises all the characters which, after careful consideration, I find to be common to all the members of the class. There are other characters which are more or less characteristic of the more familiar forms of recent brachiopods, but which are not characteristic of the group as a whole. Thus, many of the recent forms are attached by a pedicel, while others in the same family are attached by the substance of the valves, and others of nearly allied groups are without an attachment of any kind. The shells of many brachiopods are perforated by minute tubuli lined by cæcal prolongations of the outer laminæ of the mantle lobes, while others in the same family, and perhaps, in some cases, in the same genus, are without these perforations. The mantle edge of many genera is provided with a more or less closely set border of setæ, while others in the same family are entirely without setæ, and even the same individual, in the earlier stages of its growth (but after the other organs are nearly complete) may be devoid of them. In some brachiopods the setæ are stated to be movable, while in others no muscles exist by which they might be moved. In some the blood is colored and in others colorless. The chemical composition of the shell differs in different genera, though in the great majority it is principally composed of carbonate of lime. The embryonic forms differ widely among themselves, some being segmented and possessing eye-spots like the fry of *Pneumodermon* and *Dentalium*, while others are unsegmented. In one genus the pedicel is developed out of the middle of the dorsal area of the embryo, so that the valves both bear a dorsal relation to the animal, while in others it would appear to extend from one extremity of the embryo, when the valves would bear a dorsal and ventral relation respectively.

It is evident that characters such as these, which are few of family, and none of ordinal value, can have no important bearing upon the classification of the group and its systematic position as a whole.

Order ARTHROPOMATA Owen.

* * Syn. = *Arthropomata* Owen, Enc. Brit. Ed., VIII, XV, Art. *Mollusca*, p. 336, 1858.
= *Brachiopodes, valves articulées* Deshayes, An. s. Vert. Ed., II, VII, p. 309, 1836.
= *Palliobranchiata, testa cardine instructa* Van der Hœven, Handb. der Zoöl., p. 692, 1850.*
= *Apygia* Bronn, Klass. Ordn. Thierr., III, 1 Abth. p. 301, 1862.
= *Articulata* Huxley, Lect. Class. 1864. Intr. Class. Anim., p. 116, 1869.
>< *Ancylobrachia* + *Cryptobrachia* + *Sclerobrachia* + *Sarcicobrachia* Gray, Ann. Mag. Nat. Hist., II, pp. 435 – 438, 1848.
>< *Brachiopodés brachidés* + *B. cirridés* D'Orbigny, Cours Elém. Pal., II, p. 82, 1849.
> *Pedunculata* Latreille, Fam. Nat. Règ. An., p. 196, 1825.

Characters. Intestine ending in a closed sac. Lobes of the mantle united posteriorly. Valves articulated by teeth and sockets.

Family TEREBRATULIDÆ.

Terebratulidæ Dall, Am. Journ. Conch., VI, p. 101, 1870.
(*Thecidiidæ* exclus.)

Subfamily TEREBRATULINÆ Dall.

Terebratulinæ Dall, l. c. p. 101, 1870.

Genus TEREBRATULA Auct. ex Llhwyd.

Terebratula Llhwyd, Lith. Britt. Ichn., 1699. Lam. Prodrome, 1799. Dall Am. Jour. Conch., VI, p. 101, 1870.
Type *T. perovalis* Sowerby, Lamarck. *T. maxillata*, Sowerby.

Terebratula cubensis Pourtalès.

Terebratula cubensis Pourtalès, Bull. Mus. Comp. Zoöl., I, No. 7, p. 109, 1867. Dall, Am. Jour. Conch., Vol. VI, pp. 105, 166, 1870.
Terebratula vitrea, var. Davidson, Mon. Ital. Tert. Brach., I, p. 9, 1870; also Jeffreys, in litt. (not of Born).
Florida reefs, May, 1868, in 100 – 200 fathoms, rarer toward the east end of the reefs. Coast of Cuba near Havana, in 270 fathoms. Pourtalès, U. S. Coast Survey.

In upholding the specific distinctness of this species, which is without doubt closely allied to *T. vitrea*, I regret that I am obliged to differ from

* I have adopted in the synonymy the very excellent system of notation proposed by Bronn and Strickland. This, or some similar system, is absolutely necessary for the comprehension of intricate synonymy. It is a matter of surprise that it has not been more generally adopted and made use of. The single asterisks denote references which I have not been able to verify by actual examination in person.

the distinguished naturalists whose names are quoted above. It must be admitted that honest differences of opinion may exist in regard to the specific limits of almost any species of animal; in this, as in other cases, I can only give utterance to my own personal opinion, based upon the material at my command. I have, in another publication, stated that I have found constant, though not extreme, differences between this species and *T. vitrea*, and, as no transition from the one to the other has yet been shown, I feel justified in considering these differences as of specific value. They were partly pointed out by M. de Pourtalès in his original description; and after a careful examination of many hundred specimens, and a critical comparison of them with a large series of *T. vitrea*, I have not been able to detect any inconstancy in the form of the loop in each species. While the other characters are more variable, yet even those show no more approach to each other than may usually be observed in two closely allied species.

The following comparative diagnoses will serve to point out these differences: —

T. cubensis has the margin of the valves laterally flexuous, varying to some extent in degree of flexuosity, with age. This diagnosis, however, refers to adult shells, in which a certain amount of flexuosity is always present. The convexity being in a hæmal direction, the margin of the hæmal valve is excavated on each side, giving the valve a subquadrangular aspect. The valves are usually rather inflated, giving the shell a tumid aspect. The hinge teeth are stout and thick, the deltidium moderate; foramen rather large. The shell is widest near the anterior margin of the valves, the cardinal border is strongly arched; the cardinal process is stout, blunt, broad, rounded and much recurved. The cardinal plate is divided; no shelly matter extending between the apophysal ridges. The shelly plates on each side of these ridges, extending to the dental ridges, are deeply concave, with the anterior border somewhat produced and rounded. The crura are short and blunt. The anterior part of the loop is characteristic and peculiar. It is strongly squarely convex in the middle, and a deep narrow gutter extends on each side of this convexity and is produced at each side into a point. Between these points and the median convexity on each side is a deep slit or fissure. The anterior end of the convexity is much produced, blunt, and square. It terminates behind in a slight sinus or indentation. The apex of the hæmal valve is much incurved.

T. vitrea has the lateral margins of the valves almost rectilinear, if there be any flexuosity the direction of the convexity is neural. Hence the outline of the hæmal valve is rounded ovate. The valves are more or less compressed, and there are frequently indications of a broad median ridge, flattened and bounded by two obscure carinæ, which is never present in *T. cubensis.* The hinge teeth are slender and delicate, the deltidium much narrower, and the foramen usually smaller than in *T. cubensis.* The shell is widest behind the middle of the valves, giving a slight coffin-shaped aspect to the valves; the cardinal border is nearly straight, the cardinal process is slender, produced, and square at the end. The cardinal plate is divided, as in the last, the shelly plates on each side are nearly flat and anteriorly emarginated. The crura are sharply pointed. The anterior portion of the loop is but slightly convex in the middle, the gutters on each side are broad and shallow, there are no lateral slits, and instead of a median prolongation there is a deep, broad emargination or concavity in the anterior edge of this part of this loop. Instead of a sinus behind, there is a sharp point, which is, however, often broken off in dry specimens. The apex of the hæmal valve is not incurved. In fact, the shell of this species is flat where *T. cubensis* is concave, emarginated where *cubensis* is produced, entire where *cubensis* is fissured, broadest where *cubensis* is narrowest, narrowest where *cubensis* is widest, subcarinate where *cubensis* is smoothly rounded, etc., etc. In both obscure fine radiating lines may be often seen. That these characters are constant throughout hundreds of specimens of *T. cubensis* I can testify from actual examination. I have found those here recorded of *T. vitrea* constant in some twenty specimens, and in all the *figures* of this species extant. Hence I have not the slightest hesitation in considering them as distinct species. The differences of the loops, solely, would distinguish them anywhere, and no more satisfactory specific character could be advanced.

In its general anatómy this species presents some similarity to *Waldheimia floridana.* I shall reserve a more explicit account of the structure for that species, and only mention here the anatomical points which appear more striking, and which are more or less peculiar to this species. Most of the soft parts are of a translucent yellowish white color. The mantle is of stouter consistency than in *W. floridana*, and may often be removed from the shell with but little injury if care be exercised. The muscles are similar in disposition to those of the other members of the *Terebratulidæ*, and present no new features. The peduncle is solid, cup-shaped at its extremity, and has the edge produced in cylindrical horny rootlets, which are attached to foreign bodies. The regular arrangement in layers of the muscles and corium, as well as the axial tube of the peduncle, found in *Lingula*, is less evident or absent in these forms. In this species the peduncle is very short and stout, broadly cordiform at its inner extremity when enveloped by its various tunics.

The brachia are arranged as in *T. vitrea*, as figured by Woodward; the central coil makes about four turns. The cirrhi are very short behind the mouth, in front of the supra-œsophageal body. A striking feature in its anatomy, which I believe has not yet been noted in any publication on Brachiopods, is the absence of that great series of sinuses in the anterior part of mantle, which was termed by Hancock the "great pallial sinuses." So extraordinary did this appear to me, that I could not believe, at first, that I was not deceived by the translucency of the membranes, and it was only after an examination of many specimens that I became convinced that they did not exist in this species. There is in the free lobes of the mantle an extensive and extremely close and fine network of minute channels; or perhaps it might be said that the whole of the mantle lobes form one great lacune, the upper and lower walls of which are held apart by a profuse number of pillars of tissue, which appear like dark spots under the microscope, and which are situated so close together that the spaces about them are reduced to minute channels. This system occupies the anterior lobes of the mantle, which in some species also contain large branching sinuses, here absent. On the outer surface of the perivisceral chamber, above and below, on each side of the attachments of the principal muscles, a small system of sinuses exists, and here are situated the genitalia which necessarily assume a reticulated aspect quite different from the loops and branches seen in *Waldheimia* and *Terebratella*. In the inner lining of the mantle are scattered, everywhere, delicate branching spiculæ, looking like briers more than like deer-horns, and, while more or less interlocked, and here and there stout and thick, are still much more delicate and slender than those of *Terebratulina caput-serpentis* and *Megerlia truncata*, and do not often exhibit a stellar arrangement. They are much more numerous in some individuals than in others, and when present in abundance are found in almost every part of the epithelium, even to the brachial cirrhi, where the spicules are slender and not branched. They are especially numerous over the perivisceral chamber and in the supra-œsophageal tissue. The oral aperture presents no special peculiarities. The œsophagus is wide and funnel-shaped, narrowest at its junction with the stomach, which it enters at an acute angle. The stomach is small and oval, tapering toward the intestine, which is nearly twice as long as the œsophagus. In the stomach was a dark mass of calcareous granules, fragments of Foraminifera, etc., filling it quite full; among the *débris* was, in one specimen, the remains of a small red crustacean with a large carapax and (?six) legs, somewhat resembling a young *Limulus*, but much smaller. Other unrecognizable crustacean fragments were noticed in other cases. Notwithstanding the crowded state of the stomach, the intestine was always empty. Its cæcal end was somewhat blunt and rounded, and several fold-like thickenings of the mesentery recalled Hancock's figures of the termination of the intestine in *W. cranium*. The pointed lower ends of the plicated openings of the oviducts were free from the body wall and attached to the parietal band on the anterior edge of the intestine a little way above the heart: first, by a tendinous process of considerable toughness; and, secondly, by the end of the plicated membrane itself. Between the two attachments a small foramen appeared, which seemed to be normal, but may possibly have been due to a lesion of the tissues. The heart in most specimens was pyriform and of moderately large size; in one or two it appeared of an hourglass shape, probably due to contraction. The disposition of the vessels was similar to that described by Hancock in *Terebratulina caput-serpentis*, as far as I was able to determine.

A very careful search was made for accessory pulsatile vesicles, but none were discovered, though I do not feel positive that they may not exist. The vessels which supply the genitalia are much looped and reticulated. The genitalia, as before mentioned, are situated in a reticulated series of sinuses, on the surfaces of the sides of the perivisceral tissues; this series does not pass in front of the muscular attachments, as far as I have been able to discover by repeated and careful examinations. It would seem as if this portion represented the pallial sinuses of Hancock, which exist in other genera, but which, in this species at least, seem to be suppressed anteriorly. The lacunes of the anterior portion of the mantle-lobe are homologous with the inner and outer pallial lacunes of Hancock. The genitalia agree in general features in all the specimens examined. They are of a yellowish color, and all appeared destitute of the reddish granular substance noticed in other species. On the other hand, a similar accumulation of reddish-yellow granules appears in the glandular funnels of the oviducts, which open by an oval and rather large aperture on each side, behind, and a short distance above the mouth.

Above and behind the mouth, and directly in front of the anterior occlusor (retractor) muscles, the external tissues of the perivisceral membrane are thickened, or a mass of cellular tissue is interposed between the laminæ of the membrane. This causes a protuberance almost exactly resembling in shape and appearance a human nose. Below the inferior and most prominent portion of this protuberance is a deep groove or incised line, under which is another protuberance, short, wide, and transverse, shaped like a roll of parchment. For want of a better name I propose to call the lower protuberance the *supra-œsophageal body;* the fissure, the *inter-corporeal groove;* and the upper protuberance, the *nasiform body.*

These organs do not exist in any of the species of Brachiopods (except *T. cubensis*) with which I am acquainted. Nothing of the kind is to be seen in *W. floridana*, *Terebratella coreanica*, *T. caurina*, *Waldheimia flavescens*, etc., etc. I am unable to say whether it occurs in *T. vitrea*, but it is very likely that it does. What may be the office of these formations I cannot imagine, unless it may be to protect the muscles. In many specimens the nasiform body was crammed with spiculæ in one heterogeneous mass, forming an excellent shield for the muscles. The brachial cirrhi before these prominences were very much shorter than the others. I am not aware that these peculiar features have been noticed in any publication on this group. The hepatic digitations enter the stomach by two ducts on each side as in *W. floridana*, but are longer and more slender than in that species. The setæ are longer and more closely set in front than at the sides; they rarely are double in the same follicle; and in no case were more than two so noticed. They seemed to be almost uniformly broken off just beyond the edge of the mantle, but in those which remained unbroken no transverse markings were seen. A few dark pigment granules were noticed around the bases of the follicles, and a line of similar granules was seen between each two setæ, passing round the bases of the follicles and joining the next line, and so on continuously. The circumpallial muscle was narrow and slender.

No peculiarities of note were observed in the shell structure. The perforations appeared to be slightly further apart than in *T. vitrea*, but the difference was not much greater than that which may be observed in the shells of different individuals of the same species.

The external layer, mentioned by Hancock as occurring at the edges of the shells of other species, was well marked in perfect examples, and extended over a large part of the shells.

Attached to a piece of rock, dredged off the Samboes on the Florida coast, was a minute polished hyaline shell 4-100 of an inch in length, which, from its general appearance and the locality in which it was found, I believe to be the young of *T. cubensis*. That species is abundant in that locality, and the only other known species to which it might be referred is *W. floridana*. The latter, even in very small specimens, has quite a different aspect.

The shell in question was ovate, with the beak of the neural valve quite prominent, and with a small but sharply defined area. There was no deltidium, and the apex of the hæmal valve was somewhat prominent, recalling that of an embryonic (?) Brachiopod described by Mr. Jeffreys, under the name of *Terebratula capsula*. The punctures were very small and widely separated, arranged in quincunx order. The ends of the prisms of which the shelly matter is composed, by impinging upon the surface, gave it a beautifully reticulated or lacelike aspect. By gumming the lower valve to a piece of card, and allowing the end of a thread moistened with gum to dry fast upon the upper valve, I was fortunately able to separate the two without breaking them or injuring the remains of the animal within. These afforded some interesting notes.

Muscular System. — The muscles were of a dark reddish-brown, and consisted of a pair of cardinal muscles attached on each side of the notch in the hæmal valve, two pair of adductors in the usual position, and the pedicel muscle. No others could be distinguished.

Brachia. — There were no apophyses, and the brachia were supported by membranes of a horseshoe shape attaching them to the adductor muscles. They consisted of a single row of distant cirrhi attached to the edge of a horseshoe-shaped membrane, which passed behind the mouth and was broadest on each side of the mouth, and prolonged anteriorly about half the length of the valves, diminishing in breadth until it terminated in a point on each side. There was no loop in the literal sense of the word. On the outer edge of the membrane were long, slender, distant cirrhi, about ten on each side. On the inner side of the membrane were a few very short cirrhi, and the series was discontinued before passing below the mouth. The external cirrhi were continuous above or behind the mouth. They were tubular, hyaline, and presented transverse markings at short intervals, somewhat as if they were annulated. They were about .018 of an inch in length. The mantle was exceedingly thin, hyaline, with a plain edge, not furnished with setæ.

Organs of Digestion. — The mouth was transverse and small, the upper "lip" somewhat produced in the median line; the stomach was straight, short, bag-shaped, and a little constricted behind the mouth. Its termination was cæcal. Around the stomach a few yellowish hepatic digitations were observed. There were no other organs; intestine, ovaries, etc., being absent. The peduncle was short and slender.

The apex of the larger valve presented a curious appearance. It was not pointed, but kidney-shaped, and its consistency appeared to be somewhat granulated, differing from the rest of the shell in texture. The indentation lay in the median line just above the foramen. In the middle of the nucleus two well-marked pores or hyaline points, apparently perforations, were clearly visible. Around the edges of the nucleus the growth of the shell appeared to have been rather toward a bag-shape, and this gave an appearance of constriction around the edges of the nucleus. The upper margin of the arch of the foramen was a short distance below this. The upper part of the arch was closed by a very thin, transparent septum of shelly matter. The edge of the apex of the smaller valve appeared to be of the same granular texture as the nucleus, but this merged imperceptibly into the rest. There was no cardinal process, and a shallow emargination or notch of rounded shape completed the opening of the foramen when the valves were together. The cardinal muscles were attached on each side of this notch to the interior of the shell. The teeth of the hinge were already well marked.

Terebratulina D'Orb.

Terebratulina D'Orbigny, Comptes Rendus, XXV, p. 268, 1847.
Type *T. caput-serpentis* Lin. sp. Syst. Nat. Ed., XII, 1153, 1767.

Terebratulina Cailleti Crosse.

Terebratulina Cailleti Crosse, Journ. de Conchyl., XIII. (3d Series, V), p. 27, pl. i, figs. 1–3, 1865. Pourtalès, Bull. Mus. Comp. Zoöl., I, No. 6, p. 109, 1867. Dall, Am. Journ. Conch., VI, p. 106, 1870.

This very distinct species was obtained by M. de Pourtalès off Chorrera, Cuba, in 270 fathoms; near Cojima, in 450 fathoms; off Double-headed-Shot Key, in 471 fathoms; and near Tennessee Reef, in 115 fathoms. Two specimens, from which the diagnosis of M. Crosse was drawn up, were obtained at the island of Guadaloupe in two hundred fathoms, by an Italian party who were searching for beds of coral. Although obtained in several localities, it does not appear to be an abundant species, as the number of specimens obtained by the United States Coast Survey Expedition was quite limited. It is well distinguished from other species by its granulated ribs, but varies so much in form and other characters, that I doubted whether all the specimens could be referred to Crosse's species, upon my first examination. They all differ from his figures in a remarkable auriculation of the valves and in the straightness of the hinge-line. These characters, though present, vary so much in the different specimens that I have come to the conclusion that the species is identical with his, and that his specimens were merely an extreme variety. The normal specimens, though varying in amount of inflation, almost exactly resemble *Terebratulina Michelottina* Davidson, described by that eminent palæontologist, in his monograph of the Italian Tertiary Brachiopoda (Geol. Mag., VII, No. 9), p. 14, September, 1870, pl. xix, figs. 22, a, b, c, from the Eocene (stage E) at Mossano, Italy. Were the two found living in the same seas, no one, I think, would hesitate to consider them identical. The median flexuosity is very variable, and often entirely absent. The nodulation of the ribs is more evident in young shells. They also vary from quite broad and flat to elongated and much inflated.

The smallest specimens of this species which I was able to find among those sent by M. de Pourtalès were nearly .1 of an inch in length. The characteristic sculpture was developed upon them to the very apex of the shell. The nucleus was already gone, being probably deciduous or soon lost by attrition upon the rocks to which the young shells attach themselves. The various muscles were already well developed. The mouth was as described in the young of the *T. cubensis*. The intestine was short, cylindrical, and straight. The lower portion was embraced by a few hepatic digitations. These lobes were very dark brown, the muscles of a deep reddish-brown, and the brachia of a flesh-color. The latter were in the shape of a horseshoe, with no trace of a median lobe. They were close set and marked with transverse lines, as in *T. cubensis*. The membrane which covered the viscera was covered internally with irregular hyaline spots with well-marked boundaries, which no doubt are the limits of the lacunar channels of circulation. The mantle was quite transparent, with a brownish edge, and in each of the internal channels, corresponding to the ribs of the outside of the shell, was a single bristle, composed of longitudinal fibres of chitine, without any of the transverse markings which are seen in the setæ of the adult. The extreme tip of the bristle alone protruded from the mantle, and its inner extremity was slightly bulbous. It was of a glistening yellow color throughout. In those adults which I examined there were only five or six of these setæ in each mantle lobe. These specimens were obtained off Havana, in two hundred and seventy fathoms water.

The very extraordinary manner in which all the soft parts were crowded and crammed with masses of calcareous spiculæ defied my best efforts to obtain any very satisfactory results from the two or three alcoholic specimens at my command. A flocculent mass of white matter resisted the action of acid, and filled all the interstices of the membranes, so as to render them quite opaque. The genitalia were in such a condition that they were quite invisible, and the animals appeared to be out of season. The intestine was cylindrical, and ended much as it does in *T. caput-serpentis*. The mouth was surrounded by a dark-brown line. There were no structures above and behind the mouth, such as are described as existing in *T. cubensis*. The attached extremities of the muscles were of a very bright red-brown. Most of the specimens were overgrown with a tough, spongy organism, like velvet. The peduncle is white, slender, and exceedingly long, the exposed portion sometimes equalling in length one third of the shell. A brownish tinge pervaded all the tissues of the adult. Transverse markings were noticed on the brachia, as described in other species by Hancock.

One specimen growing on a rock which had become covered with sponge afforded an interesting observation. The peduncle was exceedingly long, and, on cleaning off the sponge, it was seen that the creature, on the growth of the sponge toward it, had apparently lengthened its peduncle to get out of the way; and while the original attachment still remained (and the glossy opalescent color of that part of the peduncle testified to its healthy condition), somewhat farther on, nearer the shell, a second attachment of the peduncle had taken place by the outgrowth, from the underside, of a bunch of cylindrical rootlets, exactly resembling the attachment of an ivy to a stone. The under side of the peduncle and the rootlets were brown; the rest, opalescent white. It is true that there is no absolute proof that the peduncle had been lengthened, but I know not how else to explain the extraordinary length and second attachment, and I see nothing intrinsically improbable in the supposition.

Genus WALDHEIMIA King.

Waldheimia King, Permian Fossils, p. 81, 1850. + *Eudesia* + *Macandrevia* King.

Type *Waldheimia flavescens* Lam. sp. Hist., VII, p. 330, 1836.

Waldheimia floridana Pourtalès.

Waldheimia floridana Pourtalès, Bull. Mus. Comp. Zoöl., I, No. 7, p. 127, 1868. — Dall, Am. Journ. Conch., VI, p. 112, 1870.

Terebratula septata Jeffreys, Proc. Royal Soc., 121, p. 446, ¶ 79, 1870.

Terebratula septigera Jeffreys, l. c.

Not *T.* (*Terebratella*) *septata* Philippi, Moll. Sicil., II, p. 68, t. 18, f. 7, 1844.

Not *T.* (*Waldheimia*) *septigera* Lovèn, Ind. Moll. Scand., p. 29, 1846.

T. (*Waldheimia*) *peloritana*, var. Jeffreys, l. c., *not* Seguenza Sicil. Brach., pl. vi, figs. 1–10, 1865.

Florida reefs, between 110 and 200 fathoms, rocky bottom, Pourtalès.

This species belongs to a peculiar group of the subgenus *Waldheimia* (*sensu stricto*), containing several recent and some fossil species. *Terebratula septata* Philippi, to which species *peloritana*, *septigera*, and *floridana* have been referred, proves to belong to a different genus (see Davidson, Mon. Ital. Tert. Brach.) from any of them. *T. peloritana* is referred by Mr. Davidson to *T. septigera*, in which Signor Seguenza concurs. We have, then, three allied but sufficiently distinct forms, as follows: *Waldheimia floridana* Pourt., *W. septigera* Lovèn, and *W. Raphaelis* Dall.* The first is from the Florida coast, the second from the seas of Northern Europe, and the third from Japan.

The following table of measurements of large adult specimens will give an approximate idea of their respective forms: —

	Length, inch.	Width.	Diameter.
W. floridana	0.90	0.90	0.70
W. septigera	1.20	1.10	0.80
W. Raphaelis	1.75	1.30	1.00

Thus it is seen that the smallest species is by far the widest and most inflated, proportionately; the second species is the flattest, in proportion to its length; and the third is the most elongated. I have taken the largest adult specimens of each species for comparison; that of the *septigera* being far larger than the ordinary form of that species, as it is one collected by

* Am. Journ. Conch., VI, p. 111, pl. vii, figs. a, b, c, d, 1870.

Mr. Jeffreys, F. R. S., on the British Deep-Sea Dredging Expedition, which was presented by him to M. de Pourtalès.* The *W. floridana* presents very little variation among specimens of similar ages. A comparative diagnosis is here given.

W. floridana. — Color grayish or brownish white. Form nearly an equilateral triangle, widest near the anterior edge; much inflated. Anterior margin very strongly flexuous, the concavity being in the hæmal (dorsal) valve. The anterior corners of the hæmal valve sharply pointed. Area very narrow and short, deltidia just completing the foramen. Sides almost flat, neural (ventral) valve broadly channelled in the middle. Apex but slightly produced, short, rather acute. Cardinal process minute, pointed, not recurved. Hinge plate wider than long; anterior point over the septum, behind the crura of the apophyses. Hinge teeth very short and slender. Anterior ends of the lateral loops of the apophyses broadly flaring, the shelly portion of these loops broadest near their ends; hæmal arms of the apophyses close together and parallel for half the length of the shell. Narrowest part of the recurved loop near its posterior end. Visceral area small, muscular impressions within the posterior third of the dorsal valve. Stomach spherical with a long cylindrical intestine.

W. septigera. — Color as in the last. Form roundly ovate, somewhat truncated and wider in front. Anterior margin more or less flexuous. Anterior corners of the hæmal valve obtusely rounded. Area much wider and longer, solid, with no median line indicating a separation or division into deltidial plates. Sides rounded, inflated. · Neural valve not channelled, slightly concave near the exuosity flat the anterior margin. Apex somewhat produced, blunt. Cardinal process broad, blunt, short, hardly differentiated from the hinge plate. Hinge plate longer than wide, anterior point passing forward between the crura. Hinge teeth very stout and strong. Anterior ends of the lateral loops incurved, their laminæ widest near their posterior portion. Hæmal arms of the apophyses diverging in a wide curve from the hinge plate. Recurved part of the loop short, sides nearly parallel. Visceral area very small, muscular attachments even more posterior than in the last. Stomach posteriorly produced into a point, without differentiation of the intestine, and very much shorter than in the last.

W. Raphaelis. — Color deep brown. Form rather elongate, squarish, widest near the middle. Anterior margin sharply, shortly flexed. The

* I have since had the opportunity, through the kindness of Mr. Jeffreys, of examining other and more normal forms of this and several other species obtained by him. These included one specimen of the *septigera*, which he regarded as a transition toward *W. floridana*, which has been figured for the Zoölogical Society, and which he very politely lent for comparison. It is elsewhere referred to.

convex flexuosities of the hæmal valve pointed, not at the outer corners, but nearer the median line. Area moderate, without any median line. Sides not inflated. Neural valve channelled for two thirds of its length, with two prominent rounded carinæ corresponding to the flexuosities of the margin. Apex very short and blunt. Cardinal process quadrate, long, abruptly recurved, like the blade of a hoe. Hinge plate longer than wide, anterior point passing between and almost beyond the crura. The latter are longer and more slender than in the previous species. Anterior ends of the lateral loops nearly parallel, the widest part of the shelly laminæ being near their posterior terminations, but the width of this part of the apophyses is nearly uniform from one end to the other. Hæmal arms of the apophyses diverging, in nearly straight lines, from the hinge plate. Recurved part of the loop proportionately much longer than in the two previous species; neural portion forming a regular ovoid. Visceral area very large, muscular impressions reaching the middle of the shell. Soft parts mostly unknown.

I have been thus explicit, perhaps more so than the subject requires, because the first two of our species have been united by Mr. Jeffreys, whose opinion is justly entitled to weight, though I am forced to disagree with him upon the present occasion. I consider *septigera* and *floridana* as two well-marked and distinct species, in which opinion I have reason to believe Mr. Davidson concurs. *W. septigera* and *Raphaelis* are more nearly allied, but the points of difference already noted are quite sufficient to distinguish them, aside from the habitat and the fact that the adult *Raphaelis* is twice the size of the largest *septigera* hitherto collected.*

The greater portion of the mantle of *W. floridana* is of the most extreme tenuity and perfect transparency. It is furthermore so closely attached to the sheil as to render its removal intact — even with the aid of acid — a matter of great difficulty. With this exception, the examination

* In the specimen already alluded to, and regarded by Mr. Jeffreys as a transitional form between *septigera* and *floridana*, all the characters of *septigera* as above given are well marked. It differs from the ordinary forms of *septigera* in being proportionately wider than many of them, and in the sharper angles of the marginal flexuosities. But it is noticeable that these last are not at the anterior corners, as is always the case in *floridana*, but are strictly within the anterior margin at some little distance from the anterior corners, as is always the case in *septigera*. Hence I cannot admit that there is any transition exhibited in this specimen, but merely an exaggeration of the usual characters of the species. The apophyses are missing. One of the other specimens of *septigera*, in the same lot, fortunately preserved the ovaria, and I am glad to be able to state that they differ entirely in form and extent from the same organs in *W. Raphaelis*. This is a good character, though it varies somewhat, within certain limits. I must again thank Mr. Jeffreys for the kindness which he has shown in forwarding specimens for examination, — an example worthy of imitation by other naturalists, and well calculated to assist in dispelling false impressions, and in adding to the accuracy of scientific work.

of its anatomy is easy. The following notes are the result of a careful dissection of several specimens. The soft parts are mostly of a translucent whitish color. The number and disposition of the muscles are similar to those of *W. australis*, already described by various authors. The muscles themselves are of a glistening tendinous appearance, except at their points of attachment, where they are of a more or less dark yellowish-brown. The peduncle is moderately long, and the portion which is external or contained in the foramen is covered with a dark, horny reddish-brown membrane or skin, and the attached extremity is trumpet-shaped. Upon opening the shell in its normal position, the median spires of the brachia are seen to be somewhat widely separated, and between them is stretched a fine translucent membrane extending forward from the under lip of the mouth and following the downward curve of the median lobes. In this great extension of this membrane this species differs from *T. caput-serpentis* and *W. australis*, in which species the cirrhi of the median lobes touch at their extremities, and are separated by only a very narrow strip of membrane between their bases, so that the appearance is almost as if there was but a single broad band of cirrhi in the median line. This intervening membrane in ordinary specimens of *W. floridana* is about .24 of an inch in width at its narrowest visible portion. The upper and lower bands of cirrhi in the lateral loops are also much more widely separated by a similar membrane, than in *W. australis*. The reason of this appears in the fact that the brachial band follows the outer edge of the apophyses in both species until it curves downward in the middle, and the shelly portions of the apophyses in *W. floridana* are very much wider than in *W. australis*; hence the greater separation. The longest of the brachial cirrhi, in front, measure about .14 inch in length; those of that part of the band which passes behind the mouth are about the same length. They are, as in other species, disposed in a double row, the cirrhi of one row being opposite the spaces of the other. The spiral portion in the middle lobe makes about two complete turns. With regard to their disposition and the manner in which the cirrhi are set upon the brachial band, I can add nothing to the observations of Mr. Hancock, with which my own agree in every particular. A series of transverse lines at regular intervals was observed on the individual cirrhi, somewhat resembling in appearance the transverse markings on the setæ. The mouth is, as usual, just in front of the posterior junction of the brachial bands, and is in a rather long flexuous groove, the edges of which are of a dark brown color, and somewhat thickened. The upper or posterior lip, if such it may be called, has a forward prolongation or convexity in the median line, to which a slight concavity or indentation in the lower lip corresponds. The œsophagus is about half as long as the intestine, and has a slight curve, of which the convexity is anterior; it is transversely flattened close to the mouth, and is a little compressed laterally, behind that portion. It is of a nearly uniform calibre throughout. It has quite a thin lining membrane, which becomes thicker, though still smooth, in the stomach, and quite thick and longitudinally plicated in the intestine. The stomach is well differentiated from the alimentary canal and intestine, and is of an oval shape. It is embraced by the hepatic digitations, which are of a greenish-yellow color, and empty into the stomach by four ducts. The orifices of these ducts are of a compressed oval shape, obliquely inclined, and the anterior pair, which correspond to the right and left anterior congeries of hepatic digitations, are twice as large as the posterior pair, which similarly correspond to the anterior lobes or bunches of digitations. The individual digitations appear to be longer, larger, and less numerous than those of *W. australis*, etc., as described by Hancock. They are traversed by numerous ducts and bloodvessels, and the hepatic matter, when separated, appeared to be of a granular consistency. Among the yellowish granules in the hepatic matter, both before breaking it down and afterward, were noticed certain darker granules, similar in general appearance to those found in the ovary. The digitations are distinctly arranged in four groups, of which the anterior pair are the larger. The upper and posterior surface of the stomach is bare, and the arrangement of the mesentery and the gastro- and ileo-parietal bands essentially agrees with the description of the same parts in other species of this group, as given by Hancock. The intestine is twice as long as the œsophagus, of uniform calibre, and perfectly straight. It leaves the stomach abruptly without any dilatation of the portion adjacent to the latter organ, and reaches about half-way to the dorsal valve. The heart is situated behind the junction of the stomach and intestine. The termination of the intestine is abruptly rounded off and not at all pointed. It is entirely closed, and is upheld by the mesentery. It is also of a much darker color than the rest of the alimentary canal, being of a deep chestnut-brown hue.

The great pallial sinuses and their ramifications in *W. floridana* are of much less extent and disposed in quite a different manner from that which obtains in *W. australis*. The hæmal pallial system consists essentially of four branches which are remarkable for their straight course and the paucity of their ramifications. The neural pallial system is very similar, with a greater number of small sinuses about the perivisceral cavity, but in both lobes the narrowness and small extent of the sinuses, as compared with those of other species, is very marked, and the same is true with regard to the ovaries. But a very few exceedingly delicate spiculæ were observed in the floor of the greater sinuses. The heart consists of a very minute pyriform vesicle situated behind the intestine at its junction with the stomach, and sending one vessel in the hæmal direction along the median line of the stomach, and another on each side laterally. It is attached by its lesser extremity, and, contracted by the alcohol, appears exceedingly minute. A very careful search failed to reveal any accessory pulsatile vesicles, yet it is possible that, from their extremely small size, they may have been overlooked. The ovaries are very limited in extent and principally confined to that portion of the sinuses which surrounds the visceral cavity, only their ultimate extremities entering the larger branches of the great sinuses. Those in the hæmal valve are vermiform, slightly hooked at their posterior extremity. Those in the neural valve form open loops, with the "bight" posterior, and the two anterior extremities just entering the two outer sinuses. Their manner of suspension is the same as in the other species of the genus. The ova were visible in all stages of growth. Those floating free in the lacunes were nearly spherical, and of a flesh color; their substance seemed of a granular consistency, due perhaps to the action of the spirit in which they were preserved. The immature ova were pyriform, attached to the ovary by their pointed ends. With the yellowish matter of the ovary were interspersed specks of a brownish granular matter, which appeared dark yellowish under a high power and intermixed with what seemed to be fat-globules. Somewhat similar specks were observed in the hepatic matter. This was more abundant toward the middle line of the ovary, but was irregularly distributed. No spermatophoræ or spermatozoa were observed in any of the specimens examined. The oviducts were situated as in *W. australis*. The lining membrane of their trumpet-shaped portion was drawn into thin plicæ. Their apices were teat-shaped, with very small orifices.

The mantle margin is folded as in other species; the fold is deeper in the sides than in front, and not wide anywhere. The setæ are very slender and fine, irregularly marked with transverse lines, but smoother toward their outer ends. They protrude from their follicles, hardly more than one third of their length. In no instance was more than one seen to issue from a single follicle. The circumpallial muscular band is very slender and narrow. No coloring matter was observed in or about the follicles. The mantle edge was brownish, and seemed to have a slightly villous epithelium. No setellæ, such as I have elsewhere described as existing on the setæ of *Discina* and *Lingula*, were to be found.

I did not observe any noticeable peculiarity in the perforations of the shell-structure. The "suture" or breaking point, described by Messrs. Jeffreys and Carpenter in *W. cranium*, exists in all the species with a reflected loop, and is due to the deposition of the shelly matter of the loop in laminæ parallel with the longer axis of the shell, which makes the loop weaker at the point of reflection than elsewhere.

Subfamily PLATIDIINÆ.

Platidiinæ Dall, Am. Journ. Conch., VI, p. 142, 1870.

Genus PLATIDIA Costa.

Platidia O. G. Costa, Faun. del Reg. Napoli, p. 47, January, 1852. — Dall, Am. Journ. Conch., VI, p. 142, 1870.

Morrisia Davidson, An. Mag. Nat. Hist., p. 371, May, 1852, and the generality of authors.

Platidia anomioides Scacchi sp.

Terebratula anomioides Scacchi; Phil. Moll. Sicil., II, p. 69, pl. xviii, fig. 9, 1844.

Platidia anomioides Costa, l. c.; Dall, Am. Journ. Conch., VI, p. 143, figs. 20, 21, 1870.

This species was dredged off the Samboes on the Florida coast in two hundred and thirty-seven fathoms. This is the second genus (*Crania* being the other) of Brachiopoda which has been added to our fauna by the researches of the United States Coast Survey Expedition. It has since been obtained by Mr. J. Gwyn Jeffreys, F. R. S., of the English Deep-Sea Dredging Expedition on the Porcupine, in 1869, in the Shetland Channel, at a depth of three hundred and forty-five fathoms. Previously this species had only been known as an inhabitant of the Mediterranean in deep water. The specimen from the Florida coast presents no differences in size or general appearance from the Mediterranean form. The calcareous prisms of which the shell is composed, and the perforations, are remarkably large and conspicuous.

Subfamily MEGATHYRINÆ Dall.

Megathyrinæ Dall, Am. Journ. Conch., VI, p. 143, 1870.

Argiopidæ King, Perm. Foss., p. 142, 1850.

Shell with a straight wide hinge line; apophyses consisting of a submarginal loop, attached to the hinge margin, provided with crura and intersected by one or more submarginal elevations or septa.

Brachia in a single series, following the loop, surrounding a smooth disk or membrane, in the posterior median portion of which the mouth is situated. Setæ absent from the mantle edge. Pedunculated.

Genus MEGATHYRIS D'Orb.

Megathyris D'Orbigny, Pal. Fran. Ter. Cret., p. 147, 1847. — Dall, Am. Journ. Conch., VI, p. 144, 1870.

Argiope Deslongchamps, Mém. Soc. Lin. Norm., VII, p. 9, 1842.

Not *Argiope* Savigny, Desc. de l'Égypte, XXII, p. 334, 1827. — Thorell, Ann. Mag. Nat. Hist., p. 190, 1868; a genus of spiders.

It has been stated by some authors that Savigny's name was *Argyope* or *Argyopes*, and hence not synonymous with *Argiope*, Desl.; but this is an error, which a reference to Thorell's paper, or to the original work of Savigny, will enable any one to correct.

SUBGENUS CISTELLA GRAY.

Cistella GRAY, B. M. Cat., p. 114, January, 1853. — DALL, l. c. p. 145.
Zellania MOORE, Proc. Som. Arch. Nat. Hist. Soc., 1854.

Shell with a single submarginal septum and bilobed loop. Surface smooth or radiately ribbed. Brachia deeply emarginated by the septum. Cardinal process absent or inconspicuous.

Type *Cistella cuneata* RISSO sp., 1826.
Habitat: living in the Mediterranean.

Cistella (? Schrammi var.) rubrotincta.

?? *Argiope Schrammi* (var.) CROSSE and FISCHER, Journ. de Conchyl., XIV (3me Ser. VI), p. 269, pl. viii, fig. 6, 1866. = *Cistella Schrammi* DALL, Am. Journ. Conch., VI, p. 146, 1870.

West of Tortugas, 30 to 43 fathoms, January 14, 1869, Pourtalès. Guadaloupe, W. I., 200 to 250 fathoms, Crosse and Fischer.

Shell small, semicircular, with the area at right angles to the plane of the hæmal (dorsal) valve. Hæmal valve rather flat, with about ten pale yellow rather strong ribs with brilliant scarlet interspaces; a slight depression externally may be noticed on the surface of the valve, and occasionally an attempt at a median rib, near the margin. Interior whitish, marked by the punctations which are clearly visible to the naked eye in a good light. Margin smooth, except for the fimbriated appearance caused by the incomplete marginal perforations which are visible as grooves under a lens. Hinge line straight, without area, hinge plate, or distinct cardinal process. Septum triangular, extending from the hinge margin to the anterior border of the shell. Most elevated point, forming the apex of the triangle in the middle of the valve, rather bulbous and of a red color. Anterior slope of the septum to the border of the shell, straight without nodules; this part of the septum is thin and even. Posterior slope of the septum irregularly concave, thick, and nodulous, tapering to a point at the hinge margin. On either side of the septum below its apex is a transverse wing or plate at right angles to the septum, of a thick nodulous form, the two wings, taken together, presenting a heart-shaped plate with the broad end downward. These extensions, however, are not confluent with the valve, except close in by the base of the septum. Apophyses attached to the hinge margin, provided with rather broad crura pointing toward each other horizontally; the lower edges of the laminæ of the apophyses confluent with the shell throughout its entire length, and attached to the septum a short distance in front of the transverse plate, and running up on the sides of the thin part of the septum for a short distance. Area behind the laminæ much thickened for the muscular impressions, excavated beneath the lower edges of the transverse septal plate. Hinge margin as wide as the shell, deeply grooved for the reception of the teeth of the neural valve.

Neural valve convex, with a straight hinge margin and broad area. Foramen usually much eroded; deltidia rudimentary, widely separated; hinge teeth strong. Interior of the valve with a low well-marked septum, rounded, broadest near the middle of the valve, where its upper edge is somewhat excavated; extending from the edge of the foramen to the anterior border of the shell, where there is a slight indentation. Length of the shell .15 inch, width .18 inch.

This shell, of which a moderately large series was obtained, has a general resemblance in form to *C. Schrammi*, but has a greater number of ribs, wants the smooth mesial area, and is of a totally different coloration, being scarlet with pale yellow ribs, while *Schrammi* is figured of a rufous brown, paler on the beaks. There are some discrepancies between the figure and the description of *C. Schrammi*, and, in spite of the apparent differences, I do not feel confident that the shells before me, and those described by Crosse and Fischer, are more than varieties of one species. The form of the septum and the transverse lamina at once separate the Coast Survey shells from any other species, but of *C. Schrammi*, unfortunately, the apophyses are not figured. I have, therefore, indicated the present form under a provisional varietal name, which will serve to distinguish it until more exact knowledge is attained. I should add that the scarlet color is not distributed in solid rays, but, under a lens, appears in concentric lines transverse to the ribs and broadest in the interspaces.

The examination of the soft parts of this species added nothing new. It appeared to resemble the next species in every particular. The ovaria were three-branched in the neural valve. The size and extent of the transverse plate of the septum varied in different specimens.

Cistella (? Barrettiana var.) lutea.

? ? *Argiope Barrettiana* DAV., P. Z. S., February, 1866, p. 103, pl. xii, fig. 3. = *Cistella Barrettiana* DALL, Am. Journ. Conch., VI, p. 146, 1870.

? ? *Argiope Antillarum* CROSSE and FISCHER, Journ. de Conchyl., XIV (3me Sér. VI), March, 1866, p. 270, pl. viii, fig. 7. = *Cistella Antillarum* DALL, Am. Journ. Conch., VI, p. 146, 1870.

Tortugas, 30 – 43 fathoms, POURTALÈS. Northeast coast of Jamaica, 150 fathoms, BARRETT, DAV. Guadaloupe, W. I., 200 – 250 fathoms, CROSSE and FISCHER.

Shell uniform light brownish-white; with twelve principal radiating ribs on each valve, and secondary riblets between them, toward the margin. Neural valve with a more or less marked depression extending from the beak to the anterior margin, where it forms a slight convexity. Corresponding to this internally is a slight rounded ridge. Hinge line straight, sides and anterior margin slightly rounded. Area flat, smooth, as wide as the shell. Pseudo-deltidia large, triangular, widely separated. Foramen very large and usually much eroded. Hinge teeth moderately large and strong. Muscular impressions very posterior, hidden beneath the area when viewed from above. Margin slightly crenulated. A few faint striæ discernible upon the surface of the ribs. Hæmal valve smaller, flatter, with a straight hinge line slightly emarginated in the middle, no area or cardinal process; teeth and sockets large and strong. Septum large and stout, composed of three or four radiating ribs, with thin shelly matter between them, forming nodules and notches on the upper edge; the whole of a subtriangular form somewhat resembling a half-opened fan. Posterior edge slightly concave, reaching a little behind the middle of the shell; anterior edge reaching the anterior margin of the shell, which is here slightly concave or emarginated, giving the valve a somewhat bilobed appearance. Muscular impressions much thickened, forming two rather concave disks. Apophyses consisting of two hæmal bands attached to the hinge margin, first with two broad crura pointing toward the median line, the arms of the apophyses extending in a rounded curve within the middle third of the shell, and attached by their lower edges to the thick disk-like muscular scars, and, lastly, to the septum on each side about its middle, close to the shell. Cardinal plate, or hinge plate, absent. Area behind the muscular disks somewhat excavated.

The anterior portion of the apophyses is more posterior than in *C. Neapolitana*, and the margin is not granulated as in that species. It would seem from Mr. Davidson's figures that the loop of *Cistella Barrettiana* Dav., is more anterior than in this species; the latter being also unprovided with the posterior extension of the septum seen in the figures of the former, and being, moreover, entirely destitute of the red markings between the ribs. It agrees with *C. Antillarum* Crosse and Fischer, as figured in general appearance, but wants the red markings attributed, in the description, to that species, and the ribs are also carried over the apex, while that portion of *C. Antillarum* is described as smooth. No comparisons can be drawn in regard to the apophyses, as Crosse and Fischer did not figure those of their species. It is possible that the present species, *C. Antillarum* and *C. Barrettiana* are forms of one species, in which case the last name has priority, or it may be that the two latter are distinct from the present species, though synonymous with each other; but they should not, as M. Crosse observes in a letter on the subject, be united until clear proofs are shown of identity, and therefore I have proposed for the present form a provisional varietal name, which may serve to distinguish it until the question is settled by the comparison of specimens. My largest specimen measured .26 inches wide by .18 long.

Small as is this species, it is considerably larger than those of the Mediterranean, and it was with much interest that I submitted it to an anatomical examination.

I have not met with much success among these small species in the use of acid in dissolving away the shell from the animal, and have been principally obliged to work with specimens forcibly removed from their shells, — a process which is not calculated to present the parts in the best condition. Nevertheless, I have been able to determine some points of interest in a satisfactory manner.

The brachia in this and the other species of the genus are arranged around the edge of a broad membrane, which covers the concavity of the shell, like a drumhead. The hoop of the drum is represented by the apophyses. The brachia differ from the same organs in the *Terebratulinæ* in being arranged in a single series instead of a double one. Of this there can be no doubt, it is very evident upon a casual inspection, and is entirely confirmed by careful dissections. In this species the drumhead membrane is divided into two lobes by the septum. The edges of these lobes are fringed with the brachia. The latter, in the alcoholic specimens, show distinct transverse markings. They are usually curled up in front and on each side, while those which are situated behind the mouth are longer than the others, and usually lie smoothly over them, extending forward without any marked curve, pointing toward the anterior margin of the shell, and extending clear over the central membrane, even beyond the posterior edge of the septum. The brachia are covered with an epithelium furnished with cilia, are tubular, and communicate with a series of brachial channels, which did not appear to differ from those of *Waldheimia* as described by Hancock, as far as I was able to discover. The great brachial canal was rendered conspicuous by a band of cartilaginous substance which seemed to form its external covering, or rather beneath which it was situated, and which was longitudinally striated. The external edge of the membranes, between which the apophyses were formed, was directly attached to the pallial lobes at the points where the apophyses are attached to the muscular disks of attachment already described. On either side of this attachment, however, was a kind of pocket, opening externally, where the brachial and pallial membranes did not coalesce; and, there being one on each side of the point of union, there were consequently four in all, two on each side of the septum.* The drumhead membrane, covering the space inside of the brachia, was translucent white or opalescent, and quite thick and tough toward the middle of each lobe.

I am inclined to think that an error has been perpetuated in regard to the position of the mouth of *Megathyris decollata*. It has been figured and described by Woodward as being of a circular form, and situated in the midst of the drumhead membrane. It is certainly not so situated in *Cistella;* and I do not believe that it is in *Megathyris*, though I have only seen dry specimens. In the present species it is placed, as in all the *Terebratulidæ*, at the back of this membrane, just in front of the posterior junction of the brachia, and at the bottom of a deep transverse groove which is of a stout membranous consistency, and the two sides of which, for convenience' sake, I have called the lips (*labia*). In the present species the oral groove is situated far back and close to the brachia, which are exceptionally long behind it, as already described. It is, in fact, entirely hidden by them until they are laid back. The groove is very long and quite deep, the entrance to the œsophagus being trumpet-shaped and flattened transversely. Were the brachia disposed as in Woodward's figure, the oral groove would be hidden. I am disposed to think that this was really the case in the specimen figured, and that the extraordinary circular mouth there figured was an accidental lesion of the dry tissues, which might easily be taken for a mouth in so small an animal. The labia, in all the Brachiopods I have examined so far, have invariably exhibited a tinge of darker color than the surrounding tissues. The present case forms no exception. The posterior lip presents a small prominence in the median line, and the anterior lip a small emargination or concavity below this prominence. This structure is also common to all the Brachiopods I have examined.

The œsophagus is wide, transversely flattened, with thin walls, and of an orange color. It enters the stomach nearly at a right angle, without much dilation. The stomach is oval with thicker and firmer walls; the inner lining appearing slightly villous and rugose. The intestine is not differentiated from the stomach on the lower side, but on the upper side a deep groove occurs at the juncture. The canal is stout and thick at its lower extremity, tapers slightly, and terminates in a somewhat bulbous, but pointed cæcal extremity, attached to the perivisceral membrane. The various membranous bands which support the alimentary system present no differences from the homologous structures in other species of the *Terebratulidæ*. The stomach was filled in each case with a yellowish flocculent matter. The hepatic lobules resembled those of other species, entering

* There is but one on each side, close to the hinge margin, in the last species.

the stomach by two ducts on each side, of which the anterior were the larger. They did not extend over or cover the sides of the intestine.

The heart is extremely small and difficult to find. It is situated lower down than in most species and between and hidden by the hepatic lobules. It is nearly spherical. No accessory pulsatile vesicles were found after close scrutiny.

The ovaries differ in appearance from those of *Waldheimia* and *Terebratulina.* They hang like a frill or puckered ribbon-like lamina from the pallial membranes, and form a simple loop on each side of each valve. Those of the hæmal (dorsal) valve were most developed. The ends of the loops extended into the great pallial sinuses. The rounded granules which studded the frills were of two kinds. Those at or near the extreme edge were of a pellucid deep brown hue, while those closer to the pallial membranes were mostly of a pale yellowish color and quite opaque. The oviducts are very inconspicuous and not easily found. They are situated in the usual position, but exhibit only a very few short folds, and the external opening directly in the midst of them, instead of being at the end of a rather long duct, as in other forms. There are only two of them. They do not appear to be attached to the intestine or mesenteries, but lie flatly upon the parietes.

The pallial sinuses are comparatively insignificant in this species, being very narrow, almost linear, channels with few branches. A few spiculæ were observed in some of them. The margin of the mantle is perfectly plain, without setæ, and adhering closely to the shell. Yet the circumpallial muscular band is much broader than usual and strongly marked. When torn from the shell, the cæcal prolongations of the mantle were beautifully shown. They were often bifurcate and occasionally had three or even four branches.

The punctate structure of the shell was very coarse. Even the crura and laminæ of the apophyses were punctate.

The nervous system was not traced out, but the œsophageal ganglia presented no special peculiarities.

The border of the mantle appeared to be ciliated. The peduncle, so wide and short as to resemble a mere muscular disk, was strongly attached to the shell by the peduncular muscle, beside which a broad tendinous band appeared to pass entirely across, in front of the dorsal adjustors (posterior retractors of Owen), giving an additional solidity and firmness to the attachments of the peduncle. The extremities of all the muscles were very much enlarged and thickened, while their median portions were slender and tendinous. No striated fibres were observed.

ORDER LYOPOMATA OWEN.

Syn. = *Lyopomata* OWEN, Enc. Brit., Ed. VIII, XV, Article *Mollusca*, p. 339, 1858.

= *Brachiopodes, valves libres* DESHAYES, LAMK., An. s. Vert., 2^{de} Ed., VII, p. 309, 1836.

= *Palliobranchiata, testa acardis* VAN DER HŒVEN, Handb. der Zoöl., p. 692, 1850.

= *Pleuropygia* BRONN, Klass. Ordn. Thierr., III, 1 Abth., p. 301, 1862.

= *Inarticulata* HUXLEY, Lect. Class., 1864. Intr. Class. Anim., p. 116, 1869.

>< *Pedunculata* + *Sessilia* LATREILLE, Fam. Nat. Règ. Anim., p. 204, 1825.

< *Brachiopodes brachidés* D'ORBIGNY, Cours. Élém. Pal., II, p. 82, 1849.

< *Sarcicobrachia* GRAY, Ann. Mag. Nat. Hist. 2d Ser. II, p. 438, 1848.

Characters. Arms free, unsupported by shelly apophyses. Intestine opening by a lateral anus. Lobes of the mantle disunited all around their borders. Brachia without a distinct median lobe. Shell, in most cases, without hinge teeth, articulation, or cardinal process.

FAMILY CRANIIDÆ.

Syn. = *Craniidæ* H. and A. ADAMS, Gen. Rec. Moll., II, p. 583, 1858. — JEFFREYS, Brit. Conch., II, p. 24, 1863.

= *Cranidæ* OWEN, Anat. Inv. Index, p. 683, 1855. — D'ORBIGNY, Cours Élém. Pal., II, p. 90, 1849.

= *Cranidées* D'ORBIGNY, Pal. Fran. Ter. Crét., IV, 1844.* Comptes Rendus, XXV, p. 269, 1847. An. Sci. Nat. c. xiii, p. 350, 1850* (fide GRAY, B. M. Cat.).

= *Craniadæ* GRAY, Syn. Brit. Mus., p. 155, 1840.* — IBID., l. c., p. 88, 1842. P. Z. S., p. 202, 1847. Ann. Nat. Hist., 2d Ser., II, p. 438, 1848. — DAVIDSON, Int. Class. Brach., p. 51, 1851. — WOODWARD, Man. Rec. and Foss. Shells, p. 235, 1854. — OWEN, Anat. Inv., p. 503, 1855. — CLARK, Brit. Test. Moll., p. 37, 1855. — GOSSE, Mar. Zoöl., II, p. 80, 1856. — DAVIDSON, Mem. Lin. Soc. Norm., X, p. 84, 1856. — SUESS, Wohns. der Brach., p. 38 (220), 1859. — MRS. GRAY'S Moll., IV, p. 202, 1859. — CARPENTER, Lect. Moll. Smithsonian Rep., p. 276, 1860. — CHENU, Man. de Conchyl., II, p. 230, 1862. — BRONN, Klass. Ordn. Thierr., III, 1 Abth., p. 301, 1862.

= *Craniadées* DAVIDSON, Mém. Soc. Lin. Norm., X, p. 226, 1856.

< *Les Cranies* FÉRUSSAC, Tabl. Syst., folio 38, 1819. — RANG, Man. Moll., p. 262, 1829. — DESHAYES, Enc. Méth., II, Table, 1830. Hist. An. s. Vert., 2^{de} Ed., VII, p. 309, 1836.

< *Craniæ* HERRMANNSEN, Ind. Gen. Mal., I, p. 315, 1846 (as of FÉR. RANG, and DESH).

≺ *Craniaceæ* MENKE, Syn., p. 56, 1828,* olim.

≺ *Craniacea* MENKE, Syn., Ed. II, p. 96, 1830. — ANTON Verz., p. xii, 1839. — AGASSIZ, Nomencl. Fasc. IX, p. 31, 1846. — MŒRCH, Cat. Yoldi, p. 64, 1852.

≺ *Craniidæ* FORBES, Mal. Mon., p. 38, 1838.* — KING, Ann. Nat. Hist., XVIII, p. 28, 1846. Perm. Fos., p. 78, 1850.

≺ *Craniadæ* FORBES and HANLEY, Brit. Moll., II, p. 364, 1853.

≺ *Les Orbicules* CUVIER, Leçons d'Anat. Comp. An. VII, I, t. 5, 1798* (fide GRAY). Règne An., II, p. 504, 1817; Tabl. El. Hist. Nat., p. 435, 1799.

≺ *Athyridæ* McCOY, Carb. foss. Irel., p. 104, 1844.

≺ *Orbiculæ* HERRMANNSEN, Index Gen. Mal., II, p. 156, 1847 (as of DESHAYES).

≺ *Les Ostracées* LAM., Phil. Zool., 1809.* (Ed. 1830, p. 317.)

≺ *Placunea* RAFINESQUE, Anal. Nat., p. 148, 1815.

≺ *Fixivalvia* LATREILLE, Fam. Nat. Règn. An., p. 205, 1825. (Ed. Berth, p. 196.)

≺ *Palliobranches à coquilles non symmétriques* BLAINVILLE, Man. Mal., p. 515, 1825.

≺ *Terebratulidea* G. B. SOWERBY, Trans. Lin. Soc., XIII, p. 469, 1822.

Shell calcareous; hingeless; without perforation for a pedicel; attached by the umbones of or the entire lower valve, or rarely free. Upper valve suborbicular, with a subcentral apex. Lower valve subcircular or pyriform. Four principal muscular impressions in each valve. Shell structure punctate. Animal with free spiral arms, the direction of the apex of the spires toward the concavity of the upper or hæmal valve. Mantle extending to the edge of the valves, closely adhering, without setæ upon its external edge. Animal holding the same relation to the attached valve which obtains in the *Terebratulidæ*, but actually reversed in relation to surrounding objects, on account of the attachment being by the surface, instead of by the recurved apex, of the neural valve.

SYNOPSIS OF THE FAMILY.

Genus *Crania* RETZ: Shell attached; upper valve with the muscular impressions usually excavated, but occasionally convex, without apophyses of any kind, inner surface vaulted, without septa; impressions of the pallial sinuses flabelliform, separated in front. Margin of the valves tuberculose or papillose. Type *Crania cranioloris*, Lin. sp. Syst. Nat., Ed. XII, p. 1150, 1767.

?? Subgenus *Pseudocrania* McCOY. Shell free, with the impressions of the pallial sinuses fimbriated and confluent in front. Margins smooth. Anterior muscular impressions larger than the posterior ones. Type *Crania* *antiquissima* Eichwald, sp. McCoy, Annals Nat. Hist., VIII, p. 388, 1851. The value of this section is doubtful.

Subgenus *Cranopsis* Dall. Attached; upper valve with two pointed slender apophyses divaricating from the internal apex, where the muscular impressions of the anterior pair are situated in the typical *Craniæ*. Type *Crania Parisiensis*, Defrance, Davidson, Mém. Soc. Lin. Norm., X, pl. xiii, fig. 23 a, b, 1856.

Genus *Craniscus* Dall. Fixed valve divided by a transverse and a longitudinal septum into three cells, the posterior of which contains the muscular impressions and the rostrellum. Type *Crania tripartita* Munster, sp. Davidson, l. c fig. 21.

It is extraordinary that the two sections here indicated have not been separated previously, and indicates that this group has received little attention from modern authors. The differences between the genera *Crania* and *Craniscus* are fully as great as any existing between the acknowledged genera of the *Terebratulidæ;* and the characters of *Cranopsis*, as separated from *Crania*, are well marked. The genus *Spondylobolus* of McCoy appears to have rather more affinity with the *Lingulidæ* than with this group, as I have elsewhere observed, and it is not included here for that reason.

The genus *Pholidops* Hall appears congeneric with *Pseudocrania* McCoy. It is known principally from casts, however, and further researches may establish its validity.

Genus CRANIA Retz.

Non binomial syn. *Ostracites minimus . . . numulus Brattensburgensis dictus* Stobæus, Act. Lit. Sci. Svec., pp. 14 and 21, 1731 * (fide Retz.), and Opuscl. I, p. 31, Tab. 1, figs. 1–3, 1752.

Helmintholithus craniolaris Linné, Syst. Nat., XII, III, p. 162, 1768.

Anomites craniolaris Brattensburgenses et Ignaburgensis Wahlenberg, Act. Upsala, 1821 * (fide Bronn).

Nummuli Brattenburgenes Waller, Syst. Min., II, p. 500, 1775.

Criopus fimbriatus + *Criopoderma* (*turbinatum*) [taken collectively] pars, Poli, Test. utriusq. Sicil., I, p. 34, 1791; II, pp. 189, 255, 261, 1795 (fide G. W. Tryon, Jr.

Ostracites minimus, &c. Beuth, Jul. et Mont. subt., p. 130, 1776.

Actual syn. = *Crania* Retzius, Schrift., Berl. Ges. Naturf. Freunde, Bd. II, p. 72, 1781. — Philippson (?), Diss. Hist. Nat., p. 11, § v, No. 1, 1788. — Schröter, Lith. Lex., IV, p. 265, 1785. —Bruguière, Enc. Méth. Vers., I, tabl. p. xiii, 1789. — Defrance, Dict. Sci. Nat., XI, p. 312, 1818. — G. B. Sowerby, Gen. Shells, fasc. XII, n. d., 1821 (?). Trans. Lin. Soc., XIII, p. 431, 1822. — Hœninghaus, Isis, p. 108, 1822 * (fide Engelman). — Nilsson, Kong. Vet. Ak. Handl., p. 378, 1824. Act. Holm., p. 326, 1825.*

Petref. Suec., p. 37, 1827. — GRAY, Ann. Phil., XXVI (N. Ser. X), p. 244, 1825. — MENKE, Syn. Ed. II, p. 96, 1830. — PHILIPPI, Moll. Sicil., p. 100, 1836.* — GRATELOUP, Cat. Zool., p. 55, 1838.*— MORRIS, Cat. Brit. foss., p. 121, 1843. — LOVÈN, Index Moll. Scand., p. 29, 1846. — KING, Ann. Nat. Hist., XVIII, p. 28, 1846. IBID., Perm. Foss., p. 84, 1850. — SOWERBY, Thes. I, p. 366, 1847. — JAY, Cat. Shells, Ed. IV, p. 94, 1850. — DAVIDSON, Int. Class, Brach., p. 122, 1853. — FORBES and HANLEY, Brit. Moll., II, p. 365, 1853. — OWEN, Anat. Invert., p. 503, 1855. — CLARK, Brit. Test. Moll., p. 27, 1855. — DAVIDSON, Mém. Soc. Lin. Norm., X, pp. 24, 226, 1856. — GOSSE, Mar. Zoöl., II, p. 30, 1856. — H. and A. ADAMS, Gen. Rec. Moll., II, p. 583, 1858. — BRONN, Klass. Ordn. Thierr., III, 1st Abth. p. 302, 1862. — CHENU, Man. de Conchyl., p. 230, 1862.— DAVIDSON, Mon. Sil. Brach., p. 78, 1866. — JEFFREYS, Brit. Conch., II, p. 24, 1863; V, p. 165, 1869 (RETZ. non PHILIPPSON, as asserted by Jeffreys). — HALL, Pal. New York, IV, p. 26, 1870.

= *Cranie* LAMARCK, Phil. Zool., Ed. 1830, p. 317; Ed. I, 1809.*

> *Crania* LAMARCK, Prodr., p. 83, 1799.* — MEGERLE v. MUHLFELDT, Entw. Syst. Schaalh., 1811* (fide SCHUM.). — LAMARCK, Hist. An. s. Vert., 1ère Ed. VI, p. 237, 1819. — FÉRUSSAC, Tabl. Syst., p. xxxviii, 1821. — GRAY, Lond. Med. Repos., 1821 * (fide HERRM.). — BLAINVILLE, Man. Mal., p. 515, 1825. — RANG, Man. Moll., p. 262, 1829. — DESHAYES, Enc. Méth. Vers, II, C, p. 15, p. 553, Tab. acéph., 1830. — LAMARCK, Hist. An. s. Vert., 2de Ed. VII, p. 297, 1836. — THOMAS BROWN, Conch. Textb., Ed. V, p. 108, 1839. — MACGILLIVRAY, Ibid., Ed. IX, p. 123, n. d. — THORPE, Brit. Mar. Conch., p. 125, 1844. — CUVIER, Règne An. Moll. Ed. Deshayes, p. 251, 1845. — QUENSTEDT, Handb. Petref., p. 494, 1852. — WOODWARD, Man., p. 236, 1854.

> < *Crania* SCHUMACHER, Essai, p. 37, 1817.

> *Crania α*, SCHUMACHER, Essai, p. 101, 1817.

Not *Crania β*, SCHUMACHER, Essai, p. 102, 1817. = *Discina*.

Not *Crania* GOULD, Moll. U. S. Expl. Exped., p. 465, 1852. = *Discina*, sp.

= *Craniolites* SCHLOTHEIM, Petref., p. 247, 1820.

= *Cranicella* RAFINESQUE, Analys. Nat., p. 148, 1815.

= *Orbicula* CUVIER, Tabl. Élém. Hist. Nat. p. 435, 1798; and Règne An., 1ère Ed., p. 504, 1817. Règne, An. Moll., Ed. Deshayes, p. 250, 1845. — LAMARCK, Hist. An. s. Vert. I, VI, p. 242, 1819.

> < *Orbicula* LAMARCK, Hist. An. s. Vert., Ed. II, VII, p. 313, 1836.

> *Orbicula* LAMARCK, Prodr., 1799.* — BOSC., Hist. Nat. Coq., II, p. 243, 1801. — LAMARCK, Syst. An. s. Vert., p. 140, 1801. — CUVIER, An. Mus., I; Mém. sur la Lingule, p. 9, 1802. — SCHUMACHER, Essai, pp. 55, 176, 1817. — DESHAYES, Enc. Méth. Vers., III, p. 668, 1832 (not tabl. 2, p. 553, 1830).

= *Orbicula* sp. EICHWALD, Sil. Schicht. Syst., p. 169, 1840; Urwelt, Russl., I, p. 98, 1840; II, p. 75, 1842.

= *Orbiculoidea* sp. RYCKHOLT, Mélanges Pal., pl. iv, fig. 3* (fide DAVIDSON, Intr., p. 128).

> *Orbicularius* Duméril, Zoöl. Analyt., p. 168, 1806.

= *Discina* sp. Turton, Dith. Brit., p. 238, 1822 (Gen. diag. exclus.).

= *Anomia* sp. Linné, Syst. Nat., Ed. X, I, p. 700, 1760; Ed. XII, p. 1150, No. 216, 1767. — Gmelin, Syst. Nat., p. 3340, 1792. — Chemnitz, Conchyl. Cab., VIII, p. 72, 1785. — Schröter, Einl., III, p. 381, 1778.* — Poli, Test. utriusq. Sicil., II, p. 189, 1795. — Dillwyn, Cat. Shells, I, pp. 285, 286, 1817.

= *Anomites* sp. Davidson, Mém. Soc. Lin. Norm., X, p. 226, 1856, in syn. (not of Linné, Syst. Nat., 1768).

= *Patella* sp. O. F. Müller, Prodr. Zool. Danica, p. 237, No. 2870, 1776; Zoöl. Danica, I, p. 4, 1788. — Gmelin, Syst. Nat., p. 3721, 1792. — Montague, Trans. Lin. Soc., XI, p. 195, 1808. — Humphrey (ubi? fide Sby. and Rve). — Koch and Dunker, Beitr. Oöl.-Geb., p. 51, 1837. — Rœmer, Verst. Oöl.-Geb., p. 135, 1840.

= *Terebratula* (part) Schweigger, Naturgesch., p. 690, 1820* (fide Gray, An. Phil., 1825).

= *Producta* ? sp. Klipstein, Beitr. Ost. Alp., VIII, pp. 60, 239, 1843.

= *Siphonaria* sp. Quenstedt, Handb. Petref., I, p. 442, 1852!

= *Numulus* Agassiz, Nomencl. fasc., IX, p. 60, 1846.

= *Siphonotreta* sp. Eichwald, Zoöl., I, p. 274, 1829* (fide Bronn l. c.)

= *Criopododerma* Agassiz, Nomencl. Ind., p. 301, 1848 (corr. Poli).

= *Criopus* Gray, Lond. Med. Repos., 1821* (fide Herrm., Agassiz) — Fleming, Phil. Zool., II, p. 499, 1822, and Brit. An., pp. 367, 377, 1828. — King, Perm. Foss., p. 84, 1849. — Leach (Gray), Moll. Gt. Brit., p. 358, Dec. 1852.

= *Cryopus* Deshayes, Hist. An. s.Vert., VII, p. 314, 1836.

Shell with or without a more or less produced beak and false area in the lower valve. The two posterior muscular impressions are near the cardinal border, and usually larger and more widely separated than the two anterior scars. The latter are near the centre of the valves, and in the lower valve are confluent in front, or barely separated by a small nose-like prominence, or *rostellum*, which is usually excavated at its most elevated extremity for the attachment of a muscle, which at its other end is attached near the cardinal border of the upper valve between the post-adductor scars; the shelly matter being slightly produced on each side of this attachment in some species, forming two slight tooth-like prominences. Margin of the shell more or less tuberculous or papillose. Lower valve differing in position and extent of attachment to extraneous objects. Upper valve conical, with the apex subcentral; internally vaulted, simple, without apophyses or septa. Lower valve without septa or apophyses, unless the rostellum be so considered. Exterior foliated, concentrically or radiately striate, or smooth. Great pallial sinuses leaving more or less flabelliform or paucidigitated impressions on the shelly matter, which impressions are not confluent anteriorly.

Soft parts with two spiral arms in the horizontal plane, with the apices of the spires directed toward the concavity of the lower valve. Intestine terminating between the lobes of the mantle on the (? right) side.

The genus as described by Retzius, was founded on several species which he confounded together under the name of *Crania Brattensburgensis.* Under this name he included the "*Ostracites minimus . . . Numulus Brattensburgensis dictus*" of Stobæus, the *Anomia craniolaris* of Linné, and a recent species said to be from the Philippines, but probably the same previously described by Müller under the name of *Patella anomala*, from the Scandinavian seas.

The question now arises as to which of these shall be taken as the type of the genus, and shall therefore retain the specific name given by Retzius. With regard to this authors have differed, and the result has been a confusion only equalled in the generic synonymy of this unfortunate group. Most of them have transferred the *C. Brattensburgensis* of Retzius to the synonymy of the recent species (*C. personata* Lam.), overlooking the fact that Lamarck's name has not priority, and ignoring Müller's name entirely, though it preceded that of Retzius. On the other hand, they have placed the *Numulus Brattensburgensis* of Stobæus in the synonymy of *C. nummulus* Lam., with the *Anomia craniolaris* of Linné, which in its turn is long prior to that of Lamarck. This disregard of priority by the earlier authors has always been a fruitful cause of confusion and annoyance to subsequent students. As Retzius evidently had the species described by Stobæus in his mind as the species of which he supposed he was describing the recent form, I think that the only course left for us is to accept Stobæus' species as the type. Schumacher, in his Essai (p. 102), says that Retzius had sent him specimens of the two species which he had described, and that the *C. Brattensburgensis* Retz. was a fossil. Now most, if not all, authors agree that Stobæus' species was identical with *Anomia craniolaris* of Linné, which is identified by Hanley and others with the *Crania nummulus* of Lam., which of course becomes a synonyme. Stobæus was not a binomial author, and Linné's name being the first binomial appellation, his specific name must stand. Lamarck, also, in adopting the genus *Crania* (Prodrome, p. 83, 1799), took *Anomia craniolaris* as the type.* Schröter, Gmelin, and Dillwyn, as well as Chemnitz, continued to confound the recent and fossil species under the name of *craniolaris*. Müller, in 1776, was the first author to describe the European form, under the name of *Patella anomala*, with a correct habitat, and it afterwards received from Poli the specific name of *turbinata*, though not in a binomial sense.

* Woodward also adopts it as the type, and Davidson, under the specific name of *Brattensburgensis*

The synonymy of the type, according to these views, will stand as follows:—

Crania craniolaris Lin. sp.

Non-binomial synonymy. *Ostracites minimus parasiticus calvarium hominis utcunque referens, numulus Brattensburgensis dictus* K. Stobæus, Diss. epist. Act. Litt. et Sci. Svec. pp. 14–21, figs. 1, 2, 1731 * (Retz., l. c. p. 74, 1781). Opuscl., p. 31, t. 1, figs. 1, 2, 1752.

Anomites craniolaris Brattensburgensis Wahlb., Act. Ups., VIII, p. 60, 1821 * (fide Bronn, Ind. Pal.).

Concha testa planiore orbiculata cranium humanum referente Linné, Fauna Svecica, p. 384, No. 1347, t. 2, fig. 1347, 1746 (a later edition is probably referred to in the Syst. Nat. l. c.)

Helmintholithus (anomiæ) craniolaris Linné, Syst. Nat., Ed. XII, III, p. 164, 1768.

Ostracites minimus sive ostracites numismalis Beuth, Jul. et Mont. subt., p. 130, t. 7, No. 46, 1776.

Actual synonymy. *Anomia craniolaris* Linné, Fauna Svecica, 2150, fig. 2150, Ed. II, 1761. Syst. Nat., Ed. X, t. 1, p. 700, No. 183, 1760. Syst. Nat., Ed. XII, t. 1, pt. II, p. 1150, No. 216, 1767. — Gmelin, Syst. Nat., t. 1, pt. VI, p. 3340, No. 1, 1792, partly (+ *C. anomala* + *turbinata* part). — Chemnitz, Conchyl. Cab., VIII, p. 72, t. 76, pars, 1785. — Dillwyn, Cat., I, p. 285, No. 1, 1817. — Hanley's Conchyl. Lin., p. 119, 1855.

Crania Brattensburgensis (pars) Retzius, Schrift. Berl. Ges. Naturf. Freunde, Band II, p. 73, 1781 (fig. excl ?) (+ *C. anomala* part ?). — Schumacher, Essai, p. 101, 1817.

Crania nummulus Lamarck, Hist. An. s. Vert., Ed. I, t. 6, p. 238, No. 2, 1819. — Lamarck, Hist. An. s. Vert., Ed. II, t. 7, p. 299, No. 2, 1836. — Hœninghaus, Mon. Crania, p. 5, No. 5, figs. 5 *a*, *b*, *c*, 1828. — Deshayes, Enc. Méth. vers, II, C, p. 17, 1830, &c., &c.

Crania personata part, Lamarck, Hist. An. s. Vert., Ed. I, VI, p. 238, 1819. Not *C. personata* of Lamarck, Ed. II, VII, p. 299, 1836.

This species is found fossil in Sweden, where Stobæus and Linné obtained their specimens, and the lower valves, furnishing a rude imitation of a face stamped on a coin, were sufficiently common to obtain the popular designation of Brattensburg money, or pennies. According to Deshayes and Sowerby, it presents the peculiarity of being attached by only a small portion of its lower valve. This, however, is a character of slight importance. I have omitted all the other ostensible synonymes of *craniolaris* Lin. and *nummulus* Lam., because I have not had the opportunity of certainly identifying them, and therefore have preferred to retain only those of which there was no doubt whatever. In order to render the matter more clear and throw as much light as possible upon the subject, I subjoin the synonymy of the second species described by Retzius.

Crania Egnabergensis Retz.

Non-binomial syn. *Numulus minor rarissimus oculi et naso prominentibus e lapicidina Egnabergensi in Gothungia* K. Stobæus, l. c. figs. 3, 4 * (fide Retz., l. c.). Opusc., p. 31, t. 1, figs. 3, 4.

Anomites cranioloris Ignabergensis Wahlb., Act. Ups., VIII, p. 60, 1821 * (fide Bronn, Ind. Pal.).

Actual syn. *Crania Egnabergensis* Retz., l. c. p. 75, t. 1, figs. 4–7, 1781. *Crania striata* Defrance, Dict. Sci. Nat., Vol. XI, p. 315, 1818. — Lamarck, Hist. An. s. Vert., VI, p. 239, 1819; Ed. II, VII, p. 301, No. 5, 1836. — Deshayes, Encyc. Méth., II, C, p. 19, No. 9, 1830 (not *C. striata* Schum.).

Found fossil at Balsberg and Charlottenlund in Scania. It is well distinguished from the preceding species by its radiating ribs.

The recent species, which may be referred to the genus *Crania*, are as follows: —

Crania Suessii Rve., Mon. Crania, pl. i, fig. 2, 1862. Sydney, Australia.

Crania rostrata Hœninghaus, Mon. Crania, p. 3, No. 3, fig. 3, 1828. — Rve., Conch. Icon., pl. i, fig. 3, 1862. — Deshayes, An. s. Vert., Ed. II, Vol. VII, p. 302, 1836. (Syn. exclus.) Mediterranean, W. Africa?

I have received a Mediterranean specimen of this species from Mr. Davidson; it may also extend along the northwest coast of Africa, as stated by Reeve. Deshayes' synonymy is very erroneous, and includes both *turbinata* and *anomala*.

Crania (?? Cranopsis) japonica A. Adams, Ann. Mag. Nat. Hist., 3d Series, XI, p. 100, 1863. Gotto Island, Japan, 71 fms.

And the following: ** —

Crania anomala Müll. sp.

A. Typical. Syn. *Patella anomala* Müll., Prodr. Zool. Dan., p. 237, 2870, 1776. Zool. Dan., I, p. 4, t. 5, figs. 1–8, 1788. — Gmelin, Syst. Nat., p. 3721, No. 151, 1792.

Patella distorta Mont., Trans. Lin. Soc., XI, p. 195, pl. xiii, fig. 5, 1808. — Flem., Edin. Encyc., VII, 65, t. 204, fig. 4.

Patella Kermes Humphrey * (ubi?) fide Sby., Tr. Lin. Soc. — Rve., Conch. Icon. Mon. Crania, sp. 4, 1862.

Anomia craniolaris (pars) Chemn., VIII, p. 72, t. 76. — Gmelin, Syst. Nat., p. 3340, No. 1, 1792. — Dillwyn, Cat., I, p. 285, 1817 (not of Linné).

Anomia turbinata Dillwyn, Cat., I, p. 286, 1817. Polii syn. exclus.

Criopus anomalus Fleming, Phil. Zoöl., II, p. 499, 1822, and Brit. An. p. 377, 1828.

** I have separated the synonymy of the var. (?) *turbinata*, in order that those who consider it a good species may make use of the synonymy, but I myself consider it as a strict synonyme of *anomala*.

Criopus orcadensis LEACH (GRAY), Moll. Gt. Brit., p. 358, pl. xiii, figs. 6–8, December, 1852.

Orbicula norvegica LAMARCK, Syst., p. 140, 1801 (not SBY., Lin. Tr. and Gen. Sh., RANG, Man., nor BLAINVILLE, Man., p. 515). — LAMARCK, Hist. An. s. Vert., Ed. I, Vol. VI, p. 242, 1819. Ibid., Ed. II, Vol. VII, p. 316, No. 1, 1836. — DESHAYES, Enc. Meth., III, p. 668, 1832, partly (+ *turbinata*, part). — SCHUMACHER, Essai, p. 176, pl. xxi, fig. 2, 1817. — THOMAS BROWN, Conchol. Textb., Ed. V, p. 107, pl. xiv, fig. 32 (no such figure there), 1839. — MACGILLIVRAY, Ibid., Ed. IX, p. 123, pl. xiv, fig. 32 (same remark applies), n. d. — DE BLAINVILLE, Dict. Sci. Nat., XXXVI, p. 292, 1825, partly (+ *Discina ostreoides*, part).

Orbicula anomala CUVIER, Tabl. Élém. de l'Hist. Nat., p. 435, 1799, and Règne An., II, p. 504, 1817; Ed. Desh. Moll., p. 251, 1845, partly (+ *turbinata*, part).

Discina ostreoides TURTON, Dith. Brit., p. 238, 1822 (not of LAM.).

? *Crania Brattensburgensis*, part, RETZ., Schrift. Berl., Ges. Naturf. Fr., Band II, p. 73, 1781 (+ *craniolaris*, part).

Crania turbinata WOOD's Ind. Test., Ed. HANLEY, pl. xi, fig. 2, 1856 (not *turbinata* POLI).

Crania personata, part, DEFRANCE, Dict. Sci. Nat., XI, p. 312 (+ *turbinata*, part), 1818.

Crania personata LAMARCK, Hist. An. s. Vert., Ed. I, VI, p. 238 (syn. exclus.), 1819. Ibid., Ed. II, VII, p. 298 (syn. excl.), 1836 (not *personata* BLAINV., Dict. Sci. Nat. Cah. V, figs. 2–9, fide DESHAYES, l. c. pr.). — SOWERBY, Trans. Lin. Soc., XIII, p. 431, 1822. Gen. Sh. Fasc., XII, figs. 1 and 2, n. d. (1821 ?). — BLAINVILLE, Dict. Sci. Nat., XXXII, p. 304, 1824. Ibid., Man. Mal., p. 515, 1825.** — NILSSON, Kong. Vet. Ak. Handl., Part II, p. 324, partly, 1825* (fide Fér. Bull. Sci. Nat. + *craniolaris* part). — THOMAS BROWN, Conch. Textb., Ed. V, p. 108, pl. xiv, fig. 5, 1839. — MACGILLIVRAY, Ibid., Ed. IX, p. 123, pl. xiv, fig. 5, n. d. — SUESS, Wohns., I, p. 41 (223), 1859.

Crania norvegica SOWERBY, Thes. Con., I, p. 368, pl. 73, figs. 15 and 17, 1847. — FORBES and HANLEY, Brit. Moll., I, pl. U, fig. 2, 1853.

Crania rostrata THORPE, Brit. Mar. Conch., p. 125, 1844 (not of HOENINGHAUS).

Crania anomala SOWERBY, Conch. Man., Ed. II, p. 125, fig. 197 *a*, 1842. — LOVÈN, Index Moll. Scand., p. 29, 1846. — FORBES and HANLEY, Brit. Moll., II, p. 366, pl. lvi, figs. 7 and 8, 1853. — DAVIDSON, Int. Class. Brach., p. 123, figs. 44–46, pl. ix, figs. 237, 238. — WOODWARD, Man. Moll., p. 235, figs. 157–159, 1854. — CLARK, Brit. Test. Moll., p. 37,

** I do not know whether Deshayes refers in his cited remarks to these two references also, but there is nothing in the context to indicate the Mediterranean form (*turbinata*), and the reference of Blainville is to *C. personata* Sowerby, which is undoubtedly *anomala*.

1855. — GOSSE, Marine Zoöl., II, p. 80, fig. 120, 1856. — DAVIDSON, Mém. Lin. Soc. Norm., X, p. 229, pl. xiii, figs. 14-16, 24, 32, 33, 35, 36, 1856. — H. and A. ADAMS, Gen. Rec. Moll., II, p. 583; III, pl. cxxxii, figs. 3, 3 *a*, 3 *b*, 1858. — SUESS, Wohns., I, p. 39 (221), 1859. — CHENU, Man. Conchyl., II, p. 230, figs. 1178, 1862. — REEVE, Conch. Icon. Mon. Crania, pl. i, fig. 4, 1862. — JEFFREYS, Brit. Conch., II, p. 24, pl. i, fig. 3, 1863; V, p. 165, pl. xix, fig. 6, 1869

Hab. North European seas.

B. var. *turbinata* POLI.

Anomia turbinata POLI, Test. Utrius. Siciliæ, II, p. 189, 261, t. 30, fig. 15, 1795, in synonymy. — DILLWYN, Cat., I, p. 286, No. 2, 1817, in part (+ *anomala*, part).

Anomia craniolaris (part) GMELIN, Syst. Nat., p. 3340, 1792. — DILLWYN, Cat., I, p. 285, No. 1, 1817 (+ *craniolaris* part).

Criopus fimbriatus (part) POLI, Test. Utrius. Sic., II, p. 189, 1795. "Hab. in *Anomia turbinata*" POLI, l. c. (animal).

Criopoderma turbinatum POLI, II, p. 261, No. 1, 1795 (shell).

Patella anomala DILLWYN, Cat., I, p. 286, in syn.

Orbicula turbinata LAMARCK, Hist. An. s. Vert., Ed. II, VII, p. 317, 1836.

Crania personata BLAINVILLE, Dict. Sci. Nat., XI, p. 312; XXXII, p. 304, pl. lxxxiv, fig. 2, Cah. xv, 1818 (not of LAM., Hist., Ed. II, VII, p. 299, note, fide DESHAYES (?). Cf. previous note, p. 33).

Crania personata DESHAYES, Encyc. Méthod., II, C, p. 16, 1830; partly; (+ *anomala* part, per citation of RETZ.).

Crania ringens HŒNINGHAUS, Mon. Crania, p. 3, No. 2, fig. 2. — DESHAYES, Encyc. Méth., II, p. 16, No. 3, 1830. — LAMARCK, Hist. An. s. Vert., Ed. II, VII, p. 302, 1836. — SBY., Thes., I, p. 367, pl. lxxiii, figs. 10, 11, 1847. — SUESS, Wohns., I, p. 41 (223), 1859.

Crania rostrata DESHAYES, Hist. An. s. Vert., Ed. II, VII, p. 302, No. 7, 1836; partly (+ *anomala* and *rostrata* part).

Not *Crania rostrata* HŒNINGHAUS, Mon. Cran., p. 3, No. 3, fig. 3, 1828. — RVE., Icon., pl. 1, fig. 3, 1862.

Hab. Mediterranean.

C. var. *alba* JEFFREYS.

Crania anomala var. *alba* JEFFREYS, Brit. Conch., V, p. 165, 1869.

Hab. Shetland, Hebrides.

The shell of *Crania anomala* is rounded, with a slight tendency toward a squarish form. The posterior border of the valves is nearly straight, and Barrett, who examined living specimens, asserts that the two valves open and shut on this edge, like the sides of a hinge. Upper valve sub-conical or depressed, with the apex not prominent and rather posterior. External surface smooth in normal specimens, or slightly marked with concentric lines of growth. Internally rather smooth, with coarse and conspicuous punctation. The margin of the valves is rough, and presents under a glass conspicuous calcareous prisms, radiating from the centre of the shell. The muscular impressions are very variable in shape and position as well as prominence. The color is usually a livid reddish-brown, with occasional white rays. The extreme nucleus of the shell is mammillated. The lower valve varies in thickness according to the object upon which it rests. If the latter be smooth and level, it is often very thin and almost imperceptible, so that Müller was not without justification in overlooking it. The margin is usually rough or tuberculose, and the muscular impressions vary as in the upper valve.

The variety *alba* of Jeffreys is pure white, or occasionally with a few radiating brown lines, but does not differ otherwise from the normal form. From specimen figures and descriptions of *C. turbinata*, I have been unable to discover any characters which are not common to varieties of *C. anomala*. I agree with Mr. Jeffreys in thinking *C. ringens* Hœninghaus, to be synonymous with *anomala* on general considerations, but I have seen no typical specimens of *ringens*.

The few specimens of *Crania* dredged by the United States Coast Survey Expedition (off the Sambos, Florida, in 116 fathoms, and off the Sand Key in 105 fathoms) offer some apparently constant differences from *C. anomala*. They are somewhat distorted, very transverse, and have obscure indications of radiating rugosities. The shells are smaller than *C. anomala*, have a strong concentric foliation caused by the imbrication of the lines of growth. The color is much the same as in *anomala*; one white specimen with a few radiating brown lines was dredged on a stone in 126 fathoms, off Sand Key, by M. de Pourtalès. The interior of the lower valves was of a green color. The posterior muscular impressions are smaller and closer together than in *C. anomala*. It is very possibly, however, a strongly marked variety of that species; but in case the collection of a larger number of specimens should prove its distinctness, I would propose for it the name of *C. Pourtalesii*.

Note. — Not having personally been able to examine Poli's Test. Utriusq. Siciliæ, I have been indebted to the kindness of Mr. George W. Tryon, Jr., for examining the work for me. It is evident to any one who appreciates the binomial system of nomenclature, that Poli was in no sense binomial. He named the animal generically and specifically, while the shell received two additional names, making four in all, if we take them together, involving the absurdity of the animal being a different genus and species from its shell.

The references of Poli given below, from Mr. Tryon's notes, are as follows: —

Vol. I, p. 34. "Genus 15, *Criopus*," description of animal as follows: "Habitat in *Anomia imperforata*."

Vol. II, p. 189. "*Anomia turbinata*," description of shell follows, and to it is added a description of the animal as "*Criopus fimbriatus*."

Vol. II, p. 255, a Table of Genera contains: —

Genus 18. *Criopus* (animal). Genus 18. *Criopoderma* (shell).

Species 1. *Criopus fimbriatus*, "Habitat in *Anomia truncata* et *capite serpentis* LIN.; in *Anomia turbinata*."

Vol. II, p. 261. List of species: —

1. *Criopoderma turbinatum*. *Anomia turbinata*.
2. *Criopoderma truncatum*. *Anomia truncata*.
3. *Criopoderma caput serpentis*. *Anomia caput serpentis*.

Plate 30, fig. 15, *Anomia turbinata*.

Poli evidently considers *Anomia* as a synonyme, and only uses it by way of explanation. It is evident that such a system of nomenclature as the above can never be fairly squared with the binomial system.

FAMILY DISCINIDÆ.

Syn. = *Discinidæ* GRAY, Syn. Brit. Mus., I, p. 155, 1840.* Ibid., p. 88, 1842. P. Z. S., p. 202, 1847. Ann. Mag. Nat. Hist., II, p. 439, 1848. — DAVIDSON, Int. Class. Brach., pp. 51, 125, 1853. — WOODWARD, Man. Rec. and Fos. Sh., p. 237, 1854. — DAVIDSON, Mém. Lin. Soc. Norm., X, p. 84, 1856. — H. and A. ADAMS, Gen. Rec. Moll., II, p. 584, 1858. — MRS. GRAY'S Moll., IV, p. 202, 1859. — SUESS, Wohns., I, p. 42 (224), 1859. — CARPENTER, Lect. Moll., Smithsonian Rep., p. 276, 1860. — BRONN, Klass. Ord. Thierr., III, I Abth. p. 301, 1862.

= *Discinidées* DAVIDSON, Mém. Lin. Soc. Norm., X, p. 231, 1856.

= *Orbiculacea* ANTON, Verzeichn., p. 21, 1839 * (fide HERRM.).

= *Orbiculidæ* KING, Ann. Mag. Nat. Hist., XVIII, p. 28, 1846. — OWEN, Anat. Inv., p. 503, 1855. — CHENU, Man. de Conchyl., II, p. 231, 1862.

< *Orbiculina* AGASSIZ, Nomencl. Index, p. 757, corr. praec. 1848 (not LAM., gen. Rhizop.).

< *Orbiculidæ* D'ORBIGNY, Cours Élém. Pal., II, p. 89, 1849.

< *Les Orbicules* CUVIER, Leçons d'Anat. Comp., I, t. v, 1798 * (fide GRAY). — Règne An., II, p. 505, 1817.

= *Orbicules* DESHAYES, Encyc. Méth., II, table, 1830. Ibid., LAM., Hist. Nat. An. s. Vert., Ed. II, Vol. VII, p. 309, 1836.

= *Orbiculidæ* McCOY, Carb. fos. Ireland, p. 104, 1844.

< *Orbiculæ* HERRMANNSEN, Ind, II, p. 156, 1847, as of DESH.

< *Craniadæ* FORBES and HANLEY, Brit. Moll., II, p. 364, 1853.

< *Les Cranies* FÉRUSSAC, Tabl. Syst., folio 38, 1819. — RANG, Man. Moll., p. 262, 1829.

≲ *Craniaceæ* MENKE, Syn., Ed. I, p. 56, 1828, olim.*

< *Craniacea* MENKE, Syn., Ed. II, p. 96, 1830. — AGASSIZ, Nomencl. Fasc., IX, p. 31, 1846. — MOERCH, Cat. Yoldi, p. 64, 1852.

< *Craniæ* Herrmannsen, Ind. Gen. Mal., I, p. 315, 1846 (as of Rang., Fér., and Desh.).

< *Brachiopea* Rafinesque, Anal. Nat., p. 148, 1815.

< *Palliobranches à coq. non symmetriques* Blainville, Man. Mal., p. 515, 1825.

< *Fixivalvia* Latreille, Syst. Règn. An., p. 205, 1825 (Ed. Berth, p. 196).

< *Terebratulidea* G. B. Sby., Trans. Lin. Soc., XIII, p. 469, 1822.

Characters. Shell structure permeated with very minute tubuli. Shell attached to foreign bodies by a pedicel passing through the neural valve, inarticulated. Valves suborbicular, with a subcentral apex. Animal with free spiral arms, with the apices of the spires directed toward the neural valve. Mantle extremely vascular, fringed with long chitinous setæ furnished with setellæ.

Synopsis of the Family.

Genus *Discina* Lam. Type *D. striata* Schumacher sp. 1817.

Subgenus *Discina, sensu stricto.* Shell with subequal externally convex valves, with subcentral apices. Lower valve with a small subtriangular longitudinal septum or prominence in the centre, with a minute circular orifice beneath it, for the peduncle, from which an impressed line or furrow extends on the inside, posteriorly, for a short distance. Shell of rather solid texture, impunctate; perforated by very minute tubuli (?). Type *D. striata* Schum., = *D. radiosa* Gld., + *D. Evansii* Dav., + *D. norvegica* Sby., + *D. ostreoides* Lam.

Subgenus *Orbiculoidea* D'Orbigny,* = *Schizotreta* Kutorga.† Shell similar to the last, but with the perforation at the posterior end of the furrow, which last is impressed from the outside, instead of from the inside as in *Discina.* Type *Orbiculoidea elliptica* Kutorga. Dav., Int., p. 129, pl. ix, figs. 253 - 255, 1852.

Subgenus *Discinisca* Dall, = *Discina* Auct. Lower valve more or less flattened, concave or compressed. Upper valve more convex; apices of both subcentral or subposterior. Lower valve with a small septum as in *Discina,* behind which is an impressed disk or area, externally concave, and internally elevated. This is perforated by a longitudinal fissure, extending from a short distance behind the septum nearly to the posterior margin, which is often slightly indented behind it. Shell more or less horny in texture, minutely tubulous. Type *Discina lamellosa* Brod. Rve., Conch. Icon., pl. i, fig. 4, 1862.

Genus *Trematis* Sharp.‡ — *Orbicella* D'Orbigny.§ Shell with the upper valve with a posterior apex and small false area. Lower valve flattened, with a

* Comptes Rendus, XXV, p. 269, 1847.

† Verh. Kais. Min. Ges., 1847.

‡ Quart. Journ. Geol. Soc., No. 13. Vol. IV., p. 66, June, 1847.

§ Comptes Rendus, XXV, p. 269, August, 1847.

large foramen extending nearly to the posterior border. Shell structure in two layers, the outer calcareous and sculptured with a peculiar netlike sculpture resembling perforations; inner layer horny, minutely tubulous, as in *Discina*. Type *Orbicula terminalis* CONRAD, in Nat. Hist. New York, Part IV, Geology (EMMONS), p. 395, fig. 4, 1842.

I am not prepared at present to admit *Siphonotreta* and *Acrotreta* into this family, but am inclined to think, with Kutorga, that they form a peculiar group by themselves.

Keyserlingia Pander (Bull. Ac. Sci. St. Petersb., III, p. 46, 1861, Type *K. reversa* Pand., pl. ii, fig. 1, *a – g*), appears to have relations with *Trimerella* or *Gotlandia*, or perhaps with *Siphonotreta*, but its position is at present doubtful.

Rarity of specimens and errors in identifying types are probably the reasons of the confusion of forms existing in this unfortunate family.

GENUS DISCINA LAM.

Syn. = *Discina* GRAY, Ann. Phil., XXVI (New Ser., X), p. 244, 1825. Ibid., transl. Isis, p. 494, 1834. Syn. Brit. Mus., p. 155, 1840,* and p. 88, 1842. — DAVIDSON, Int. Class. Brach., pp. 51, 126, 1853. — WOODWARD, Man., p. 237, 1854. — DAVIDSON, Mém. Soc. Lin. Norm., X, p. 84, table, p. 232, 1856. — H. and A. ADAMS, Gen. Rec. Moll., II, p. 584, 1858. — MRS. GRAY'S Moll., IV, p. 202, 1859. — SUESS, Wohns., I, p. 42 (224), 1859. — CARPENTER, Lect. Moll., Smithsonian Rep., p. 276, 1860. — HALL, 13th Regent's Rep., p. 77, 1861. — BRONN, Klass. Ordn. Thierr., III, 1st Abth., p. 301, 1862. — HALL, 14th Regent's Rep., p. 130, 1864. — Pal. N. Y. Vol. IV, Part I, p. 15, 1870.

> *Discina* LAMARCK, Hist. An. s. Vert., VI, p. 236, 1819; Ed. II, VII, p. 296, 1836. — RANG, Man. Moll., p. 263, 1829. — CUVIER, Règne An. Ed. Voigt, III, p. 602.* — THOMAS BROWN, Conch. Textb., Ed. V, p. 108, 1839. — MACGILLIVRAY, Ibid., Ed. IX, p. 124, n. d.

= *Crania* β SCHUMACHER, Essai, p. 102, 1817.

= *Crania* (sp.) GOULD, Moll. U. S. Expl. Exped., p. 465, 1852.

= *Orbicula* SOWERBY, Min. Conch., VI, p. 4, pl. 506, 1830. — DESHAYES, Enc. Méth. vers, II, tab. aceph., 1830 (not Ibid., III, p. 668, 1832). — G. B. SOWERBY, JR., Conch. Man., Ed. II, p. 209, 1842. — MORRIS, Cat. Brit. foss., p. 123, 1843. — KING, An. Mag. Nat. Hist., XVIII, p. 28, 1846. — SBY., Thes., I, p. 365, 1847. — MŒRCH, Cat. Yoldi, p. 64, 1852. — OWEN, Anat. Invert., p. 503, 1855. — CHENU, Man. Conchyl., II, p. 231, 1862.

= *Orbicula* (sp.) LAMARCK, Hist. An. s. Vert., Ed. II, pp. 317, 318, 1836. — EICHWALD, Urwelt Russl., II, p. 76, 1842.

> < *Orbicula* LAMARCK, Phil. Zoöl. (Ed. 1830, p. 317), Ed. I, 1809.* — SOWERBY, Gen. Sh. fasc. XIII, n. d. (1821). Trans. Lin. Soc., XIII, p. 466,

1822. — BLAINVILLE, Dict. Sci. Nat., XXXII, p. 304, 1824. Ibid., XXXVI, p. 291, 1825. — DEFRANCE, Ibid., XXXVI, p. 293, 1825.

= *Patellites* (sp.) SCHLOTHEIM, Petref., I, p. 114 ; II, p. 108, 1820 – 1823.

= *Patella* (sp.) BRONGNIART, Tabl. des Terr., p. 419, 1829.

= *Calyptræa* (sp.) GOLDFUSS, Alberti, Betr., Mon. Trias, pp. 54, 93, 1831 * (fide BRONN, Ind. Pal.).

= *Terebratula* pars, SCHWEIG., Naturg., p. 690, 1820 * (fide GRAY, An. Phil.).

Not *Orbicula* CUVIER, Tabl. Élém. R. An., p. 435, 1798. — LAMARCK, Hist. An. s. Vert., I, VI, Part I, p. 242, 1819. — DESHAYES, Enc. Méth. Vers, III, p. 668, 1832. — SCHUMACHER, Essai, p. 55, 1817. — THOMAS BROWN, Conch. Textb., p. 107, Ed. V, 1839, nor MACGILLIVRAY, Ibid., Ed. IX, p. 123, n. d. (= *Crania*).

SUBGENUS DISCINA (LAM.) DALL.

Shell of rather solid texture, with a considerable amount of calcareous matter in it ; no signs of punctation to be seen with a half-inch objective. Valves convex, the lower valve varying in amount of convexity with its habitat, but always more or less inflated. A small, sharp, longitudinal septum rises from the centre of the lower valve, of a subtriangular shape, covering and hiding a small tubular perforation of the apex of the shell. This perforation is very oblique, and from its internal opening a groove extends backward nearly half-way to the posterior border of the shell inside. The anterior muscular scars meet in front of the septum and form a semilunar elevation with the points directed backward. The posterior scars in the lower valve are small and widely separated. On the external surface the foramen appears nearly in the middle of the shell, and the furrow is continued *anteriorly* for a short distance. (There is no furrow in my specimens outside *behind* the foramen, which is the only point of difference from Sowerby's figures.)

Upper valve convex, apex subcentral; a slight median longitudinal callus internally. There is no strongly impressed disk about the foramen as in *Discinisca*, though slight traces of a differentiated area exist there.

Type **Discina striata** SCHUM. sp.

Syn. *Crania* (β) *striata* SCHUMACHER, Essai, p. 102, pl. xx, figs. 1 *a – f*, 1817 (not of DEFRANCE). Habitat ?

Crania radiosa GLD., Moll. U. S. Expl. Exped., p. 465, figs. 480, *a – c*, 1852. Hab. Cape Palmas, Liberia, not Rio.

** Not *Orbicula striata* Sby., in Murch. Silurian Syst., tab. v, fig. 21, 1839, and Siluria, pl. xx, fig. 3, 1859. This species is perhaps identical with *Discina Verneuilii* Dav., 1848; but if it should prove distinct, it must have a new name, as that of Schumacher has many years' priority. It occurs in the upper Ludlow rocks of Shropshire, and the *D. Verneuilii* in the Wenlock limestone of England.

Orbicula striata SOWERBY,** Thes. Conch., I, p. 366, pl. lxxiii, fig. 9, 1847. — FORBES and HANLEY, Brit. Moll., II, p. 368, 1853. — DAVIDSON, An. Mag. Nat. Hist., IX, p. 376, 1852. Habitat ?

Orbicula Evansii DAVIDSON, P. Z. S., 1852, p. 81, No. 12, pl. xiv, figs. 32 - 34. An. Mag. Nat. Hist., IX, p. 376, 1852. — SUESS, Wohns., I, p. 44 (226), 1859. Hab. Bodegas, Cal., in error.

Orbicula norvegica SOWERBY, Trans. Lin. Soc., XIII, p. 468, pl. xxvi, fig. 2, 1822. Syn. exclus.; Gen. Shells, fasc., XIII, figs. 3 - 5, n. d. (1821 ?), (not. of LAM.). Ballast, North Africa.

Orbicula (s. g. *Discina*) *norvegica* BLAINVILLE, Dict. Sci. Nat., XXXII, p. 304, 1824. Man. Mal., p. 515, pl. lv, fig. 5, 1825 (not of LAMARCK).

Orbicula (s. g. *Discina*) *ostreoides* RANG, Man. Moll., p. 263, 1829.

Orbicula ostreoides REEVE, Conch. Icon. Mon. Orb., No. 7, pl. 1, figs. 7 *a*, 7 *b*, 1862.

Discina ostreoides LAMARCK, Hist. An. s. Vert., Ed. I, VI, p. 237, 1819. Ibid., Ed. II, VII, p. 297, 1836 (no description). — THOMAS BROWN, Conch. extb., Ed. V, p. 108, pl. xiv, fig. 8, 1839. — MACGILLIVRAY, Ibid., Ed. IX, p. 124, pl. xiv, fig. 8, n. d.

Not *Discina ostreoides* TURTON, Dith. Brit., p. 238, 1822 (= *Crania anomala*).

Discina norvegica CROUCH, Int. Lam. Conch., pl. xiii, fig. 2 * (fide FORBES and HANLEY, II, p. 368).

Patella anomala SOWERBY, Trans. Lin. Soc., XIII, p. 468, 1822, in synon. (not of MÜLLER).

When changes in nomenclature depend upon the identification of types described by the earlier authors, the work is one of great difficulty, and requires the utmost caution, lest fresh confusion be the result. In many cases an approximation to a determination alone can be arrived at, and authors may conscientiously differ as to the decision, and its bearings on nomenclature. In the present case, however, there is but little difficulty, as the species under consideration has been well described and carefully figured by the describers, though under several names; the history of the type specimens is very clear, and was put on record at the time.

Lamarck constituted the genus *Discina* to receive a shell which he called *D. ostreoides*, but of which he did not give any figure or specific description. The specimen was received from Mr. J. Sowerby, and is the same species and from the same lot of specimens, as the shell described by Mr. G. B. Sowerby in the Lin. Transactions, and well figured by him there, under the name of *Orbicula norvegica*. His very excellent figure enables me to speak with positiveness in saying that it is identical with *Crania radiosa* Gould, of which the type specimens are before me. The figures of Schumacher are sufficiently exact to allow of identifying the species with his *Crania striata*. The figures given by Reeve and Davidson are excellent, and almost certainly represent the same species, though this is a matter of little consequence, the main point being the identification of Sowerby's shell with the specimens before me, which may be regarded as certain. The habitat of the species is undoubtedly African, the localities "Rio," "Bodegas," etc., being erroneous.

The fact of the type being settled, only one course remains, — to rearrange the genus in accordance with the facts. Objections may, and probably will, be raised against such rectifications, but accuracy being the aim and basis of all science, nothing else is worth regarding, and rectifications, however long delayed, are inevitable at last.

The species has been well described by various authors, and there is nothing further in regard to it for me to add. The catalogue number of Dr. Gould's types, in the Smithsonian Cabinet, is 5962. They were obtained at Cape Palmas, West Africa. The exceedingly minute foramen hidden beneath the septum might well excuse Dr. Gould for calling it a *Crania*. I am not aware of any other species of true *Discina* in a recent state, but there are several species usually denominated *Discina*, with which I am unacquainted autoptically.

There are no species of *Orbiculoidea* or *Trematis* known in a recent state.

The following species of *Discinisca* have been found living. I have examined only those after which an exclamation-point is placed.

Discinisca stella ! GOULD, Proc. Bost. Soc. Nat. Hist., VII, p. 323, Sept., 1860. — REEVE, Conch. Icon., pl. 1, fig. 1, 1862.

Singapore and Phillipines. CUMING. China Seas. STIMPSON.

Discinisca lamellosa ! BRODERIP, P. Z. S., 1833, p. 124. — REEVE, Conch. Icon, pl. 1, fig. 3, 1862.

Panama to Peru.

Type of the subgenus. I have examined an immense number of specimens from Panama, and find that they exhibit many varieties. The apex of very young shells is circular, whitish, and of a different texture from the remainder of the shell. This circumstance was first pointed out by Mr. E. S. Morse. The nucleus is probably the remains of the embryonic shell. The species has no radiating striæ, and is a thinner shell than *lævis*.

Discinisca tenuis SBY., Thes., I, p. 366, pl. 73, figs. 4, 5. (not REEVE, Conch. Icon., pl. i, fig. 5, 1862).

Hab. ?

Reeve's figures of "*Orbiculis tenuis*" do not represent Sowerby's species, but agree very well with some of the varieties of *D. lamellosa*. I have seen no specimens of either of the former species, but the figures exhibit discrepancies too great to be reconciled. Sowerby gives no localities, and

Reeve's localities, or one of them, probably refer to the form which he figures. It can hardly, however, be found both in Chili and South Australia, and the double habitat is probably due to an error in labelling or identification.

Discinisca lævis! Sby., Trans. Lin. Soc., XIII, p. 468, pl. xxvi, figs. 1 *a* – *d*, 1822. — Reeve, Conch. Icon., pl. i, figs. 4, *a*, *b*.

Concepcion, Chili. Cuming.

A specimen of this species was received from Peru through Mr. Cuming, labelled *strigata* Broderip.

Discinisca Cumingii! Brod., P. Z. S., 1833, p. 124. — Reeve, Conch. Icon., pl. i, fig. 6, 1862. = *D. strigata* Brod., teste Reeve.

Cape St. Lucas to Panama.

Mr. Reeve's figure offers no characters by which it might be distinguished from the last species. The specimens received under this name from Mus. Cuming cannot be distinguished from *D. stella* Gould, by constant characters.

Discinisca (?) antillarum D'Orbigny, Moll. Cuba, p. 368, pl. xxviii, figs. 34 – 36, 1853. — Reeve, Conch. Icon., pl. i, fig. 2, 1862.

Cuba, Martinique. Cuming.

I have never seen this species, which is stated by Reeve to resemble *D. stella*. It has relations with *D. Cumingii*, and a series should be compared. This species was not obtained by M. de Pourtalès.

Discina (Discinisca ?) atlantica Jeffreys, MSS.

Northeast Atlantic.

I am indebted to Mr. Jeffreys for information in regard to this species, which is on the point of being published in the Proceedings of the Zoölogical Society of London.

The following species of Brachiopods, which were not obtained by the Coast Survey Expedition, are known to inhabit the Caribbean province.

Cistella Woodwardiana Davidson, P. Z. S., Feb. 1866, p. 103, pl. xii, fig. 4, *a*, *b*, *c*.

Northeast coast of Jamaica in 60 fathoms, Barrett.

Thecidium Barrettii Woodward. Davidson, Geol. Mag., I, pl. ii, figs. 1 – 3, 1864. P. Z. S., 1866, p. 104.

With the last-mentioned species.

Glottidia (?) antillarum Reeve, Conch. Icon., pl. ii, fig. 8, 1861.

Martinique. Cuming.

REFERENCES TO PLATES.

Plate I.

Fig. 1. Diagram of *Terebratula vitrea*, natural size.

2. Diagram of *Terebratula cubensis*, natural size.

3. Diagram of *Waldheimia floridana*, natural size.

4. Diagram of *Waldheimia septigera*, natural size.

5. Diagram of *Cistella lutea*, much enlarged, showing the loop, septum, and disk-like muscular attachments.

5 *a*. Side view or section of the same, showing the ribbed septum.

6. Diagram of *Cistella rubrotincta*, much enlarged, showing the interior and the transverse plate of the septum.

6 *a*. Side view of the same.

7 *a*, *b*. *Crania* (? *anomala* var.) *Pourtalesii*, inside and outside of the upper valve much enlarged.

8. Fry of *Terebratula cubensis*, very much magnified: *a*, nucleus of the neural valve with its two pores (*b*); *c*, constricted neck of the valve beyond the nucleus; *d*, thin septum closing the upper part of the foramen; *f*, foramen; *h*, nucleus of the hæmal valve with pores.

It will be observed that, in the closed apical termination, the posterior lamina partly closing the foramen, and the lateral grooves or areas on each side of the latter, this immature form presents characters entirely analogous to those (upon which Professor King has lately based a genus, *Agulhasia*,) exhibited by a species which I am inclined to regard as an immature *Terebratulina*.

9. Soft parts of the same: *a*, horseshoe-shaped membrane; *b*, *f*, muscles; *c*, mouth and bag-shaped stomach, with (*d*) hepatic lobules.

10. Spicule from adult *Terebratula cubensis*, much magnified.

11. Cœcal termination of the intestine of the same, enlarged.

12. Ovaria of *Terebratula cubensis*, enlarged, showing the position with relation to the muscles of the neural valve.

13. Same, in the hæmal valve.

14. Diagram of the parts about the mouth from the side, enlarged: A, nasiform body; B, intercorporeal groove; C, supra-œsophageal body; D, excavation below it and behind the brachia; E, brachia; F, mouth; H, dorsal adjustor muscles (retractors of Owen); I, hepatic lobules; J, heart with vessel; K, side of stomach and intestine, from which the hepatic lobules have been removed, showing the two ducts, by which the lobules communicate with the cavity of the stomach.

15. Diagram of the supra-œsophageal portion of the body from in front,

enlarged: A, dorsal adjustors; B, frilled portion of oviducts, seen as if through the transparent tissues; C, anterior tubular portion of oviducts, terminating externally in (E) the oblique genital foramen; D, D′, upper and lower portions of the nasiform body; F, intercorporeal groove; H, supra-œsophageal body; I, space between the last and the brachia; J, stumps of brachia, cut off to expose the other parts; K, oral groove between the superior and inferior labia; L, mouth, with the median prominence of the superior labium above it; M, median notch or sulcus of the inferior labium (N).

16. Attachments of the free end of the frilled portion of the oviduct, much enlarged: A, free end of right oviduct; B, attachment of the same to the mesentery (E); C, apparent foramen; D, secondary attachment, which appears to be of a tendinous consistency and carries a bloodvessel which enters the oviduct, to all appearance.

Plate II.

Fig. 1. Diagram of the soft parts of *Waldheimia floridana*, much enlarged. In this figure the pedicel, the peduncular muscles, and all the other muscles except the occlusors, have been removed. The posterior parts of the mantle lobes are not represented, as they would cover the parts which it is desired to exhibit. The neural lobe is above and the hæmal lobe below. The pallial sinuses are represented with much more prominence than they actually exhibit. They are really almost invisible and are exceedingly difficult to trace even under a high power, so that their outlines as here given must be regarded as provisional, though they are probably sufficiently accurate. The parts are represented as they appear (with the calcareous matter removed by acid), floating in water, with the peduncular end towards the observer. The small genitalia are suspended in the posterior part of the sinuses. The posterior end of the stomach, with the heart and hepatic lobules, appear between the occlusors. Below them is the fold in which the septum of the hæmal valve extends half-way to the margin between the median sinuses. The oviducts are seen in their proper position. The broad brachial disk, with its appendages so widely separated, is seen through the transparent membranes. The pallial lobes are fringed by the very short close-set setæ, inside of which runs the slender circumpallial muscle.

2. Represents the stomach with its appendages from behind. The hepatic digitations, obscurely divided into lobes, cover the lower portion of the stomach, and above them is seen the heart at the junction of the intestine and stomach. On each side are seen the edges of the oral groove or labia in front.

3. Side view of the same, with the hepatic lobules removed to show the

openings of the ducts. The position of the brachia and labia with regard to the œsophagus, and of the heart, are shown.

4. Diagram of *Cistella* var. *lutea*, representing the animal in the shell, with the long brachial cirrhi behind the oral groove turned back to show the groove and position of the mouth. The other cirrhi are curled up in their natural position.

5. Side view of the stomach, intestine, and hepatic lobules of the same species, with a section of the œsophagus, showing the position of the cirrhi and labia. The heart is seen below, just behind the hepatic lobules.

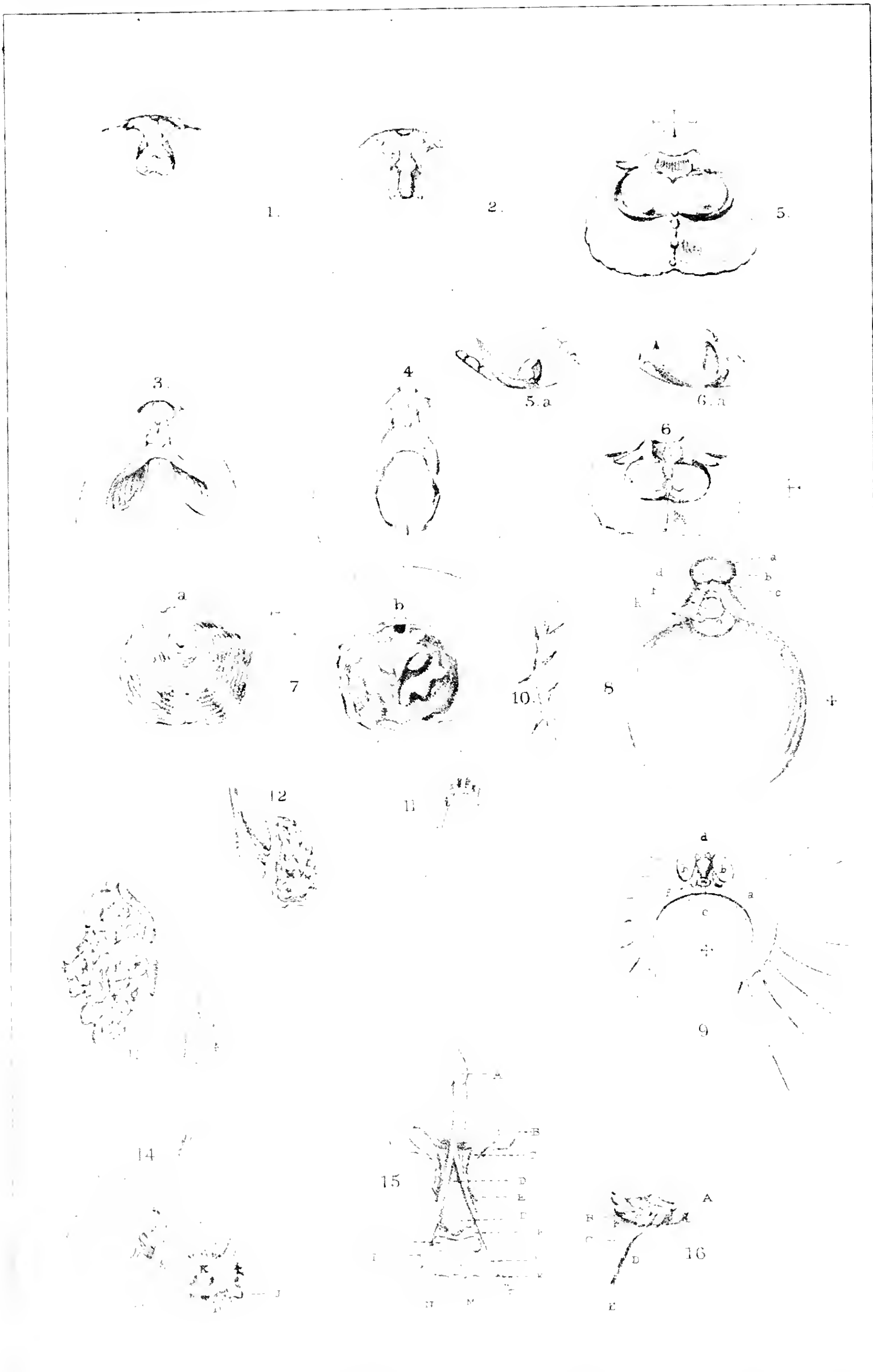
6. Same, with the lobules removed, showing the openings of the ducts, the position of the heart, and the shape of the mesentery in which the intestine is suspended.

7 Genitalia of the same, showing how they are suspended from a ribbon-like lamella, with the ova in various stages upon the edge of it.

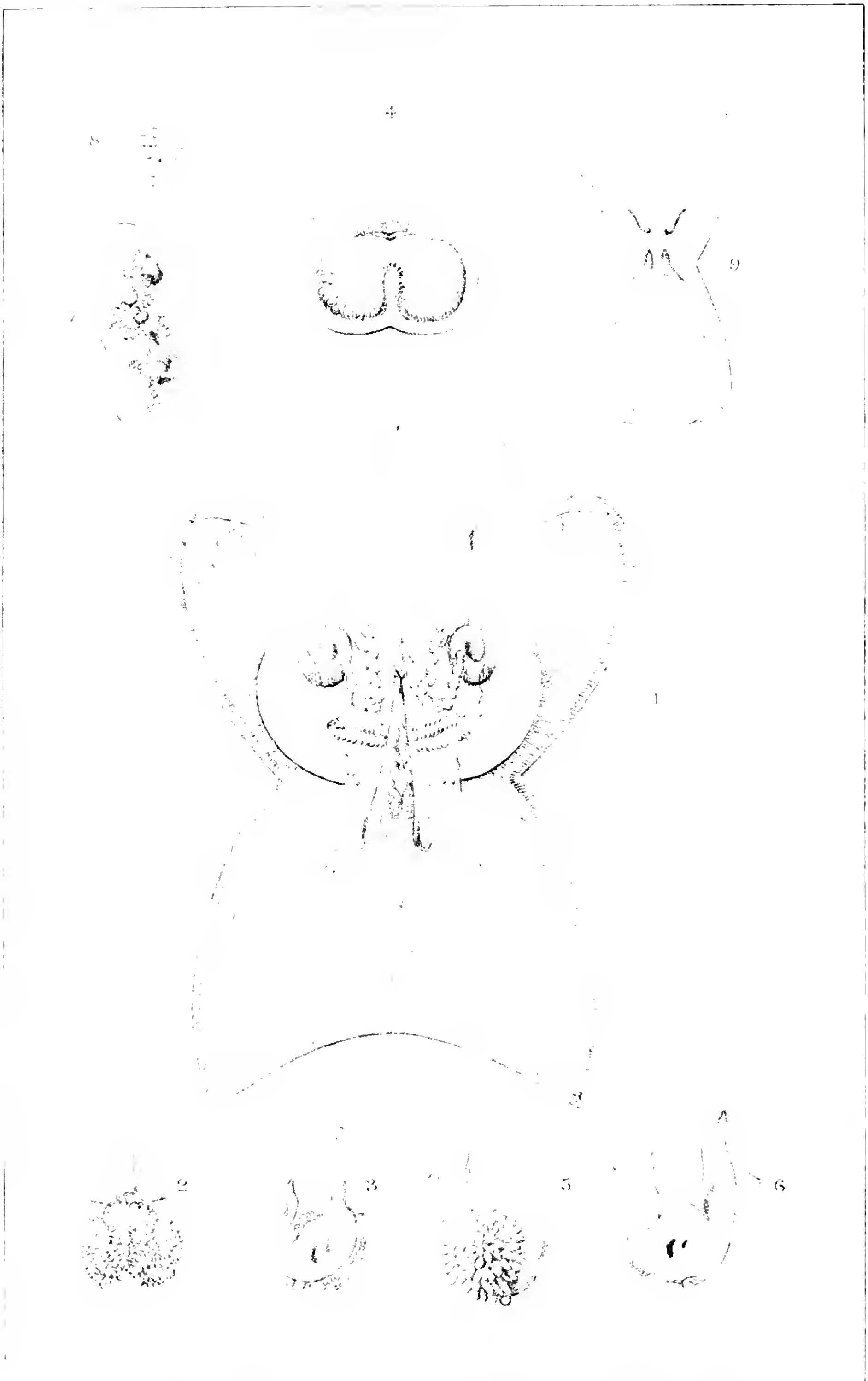
8. Rudimentary folds and simple opening of the oviducts of the same.

9. Diagram of the pallial sinuses of *Waldheimia septigera*, with the ovaria, from a dry specimen. The hæmal lobe is above.

CAMBRIDGE, May, 1871.



BRACHIOPODA



BRACHIOPODA

No. 2.—*Application of Photography to Illustrations of Natural History. With two figures printed by the Albert and Woodbury Processes.*

No attempts have thus far been made to apply the comparatively new processes of carbon printing to general illustrations of Natural History, though excellent figures of microscopic preparations have been printed by carbon processes by Deane, Woodward, and others. The lithographic plates of many memoirs on natural history have been made up with the assistance of photographs, but the want of permanence of the common photographic prints has prevented their use beyond that of auxiliaries to lithography. The rapid progress made in carbon printing by the Woodbury and Albert processes promises to furnish us, within a short time, the means for direct application of photography to illustrations of natural history, and these new methods of printing are likely to replace to a great extent the ordinary lithographic plates.

The accuracy of a photographic illustration is of course far beyond that of an engraving or lithograph, and as soon as a few practical difficulties of printing the separate figures of a plate at one impression are overcome, we shall be able to illustrate our memoirs accurately and economically, and give figures with an amount of detail which the great expense of engraving or lithographing would usually make impossible, even were it mechanically practicable.

The accompanying plates are fair specimens of what can be obtained by the Albert and by the Woodbury processes, and give a good idea of the character of the two modes of printing; the one imitating a common photographic print, the other a lithograph. These figures are taken from the illustrations of my forthcoming "Revision of the Echini." The one is a figure (natural size) of *Echinocidaris punctulata* DESML. from South Carolina, printed by the Albert process; the other, a section (slightly reduced) of *Laganum decagonalis* LESS. from Hong Kong, printed by the Woodbury process ; both negatives, of course, being taken from nature.

Mr. Jno. Carbutt, of Philadelphia, is the superintendent of the American Photo-relief Printing Company (Woodbury process).

Mr. E. Bierstadt, of New York, is in charge of the Photo-plate Printing Company (Albert process).

ALEXANDER AGASSIZ.

CAMBRIDGE, November 30, 1871.

WOODBURYTYPE A.P.R. PTC. CO., PHILA.

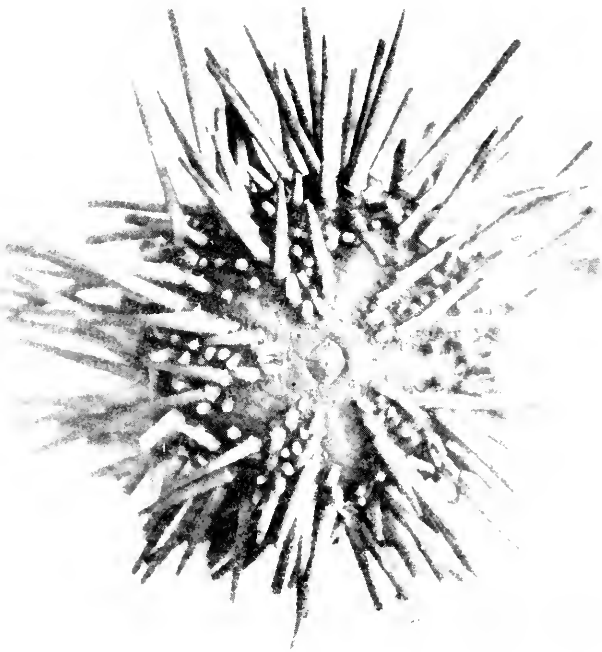


PHOTO-PLATE PRINTING CO.
ALBERT TYPE PROCESS
E. BIERSTADT SUPT., N.Y.

No. 3. — *A Letter concerning Deep-Sea Dredgings, addressed to* PROFESSOR BENJAMIN PEIRCE, *Superintendent United States Coast Survey, by* LOUIS AGASSIZ.

CAMBRIDGE, MASS., December 2, 1871.

MY DEAR FRIEND, —

On the point of starting for the Deep-Sea Dredging expedition, for which you have so fully provided, and which I trust may prove to be one of the best rewards for your devotion to the interests of the Coast Survey, I am desirous to leave in your hands a document which may be very compromising for me, but which I nevertheless am determined to write in the hope of showing within what limits Natural History has advanced toward that point of maturity when science may anticipate the discovery of facts.

If there is, as I believe to be the case, a plan according to which the affinities among animals and the order of their succession in time were determined from the beginning, and if that plan is reflected in the mode of growth, and in the geographical distribution of all living beings; or, in other words, if this world of ours is the work of intelligence, and not merely the product of force and matter, the human mind, as a part of the whole, should so chime with it, that, from what is known, it may reach the unknown; and if this be so, the amount of information thus far gathered should, within the limits of errors which the imperfection of our knowledge renders unavoidable, be sufficient to foretell what we are likely to find in the deepest abysses of the sea, from which thus far nothing has been secured.

I will not undertake to lay down the line of argument upon which I base my statement, beyond what is suggested in the few words preceding, namely, that there is a correlation between the gradation of animals in the complication of their structure, their order of succession in geological times, their mode of development from the egg, and their geographical distribution upon the surface of the globe. If that be so, and if the animal world designed from the beginning has been the motive for the physical changes which our globe has undergone, and if, as I also believe to be the case, these changes have not been the cause of the diversity now observed among organized beings, then we may expect from the greater depth of the ocean representatives resembling those types of animals which were prominent in earlier geological periods, or bear a closer resemblance to younger stages of the higher members of the same types, or to the lower forms which take their place nowadays. And to leave no doubt that I have a distinct perception of what I may anticipate, I make the following specific statement.

It lies in the very nature of these animals that, among vertebrates, neither Mammalia nor Birds can exist in deep waters, and if any Reptiles exist there, it could only be such as are related to the extinct types of the Jurassic periods, the Ichthyosauri, Plesiosauri, and Pterodactyles; but even of these there is very little probability that any of their representatives are still alive. Among the fishes, however, I expect to discover some marine representatives of the order of Ganoids of both the principal types known from the secondary zoölogical period, such as Lepidoids, Sauroids, Pycnodonts, Cœlacanthes, Amioids, and Glyptolepis-like species may even be looked for. Among Selachians some new representatives of Cestraciontes or Hybodontes may be forthcoming, connecting the latter more closely to Odontaspis. I also look forward to finding species allied to Corax, or connecting this genus with Notidanus, perhaps also Jurassic-like forms. Among Chimæroids we may expect some new genera more closely related to the extinct types of that family than those now living. Among ordinary fishes I take it for granted that Beryx genera may be added to our list, approaching perhaps Acanus, or rather Sphenocephalus; also types allied to Istieus, to Anenchelum, and to Osmeroides, Elops, and Argentina. Dercetis and Blochius may also come up. Species of all classes of the animal kingdom which have been very rarely met with by fishermen and naturalists are likely to be found in the deepest waters, in which neither hooks nor nets are generally lowered. Nothing is known concerning the greatest depth at which fishes may live. Upon this point I hope to obtain positive data.

The Mollusks will, no doubt, afford a rich harvest of novelties, among which some may be of the deepest zoölogical interest. It stands to reason that a variety of Nautiloid Cephalopods may be discovered when Nautilus proper and Spirula are so rarely found alive, and among new forms there may be those combining characters of Argonauts with features of Nautilus; some may even be coiled up like Turrilites. Belemnitic Squids would appear natural. Among Gasteropods we may look for high spired Natica-like types, for representatives of Acteonella, Avellana, and the like; for small Volutoids of the tertiary and cretaceous types, for Rostellarias, even for Nerineas, and more particularly for forms intermediate between Firula and Cyprea. Among Acephala I would expect a variety of Myacea approaching those described in my monographs of that family from the Jurassic and cretaceous formations, such as Ceromya, Corimya, Circomya, Goniomya, Myopsis, etc., with Panorpa and Pholadomya, and others recalling perhaps also Cardinia, Gresslya, or Cardiacea more closely related to Conocardium than the living species, perhaps leading to Opis, or Trigoniae of extinct types akin to Myophoria, with Pachymya, Diceras Grammisia, Inoceramus, Pterinea, Monotis, and Posidonia. Rudistes should take the place of oysters, and the harvest of Brachiopods should be large.

Among Crustacea it is natural to suppose that genera may be discovered reminding us of Eryon or of Pemphyx Gampsonyx, or some Amphipods, and Isopods aping still more closely the Trilobites than Serolis, or Limuloids approaching that extinct family. The classification, embryology, and order of succession of Echinoderms is now so well known, that it is perhaps still more easy to anticipate the character of discoveries in this branch of the animal kingdom than in any other. I expect confidently, to find Spatangoids approaching Holaster, Toxaster, Ananchytes, Hemipneustes or Metaporhinus, and others akin to Dysaster, Echinolamps approaching Pygurus, Nucleolites tending to Clypeus, Galerites, like Pyrina or Globator, etc., etc., and again Cidarids akin to C. glandifera and clavigera with Glypticus-like species, and Codiopsis, Cœlopleurus, Cyphosoma, and Salenia.

Among Starfishes the types of Goniaster and Luidia are likely to prevail, with simple rayed Euryaloid genera, and among Crinoids a variety of genera reminding us of Pentremites, Marsupites, Pentacrinus, Apiocrinus, and Eugeniacrinus.

The question of the affinities of Millepora will probably receive additional evidence, and genera connecting more closely the Rugosa and Tabulata with one another, and with the Acalephs may be expected in the shapes of branching Heliopores and the like.

With the monograph of Pourtales upon the deep-sea corals before me, it would be sheer pretence to say anything concerning the prospect of discovering new representatives of this or that type. His tables point them out already.

But, there is a subject of great interest likely to be elucidated by our investigation, — the contrast of the deep-sea faunæ of the northern with those of the southern hemisphere. Judging from what Australia has already brought us, we may expect to find that the animal world of the southern hemisphere has a more antique character, in the same way as North America may be contrasted with Europe, on the ground of the occurrence in the United States of animals and plants now living here, the types of which are only found fossil in Europe.

A few more words, upon another subject. During the first three decades of this century, the scientific world believed that the erratic boulders, which form so prominent a feature of the surface geology of Europe, had been transported by currents arising from the rupture of the barriers of great lakes among the Alps, or started from the north by earthquake waves.

Shepherds first started the idea that within the valleys of Switzerland these huge boulders had been carried forward by glaciers, and Swiss geologists, Venetz and Charpentier foremost among them, very soon proved that this had been the case. This view, however, remained confined to the vicinity of the Alps in its application, until I suggested that the phenomenon might have a cosmic importance, which was proved when I discovered, in 1840, unmistakable traces of glaciers in Scotland, England, and Ireland, in regions which could have had no connection whatever with the elevation of the Alps. Since that time the *glacial period* has been considered by geologists as a fixed fact, whatever may have been the discrepancies among them as to the extent of these continental masses of ice, their origin, and their mode of action.

There is, however, one kind of evidence wanting to remove every possible doubt that the greater extension of glaciers in former ages was connected with cosmic changes in the physical condition of our globe. All the phenomena related to the glacial period must be found in the southern hemisphere with the same characteristic features as in the north, with this essential difference, that everything must be reversed; that is, the trend of the glacial abrasion must be from the south northward; the lee side of abraded rocks must be on the north side of hills and mountain ranges, and the boulders must have been derived from rocky exposures lying to the south of their present position. Whether this is so or not has not yet been ascertained by direct observation. I expect to find it so throughout the temperate and cold zones of the southern hemisphere, with the sole exception of the present glaciers of Tierra del Fuego and Patagonia, which may have transported boulders in every direction. Even in Europe, geologists have not yet sufficiently discriminated between local glaciers and the phenomena connected with their different degrees of successive retreat on one hand, and the facts indicating the action of an expansive and continuous sheet of ice moving over the whole continent from north to south. Unquestionably, the abrasion of the summits of the mountains of Great Britain, especially noticeable upon Schiehallion, is owing to the action of the great European ice-sheet during the maximum extension of the glacial phenomena in Europe, and has nothing to do with the local glaciers of the British Isles.

Among the facts already known from the southern hemisphere are the so-called rivers of stone of the Falkland Islands, which attracted the attention of Darwin during his cruise with Captain Fitzroy, and which have remained an enigma to this day. I believe it will not be difficult to explain their origin in the light of the glacial theory, and I fancy now they may turn out to be nothing but ground moraines, similar to the "Horsebacks" of Maine.

You may ask what the question of drift has to do with deep-sea dredging? The connection is closer than may at first appear. If drift is not of glacial origin, but the product of marine currents, its formation at once becomes a matter for the Coast Survey to investigate, and, I believe, it will be found in the end, that, so far from being accumulated by the sea, the drift of the lowlands of Patagonia has been worn away to its present extent by the continued encroachment of the ocean in the same manner as the northern shores of South America and of Brazil have been. . . . . .

Hoping some, at least, of my anticipations may prove true,

I remain, ever truly yours,

LOUIS AGASSIZ.

PROF. BENJAMIN PEIRCE,
Superintendent Coast Survey, Washington, D. C.

No. 4. — *Preliminary Notice of a few Species of Echini*, *by* Alexander Agassiz.

The following species are briefly noticed in advance of the fuller descriptions of the Illustrated Catalogue to complete the synonymy of the species of Echini in the collection of the Museum.

Strongylocentrotus armiger.*

Test thin, flattened above, regularly arched below; is at once distinguished from its congeners by its peculiar short, blunt, stout spines, swollen in the middle of the shaft, resembling those of Echinometra oblonga. The large primary tubercles, arranged in two principal vertical rows, in both areas, flanked by indistinct vertical rows of secondaries, are all placed nearer the abactinal pole on the depressed portion of the test, decreasing rapidly in size towards the actinostome. Genital pores large. Poriferous zone broad, pores arranged in arcs of from six to seven pairs.

Free Public Museum (Liverpool); Brit. Museum; Mus. Comp. Zoöl. — Australia.

Sphærechinus Australiæ.†

The Museum has received at various times, from Mr. Henry Edwards, a sea-urchin intermediate between Psammechinus and Strongylocentrotus, remarkable for the thickness of its test, its compact abactinal system, the uniform size of the primary tubercles; the secondary tubercles closely packed and filling completely the whole space between the primaries, both in the ambulacral and interambulacral areas. The test is globular, resembling, in outline, somewhat Amblypneustes, has no ambitus, a very small actinostome, with short, sharp, narrow actinal cuts. The poriferous zone divided by secondary tubercles into an inner vertical row of pairs of pores far above one another, and an outer part with pores arranged in from three to four pairs, all the pores deeply sunken between the secondaries. Actinal membrane covered by large elliptical

* The species included in this genus by Brandt are, S. chlorocentrotus = Echinus Dröbachiensis Müll (teste Grube), and the species of section D of Blainville, including E. lividus, parvituberculatus, ... ; in a different section he places E. tuberculatus Blainv.?

† Cryptopora Australiæ *Michelin* MS. École des Mines, Paris.

plates moderately closely packed. The spines are short; in dried specimens, violet at base tipped with green, test violet with greenish tubercles.

École des Mines; Mus. Comp. Zoöl. — Australia.

Amblypneustes pentagonus.

Unlike the other species of Amblypneustes, the outline of the test from above is pentagonal; the ambulacra projecting considerably beyond the concave interambulacra. The coronal plates are high, not half as numerous as in other species of the genus of the same size. There is but a single primary vertical row of tubercles both in the ambulacral and in the interambulacral spaces; secondary tubercles few in number, very irregularly scattered; sutural pores small, limited to angle of plates; test thin, high, remarkable for the great size of the primary spines. Abactinal system delicate, and not prominent and stout as in other allied species.

Mauritius?

Amblypneustes inflatus.*

Test moderately stout, nearly spherical; poriferous zone more than equalling in width the median ambulacral region, where the tubercles form irregular horizontal rows of from two to three tubercles for each plate. In the interambulacral space there is for each plate a larger primary, forming a distinct vertical row, and from one to six smaller tubercles on each side of the median interambulacral line forming horizontal rows, and very indistinct vertical rows. No bare median ambulacral or interambulacral spaces.

New Holland.

This as well as the following species belong to the section of Amblypneustes (Holopneustes),† in which the poriferous zones are arranged in three vertical rows of pores, the middle row often extremely sporadic, as in H. porosissimus, and having no sutural pores.

Amblypneustes purpurascens.*

Actinal and abactinal diameter equal, poriferous zone equal in width to the corresponding tuberculiferous ambulacral space. In large speci-

* *Lütken* MS. in litt.

† It is possible that these two species may turn out to be only different stages of growth of H. porosissimus. The variation in the other species of Amblypneustes is very great, but here is confined to the poriferous zone, which makes it difficult to decide the point for want of material.

mens the middle row of pores is very irregular, forming zigzag lines, while in younger specimens the middle row is nearly as uniform as the inner and outer rows; the latter is characterized by the greater size of the inner pore, and the distance separating the pores of a pair. The tubercles of both areas form most regular horizontal rows, as many as ten tubercles of nearly uniform size on each side of the median line, and from one to three for the ambulacral spaces, forming no distinct vertical rows.

Mus. Copenhague; Mus. Hamburg; Mus. Comp. Zoöl. — New Holland.

Spatangus Lütkeni.*

Closely allied to Spatangus purpureus, test relatively more convex and abactinal diameter greater. Seen in profile test nearly semicircular, somewhat more curved anteriorly; anal plane lower and more oblique than in S. purpureus, the subanal fasciole belonging properly to the actinal surface. The shape and proportions of the ambulacra, as well as the distribution of the large tubercles between the ambulacra, is not materially different from S. purpureus. The shape of the subanal fasciole (having three pores on each side) is very different from that of S. purpureus (having but two pores); it is in the latter species about three times broader than long, while in S. Lütkeni it is only one and a half times broader than long, in specimens of about the same size. The color in alcohol is dark violet.

Mus. Copenhague; Mus. Comp. Zoöl. — China Seas (Salmin).

Lovenia cordiformis.†

Differs from the other species of the genus by the great convexity of the test, the anterior vertex, compared to L. hystrix, the relatively smaller number of primary tubercles in the anterior interambulacral spaces, the narrow band of large tubercles upon the edge of the actinal surface, the small size of the purses of these tubercles, the large size of the tubercles within the peripetalous fasciole on each side of the anterior ambulacrum near vertex, the flatness of the test round mouth not forming a prominent posterior lip.

Mus. Comp. Zoöl. Guayamas; Smith. Coll. Gulf of California.

* Sp. altus *Lütken* MS. in litt.

† Lütken MS. in litt.

Mœra stygia.*

In the British Museum and Copenhague Museum are specimens of a Mœra allied to M. atropos, holding to it the same relation which Echinocardium gibbosum holds to E. cordatum. The test has a short, longitudinal diameter, is remarkable for the great height of the abactinal axis, the sharply truncated anterior extremity, the narrow lateral ambulacra, the elongate anal system, and the prolongation of the anal plastron in a sharp keel.

A specimen in the Mus. Comp. Zoöl. is said to have come from the Red Sea.

Rhynobrissus pyramidalis.

I am indebted to Mr. Thomas J. Moore for a specimen of this remarkable Spatangoid. It is allied to Brissopsis, having like it a peripetalous fasciole (narrow), a subanal and anal fasciole (broad); it has, however, no anterior groove, the test being uniformly convex anteriorly, the vertex is posterior slightly in advance of the bevelled posterior extremity. The anal plastron is heart-shaped, somewhat as in Metalia, projecting like a keel beyond the outline. Seen from above, the outline of test is diamond-shaped, rounded anteriorly. The ambulacral petals but slightly sunken, resembling those of Faorina. The actinostome is crescent-shape, very narrow, extends well across the test, immediately surrounded by a broad, bare space, which forms rapidly narrowing bare ambulacral spaces on each side of the narrow elongate actinal plastron. The spines of the lower surface are long, curved, and slender, while those of the rest of the test are short, hair-like; their coloring is light violet. The anal fasciole is open above the anal system, but a secondary subanal plastron is formed independent of the principal one by a broad band passing below the anal system, slightly above the origin of the anal fasciole, — a feature which thus far has not been noticed in any other genus of Spatangoids, finding its parallel only in the double branch of the anterior part of the peripetalous fasciole of Faorina.

Free Public Museum (Liverpool); Mus. Comp. Zoöl. — Linguin. China Seas.

CAMBRIDGE, January 10, 1872.

* *Lütken* MS. in litt.

No. 5. — *Fossil Cephalopods of the Museum of Comparative Zoölogy. Embryology, by* Alpheus Hyatt.

The researches recorded in the following pages were originally undertaken in order to ascertain the limits of the embryological period among the typical Ammonites.

During this period, which begins with the ovisac, the different species possess a common form, and are very similar in the characteristics of their septa, siphons and shells. It was at first proposed to give the descriptions only in conjunction with the different groups to which the young belonged; but the intimate connection and importance of the facts, elicited by a general comparison of the young of Nautilus, Goniatites, and Ammonites appeared to demand a separate publication.

The necessary illustrations have been furnished with unstinted liberality by the Director of the Museum, Professor Louis Agassiz. The collections also, which are extremely rich, have been placed entirely at my disposal, and I have been permitted to break up whatever specimens were considered suitable for the present purpose.

As this is my second formal publication upon the Cephalopods in the Bulletin, it is only becoming to correct certain errors which are to be found in the first (No. 5, Vol. I, Bulletin of the Museum of Comp. Zoölogy), under the same general title as this number.

Proper credit was not given in the preface to Professor Edward Suess for having been the first to publish the fact, that the typical forms of Ammonites were capable of generic division, and two of his names, Lytoceras and Phylloceras, should supersede two of those given in that number of the Bulletin, namely Thysanoceras and Rhacoceras.

I have been rather severely criticised by Laube and Zittel for giving Professor Agassiz the credit of having been the first to perceive that the Ammonites were divisible into distinct families and genera, but it will be noticed that this is given to him as a personal matter between an instructor and his student. This I must be excused from withdrawing. But I did know, however, that ever since Professor Agassiz published his French translation of Sowerby's Mineral Conchology, he has regarded the Ammonites, not as a family, as Suess does, but as a large group, perhaps equivalent to a sub-order, and composed not of a few genera, but of several families containing many genera.

The fact that two of the genera were precisely equivalent to those of Professor Edward Suess ought to have secured some credit, at least among his admirers, for the twenty-odd other precisely equivalent genera established by Professor Agassiz and myself; but such has not been the fact.

Either we knew of Suess' publications and patterned after them, only increasing the number of genera, or else the investigation was independent. Besides the fact, well-known to palæontologists in this country, that these investigations began some years before Suess had published anything, there was no object in concealing our acquaintance with his researches. On the contrary a prompt acknowledgment would have been of great advantage, since it would have been easy to show, that, in our much more complete classification, the genera were founded upon the same system of characteristics as those used by Suess to distinguish Lytoceras from Phylloceras.

There has been nothing besides the above in the criticisms advanced except general statements of disapproval, which, of course, cannot be dealt with specifically and are of no importance.

I will say, in conclusion, that I have nearly finished a very thorough review of the same groups without being able to effect any very material alterations.

The same divisions are found to be sharply defined divergent series, and whatever name or value may be given them, they are natural groups; this being so, my object is attained.

This object is, as in the present publication, to obtain some faint insight into the laws of descent of these forms one from another, by means of such indications as may be afforded by a close study of the developmental and adult characteristics, corrected or verified by the observed geological positions of the species.

Every one who has studied the coiled shells of Cephalopods and Gasteropods, is aware that they retain in the interior of the umbilicus the younger whorls, which are necessarily more or less covered up and protected by those of later growth. By breaking away the older whorls, one can therefore eventually arrive at those portions of the involved cone which represent the very youngest periods of growth.

This in Ammonites and Goniatites has been shown to be a minute globular sac. In Nautilus, however, this sac is not retained, but traces of its former existence are apparent on the apex of the first whorl, in the form of a scar or cicatrix. The shell of the neck of the ovisac, in Ammonites and Goniatites, has the same form as the shell of the first whorl, whereas in Nautilus it is evident that the shell of the ovisac roofed over the living chamber, somewhat as in Gomphoceras. The opening into the apex or neck of the ovisac, where it joined the first whorl, was, as shown by the cicatrix, a narrow vertical slit bearing a slight resemblance to the opening of the living chamber in Gomphoceras.

All of the animals of these three groups undergo a true metamorphosis in passing from the globular ovisac into the first whorl.

The first septum occurs at the junction of the ovisac and the first whorl, in both Goniatites and Ammonites, and has an entire abdominal cell with two simple lateral lobes as in Nautilus.

The second septum in the Jurassic species of Ammonites, which alone were examined,* had no positive resemblance to the adult of any species of Goniatites, but the entire, simple sutures and simple ventral lobes have a general resemblance to that type, though the superior lateral lobes are present and undeniably Ammonitic even at this early age.

The second septum of the closely-coiled Goniatites has a much shallower ventral lobe than in Ammonites, and no superior laterals. The sutures resemble those of the adults of the Silurian Goniatites, but the ventral lobe is shallower and broader. The superior lateral lobes which are first seen in the third septum have the sharp outlines which distinguish the Goniatites.

This first whorl, or apical portion of the shell, is closely coiled in Ammonites, more or less involute, and resembles the adults of the typical Goniatites in form.

The form of the first whorl in Goniatites as well as the development of the septa varies excessively in the different species, or even in different varieties of the same species. In some the form and septa must be very similar to those of the straight Nautiloids, such as Orthoceras or Endoceras, while in others we have representatives of the arcuate Cyrtoceras, and finally those which are closely coiled, involute, and hardly distinguishable in external appearance from the young of Ammonites. This variability is, so far as we know, greater in the earlier or Silurian, than in the later or Devonian and Carboniferous

* Species of simpler adult structure and earlier occurrence, among the Ceratites or Clydonites, would probably present an aspect more like some of the adult Goniatites in their young.

species, and prepares the observer to find a common fixed type of form in the young of the Jurassic species of Ammonites, which belong to the same order and are intimately connected by transitional genera.

Everywhere the closest correlation is traceable between the amount of coiling, the amount of involution or envelopment of the whorls, the form of the whorl, and the development of the septa, — the simpler sutures being invariably associated with shallow concave slowly changing septa, an elliptical form, and open coils. The more complicated sutures, whose characteristics change more quickly in course of growth, are combined always with a more or less crescent-shaped whorl, and closely embracing or involving coils, whether found among Nautiloids or Ammonoids.

This agrees with the correlations of the structure and morphology of the adults as worked out by Bronn, Barrande, and others, among Nautiloids and Ammonoids, from the straight Orthoceras to the coiled Nautilus, and inversely, among Ammonoids, from the closely coiled Goniatites and Ammonites to the straight Baculites; the general morphology being readily and accurately expressed as a coiling up of a straight cone and the subsequent uncoiling of the same at later stages of the earth's history. The shells are almost universally classified in accordance with this coiling and uncoiling, with which also the structure of the siphon and septa are more or less correlative.

The siphon in Nautilus, Goniatites and Ammonites terminates, or rather begins, with a blind sac, or siphonal cœcum.

In Nautilus, this occupies a central position somewhat nearer the ventral than the dorsal side, and is enclosed by the shell at the apex of the first whorl. In Goniatites and Ammonites the siphonal cœcum has a cone-like prolongation, which appears to open into the bottom of the siphonal cœcum in Goniatites. The siphon is developed earlier in the last two than in Nautilus, since it is found within the neck of the ovisac.

The ovishell consists, in Ammonites and probably in Goniatites, of an inner lining layer similar to that of the chambers of the whorls, and an outer thicker layer. They both extend entirely around the ovisac, but the outer layer is very much thicker on the sides and abdomen. The inner layer bends inward and forms part of the under side of the first septum. The outer layer overlaps the inner and outer layers of the abdomen and sides of the first whorl, showing that here was the mouth of the ovisac, and that the outer layer of the ovisac corresponded with both the inner and outer layers of the first whorl. Both of the latter are continuous with the outer layer of the ovishell, in the same sense that they are subsequently continuous with each other whenever the growth is interrupted, and an imbricated suture or break is formed.

The shell of the young and mature whorls is composed of an inner and an outer layer, the latter being divided into two portions, the external or colored stratum, and the internal or white stratum. In Nautilus both the layers extend entirely around the shell in the young, but as soon as one revolution of the whorl is completed, the black excretion of the hood replaces the outer layer to a considerable extent on the dorsal or involved side. The outer layer is still present, but is very thin.

In Goniatites and Ammonites the same layers are present, but do not extend around the dorsal side, except in the loosely coiled young of certain species.

In Nautilus, Goniatites, and Ammonites a thin layer lines the interior of each chamber and coats the exterior of the siphon. This alone appears upon the dorsal or involved portion of the whorls in the last two groups.

All the layers, with the exception of the black layer of the hood and lining layer, betray everywhere an imbricated structure which shows that they were deposited by the edge of the mantle from within. The lining layer, and the black deposit of the hood are continuous throughout wherever they occur.

The siphonal cœcum of Nautilus is formed by the funnel of the septum, which projects posteriorly until it comes in contact with the shell of the apex. The funnels of the younger septa are longer than those of the older septa, and the sheath of the siphon which springs from the funnel of the second septum extends posteriorly and lines the interior of the siphonal cœcum, forming a second siphonal cœcum within the first.

In Goniatites and Ammonites the cœcum is formed in a similar manner, but the latter is not lined, the siphonal funnel and sheath of the second septum extending only far enough to close the opening in the first septum.

Subsequently the siphon is composed of the funnel and the sheath which is continuous with it, but has a looser and more porous texture. The sheath is discontinued at the opening of the funnel of the next younger septum, into which it closely fits and thus forms the outer wall of the siphon. Internally is found the corneous layer, which is continuous throughout.

In Nautilus and Goniatites, and in the youngest stages of Ammonites, we find only the parts described above, but in the further development of Ammonites, another is added. At first only a portion, and lastly, nearly the entire thickness of the septum bends in the opposite or anterior direction, forming a loose collar around the siphon, but not built into it, as is the shorter funnel below.

The siphonal cœcum is close to the abdomen in Goniatites and Ammonites, but the siphon, which springs from the neck of the cœcum as it passes through the second septum, diverges nearer to the centre of the whorl.

This position of the siphon, its structure, more especially in the young Nautilus and the prevalence of shallow concave septa, the Nautilian character of the first septum in Goniatites and Ammonites even in the closely coiled young, the prevalence of simply arcuate forms in the young of several Devonian, and the straightened first whorl of the varieties of two Silurian species, the continuity of the layers and their thickness on the dorsal side of the young, are all characteristics which appear to converge towards the structure and form of the siphon and shell in the Vaginati, especially Endoceras (Orthoceras) duplex of De Verneuil and Keyserling.

It is in this group, therefore, or in some closely associated genus that we must look for the ancestors of the Tetrabranchiate Cephalopods.

I select Endoceras rather than Beatricea, which I have always regarded as the prototype of all the Nautiloids, because there still remain several characteristics in the structure of this form which must be more thoroughly worked up, before the affinities can be settled beyond a doubt.

The structure of the septa, and of the siphon in Endoceras is not so irregular or vesicular as those of the shell in Beatricea, but there is a wonderful resemblance of the cup-like internal chambers of Beatricea to a line of siphonal cœca. The young of Endoceras, if this view obtain, would be expected to resemble, or to show some approximation to, Beatricea. It ought either to be alone composed of thick conical septa of the adult siphon, and each of these terminating at the apex in a closed sac, or, at least, the siphon should be larger proportionately in the young, and the true septa have a much smaller comparative area than in the adult.

The outlines and coarser shading of all the figures were drawn with the aid of the Camera Lucida by me, and these were worked over, and artistically finished with the greatest care by Mr. Konopicky, Draughtsman to the Museum. These outlines were often repeated and verified in obscure or doubtful cases, and the camera drawing invariably corrected by the careful study of the more minute structural details. The statement of the number of diameters to which a specimen has been magnified does not show that this power alone was used; frequently in working out the minor details much higher powers were employed, the results being noted in the general outlines already drawn with a lower power.

The objectives employed were made by Tolles & Wales, in their best manner, the glass most relied upon being a one-half inch of remarkably good definition, and working distance made by the first named.

The enlargement of the figures was measured by a direct comparison of the Camera Lucida image, at a distance of ten inches from the eye-piece with the size of the object on the stage as shown by a graduated ruler, or in the higher powers by a stage micrometer.

As others may possibly desire to repeat these observations, I will conclude this preface with a few words upon the preparation of specimens intended for examination.

Those specimens in which the shell is replaced by iron pyrites or in which the matrix is stained with iron, are seldom well suited for the observation of the very earliest period. The centre does not generally, in my experience, break out as well as in those which are fossilized by the ordinary Carbonate of Lime, and they are too opaque. Specimens with which I have been most successful are found in the hard dark blue limestones. The centres of these are usually filled with translucent carbonate of lime even when the older parts of the whorls are opaque.

The first process of reduction may be generally effected by breaking away the whorls with chisels of suitable sizes, care being taken not to strike too near the centre; then the young shell should be bedded in Canada balsam which has not been overheated. If scorched, the balsam is apt to give way in large splinters and fly off the slide, carrying the minute ovisac with it. The removal of the last three or four whorls is best accomplished under a dissecting microscope, with the aid of the long-handled instruments used by dentists. These are chisels of various forms, bent at the ends so that they can be held horizontally; and almost every desirable point can be purchased, or obtained by grinding down those commonly used.

Great care must be taken in grinding down specimens for transparent sections not to get them too thin. After a certain thinness is attained, the carbonate of lime is apt to crack in a very irregular manner, obscuring the structure and seriously enhancing the difficulty of making accurate observations.

The siphon is hardly ever at all points in the same plane, so that the best practice in grinding the first side is not to pass beyond the outer limits of this organ. Then, when the specimen is turned and recemented to a clean slide, the reduction of the exposed portion may be carried forward to any desired level. The whorls are very apt to break off or loosen during this last process, and the delicate crystals of lime on the edges to become fractured, and therefore in most cases it is better to allow a number of the earlier whorls to remain attached to the ovisac as a support for those which are to be examined.

EMBRYO.

It has been customary to consider that one of the differences existing between Goniatites, Ammonites, and Nautilus was to be found in the absence of a globular ovisac at the beginning of the whorls in the two latter. This view is very plainly expressed by D'Orbigny, Guido and Fridolin Sandberger,* and Barrande; but how this mistake could have been made among Ammonites it is difficult to understand, unless indeed the specimens the last-named authors examined, *Amm. lævigatus* and *complanatus* Rein., had really lost their ovisacs.

* "Bei der Unterscheidung der Gattung Goniatites von Ammonites ist dieses Merkmal nicht unwesentlich. Es scheint nämlich, dass den Ammoniten eine in dieser abgeschnürten Kugelgestalt sich erhaltende Anfangselle nicht zukomme. Mehrere wohlerhaltene Arten, unter anderen *Ammonites lævigatus* und *complanatus* Rein. aus den unteren Oolith von Thurnau zeigten schon von der Anfangselle aus regelmässig kegelförmiges Anwachsen ohne jene Abschnurung." — *Die Versteinerung von Nassau.* G. und F. Sandberger. Wiesbaden, 1850–56, p. 59.

Saemann, in Dunker and Meyer's Palæontographica,* has shown that *Lytoceras fimbriatus* had a distinct globular ovisac, and figured the young of this species in comparison with the pointed young of *Nautilus atratus.*

D'Orbigny describes the aspect of the apex of the whorl in Nautilus as an obtuse cone, and in Nautilus lineatus of the Jura, writes of this cone as resembling a Patella. Barrande, in criticising this view, remarks very justly, that the cone must have been at one time the living chamber of the animal, and as this must have extended for some distance, there are no grounds for comparing it with the flattened cone of Patella.

When observed at the bottom of the umbilicus, the ovisac of the Ammonites appears as an oval body, generally more or less denuded of the shell, which breaks away with the matrix.† When the whorls which encompass it are removed, the ovisac is seen to be much larger than these exposed lateral areas, which are merely extreme portions of the narrow sides of the embryonic shell or ovisac.‡ The entire form, when seen from the side, is that of a very broad symmetrical oval, flattened considerably on the abdomen, § and lenticular when viewed from the abdominal or dorsal sides.¶

These outlines may vary considerably in the same species. In some specimens of *Deroceras planicosta* the abdomen is flatter than in others, and often depressed as it nears the sides, giving the latter a remarkably bulging aspect.**

Among the Arietidæ, the species examined, Arnioceras semicostatum,†† and Asteroceras obtusum ‡‡ presented no considerable variation, except such as would naturally result from difference of size in the species.

Even in the abnormal forms, Scaphites and Crioceras, the ovisac fills the fundus of the umbilicus, or, in other words, is closely enveloped by the first whorl. Whether the young of the still more uncoiled genera,

* Vol. III, p. 158, pl. 19, Figs. B, C.
† Plate I, Figs. 7, 8. Plate II, Fig. 9.
‡ Plate I, Fig. 6, A. Plate II, Fig. 7.
§ Plate I, Fig. 4.
¶ Plate I, Figs. 1, 2.
** Compare Fig. 2 with 5, and Fig. 6 with 1 on Plate I.
†† Plate II, Figs. 8, 9.
‡‡ Plate II, Fig. 11.

especially Baculites, have young which are straight or closely coiled, I could not ascertain by direct observation.

The ovisac of Goniatites does not, in the majority of the species, differ very materially from that of Ammonites. It is evidently an elliptic or globose body more or less flattened on the abdominal side as in the typical Ammonites.* It however presents very remarkable differences in the relations of the ovisac to the first whorl and to the umbilicus, and in its variability of form in the same and different species.

Dr. Guido Sandberger figured several species, all of which are reproduced in the first Plate of this paper,† and from these and others, also examined but not figured, he inferred that the species themselves might be distinguished by the differences of the embryos. The figures certainly appear to justify this remark, and my own observations, as well as those of Barrande, though apparently contradictory, are really strongly confirmatory. Barrande found in the silurian of Bohemia *Goniatites fecundus*, and *Goniatites plebius* with two well-marked varieties, and was so fortunate as to obtain also the very youngest stages of growth in each variety of the former.‡ These are also reproduced on Plate I of this work.§ According to Barrande the ellipticity of the orbit in the adult of one variety is due to the straightness of the first portion of the first whorl, and the regular spiral of the other variety to the close coiling of the young. He also observed and figured the same elliptical form at all stages of growth. This would seem to be sufficient to establish the two varieties as distinct species; but the presence of all intermediate varieties between the two produced here, the similarities of the adult shells, and the occurrence of the same variations in *Goniatites plebius* forbids their separation.

Goniates crenistria, in one so-called variety, has a decidedly rounded abdomen, and the ovisac fills the fundus of the umbilicus, while in the

* Plate III, Figs. 3 4.

† "Diese ist stets stark aufgebläht und wie die Figuren 26 bis 33 (Pl. I, Figs. 11–18) beweisen, bei den verschiedenen Arten oft von sehr characteristischer Gestalt, so das sie in manchen Fällen ein zur Unterscheidung der Species geeignetes Merkmal abgiebt." — Guido Sandberger, *Beob. Über Goniatiten, Jahrbuch der Nassau Verein*, 1851.

‡ Syst. Sil. de Bohême. Cephalopods. Vol. II, pp. 32 and 37. Plates 7, 10, 11, 17 and 5, 6, 7, 241, 242.

§ Plate I, Figs. 9, 10.

other, with a flatter abdomen, it lies against one side of the first whorl, occupying but a very small portion of the entire space.* Here there can be but little doubt of the specific value of the differences which are manifested, not only in the youngest stage, but throughout life, and affect not the symmetry of the orbit of revolution, but the form of the whorl itself.

In all of the seven species observed by Sandberger, as may be seen by his figures † and in the four distinct species observed by me, counting Gon. crenistria as two good species, the differences of the ovisac are very distinct, whereas in several individuals of the same species, Goniatites crenistria, the so-called variety with a flat abdomen, which I have observed, and in several of Go. atratus, no such differences were observed between the different individuals. The slight differences in the amount of coiling between the young of varieties latidorsalis and calculiformis of Go. lamed, figured by Sandberger,‡ were probably therefore unusual among the Devonian and Carboniferous species.

The succession also indicated by the foregoing facts is precisely what might have been anticipated from the general morphology of the Tetrabranchiate Cephalopods.

The range of form has been among the Nautiloids from the straight Orthoceratite through intermediate arcuate genera, to the partially coiled Lituites, and finally the closely coiled Nautilus. Such being the case, if there is any truth in the doctrine of evolution, we must expect to find some reference to the peculiarities of the parent Nautiloid stock in the earlier stages of development among the Ammonoids. And further, as a direct and unavoidable corollary of the above, we ought to find this reference more distinct in the young of the earlier species of Ammonoids, the Goniatites of the Silurian, and less noticeable in the Goniatites of the Devonian and Carboniferous, and, finally, almost obliterated, or, at any rate, still less distinct in the typical Ammonite of the Jura.

So far as the facts have been ascertained, they all point in this direction. The simple Nautiloid-like Goniatites of the Silurian may exhibit an Orthoceratitic or straight form, or be closely coiled in the young of different varieties of two distinct species. A species therefore, on this horizon, may have a range of variation in form, during the earlier

* Plate III, Fig. 7. † Plate I, Figs. 11, 18. ‡ Plate I, Figs. 15, 16.

stages of development, equivalent to that occurring among the adult forms of Nautiloids from Orthoceras to Lituites.

The Goniatites of the Devonian, however, even in such simple species as Go. compressus,* exhibit only arcuate whorls, and in the majority of cases are more or less completely coiled. No elliptical varieties have been observed in the adults, and the variations of form in the young of the same species probably do not exceed what has already been observed.†

Among the typical Ammonites of the Jura, not only is the young of the same species invariably similar, so far as the coiling and form of the ovisac is concerned, but the young of all the closely coiled or normally formed species are also closely coiled and involute or enveloped.‡

We find in this a perceptible acceleration in the development of the young precisely proportionate to the estrangement, either in time, or in adult organization, of the Ammonoids from their supposed parent stock. There are evidently two tendencies at variance with each other: one strongly reversionary, appearing in the frequency with which the earlier Goniatites repeat the parent form in certain isolated instances in the young of varieties, and in the different species of the later Goniatites manifesting itself in the arcuate cone of the young of Goniatites compressus and others of the Nautilini, and in the closer, though non-involute coiling of the young of other forms. Evidently this tendency is losing its power to affect and modify the organization, or, in other words, its prepotency. The other tendency, which is expressed in the closer coiling of the whorls, and finally in their increasing involution, is decidedly progressive, increasing in power to the final and ultimate extinction of all reference to the ancestral type, except in the internal organization. Here, as will be shown, the siphon for a limited time remains central in the first whorl, and the first septum has a large entire abdominal cell, and simply concave lateral lobes, as in the Nautiloids.

The form, however, of the first whorl of the Ammonoid is like Goniatites, the shell similar, and the second septum has the invariable abdominal lobe, superior lateral cells, and lobes of the simpler adult

* Plate I, Fig. 11.

† As already noticed between Figs. 15 and 16 of Goniatites lamed. Plate I.

‡ Plate I, Figs. 2, 4, 5, 6, 7, 8. Plate II, Figs. 7 - 9, 11.

Goniatites, but not by any means of the simplest Goniatites. The simplest adult Goniatites have no proper lateral cells, but only broad lateral simple curves to the septa, as if the first septum of the Ammonite was modified or broken by a small abrupt lobe on the abdominal side. Contrast this with the development of the septa, and their gradual change in Goniatites compressus, and we see at once that the development of the same parts is very much quickened or accelerated in the typical Ammonite.

That this acceleration of development is due to the prepotency of the same progressive tendency as the closer and closer coiling, and final involution of the ovisac, by the first whorl, can hardly be doubted. Thus, not only in the whole series of Nautiloids are the forms more or less completely coiled and finally enveloping, but in the young Ammonoids this process is repeated, but only as a reversionary tendency of individuals and species, or at most, perhaps, by the group of Nautilini.

In the Arietidæ, and many other groups of typical closely coiled Ammonites, the same process is repeated to a greater or less degree in nearly every series of species, the progress being from a non-involute, or slightly involute, to a more involute form, and even in varieties of species there is occasionally a marked difference in the degree of involution of the adult whorls. Everywhere, throughout the order of Ammonoids, we meet with this constant repetition without reference to the geographical position or distribution of the species.

This increase of involution is, of course, due to the extension of the sides of the whorls inwardly, and is invariably accompanied by a decrease in the lateral or transverse diameter of the whorl, flattening of the sides, and a corresponding elevation of the abdomen.

In those series, however, such as the Dactyloidæ and Cycloceratidæ, in which the amount of involution remains the same throughout, the highest species, such as Dactylioceras Braunianum, and Cycloceras Ægion, or Masseanum, have flattened sides and acute abdomens. These modifications, being the same as those which are correlative with the increasing involution of the species in other series, produce, also, mimetic forms which only need one characteristic, that of involution, to become closely representative of the deeply involved species.

Thus, all the typical Ammonites may be resolved into natural series, in which the different forms in each series are related to each other very much as Lytoceras fimbriatum and others are related to the more involute Phylloceras, and the different series contain more or less representative or mimetic forms due to the resemblance occasioned by the amount of the involution or the characteristics which are usually correlative with the amount of involution. The differences between the series are found in the development of the young, and the structural peculiarities of the shell and septa.

When, however, the organization of the group no longer progresses, but retrogrades by the uncoiling of the whorls in Scaphites Ancyloceras, and Baculites, repeating — as shown by several authors, but notably by Barrande — the earlier forms of the Nautiloids in inverse order, these, though strictly mimetic, are produced by the encroachment of senile characteristics. These are observed in the old age of such species as Amm. Humphriesianus, where the old whorl becomes smaller, more cylindrical, and if growth was continued, must eventually strike off from the regular spiral as in Crioceras or Lituites. This irregularity is found at earlier and earlier stages of growth, and finally affects the whole form as in the completely straightened Baculites. Direct inheritance of senile characteristics is not claimed, but merely that the retrogression of the individual in old age and the retrogression of the group are similar, and both due probably to the same cause, exhaustion of the powers of growth.

There is, however, a notable exception, which can be accounted for only by Professor Cope's law of "retardation," and which, to me, was inexplicable until the appearance of his essay on the Origin of Genera; the two Gasteropod-like genera, Turrilites among Ammonoids, and Trochoceras among Nautiloids. With regard to the latter, there are no certain data; but the former are produced at first in varieties of species, which have, according to Quenstedt's, Oppel's, and my observations, simply prolonged into the adult an individual variation common enough in the young shells. The young of several species of typical Ammonites often assume the spiral, although this is entirely suppressed at a later stage, and the succeeding whorls resume the normal mode of growth and revolve in the same plane. When, therefore, the normal mode of development is "retarded," we find even in the adult this Turrilites-like condition of the young, which is as truly reversional as the Orthoceratitic young of Goniatites fecundus. This happens occasionally in the lower Jura, and finally, after the progressive stage of the whole order passes its climax in the lower and middle Jura, we find the development of a whole group affected by this retardation, and the spiral is common to several generic forms.

The ovisac of Goniatites crenistria differs from that of the Ammonites in the greater breadth proportionally of the abdomino-dorsal axis. The ovisac of G. primordialis, G. retrorsus var., and G. diadema do not seem to differ in this respect. Even the two depressions and the bulging of the sides are as well marked as in the ovisac of Deroceras planicosta.*

The ovisac of Nautilus was not present in any of the seven specimens examined by me. The form of the mouth of this, however, can be inferred from the oval ridge on the apex of the first whorl, and the central scar which marks the former aperture through which the animal probably passed into the fundus of the first whorl.† The outer limits of the area thus marked out are flask-shaped. The lower portion or abdomen, if it were extended laterally, would correspond to the broader abdomen of the Ammonoidal ovisac, and the depressions on either side of the dorsum to the embryonal umbilici. The apex of the whorl rises in a well-defined ridge which marks out this area on the dorsum and the sides. At the abdominal extremity the defining ridge is hardly distinguishable, and the shell rises directly to the cicatrix, which is here the most elevated portion of the apex. The striæ of growth and the longitudinal furrows both cross this area, but are arrested at the edge of the scar. The ridge, when seen from the side, is found to be accompanied by a narrow, shallow, slightly concave band, which at the dorsal end is particularly well marked. The edges of the cicatrix, which is a flattened, corrugated, elongated narrow space, are tumid and more or less elevated.

The ridge appears to mark the line along which the extreme outer edge of the mouth of the ovisac abutted against the apex of the whorl. The lips of the embryo shell were probably inflected as in Gomphoceras, but instead of being convex as in that genus, were probably concave. The projecting edge of this concave area would then have fitted neatly into the shallow channel or area running around the inner side of the ridge, and the concavity have been the mould upon which

* Plate III, Figs. 3, 4, 5. The ovisac differs more when viewed laterally, since the outline of a section through the centre, as in Fig. 5, is more decidedly circular.

† Plate III, Fig. 1, and ideal section last page of the text.

the convexity of the central portion of the scar was formed, the cicatrix itself being left vacant for the passage of the animal.

The abrupt and broken character of the border of the external layer on the edge of the cicatrix, and its crenulated aspect indicate that here is the true location of the former junction of the ovisac and the shell of the first whorl. When we consider how narrow and vertical are the apertures of some of the arcuate Nautiloids of the Silurian epoch, and how closely they approximate to the simplicity of the outline of the cicatrix, this view acquires additional probability, and it seems to be the only one which can reconcile the continuity of the external layer and its markings over this region.

It still remains difficult, however, to account for the passage of the large body of the embryo through the narrow aperture thus made, and future investigations upon the embryology of Nautilus are much needed, in order to settle this interesting question, as well as the true affinities of the form and structure of the embryo.

The cicatrix occupies, as has been described, the true apex of the whorl, as determined by the structure of the shell, but only the lower end, which is curved dorsally, occupies the actual apex; the remainder runs along what appears to be the inner or dorsal side, though this really begins higher up at the dorsal border of the cicatrix.

The absence of the ovisac is due either to its delicacy and the readiness with which it could be broken away from its attachment, or to the advance of the mantle, which in course of growth strikes the cicatrix a little inside of the extreme abdominal end, and then bends up over it, and either absorbs or pushes the ovisac away. Whatever may be the ultimate resolution of the question, one fact is very evident: the embryo of Nautilus differs not only in its form, which is a vertical oval, from the Ammonoids, which is a horizontal oval, but in the mode of its passage into the first whorl.

The whole aperture, or lip, of the ovisac in the Goniatites and Ammonites is united and continuous with the shell of the first whorl, which opens into it at the apex. The siphonal cœcum also has the peculiar pointed cone-like prolongation extending into the ovisac, through the first septum, which shows that the important organ which secreted it differed not only in comparative size, but in shape, and in the earlier period at which it was developed.* The siphonal cœcum

* Plate III, Figs. 2, 5, 6.

of Nautilus was not formed until after the animal had passed its first stage of growth and occupied the first whorl sufficiently long to build the first true septum. Even then this organ had not the size and importance to which it subsequently developed. I have examined the apices of many fossil Nautili without succeeding in finding any sufficiently well preserved to show the original condition of the external shell. One fine specimen of Nautilus Koninckii, from Tournay, had apparently a smooth termination; the longitudinal plications which cover the young shell of the ornamented Carboniferous Nautili reached only a little beyond the second septum. The whorl was here a rapidly increasing cone, the abdomen, however, quite as gibbous as the dorsum, whereas in the adult the latter is the more prominent, the abdomen becoming deeply inflected. The termination of the whorl was very much flattened, so that from the side it had quite a pointed aspect, whereas an abdominal view showed it to be rounded at the extremity.*

Nautilus Koninckii, it will be remembered, is a Carboniferous species with a very large umbilical perforation. In fact, the whorls do not even touch at first. The tip of the cone is free for some distance before the involution brings the whorls in contact. No marks of a cicatrix were discernible.

Saemann's original specimen of Nautilus atratus is the finest I have ever seen, and yet this is only a cast. The apex, however, is formed by a cake of iron, which has a rough, lumpy surface, difficult to account for on the supposition that it was the cast of the smooth interior of an unbroken shell.† The area between the first and second septa is smooth, the abdomen flattened, and a faint median depression is noticeable near the suture of the first septum. This, and the second septum, incline towards the umbilicus at a greater angle than any of the succeeding septa.‡ The point of the external shell is the corner which it makes on the abdominal side, as it passes around the angle of suture. This has been habitually mistaken for the apex, whereas the organic apex is really further inward, and nearly parallel to the first septum, and, in some Nautili, such as Nautilus lineatus Sow., is an almost flattened area apparently on the dorsal side.§ Nothing approaching a cicatrix was actually discovered, and yet, besides the general form, which is similar to that of N. Pompilius, the aspect of Saemann's

* Plate IV, Figs. 7-9.

† Plate IV, Fig. 6.

‡ Plate IV, Fig. 5.

§ Plate IV, Fig. 10.

cast, and the sections of N. lineatus, which I have seen, indicate that it is present. One of these casts has a very thick tumid shell over the apical portion, and the other, which has a thin shell, exhibits a transverse depression just inside of the siphonal cœcum. This shows that the shell not only differs in thickness on the apex, but is more or less corrugated also, as if by a scar.

The oval outline of the area of the cicatrix, slightly flattened on the ventral side, is singularly like the adult of the Nautilus Bohemicus, and others of the Silurian Nautili described by Barrande.* The regular ellipse of the young of the latter, and the flatter cone of the young of the Carboniferous Nautili, is not represented at all in the young of N. lineatus and N. atratus of the Jura.

UMBILICUS.

As the embryo of the typical Ammonites, and the closely coiled Goniatites, such as G. diadema, approaches the beginning of the first whorl, its flattened dorsum becomes depressed or concave on either side as previously described, and when the apex of the first whorl bends dorsally, hollows are formed on either side, closed at the centre. These are the embryonal umbilici.

They do not exist in Nautilus, but their homologues are probably found in the ovisac, as previously pointed out, though they can form no umbilici properly so called. The close coiling of the first whorl forms the umbilici by enclosing these spaces in Goniatites and Ammonites. In Nautilus they can never be so enclosed, owing to the loose coiling of the first whorl. The umbilicus of Nautilus Pompilius penetrates entirely through the whorls, as it does in the group of Nautilini among the Goniatites, where the ovisac does not fill up the centre. The lateral depressions or sinuosities observable on the sides of the outer rim of the scar in N. Pompilius, the homologues of the umbilici of Ammonites, were not observable in N. atratus, since, as previously stated, no well-defined scar was observable among the fossils which came under my observation.

WHORLS.

The whorl of the typical Ammonites, and the closely coiled Goniatites is at first as broad as the ovisac, then rapidly contracts, becoming

* Plate IV, Fig. 6.

considerably narrower.* Before the completion of the first revolution, estimating from the neck of the ovisac until the whorl again touches this point of origin, it reassumes the normal rate of increase.

The increase in the dorso-abdominal diameter appears to be very marked at first, and this gives a peculiarly broad aspect to the sides of the whorl, just beyond the embryonal umbilicus ;† subsequently the increase is constant and invariable in all the diameters.

The form of the whorl is notably distinct from what it afterward becomes, and is identical with that of a typical adult Goniatite, and an equally close representative of the young of G. diadema and other closely coiled Goniatites. There is the same broad, even, somewhat flattened curve to the abdomen, and abrupt sides. The retention of this Goniatitic outline is greater or less in different species, and it is necessary to be cautious in estimating the duration of this period of growth. The septa give an accurate measure of the time during which the young animal may be said with truthfulness to have resembled an adult Goniatite in some of its characteristics.

The types I have examined are evidently too far removed from the Goniatites in the structure of the adults, and their development consequently too much accelerated, for any very extended or exact reference, in all their characteristics, at any one period of growth. Such precise identity of the young with the adults of the parent type can only be expected in the Clydonites, or some of the simpler transitional groups, where the Goniatitic stage must necessarily be of longer continuance.

The outline and septal structure of the young are almost identical between the Goniatites and Nautiloids, more especially the arcuate forms of the young with plain concave septa, such as G. compressus, when compared with the arcuate forms such as Cyrtoceras. Sandberger's figures show in section the young whorl of this species, which is a regular ellipse, and has an outline and septa very like Nautilus Bohemicus; the siphon also being at an earlier period undoubtedly abdomino-central, we have here at one stage a close approximation in the general characteristics of the structure.

The umbilical perforation is very contracted and small in Nautilus Pompilius, when compared with the fossil, and differs also in form from

* Plate I, Fig. 6. Plate II, Figs. 2, 11.

† Plate I, Fig. 7.

the Palæozoic species. The Nautili of the Silurian, such as Nautilus Bohemicus, Nautilus Sternbergii, Nautilus tyrannus, Nautilus Sacheri, figured by Barrande, have very large umbilical perforations. The Devonian Nautili, like those of the Silurian and Carboniferous, all belong to the group of Imperfecti, and have large umbilici, showing the entire spire. What is the exact size of the umbilical perforations I cannot state, but doubtless it is in the majority of the species large, and the young whorls rounded as in the Carboniferous and Silurian members of the same group.

The Carboniferous forms are distinguished by their highly ornamented and varied adult shells, as well as by their exceedingly large umbilici. Nearly all of these DeKoninck * has pointed out are characterized by a large umbilicus, showing the entire spire. Even the Nautilus oxystomus, a species in which the whorls are considerably involute, has an umbilicus, and at first a rounded whorl, which subsequently becomes hexagonal and then lanceolate in transverse sections, and involute. The umbilical perforation in this species is much smaller than in those species with non-involute whorls. The Museum has among other treasures the entire collection of DeKoninck, and I have been able to verify these observations.

The species of the Trias and Permian I have been unable to examine. But of the two species figured by King,† N. Freislebeni, and N. Bowerbankianus, one has a closed, or what is generally called a closed, umbilicus, i. e. with probably, as in the modern N. Pompilius, a small perforation. N. bidorsatus of the Muschelkalk also has a form like many of the Jurassic species, and a much smaller umbilical perforation than is common in Carboniferous species. Other species of the Muschelkalk, such as N. mesodiscus, N. Sauperi, N. reticulatus, are as completely coiled, and as involute as any of the Jurassic and succeeding formations. It is probable, therefore, that the earliest general change in the size of the umbilical perforation will be found to take place in this formation.

The Nautili of the Jura, as pointed out by Pictet, ‡ approximate closely to the existing species in the adult stage, and, as DeKoninck has shown, their umbilici are comparatively closed. The young of two

* Animaux Fossiles, p. 544.

† Permian Fossils of England, p 219.

‡ Pictet, Traité élémentaire de Paléontologie, 1845, Vol. II.

species are figured by D'Orbigny, and these are decidedly in advance of the circular and very slowly increasing whorls of the young of the Carboniferous and Silurian Nautili, and the umbilical perforations are much smaller. Barrande says of the umbilical perforation, "Au centre de la spire, il existe une vide ou perforation, qui est remarquable par sa constance, et son étendue dans les Nautiles paléozoiques. Nous retrouvons cette perforation, quoique très-réduite, dans les espèces fossiles des époques postérieures et même dans les Nautiles qui vivent dans nos mers." The Jurassic shells belong almost wholly to the Striati, a group with longitudinal ridges or plications on the whorls.

The young of Nautilus lineatus of the Jura presents an umbilical perforation quite as small as that of the modern Nautilus. The whorl, however, does not make the graceful curve of Nautilus Pompilius, but bends inward more abruptly, and instead of touching the apex of the whorl first, it strikes the dorsal ridge of the area of the cicatrix, fitting itself to its flattened surface.* The result is an irregularity in the curvature of the dorsum at this point, which appears to be abnormal, but is probably characteristic at least of the species, since I found it in two different specimens.

This fact, however, as well as the figures of the young given by various authors, shows that in the Jura the whorling probably becomes, in several species, as close, and perhaps closer than in the modern Nautilus; certainly, in all those forms which, like Nautilus lineatus, are very involute in the adult.

The Radiati of the Cretaceous are, as a whole, more deeply involute than the Striati of the Jura, though not differing as respects the size of the umbilical perforation. The earlier age at which the involution begins is particularly noticeable, and the consequent prevalence of forms which increase in size more quickly than the majority of Jurassic species may be assumed with confidence, though the material at my command does not enable me to substantiate this statement by actual observation made upon the uncovered young.

It is founded, however, upon the fact which appears to be universal among Ammonoids and Nautiloids, that the earlier a species begins to become involute, the quicker must be its increase in size. Involution, indeed, is only one method of expressing the expansion of the shell inwardly by the growth of the sides over the umbilical area, and it is

* Plate IV, Fig. 10.

evident that this, when it occurs early in life, must, as in the modern Nautilus, occasion a more rapid spreading of the sides at the apex than is to be found in the Striati of the Jura. This, of course, does not exclude the effect of the spreading of the sides independently of involution, as in Nautilus excavatus Sow. of the Jura; but this is not generally so well marked in the young as in this species, and has no bearing upon the question, which concerns only the prevalence and early development in time of involution, as it may be observed in full-grown specimens.

The Lævigati of the Tertiary appear to come no nearer to the existing Nautili than the Radiati, except in their smoother shells. The group of Aganites or Nautili, with deep lateral lobes like those of Clymenia, form a distinct genetic series, but they are no exception to the rule. Nautilus aganiticus, gravesianus, and sinuatus of the Jura are all less involved than either Nautilus aturi, zic-zac, lingulatus, or Morrisii, and others of the Tertiary.

Another peculiarity, the concavity of the dorsal side, is earlier developed in the closely coiled young of Jurassic, Tertiary, and existing Nautili than in the Palæozoic forms. Barrande, among the Nautilini of the Silurian, treats this characteristic as one which is due to the involution of the whorls. His figures show that it is very slight, and arises at a comparatively late period, and only after the whorls come in contact. It does not exist at all in Nautilus vetustus, which is a very loosely coiled whorl. The conclusion here also seems to be inevitable that a characteristic, at first fluctuating, and pertaining exclusively to the older periods of growth, becomes more embryonic in the later species of the same genetic series. In this instance also we have, as the result of this law of acceleration, a characteristic which is at first dependent upon another characteristic, the involution of the whorls, becoming incorporated in the organization, and finally manifesting itself independently, in the growth of each individual, before the whorls touch each other. It is certainly universally present at a very early period in the young of the Jurassic and succeeding periods, though absent in many of the Carboniferous forms.

These exceptions may be said to prove the rule, for species, such as N. Koninckii, in which it is absent, have their backs convex instead of concave, because the abdomens of the whorls which they involve are concave instead of being convex.

The dorsal concavity in the young of Nautilus atratus is marked at the very commencement of the whorls by the flattening of the elliptical outline of the second septum.* In Nautilus Pompilius, however, the dorsum is flattened at an earlier period, the concavity affecting the conformation of the first septum.

Sandberger † and Richard Owen ‡ both allude to the Goniatitic stage, and also to a subsequent Ceratitic period. Sandberger's recognition of these periods of development, though not quoted by Owen, has priority in point of time, and is much fuller and more comprehensive. He also shows that Hauer really first called attention to them by his figures of Amm. floridus. § Sandberger, however, failed in seeing their full significance, since he most emphatically denies that these transformations show any affinity between Goniatites and Nautilus in the following words: "Obgleich ich die letztere Thatsache" (the simple Nautilian characters of the septa of young Goniatites) "keineswegs für einen weiteren Nachweis vewandschaftlicher Verhaltnisse von Goniatites und Nautilus geltend zu machen gedenke und angesehen wissen will." Owen describes the transformations of an Ammonite, only in order to show that they were simpler in the young than in the adult, and that the young of the same species at different periods of growth had been by different authors referred respectively to Goniatites, Ceratites, and Ammonites.

The so-called Ceratitic stage exists only in the septal sutures, and will be referred to further on.

After the Goniatitic stage is completed among the typical Ammonites the outlines of the whorls assume no general form, but vary according to the group or genus in which the shell is found.

SEPTA.

The first septum of the typical Ammonite is situated at the junction of the first whorl and the ovisac. It has deep, entire, simple lateral lobes on either side, and a prominent abdominal cell as in Nautilus.||

The dorsal side was not so accurately observed. It is probable,

* Plate IV, Fig. 6.

† Oberhessische Gesellschaft für Natur-und-Heilkunde, 1858.

‡ Palæontology: Second edition, p. 99.

§ Cephalopod, von Bleiberg. Plate I, Fig. 14.

|| Plate I, Figs. 2, 5.

however, that the lines "X" delineated in the interior of the specimen of Deroceras planicosta, Plate I, Fig. 6, show the junction of the first septum with the dorsal side of the whorl. They are in the proper position with relation to the external suture, and it is difficult to imagine any other structure to which they could belong. I failed to find anything similar in other specimens, and the original was accidentally lost after the figure had been drawn, while transferring it from one glass slide to another.

The huge size and depth of the abdominal cells of the first septum has no exact parallel, so far as I am aware, in any known adult Cephalopod. The pouch-shaped lateral lobes also appear to be peculiar. The sutures, however, vary considerably in the young of the same species. In some specimens inferior lateral cells* appear on the sides, and the lateral lobes are not so high, the abdominal cell, also, varying proportionally in breadth and depth. These lateral cells, however, do not exceed the strict Nautilian limits, and remind the observer of the slight inferior lateral cells of Nautilus Pompilius, both in position and in outline. Often, however, they occur so exactly on the edge of the embryonal umbilicus, and the descent into the lateral lobes is so abrupt that the observer confounds the suture with the projecting edge of the first whorl.† When such a specimen is viewed from the side by transmitted light, and the ovisac is transparent, as it frequently is, the shell appears to be pointed as in Nautilus, and the ovisac absent. When, however, a few specimens are completely broken down, and the ovisac and first septum laid bare, the error is easily corrected.

In section, the first septum appears to blend with the wall of the siphonal cœcum.‡ The enclosed transparent spaces, however, as indicated at 1 e, 2 e, Plate II, Fig. 1, between the siphonal wall and the inner side of the shell proper, probably represent all of this septum which obtains along the median line. In other specimens which I have studied this cannot be so plainly made out, and I should still be in doubt if these transparent spaces had not been enclosed by the lining layer of the shell. They can be compared in other respects also with the succeeding septa, which they resemble in position, size, and the peculiar spreading or fan-shaped sections of the sutural portions or junctions. The texture of the septum seems to be very distinct, but the drawing

* Plate I, Figs. 2, 5.

† Plate II, Fig. 7. Plate I, Fig. 4.

‡ Plate II, Fig. 1, 1 e.

necessarily exaggerates its transparency as well as the opacity of the siphonal wall. They cannot really be distinguished at their borders, the one from the other, but in every case the true calcareous septum blends with the brown of the wall of the siphonal cœcum. This may be the effect of fossilization, since, in other instances, at a later age, there was no difficulty in distinguishing the two at their junctior

The second septum* has a very distinct, deep, broad ventral lobe, divided by a ventral cell and siphonal fissure, deep superior lateral cells with shallow superior lateral lobes and inferior lateral cells equally slight, the inferior lateral cells beginning to appear upon the border of the whorl. Thus, when seen from the front, this septum has an appearance which leads the observer to suppose that it is interrupted.† An abdominal view,‡ however, readily corrects this mistake, especially in section where the continuity of the suture is readily defined, and a lateral view of the succeeding septa shows the divided ridges of the ventral cell very plainly. § These two ridges normally form one cell. The fissure is probably due to the prolongation of the siphonal funnel. This is a collar-like inflection of the septum, directed posteriorly, the circular extremity resting upon the sheath of the siphon. This funnel has a shallow channel on the ventral side, which is found in Nautilus also. When, therefore, the siphon is near enough to the shell, this channel divides the ventral cell; otherwise, it ceases to depress the septum before arriving at the edges, and leaves the suture entire.‖ These facts also demonstrate another, of some importance, that the ventral cell is no adventitious product of the near approach of the siphon to the ventral side in Goniatites and Ammonites, but an independent characteristic, constantly present in the latter, but absent from many species of the former. This conclusion is substantiated by a specimen, two septa of which are figured below.¶ No abdominal channel or gutter was present, and the abdominal cell was left entire.

The species in which the gutter is absent, among the Goniatites, have a simple ventral lobe, as many of the Nautilini, Goniatites discoideus Hall, and Goniatites Patersoni Hall. In some, however, as pointed out by Barrande in Goniatites plebius, the ventral prolongation of the funnel deepens the ventral lobe itself. This is due, perhaps, to the extensive

* Plate I, Figs. 4, 5. Plate II, Figs. 7, 8.
† Plate I, Figs. 1, 0.
‡ Plate I, Fig. 2.
§ Plate II, Fig. 8.
‖ Plate II, Figs. 10, 0.
¶ Woodcut on last page of text.

development of the funnel in Goniatites, which contrasts with the slighter proportional development of this part in Ammonites.

Leaving the funnel to be more fully described in treating of the structure of the siphon, we can proceed to the dorsal side of the second septum. This suture is precisely similar to the ventral side in the number of the lobes and cells, though these are shallower and narrower, as might be expected from the more confined limits within which they are necessarily distributed. The young Ammonite in the second septum, therefore, really possesses, like the simpler forms of Goniatites, — the Nautilini, which almost exclusively occupy the Silurian epoch, — only large lateral lobes, which, with their duplicate dorsals, make four in all, together with one dorsal, one ventral, and two inferior lateral lobes.

These last occur upon the edge of the whorl, and are therefore filled, at first, only by single lateral projections of the animal's body. They, by growth, become duplicated on the ventral and posterior sides; but, at this stage, they are single. The sutures of the second septum, therefore, possess one pair of median lobes, the ventral and dorsal; two pairs of superior lateral lobes, and one pair of inferior lateral lobes, making eight in all.

Six is the number which has always been attributed to the young Ammonites, and also the normal forms of Goniatites, though differently counted. The external lateral lobes were counted by D'Orbigny and others separately from their duplicatures on the dorsal side; very inconsistently, however, the dorsal lobe, which is plainly only a duplication of the ventral, was enumerated as a separate lobe. In this way observers have found only two external inferior, and two external superior lateral, with one external, and one internal median lobe, making six in all. D'Orbigny was strictly correct, so far as he went, in assigning six lobes to the young Ammonite, though at fault, with the exception of the ventral lobe, in not observing their counterparts on the dorsal side.

The third and succeeding septa * on the first volution differ only in the fuller development of these same lobes and cells; on the early part of the second volution in Deroceras planicosta, and on the latter part of the first whorl in Arnioceras semicostatum, however, the increase in breadth of the whorls exceeds the normal increment of growth of the lobes and cells. When this takes place, the inferior lateral lobes no longer occupy their old position on the umbilical border, but retire with-

* Plate I, Fig. 4. Plate II, Figs. 7, 8.

in, and the inferior lateral cells appear.* The whorl continues to enlarge, and finally these also retire to make way for the first auxiliary lobes. This occurs in Deroceras planicosta upon the last quarter of the second volution; but in Arnioceras semicostatum the development is much accelerated, the first auxiliary lobe appearing on the first quarter of the second volution. The first auxiliary cell succeeds these lobes in the latter species, certainly as early as the second quarter of the third whorl, and in the former they are delayed until the second quarter of the fourth.

The peculiar minor lobe dividing the superior lateral cells, the first decisively Ammonitic characteristic assumed by the sutures, is fully expressed in Arnioceras semicostatum, on the latter part of the third volution, while in Deroceras planicosta the minor lobes are hardly apparent on the latter part of the fourth.

Further than this it is not my present purpose to carry the history of the development of the sutures. From this point, or rather after the first two whorls, the sutures should be studied in connection with special series and groups of series.

D'Orbigny, who studied more thoroughly than any other author the mode of apparition of the auxiliary lobes upon the umbilical side, decided that they were due to the increase in breadth of the whorl, and the facts here recorded confirm the accuracy of his statements.

My observations do not lead me to recognize the so-called Ceratitic period of other writers. If there is anything peculiar to the Ceratites, it consists in the presence of an indefinite number of small, club-shaped, serrated lobes. No corresponding features exist in the young Ammonite, not even in Amm. floridus, as figured by Hauer. The smooth and deeply sinuous sutures of the young Ammonite, such as Arnioceras semicostatum, have a faint resemblance to those of the adult of Goniatites Hyas, from Rockford, Indiana, and to some adult Clydonites or young Ceratites. These are mere similarities, however, which do not impress the observer as anything more than mimetic changes, such as are observable everywhere between the structures and forms of distinct, but genetically connected series. The fundamental characteristics of the simpler and earlier-occurring Nautiloids and Goniatites are very distinctly repeated in the young Ammonite, but beyond this comparisons can only be safely made by tracing series downward. I have succeeded, by the aid of the

* Plate I, Fig. 8. Plate II, Fig. 9.

splendid material accumulated by Professor Agassiz, in doing this with considerable certainty for the Arietidæ, Liparoceratidæ, Cycloceratidæ, and somewhat less completely for several other families of typical Ammonites.

Goniatites has the first septum very similar to that of the typical Ammonites, but on the ventral side a deep siphonal fissure occurs, owing to the near approach of the conical prolongation of the siphonal cœcum to the ventral side.* The sutures of the first septum follow the cone in two specimens of Goniatites diadema, but in both the necessarily violent removal of the shell probably carried away the outer side of the siphon.

Barrande's observations show that this frequently occurs in the adult, when the whorls of the Silurian Goniatites are torn apart in order to expose the ventral side. The broken edges of the upper part or neck of the siphonal cœcum, in both the specimens alluded to, as in the one figured,† make continuous sutures along the abdomen from the first to the second septum, and this could hardly be accounted for under any other conditions.

A comparison of sections of this part of Deroceras planicosta and Goniatites diadema ‡ show that in both the same conical prolongation exists, and has about the same relation to the shell. In the former, however, the cone ceases to be an integral portion of the siphonal cœcum, and the invariable continuity of the suture of the ventral cell is due to the manner in which the first septum bends inward to form the floor of this part only, instead of being more deeply inflected to form the cone, as in Goniatites.§ Both are normally entire, but in Ammonites alone, owing to the structure of the cone, is this apparent in all specimens. The suture of the second septum in Goniatites diadema is continuous; the neck of the siphonal cœcum not being so close to the shell, it is not easily obliterated, and the dark line of the suture is readily traced across the siphonal area. This septum has entire outlines, a shallow broad ventral lobe, and superior lateral cells, with narrower, but still very well marked lateral lobes near the embryonal umbilicus.‖ The dorsal sides of neither of these septa were observable on account of the opacity of the specimens.

* Plate III, Figs. 3, 5, 6.

† Plate III, Figs. 3, 5, 6.

‡ Plate I, Figs. 3, 4. Plate III, Figs. 5, 6.

§ Plate II, Fig. 1, 1 e.

‖ Plate II, Figs. 3, 4.

Comparing the first septum with the corresponding septum of Deroceras planicosta, it is noticeable that the ventral cell and the lateral lobes are deeper and narrower in the latter; a characteristic liable, probably, to considerable variation, since it accords with the larger size of the neck of the ovisac, and the consequently greater spread of the sutures in Goniatites diadema.

The suture of the second septum differs far more from its representative in the young Ammonite. The ventral lobe of the latter, with its siphonal fissure, is represented by an entire shallow lobe; the superior lateral cells have their counterparts in wide, shallow, evenly curved sutures, unbroken by any superior lateral lobes. This comparison, and the abrupt introduction of the superior lateral lobes in the third septum of Goniatites diadema,* also show plainly that the superior lateral lobes do not arise, as do the inferior lateral and auxiliary lobes, from projections of the body, which appear first as single lobes upon the edge of the umbilicus, subsequently becoming double (i. e. divided into dorsal and ventral, *vis-à-vis,*) by the spreading of the sides of the whorls. On the contrary, they are derived from the direct growth of a lobe which bisects the large entire superior lateral cell, and divides it into superior and inferior lateral cells. The inferior lateral lobes are present in both. The outline of this suture in Goniatites diadema is very like that of the adults of Nautilus atratus and similar species among the Nautiloids which have sweeping lateral and shallow abdominal curves.

The next, or third septum of the young Goniatites diadema introduces the superior lateral lobes as a minute angular indentation, not at all similar to the rounded superior laterals of the young Ammonites. The development of the sutures is more accelerated in the growth of the latter than of the former. since here we have two septa with Nautilian characteristics, in place of one among the later-occurring and more complicated Ammonites. When the young Goniatites diadema is contrasted also with those of its own group, we find some interesting resemblances. The Nautilini never develop superior lateral lobes, the Retrorsus group, Magnosellares of Sandberger, not until a very late stage of growth, and in some varieties, as shown by the masterly researches of the last-named author, these lobes are very slight, even in the adults. I have not examined the young of other species and

* Plate III, Fig. 4.

groups with more complicated sutures. This additional evidence is not necessary, however, to show that within the Goniatites there is still greater acceleration displayed between the young of different groups in the development of the lobes and cells, than can be found between the young of the latter and the typical Ammonites. This also corresponds with the scope of the modifications observable in the adults of the entire division between the simple Nautilini, and the Genuifracti or Serrati, or the range of variations in the adults of the same species, as exhibited by Goniates retrorsus and others. No such variability of the sutures exists among typical Ammonites, excluding the allied divisions of Ceratites. Thus, in the adults as well as in the form of the young and the amount of involution, we find greater fixity resulting from the acceleration of the development as we rise higher in the type. This continues until senility or the decline of the type again produces something similar among the aberrant uncoiled genera of the upper Jura and the Cretaceous. The fourth, and succeeding septa of the young Goniatites merely increase the divergence from the common type, the rotund ovisac, and first septum, and the history of these later stages will undoubtedly be found to be characteristic of, and highly useful in the definition of special groups.

The first true septum of Nautilus has exceedingly shallow lateral inflections of the sutures, and a ventral cell of corresponding curvature. These could hardly be termed lobes and cells, so slight are they, if it were not for the greater intensity of their expression in the second and succeeding septa. A very important feature of this first and all the succeeding septa, is the dorsal lobe. This has been previously noticed by De Montfort,* who founded his genus Bisiphites upon this feature, and by other authors, as an adult characteristic of many of the fossil and recent Nautili. Its developmental history has not, however, been followed out, except by Quenstedt.† This observer described only its later stages, and its disappearance in the adult. He appears also not to have noticed that, in the adult, a slight inflection remains in the suture after the lobe in the septa ceases to exist. Barrande describes the sutural lobe and the corresponding conical depression of the septa, but considers that they may be independent of each other. They are, however, so closely connected in the extreme young, that the sutural

* Conchyl. Syst. 1808.

† Petrefactenkunde Deutschlands, Ceph. p. 55.

inflection, which is alone retained in the adult, should be regarded as a remnant of the more complete lobe of the young. In the Aganites group, the lobed and its accompanying sutural inflection are present whenever the siphon funnel is not too close to the dorsal side. When this occurs, as in Nautilus zic-zac, the lobes of the septa are not developed, but the sutural inflection appeared to be distinctly marked. Whether this was really persistent, or whether the depressions I saw were due to the violent removal of a portion of the funnel, was not satisfactorily determined. The dorsal lobe of Nautilus Pompilius impinges against the internal portion of the upper end of the cicatrix, just as the siphonal cœcum does against that of the lower end, and is apparently the result of the passage of some organ or part from the ovisac into the shell, but the entire outline of the first septum in the young of Nautilus atratus, N. Koninckii, is conclusive against such a supposition.* It is evidently only another of the same kind as those characteristics already cited, which are developed earlier in later species of the same genetic series, according to the law of acceleration of development. When compared with the small area of the first septum of Nautilus Pompilius, it is seen to be a large and very well marked lobe. The size, however, does not increase proportionally with the growth of the shell and the area of the septa, and thus in the adult it becomes comparatively insignificant. During the younger stages, also, it modifies not only the sutures, but forms a decided conical depression in the septa themselves, so that the latter bend posteriorly at their junctions with the dorsal side of the shell. The lobe in the suture, however, is formed higher up, just under the cone of the next older septum. This is due to the great extension of the septa of Nautilus on the dorsal side, which reach so far that they are overlapping or imbricated. This cone disappears on the first quarter of the third whorl, and the septa, instead of bending posteriorly into a lobe, are simply rectangular with a minute depression on the surface. This, however, speedily disappears, and a slight ridge, evidently marking the trace of some organ or part, makes its appearance. This is found first bisecting the sutural lobe, and seems to extend continuously underneath the septa built upon the inner surface of the dorsal side of the shell. The septa, after the appearance of the ridge, lose their rectangularity, and become evenly concave, the narrow,

* Plate IV, Figs. 5-9.

shallow depression in the edges of the suture being the only remnant of the dorsal lobe.

The second and succeeding septa of the young Nautilus Pompilius differ in the possession of a narrow ventral cell upon the median line. This subsequently loses its prominence, but is not wholly lost in the general expansion of the cell; even in the adult there is a slight rising of the suture as it approaches the median line of the abdomen on either side. The first septa of Nautilus Pompilius, as might be supposed from the form of the whorl, are remarkably broad from side to side, and slightly inflected on the dorsum on either side of the posterior inflection or deep dorsal lobe previously described.

In the Clymeniæ the dorsal lobe exists, and it may be observed at an early stage, very large and distinct even in the simple sutures of Clymenia lævigata. Sandberger's researches show that it is a common characteristic of all the species of this Devonian group. The siphonal funnel of the Clymeniæ, which occupies the bottom of this lobe, is evidently entirely independent of the lobe itself, as in the case of the ventral lobe of Goniatites and Ammonites. The homology of the dorsal lobe in the young Nautilus with that of the adult Clymeniæ, can hardly, therefore, be considered doubtful. It occupies the same position, and has a similar conical form, with an accompanying broad, deep, and rounded sutural inflection. This is especially marked in the Aganites group of the Tertiary, where the siphon is variable in position, and sometimes close to the dorsum occupying the area of the dorsal lobe, as in Nautilus zic-zac, and in other species more central. Here we have an additional reason, besides that previously found in the earlier occurrence of the Goniatites, for separating the Clymeniæ including also Aganites as a distinct genetic series from the Ammonoids, notwithstanding the ventral lobe of Clymenia pseudogoniatites.

The young Nautili of the Silurian, as figured by Barrande, have shallow concave septa, and a more or less shallow outline in accordance with the elliptical or circular shape of a section of the young. This is especially noticeable in the figure of Nautilus ellipticus by Barrande.*

At a more advanced age all the species except Nautilus vetustus have an elliptical outline more or less flattened on the abdomen. They also possess, in the adult, a narrow ventral cell, like that of the young Nautilus Pompilius, on the third and succeeding septa. The Carboniferous

* Op. cit., Plate XXXII, Fig. 1.

species, which have similar cone-like young, have also similar septa. Nautilus Koninckii * at least, has septa, which differ from the more advanced stages of the young of Nautilus Bohemicus, possessing a faint dorsal cell, or rather subangular outline to the dorsal side of the septum. The suture of the first septum was observed upon one side, though obscured on the other, and this evidently possesses decided, though very shallow ventral and dorsal cells, with correspondingly slight lateral lobes. The septa were elliptical in outline, with the dorso-ventral axis longest, as in the Silurian Nautili, though they speedily reverse this in course of growth, the transverse axis becoming the longest in the adult. The dorsal lobe appears first in Nautilus Barrandei, Hauer,† or at least has not been described or seen in any species occurring earlier, though it is a characteristic not likely to escape observation, and was well known to Barrande, Sandberger, and others who have worked up the Nautili of the earlier formations. The developmental history of the septa of the Jurassic species shows a decided acceleration in the septal characteristics. Saemann's original specimen, when thoroughly cleansed,‡ showed that the outline of the first septum was an ellipse, slightly flattened on the ventral side, correspondingly with the flatness of the external outline, and nearly parallel with the area of the cicatrix.§ Sections of two different specimens of Nautilus lineatus show the same characteristics. The first septum of Saemann's cast has an entire cell on the dorsal side, as in the young of Nautilus Koninckii of the Carboniferous, though in accordance with the shape of the dorsum it is much broader, and this cell is still more prominent in the second septum, and broken by a dorsal lobe. The second septum crosses the central axis of the spiral at a different angle from the first septum, and is not, therefore, parallel with the area of the cicatrix. The dorsal lobe is very distinct in the third septum, and is supplemented by a decided though shallow inflection of the large dorsal cell forming a shallow supplementary lobe, such as has been already described in Nautilus Pompilus. The concavity of the dorsum becomes apparent between this and the second septum.

* Plate IV, Figs. 7, 9.

† Haidinger's Naturw. Abhandl. Ceph. von Hallstadt. By Hauer. Vol. III.

‡ It was covered with a thick coating of iron-rust, which obscured the sutures, and entirely concealed the first septum, which was consequently omitted in Saemann's figure of this specimen.

§ Plate IV, Figs. 5, 6.

The lateral lobes are only very faintly marked, as is also the ventral cell. In the next three septa all these features are intensified, but in the sixth and seventh septa a change takes place. The ventral cell becomes flattened, and forms a transition to the slightly concave ventral cell of the eighth septum. After this period the concavity becomes deeper, and the shell, by growth, increases the depth and size of the other lobes and cells which have been described, but otherwise does not materially change them.

Thus the Jurassic Nautili, with a shallow lobe instead of a cell on the abdomen, do not possess this characteristic in the young, but have the usual projecting cell of the Silurian Nautili. Their septa also resemble, at the earliest period, those of the same forms when considerably older, but this outline changes in the second septum. The development is also accelerated in another way than by the earlier appearance of the Silurian characteristics. The increased involution, as previously shown in the small size of the umbilical perforation, and tendency of the whorls to spread inward, causes the second septum to advance its outer or ventral edge, and make a sharp angle with the first septum. The antero-posterior axis of the whorl, in other words, curves suddenly instead of slowly, as in the Silurian and Carboniferous Nautili, and the first septa are not consequently parallel either with the mouth of the ovisac, as indicated by the area of the cicatrix, or with each other.* The second septum resembles the first, however, in its shallowness, and is a transition to the third, which crosses the whorl at the same angle as the older septa, and also resembles them in its deeper concavity, and the shape of the dorsal cell and lobe. The acceleration of the development shows itself very decidedly in the modern Nautilus. The outline of the first septum of Nautilus Pompilius is broader, but otherwise the suture is identical with that of the third septum of Nautilus atratus, and like that has the same trend as the older septa, and is deeply concave. Its breadth, also, is due to the accelerated rate of growth of the young, as are also the absence of any stages corresponding to the first and second septum of Nautilus atratus. The outline of the area of the cicatrix is very similar to that of the first septum in Nautilus atratus, and this shows that, in all probability, the neck of the ovisac resembled in shape the apex of the first whorl in the Jurassic Nautili.

* Plate IV, Fig. 10.

SIPHON.

The siphon has been so much studied and so fully described that at first sight it seems impossible to add anything to our knowledge in this direction. The structure, however, in many of the most essential features has been either misinterpreted, or only partially understood, on account of the disuse of the microscope in palæontological researches. The siphon in Nautilus Pompilius * begins with a closed cœcal prolongation of the first septum. This is circular in outline, apparently flattened at the bottom, and rests directly upon the lower end of the cicatrix. The ventral side is somewhat inclined, the dorsal more or less abrupt, the cœcum swelling out below the septum in the specimen examined. Above the first septum the siphon expands, becoming much larger. The walls, as well as the bottom of the cœcum, are lined internally by an extension of the sheath, which is continuous with the siphonal funnel of the second septum. There is also in the figure on Plate IV a layer lying between the internal corneous layer of the siphon and the sheath. The walls of the third septum are continuous beyond the mouth of the siphonal funnel of the second septum, and seem also to coat the inside of the cœcum, but I have been unable to verify this observation upon other specimens, and prefer to consider it doubtful.

The structure of the outer wall, or sheath of the siphon, differs from that of the septum itself, in being of a looser and more granular texture. This, in the specimen examined, was more marked upon the dorsal than upon the ventral side, between the apex and the first septum, as well as between the latter and the second. At the third septum, however, this difference is not so noticeable; the denser portion of this septum, or the siphonal funnel, extends posteriorly nearly as far on the dorsal as on the ventral side. As previously described, the siphonal funnel rests upon the looser-textured wall, and is really continuous with it. The difference in texture merely results from the quicker formation of the latter, while the animal is passing from one septum to the next in age, and the quieter deposition of the former while the animal is taking its periodic rest, and building up a septum.

The siphonal funnel is always spoken of as belonging to the septum, and not to the siphon proper. This is true of the adult, but not of the

* Plate IV, Fig. 4, R.

young. The siphonal cœcum is entirely made up of the funnel of the first septum. The funnels of the second and third septa are excessively long, but in the fourth a decided decrease in this respect is noticeable, and on the fifth septum it assumes very nearly the short aspect of the same part in the full-grown shell. The lips of the funnel incline inward, resting upon, and surrounded by, the looser-textured wall of the siphon, which reaches exteriorly considerably beyond the lips of the funnel in the young, and in the adult sometimes to the bottom of the septum itself. Barrande describes the length of the funnel as exceedingly variable in the Silurian Nautili; but this does not appear to be true among the modern forms. I was unable to determine whether the funnel in the Jurassic Nautili was longer in the young than in the adult. It is probable, however, that, as in other characteristics, this will be found to have acquired greater constancy, as we proceed in time; in fact, the funnels of the young Nautilus Pompilius, invariably longer than those of the adult, show that the length has not only become more constant, but has even been reduced, in accordance with the law of acceleration, to an embryonic characteristic.

Sandberger and Barrande, who have studied the siphonal funnel more than other authors, use a somewhat different terminology, the former speaking of it as a funnel and the latter as a conical neck. I prefer Sandberger's term, because it seems to me to express the form quite as well as the latter. In all the species that I have examined, whether Nautili, Goniatites, or Ammonites, the aperture is always somewhat wider than the bottom, and one side, the ventral, inclined, the opposite being more abrupt.

In other Nautili, however, the funnel form is more distinctly expressed, as in Nautilus zic-zac. Here the structure which I have described, the continuity of the outer layer of the siphon or sheath with the septum, is most plainly expressed. The siphonal funnels in the adult extend posteriorly, as in the young Nautilus, to the opening of the next younger funnel. They become narrower posteriorly, until near the junction, and then a tumid band plugs up completely the siphon, some distance outside of, or posterior to, the flaring sides of the funnel. In other words, the funnels set into, and not upon, each other, like a pile of the necks of broken bottles, when the septa are fractured in order to expose them to view. The shell of the funnel throughout is of the same close, pearly texture, except the swollen band at the junction. When this is more closely examined, it is seen to be composed of two portions, the tumid external sheath of looser granular texture, and the narrowing neck of the funnel. Thus the tumid band is really, though so narrow, the representative of the external sheath of the siphon in Nautilus Pompilius, and performs the same function of uniting the siphonal funnels, and protecting the continuous horny layer of the interior. In other Nautili, such as Nautilus lineatus of the Jurassic, the siphonal funnel becomes a ring or section of a cylinder, flaring or inclined outward both above and below like an eyelet.

Inside of the funnel and the sheath in Nautilus Pompilius is a layer, which is also of a loose texture similar to the sheath, and inside of this, the continuous dark corneous layer. The intermediate layer has not been previously observed, and I have unsuccessfully endeavored to find it in the siphon of the adult. The condition of the specimen was such that I cannot now be sure that it is really a distinct layer.

The sheath in the adult is not simply of a loose granular texture, but looks more like the rough surface of a sponge pierced with holes, which are visible with an ordinary magnifier in desiccated specimens. Externally, the sheath is covered by the lining membrane of the chambers, and has a pearly aspect in many specimens. The thickness of the sheath and its color vary greatly. In one specimen it was so excessively thin and porous, even in the adult, that the color of the corneous layer shone through. At an older stage, however, it assumed the usual opaque aspect. Viewed from the interior, it is usually smoother, pearly, and shows broad bands, probably bands of growth. If so, the animal must progress neither quickly from septum to septum, as supposed by Owen, nor slowly and constantly, as described by Valenciennes, but probably with many intermediate periods of arrest marked by the deposition of these bands.

The siphonal cœcum of Nautilus lineatus* occupies a different position from that of Nautilus Pompilius. The cœcum lies against the inner side of the area of the cicatrix near the centre in Nautilus lineatus, and both sides swell out under the first septum as on the dorsal side of the same organ in Nautilus Pompilius. The siphon between the first and second septa makes a curve like the central portion of the letter S, first inclining ventrally, and then bending again towards the centre. The position

* Plate IV, Fig. 10.

of the cœcum nearer the centre accords with the situation of the first septum, and its parallelism to the area of the cicatrix, but it is still, as in the recent Nautilus, considerably nearer to the ventral than to the dorsal side. Owing, however, to the position of the first septum with relation to the angle or apex made by the bending of the external shell around the ventral edge of the first septum, the cœcum is not so near the so-called apex of the whorl as in Nautilus Pompilius. In other words, it lies nearer the centre of the actual apex, the centre of the cicatrix, and farther away from the apparent apex, or angular termination of the outline, than in Nautilus Pompilius. The peculiar abrupt curves which it subsequently makes are due partly to the abruptness of the ventral side of the cœcum, and partly to the angle at which the first septum lies with relation to the second. All of these characteristics are thus shown to be dependent upon the altered or accelerated development of the septa in the young of Nautilus Pompilius, which causes the first septum to assume a position and other characteristics similar to those of the third septum of Nautilus atratus and lineatus. Another fact in the same direction is the ventral position of the cœcum in the Jurassic and existing species, as contrasted with the central siphon of the young of the Silurian and Carboniferous Nautili. The extreme variability of position of this organ among the adult forms of the Silurian of course renders this characteristic somewhat doubtful, but it is a curious fact that we should find it so strictly accordant or correlative with the other characteristics already described. It must evidently be added to our other list of characteristics, which though at first variable, become in course of time fixed and invariable, through the action of the law of acceleration.

The siphon of Goniatites differs in a remarkable manner from that of Nautilus. It has a long conical termination which penetrates the first septum, and lies so close to the abdomen as to form a very decided fissure, probably due, however, as previously explained, to the removal of the shell. Otherwise the siphonal cœcum would be open on the abdominal side, which it does not seem to be when seen from the side, and covered by the shell. The cœcum above is flask-shaped, the neck of the flask lying between first and second septa. The first septum forms the round bottom of the flask and the closed conical prolongation; the second septum, the neck and part of the body of the upper portion. The neck, however, continues to decrease in size until it reaches the third septum. The siphonal funnel is apparent even in the first septum, as may be seen in the ventral view of this part in Goniatites diadema, on Plate IV, where the sutures incline posteriorly at their junction with the cœcum. Thus, instead of being entirely out of the ovisac as in Nautilus, whether recent or fossil, the siphonal cœcum is to a considerable extent developed within the ovisac. In other words, this part is developed and completed later, as is also the first true septum, of which it is an integral part, in the existing Nautilus, than in the fossil Goniatites, certainly as early as the Carboniferous and perhaps earlier. I should expect, however, to find some change in this respect in the Silurian forms of Goniatites.

The cœcum is made up of the same elements, if we consider that the internal corneous element has probably been destroyed in the course of fossilization.

The siphonal funnel at a later age becomes more distinct, and is not confounded with the sheath of the siphon as it is in the first and second septa, and perhaps the third also, but this last fact could not be determined satisfactorily. At a later stage the funnel is very distinctly seen, and, as described by Guido Sandberger, is continuous on the ventral side, though it lies almost its entire length against the shell. Barrande has described this occurring in the same manner in the Goniatites of the Silurian, and thus accounts for the appearance which deceived Von Buch. This author supposed that one of the main distinctions between Goniatites and Nautili lay in different positions of the siphon. He removed the shells of certain Goniatites and Ammonites, and apparently exposed the siphon lying in immediate contact with the shell, whereas he had really torn off the ventral lip of the siphonal funnel with the shell. Barrande, on removing the shells of Goniatites, found that this frequently occurred, and thus established the truth of Guido Sandberger's observations.

The posterior edges of the funnel* rest in and upon the siphonal sheath very nearly as in Nautilus Pompilius, and this sheath, also, as in the latter, connects the siphonal funnels of adjacent septa, as described in Nautilus.

The siphonal cœcum of Ammonites possesses very nearly the same form as in Goniatites, but is, in the species examined, perhaps somewhat flatter dorso-abdominally. It has the same position, but yet no difficulty was experienced in removing the shell without disturbing the cœcum,

* Plate III, Fig. 8, P.

or breaking the continuity of the suture of the first septum on the abdomen. The prolongation into the ovisac was not discernible on the abdomen, except in one specimen, and from the side not so distinct as in Goniatites.* The figures of this portion, owing partly to the great thickness of the specimen, and to its more attenuated structure, were completed with great difficulty, and only after repeated observations. By the use of dark ground illuminations and a powerful condenser, the cœcum extending below the first septum was seen from the abdominal side in Fig. 5, Plate I, though the walls seemed broken and partly destroyed; the cone, however, was not made out. Longitudinal sections of several specimens gave substantially the same results as the single one figured. The cœcum is formed as in Goniatites by the siphonal funnel of the first septum, but the conical prolongation does not open into the cœcum,† and its interior is filled either with a succession of other cones, or by a number of pillars stretching across its interior. The peculiar aspect of this portion in the specimens examined has suggested an explanation of this remarkable modification. When the first septum was formed, it may have been composed entirely of the thin membraneous layer on the ventral side of the cœcum, and the first thick layer at *y* in the figure; as the siphonal sheath was built up or thickened, it was carried forward on the ventral side, the different successive layers or partial septa from *y* upwards, marking the resting-places in this transit until at 1 *e* the first septum was completed. Whether this be so or not, the conical part of the cœcum has not, as far as my observations go, any decided connection with the cœcum when closely examined in section, though when seen from the side, as in Plate I, Figs. 3, 4, a connection appeared probable.

Von Buch pointed out the anterior direction of the so-called siphonal funnel of Ammonites, and has been followed by all authors since his time. The use of the microscope, however, readily detects here a very curious error. The anterior siphonal funnel of Ammonites is not identical with the true funnel of Goniatites and Nautilus, but an additional organ.‡ In the adult nearly the whole thickness of the septum bends in an anterior direction, reversing the shape of the lips of the funnel.§ In the young, only a small part of the septum bends anteriorly, and the funnel is partially maintained, while in the very youngest stages no such

* Plate I, Figs. 3, 4.

† Plate II, Fig. 1 y.

‡ Plate II, Fig. 4.

§ Plate II, Fig. 5.

anterior extension is apparent.* In all cases this anterior deflection of the septum forms an open collar surrounding the sheath. The lining membrane of the chambers, of course, surrounds it as well as the sheath, but otherwise it cannot be considered as connected with the sheath. The difference between Ammonites and Goniatites consists, then, so far as the adult siphon is concerned, in the possession by the former of a more completely rounded siphonal cœcum and the siphonal collar. Besides the earlier development and different form of the siphonal cœcum in the Goniatites and Ammonites, as compared with Nautilus, we find extensive differences in the formation of the siphonal funnel. This, instead of lining the interior of the cœcum by its extension from the second septum, as in Nautilus, only reaches the mouth of the opening through the first septum, and in the succeeding septa, instead of reducing the length gradually, the funnel becomes at once, in the third septum, very short and distinct from the sheath. They all three, Nautilus, Ammonites, and Goniatites, agree, however, in having, during the earlier stages of development, a siphon formed by a cœcal prolongation of the first septum. The large size of this cœcum, as compared with the area of the first and second septa, is also an important fact in this connection.

If there is any truth in the application of embryology to the solution of the problem of evolution, or even of the relative rank of forms, it is evident that in either sense the true prototype of the Cephalopods must have these characteristics, namely, a large siphon, composed of circular prolongations of the septa, or siphonal funnels closed at their posterior ends. Consulting the development of the simpler Nautilus, we see also that these siphonal funnels should set one into another, like a pile of cups, or cones, and the septa be concave and very shallow, as in the Jurassic and Carboniferous species. The conditions are partially fulfilled by the genus Endoceras, whose septa are shallow and concave, and the siphon consists of a series of cones, placed one within another, and closed at the posterior extremity. These cones are not strict siphonal funnels; the funnel portion really only extends from the opening of one septum to that of the next, and the cones, which are evidently the homologues of the sheath of Nautilus, are built against the continuous wall thus formed, as partitions in the siphon itself. These are the characteristics of the adult only, and it can be reasonably anticipated that the young of Endoceras would exhibit a

* Plate II, Fig. 1.

siphon composed wholly of cœcal prolongations of the septa themselves.* The discovery of the adult corresponding to the young of Endoceras is yet to be made, and even the young of Endoceras has, I believe, never been described. A fragment of an Endoceras, the Orthoceras duplex of Verneuil and Keyserling, can be even more closely compared with the young of Nautilus, than our American species. In this the septa bend posteriorly, forming extraordinarily long funnels. Instead of simply connecting adjoining septa, as in the ordinary forms, the funnel overlaps and extends just twice as far, to a point opposite to the second younger septum, posterior to that from which it takes its rise.† This compares with the tendency of Nautilus to increase the length of the funnel in the young, and the slighter distinction which exists between the texture of the sheath and the siphonal funnel itself, until at the earliest period, the siphonal cœcum is wholly composed of the siphonal funnel closed at the posterior end. Evidently a similar method of development is to be anticipated in Orthoceras duplex, and as the funnels extend so far, we ought also to find more than one cœcum. That is just as in the young Nautilus Pompilius we find that the sheath of the second septum extends into the siphonal cœcum and is closed, forming really a second cœcum; so, in the young of O. duplex the siphonal funnel of the second and third septa at least will probably be found fitting into the siphonal cœcum, and closed at the bottom.

I have industriously examined the young of Orthoceras in order to ascertain whether they too had any close resemblance to the adult of Endoceras; so far, however, my search has been fruitless, probably owing to the unfitness of the forms which have come into my hands for microscopical examinations. In the group of the Vaginati to which Endoceras belongs, it is common to find the huge siphon filled to a greater or less extent by calcareous deposits, differing considerably from those filling the living chamber and the septal chambers. Barrande, with his masterly grasp of facts, has demonstrated that these deposits are made by a posterior prolongation of the body of the visceral sac, and are not the result of fossilization. Barrande, also, considers the cones of Endoceras to have been deposited in a similar

* If, indeed, any septa remain in the extreme young.

† De Verneuil and Comte de Keyserling, Russie et l'Oural. Vol. II, Plate XXIV, Fig. 7.

manner, and attributes the spaces between them to the suddenness with which the animal arose from one resting-place to another, which did not permit the secreting surface to fill up the entire tube. Whether this is the true explanation or not does not here signify, since the main points of structure are the same, and the siphon is closed, according to both authorities.

Barrande has also, in his immortal work on the Silurian Cephalopods of Bohemia, given, with his customary fulness and accuracy, a complete analysis of the elements of form and structure among the Nautiloids. He has, however, settled upon Ascoceras as the prototype, regarding the Vaginati as the nearest allies of Ascoceras. In describing the structure of Ascoceras, this author acknowledges the existence in the young of simple concave shallow septa, pierced by a true siphon, which opens into the bottom of the living chamber, as usual in all the Tetrabranchiata.

On one side of the living chamber a series of septa are built up, whose sutures reach only partially around its circumference, and the septa themselves in the interior are equally incomplete. The imperfect septal chambers thus formed do not open into the living chamber, but are closed by the bent edges of the septa, whose free internal borders bend posteriorly until they come in contact with each other. These posterior prolongations are, in Barrande's opinion, the equivalents of the siphonal funnels of the Vaginati, many of which group have siphons open on one side, and constructed not unlike this large posterior prolongation of the living chamber in Ascoceras. There would be not the slightest hesitation in accepting this opinion, if it were not for the siphon and perfect septa existing in the young. This, according to the laws of development, as they are now understood, would constitute the Ascoceras a degraded type, one which like the Cirripeds among Crustacea, had developed into a structure simpler and of a lower zoölogical rank, than if the growth had been arrested at a comparatively early period. This would meet one of Barrande's principal reasons for considering Ascoceras as lower than the Orthoceratites, which is, that it certainly could not be placed above them, and really possessed, in its immense, incomplete, adult siphon, or posterior prolongation of the living chamber just described, a much simpler structure than any of the other Nautiloids. There is probably but little doubt that the Ascoceratites, as claimed by Barrande, have all the elements of structure found in subsequent forms besides their greater simplicity, but this can be accounted for best by considering them as forms having a truly retrogressive development, what has usually been described as a retrograde metamorphosis.

The types of Ascoceras which I have seen are much too imperfectly preserved to enable me to speak from my own knowledge of the nicer points of structure described by Barrande, but that author's unsurpassed and minutely accurate figures supply all deficiencies. One peculiarity of the structure appears to be very unfavorable to the view here presented and is so considered even by the author himself; this is the want of connection between the young siphon and the supposed larger siphon of the adult. The first of the imperfect septa bends posteriorly, as do the others, but is not, however, discontinued when it reaches the last of the entire septa of the young. It is prolonged over the surface, and is really a complete septum, not pierced by any siphonal opening. We cannot imagine any normal progressive mode of growth by which the minute so-called siphon of the young Ascoceras could be changed into the huge visceral prolongation of the living chamber of the adult, without some of the intermediate steps of this change being visible, and some connection maintained with the siphon of the young. Barrande also states that in no instance has he found any more than one of the perfect elliptical septa of the young preserved; that over this he has observed the striations and markings of the external shell; and further, that the so-called minute siphon, or elliptical funnel, penetrates this septum. Now this condition is precisely what we should expect to find, if a portion of the exposed lower end of the Ascoceras, or area of the first septum represented the scar left by the ovisac on the apex of the whorl, as in Nautilius Pompilius. This would not only account readily for the presence of the striæ of the shell upon the exterior, but also for the projecting end of the so-called siphon. The latter would then represent the siphonal cœcum, which, as in Goniatites and Ammonites, penetrated the first septum, and by the removal of the ovisac had been left exposed.

Of course this explanation can only be considered as a suggestion calling for a re-examination of some of Barrande's fine specimens, and is quite as likely to be overthrown as to be confirmed by such a process.

Whether this be so or not, the young Ascoceras was evidently, as described by Barrande, in possession of a siphon, or the representative of one in the young, and occupied the entire cavity of the living-chamber; whereas, it subsequently lost this siphon, and built up a portion of the living-chamber with imperfect septa, leaving a cylindrical hollow, which was evidently occupied by the visceral sac, thus plainly retrograding in structure, and undergoing retrograde metamorphosis, like Orthoceras in the young, and perhaps somewhat similar to Endoceras, or others of the Vaginati in the adult.

THE SHELL.

The shell of the young Nautilus, at the apex of the first whorl, consists of two layers, an imbricated internal nacreous layer, and a layer of denser texture.* The internal layer is at first a single plate deposited at the apex. The zones subsequently secreted overlie this internally on both the dorsal and ventral surfaces, and from this point the imbricated structure is maintained throughout. This shows that the internal layer is entirely deposited from within, and probably by the border of the mantle. Whether seen in transverse or longitudinal sections, it presents the crenulated aspect common to nacreous shells. It is considerably thicker on the dorsal side, owing to the longer time which the mantle must take in passing a given point on the dorsal or inner side of the spiral. This thickness is increased by the manner in which the septa extend and overlap their borders on the same side, though in the figure this is not shown, because the cut extended through the side of the dorsal lobe. Subsequently, as the whorl grows larger, this difference between the absolute thickness of the shell decreases, and in the adult they are about the same on either side.

The external layer is quite thin on both surfaces in the young, but becomes also rapidly thicker on the dorsal surface, and assumes a denser and more opaque structure than the interior. A break in this layer on the dorsal surface just before it completed the first revolution, and came in contact with the apex,† shows that this layer was probably also deposited by the border of the mantle. At this point the layer is

* Plate IV, Fig. 4.

† The break is marked by a very faint line in the figure, near the angle of the umbilical perforation. This has accidentally been made too slight in the drawing; the break is much thicker and more decided.

imbricated, and the direction of zone the same as those of the internal layer.

When the first revolution is completed, the hood begins to deposit the dark layer on the external surface of the ventral side of the first whorl, and the true external layer becomes very thin, and is often hardly definable, appearing in the section as a very faint band next to the black deposit of the hood. On the ventral side, however, it steadily increases in thickness. It is this layer also which attains such an excessive development, and composes the principal part of the shell, close to the umbilical border. The brownish color of the exterior does not seem to be distinct, but rather to be intimately blended with this layer. A faint tinge is visible before the completion of the first volution, probably beginning somewhere between the fourth and fifth septa, which gradually extends in breadth and thickness, until it assumes the aspect which distinguishes the adult. The bands on the sides, however, were not observed in the young.

Valenciennes has fully described these three parts in the adult, distinguishing the internal and external layers, and also the outer colored portion of the last, which, however, he described as a distinct layer. He regarded the two last as confined to the exposed sides and ventrum of the adult, and for this reason attributed their production to the ventral arms of the animal. I am at a loss, however, to account for their imbricated structure, precisely similar to the internal layer, or for the presence of these layers upon the dorsal side of the young, unless they have been deposited from the interior by the edge of the mantle, as were the zones of the internal layer. The replacement of the mantle-edge by the hood when the first revolution was completed, as shown by the appearance of the black deposit, would, if this view were accepted, account for the very slight traces of the external layer left on the dorsal side after the hood came in contact with the apex of the first whorl. A fine specimen of Nautilus Pompilius in the possession of the Museum, with the contained animal in an excellent state of preservation, has been examined, and the structure of the mantle-edge confirms the view here taken. The entire mantle-border is thickened, as described by previous authors, but the edge on the sides and ventrum has a somewhat different structure from that of the dorsum. The edge is tumid and divided, as in the Lamellibranchiata, into lips, containing in the channel between them a brownish substance, probably the remains of the animal matter which colors the external layer. This brownish matter is friable and not a consistent horny membrane or epidermis. The mantle-edge on the dorsal side, however, is thin and lies posterior to the hood described by Owen and Valenciennes which secretes the black layer. That on the ventrum is much thicker, with tumid border and one channel. Farther down on each side, and corresponding to the increased thickness of the shell, the border becomes exceedingly thick with two channels, an outer and an inner, each still partly filled with soft matter, evidently unformed shelly excretions, whereas the dorsal border has no such material left in its channel.

Barrande states that the dark layer of the hood is wanting in the Silurian Nautili, and this accords admirably with the continuity of all the layers on the dorsal side in these species, and also in the slightly involute Carboniferous Nautili, which I have examined. Like the size of the umbilical perforation, and the concavity of the dorsum, the presence or the absence of the dark layer and the extent of the external layers depend upon the greater or less closeness and increasing constancy of the involution of the whorls. It could not be inferred from this, however, that the fold of the mantle or hood was absent or present in the same proportion. The black deposit simply indicates, so far as we know, the secreting power of the hood, and shows that this organ came in contact with the whorls, but nothing more. The external layer is visible with a common hand lens in Nautilus lineatus of the Jura, and exhibits characteristics similar to those of Nautilus Pompilius.

Lining all of the chambers, and the exterior of the siphon, is an exceedingly thin membrane, which upon the septa, and the sides of the shell proper, though not upon the siphon, is generally, but not invariably, connected with an equally thin layer of nacre, and in the desiccated specimens; they may be observed peeling off together. Even in Jurassic fossil shells, it is distinct and easily traced, probably owing to its connection with the nacreous deposit described above.

The same layers are traceable in the ventral and lateral sides of the shell of Goniatites. All the layers * consist of imbricated plates, laid on internally. There is in many specimens a dark-colored layer, equivalent, however, to the external layer of Nautilus, and like that, invested by a layer which corresponds to the smooth, colored layer of Nautilus Pompilius. In one specimen, figured on Plate IV., I was for-

* Plate IV, Fig. 11.

tunate enough to find in section all these parts, where a transient mouth had been formed, and the deposits continued from this break. Here all of these layers are decidedly imbricated; even the thin external colored zones show their imbrications in its external portion as zones of growth, evidently due to internal deposition. Keyserling has described and Sandberger figured what they have called the wrinkled layer, lying between the involved ventral and the dorsal side of the shell of the next whorl. This I have not seen, nor succeeded in detecting anything analogous in the specimens I have examined. The figures of Sandberger, however, are known to be very accurate, and the wrinkled layer is plainly shown, limited to the involved portion of the whorl, and not extending outside of these limits. The specimens I have examined with success are all young, and it may be that this layer is absent from the younger periods of Goniatites. Besides the two layers there is, as in Nautilus, an internal lining, layer, or fossilized membrane, visible in some specimens, and this, with the prolonged edges of the septa, appears to be all that is deposited on the dorsal side. Not only the external layer is wanting on the involving dorsal side, as in Nautilus, but the internal also.

The shell of Ammonites also consists of two layers * besides the internal lining layer, which both here and in Goniatites, may be often seen to pass between the septa and the shell, as it really does also in some instances in Nautilus.† It is evidently due to the mantle, which deposits a film upon the surface whenever it rests for a sufficiently long period in any one chamber of the whorl. I was also unable, in the young, to observe any deposit similar to the wrinkled or black layer of the Nautilus or Goniatite. ‡ Only the internal lining layer of the chambers thickened by the edges of the septa is deposited on the enveloped region or dorsal side as in Goniatites.

The shell in Ammonites, as in Goniatites, also extends over the ovisac on the abdomen and the sides. This, at first, led me to suppose that here, at least, it was deposited by the arms of the animal, as in Argonauta, and as supposed by Valenciennes, for the external layer in Nautilus. But nothing in the structure of the shell itself confirms this

* Plate IV, Figs. 1, 2, 3.

† Plate II, Fig. 1.

‡ The wrinkled layer undoubtedly exists in the adults of several species, especially in *Amaltheus margaritatus*, as described by Sandberger.

view. The ovishell of Deroceras planicosta, as figured below,* is composed of two layers, — the internal lining layer, and an external thicker layer, which is not continuous with any of the layers in the shell of the first whorl. The internal lining layer bends internally, and coats the inner side of the first septum. The external layer is very thin upon the dorsal side, and was perceptible only by the aid of a fifteenth. The increase in thickness of the external layer is quite abrupt upon the abdomen, but not so abrupt as upon the sides, especially at the edges of the embryonal umbilici.† The external layer reaches beyond the neck of the ovisac, overlapping the edges of the layers which compose the apex or beginning of the first whorl. These are evidently the product of the mantle-edge, and show that the external layer of the ovisac must have been secreted from the interior by the body of the embryo. The shell of the whorls consists at first of two layers, besides the internal lining layer of the chambers.‡ These, unlike the external layer of the ovisac, to which they collectively correspond, are absent from the dorsum. The presence of the external layer on the dorsum, and its extreme thinness there, as compared with what it is upon the abdomen and sides of the ovisac, is a characteristic also of the adult of Nautilus.

The absence of all the external layers, however, from the dorsal side in Goniatites and Ammonites, appears to begin at the earliest period in the closely involved species. The septa upon that side in the latter, from the first to the sixth inclusive, extend their borders considerably, and build up quite a dense thick layer, which, however, ceases with the seventh septa. § After this, only the lining layer, probably accompanied by a thin nacreous deposit, is found on the dorsal side. A close examination of the layers showed everywhere indications of arrests of growth, and the formation of more or less permanent mouths, ‖ or zones of growth, always, however, imbricated as in Goniatites and Nautilus. The last formed, beginning inside of the edges of the earlier deposited zones, a structure entirely at variance with the supposition that any portion of the shell was laid on from the exterior.

Comparisons have also been made with the shell of Argonauta, which

* See woodcuts on last page of the text.

† Plate II, Fig. 3.

‡ See last page of the text.

§ Plate II, Fig. 1, and last page of text.

‖ Plate IV, Fig. 1.

is known to have been, partially at least, deposited by the enveloping arms of the animal. The shell consists of three layers; the inner and outer layers have a similar structure. These two are composed of minor plates or zones of variable lengths, but these are never imbricated, they are simply laid one upon another.* The median layer is very irregular when seen in longitudinal section, showing thicker and thinner portions, the thicker being somewhat more opaque than the thinner parts. In a transverse section, this layer presents a similar aspect, but the structure varies from a smooth, even shade, to a granular aspect. When viewed from above, this layer presents a reticulated aspect, due to the presence of numerous white opaque thread-like lines of growth. These are parallel with the lips of the shell, notwithstanding their minor irregularities, and may be, in some instances, followed for a considerable distance across the whorl. Especially when they represent the former edge of some one of the numerous mouths, marking the periodical arrest and renewal of the growth. They bend posteriorly on the abdomen, and anteriorly on the sides, and are covered everywhere by the internal and external layers which possess no such marks of growth. There are no marks of an imbricated structure, and the absence of lines of growth from the external and internal layers, as well as their presence in the median layers, shows also that the structure is entirely distinct everywhere from the shells of either Nautilus, Goniatites, or Ammonites. It is evident that the internal layer is deposited by the body of the animal internally, the median layer by either the mantle-edge, or by the anterior edge of the abdominal arms, externally, in successively thicker or thinner, but more or less irregular zones, and lastly, the external layer probably by the inner side of the expanded portion of the arms.

* Plate IV, Figs. 12-16.

CAMBRIDGE, June 5, 1872.

Figure I.

Deroceras planicosta. Two septa showing the siphonal funnel, **P**; the dorsal lobes, **H**; and the ventral cell, **J**.

Figure II.

Deroceras planicosta. Shell of embryo. d′, lining layer; **X**, external layer; d″, median layers of the apex of first whorl, an internal transparent and a thicker darker layer, both overlapped by **X**; d‴, external layer of first whorl next to dark layer of d″; d, additional layers deposited by the dorsal portion of the body of the animal in passing from neck of ovisac to seventh septum; 1e, first septum.

Figure III.

Nautilus Pompilius. An ideal outline of the ovisac and apex of first whorl. **A**, ovisac; **1c**, first whorl; **W**, shoulder formed by the external ridge of the cicatrix; **X** shows where the shell of first whorl connected with the shell of the embryo, and also where it is always found broken. The two dotted lines from **X** show the area of the scar itself as seen from the side; **T** is the line of involution showing the extent to which the apex is enveloped at the first revolution of the shell.

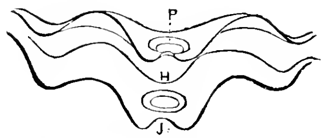


Fig. I.

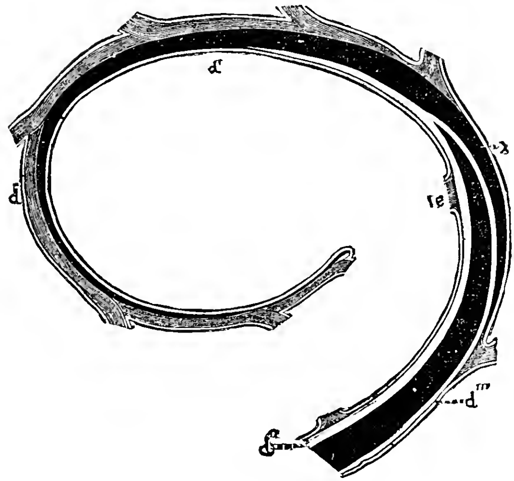


Fig. II.

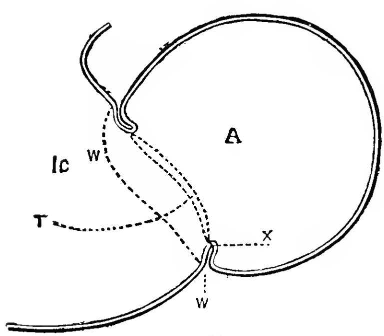


Fig III.

EXPLANATION OF SIGNS USED IN THE PLATES.

A. Ovisac.
B. Ovishell.
C. Whorls.
1c. First whorl.
2c. Second whorl.
D. Shell.
d'. Lining layer.
d''. Median layer.
d'''. External layer.
d^{+}. Black deposit or layer of the hood.
E. Septum.
1e. First septum.
2e. Second septum.
F. Abdominal lobe.
G. Lateral lobes.
g. Superior lateral lobes.
g''. Inferior lateral lobes.
g'''. Auxiliary lateral lobes.
H. Dorsal lobe.
h'. Superior dorsal lobe.
h''. Inferior dorsal lobe.
h'''. Auxiliary dorsal lobes.
$\bar{h}$. Minor lobes.
J. Abdominal cell.
K. Lateral cells.
k'. Superior lateral cells.
k''. Inferior lateral cells.
k'''. Auxiliary lateral cells.
L. Dorsal cell.
l'. Superior dorsal cells.
l''. Inferior dorsal cells.
l'''. Auxiliary dorsal cells.
M. Marginal lobes.
N. Marginal cells.
O. Siphonal fissure.
P. Siphonal collar.
$\bar{P}$. Siphonal funnel.
R. Siphonal cœcum.
S. Siphon.
s'. Horny layer of siphon.
s''. Accessary layers of siphon.
s'''. Sheath.
U. Embryonal umbilicus.
y. Cone of the siphonal cœcum.
X. General mark.

Plate I.

Deroceras planicosta.

Fig. 1. Front, or dorsal view of ovisac, with a portion of first whorl, magnified + 80 diameters. A, ovisac; U, umbilicus; 1e, first septum; 2e, second septum; R, siphonal cœcum; O, siphonal fissure.

" 2. Abdominal side of same specimen.

" 3. Section of the same, the ovisac worn down somewhat, and the first whorl split off still lower, giving section of siphonal cœcum. D, Shell; S, beginning of true siphon.

" 4. Side view of the same, showing also the third septum 3e. Magnified 123 diameters.

" 5. Dorsal view of another specimen, magnified + 80 diameters.

" 6. Abdominal side of another specimen; 1c, first whorl; **X**, lines in the interior, probably indicating sutures made by the intersection of first septum, or siphonal cœcum with the shell of the first whorl. Magnified + 80 diameters.

" 7. Same specimen before being so completely reduced; only the sides of the older whorls are worn down, admitting the light to the exposed portion of the ovisac, and the embryonal umbilicus. Magnified·80 diameters.

" 8. Another specimen with the septal outlines for four and a quarter whorls. Magnified 21 diameters.

All of the above, from 1 to 8 inclusive, were taken from the same block of dark blue limestone. Loc. Wiltshire, England.

Goniatites fecundus.

" 9. Young of circular variety. Barrande. Ceph. Bohemia. Plate XI. Fig. 2.

" 10. Young of elliptical variety. Ibid., Plate XI. Fig. 4.

Goniatites after Sandberger's Figures.

Fig. 11. Young Gon. compressus. Sandberger, Jahrb. d. Nass. Verein. 1851, p. 15, Pl. III.

" 12. Young Gon. subnautilinus. Sandberger, Jahrb. d. Nass. Verein. 1851, Fig. 27.

" 13. Young Gon. canaliculatus, var. gracilis. Sandberger, Jahrb. d. Nass. Verein. 1851, Fig. 28.

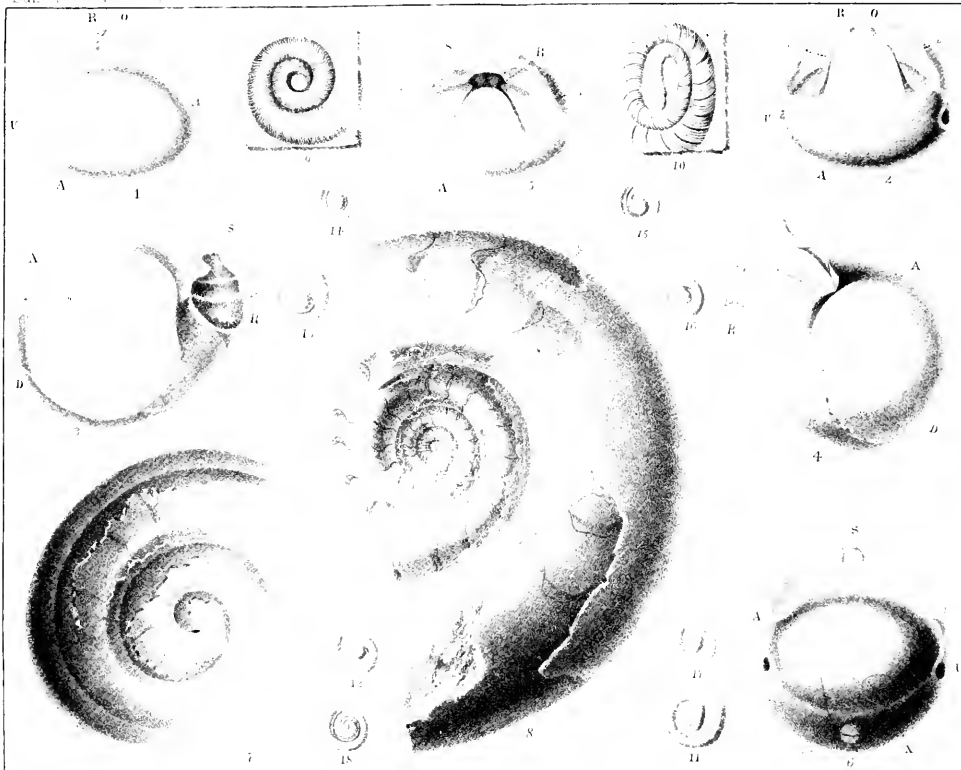
" 14. Young Gon. sublamellosus. Sandberger, Jahrb. d. Nass. Verein. 1851, Fig. 29.

" 15. Young Gon. lamed. var. latidorsalis. Sandberger, Jahrb. d. Nass. Verein. 1851, Fig. 30.

" 16. Young Gon. lamed. var. calculiformis. Sandberger, Jahrb. d. Nass. Verein. 1851, Fig. 31.

" 17. Young Gon. planorbis. Sandberger, Jahrb. d. Nass. Verein. 1851, Fig. 32.

" 18. Young Gon. diadema. Sandberger, Jahrb. d. Nass. Verein. 1851, Fig. 33.



A. Hyatt, Del. New Eng. Lith. Co. Boston

Plate II.

Deroceras planicosta.

Fig. 1. Section of siphon and siphonal cœcum. B, ovishell; d′, lining layer of the shell; d″, median layer; d‴, external layer; d, dorsal layers of the young; 1e, first septum; 2e, second septum, and so on; R, siphonal cœcum; s′, remnant of the horny layer of the siphon; s″, accessory layer, lining the interior; s‴, sheath. Magnified 317 diameters.

" 2. Section at right angles with siphon * showing the form of the whorls. Magnified 21.5 diameters.

" 3. Centre of fig. 2 enlarged. D, shell; U, embryonal umbilicus. Magnified 70 diameters.

" 4. Segment of the siphon from Plate IV, Fig. 1, on first quarter of the whorl; D, shell on the abdominal side; E, septum; P̄, the siphonal funnel; P, siphonal collar. Magnified 158.5 diameters.

" 5. Section of same specimen of nearly the same age. Amplification same.

" 6. Enlarged drawing of one of the sections of the siphon in Fig. 2; O marks the bottom of the siphonal fissure; J, the lateral wings of the abdominal cell divided by the fissure, as seen from behind; F, the two truncated branches of the abdominal lobe. Magnified 104 diameters.

" 7. Young, with nine first septa delineated, and the amount of the involution of the first whorl around the ovisac is shown by the shaded line reaching from the broken edge of the whorl. Magnified 80 diameters.

All the specimens described above are from the same block of Wiltshire limestone as those given in Plate I, Fig. 1 – 8.

Arnioceras semicostatum.

Fig. 8. Side view of the young with eleven septa, magnified + 10 diameters. F, ventral lobe; H, dorsal lobe; g′, superior lateral lobe; h′, superior dorsal lobe; g″, inferior lateral lobe; k′, superior lateral cell; l′, superior dorsal cell; k″, inferior lateral cell; l″, inferior dorsal cell.

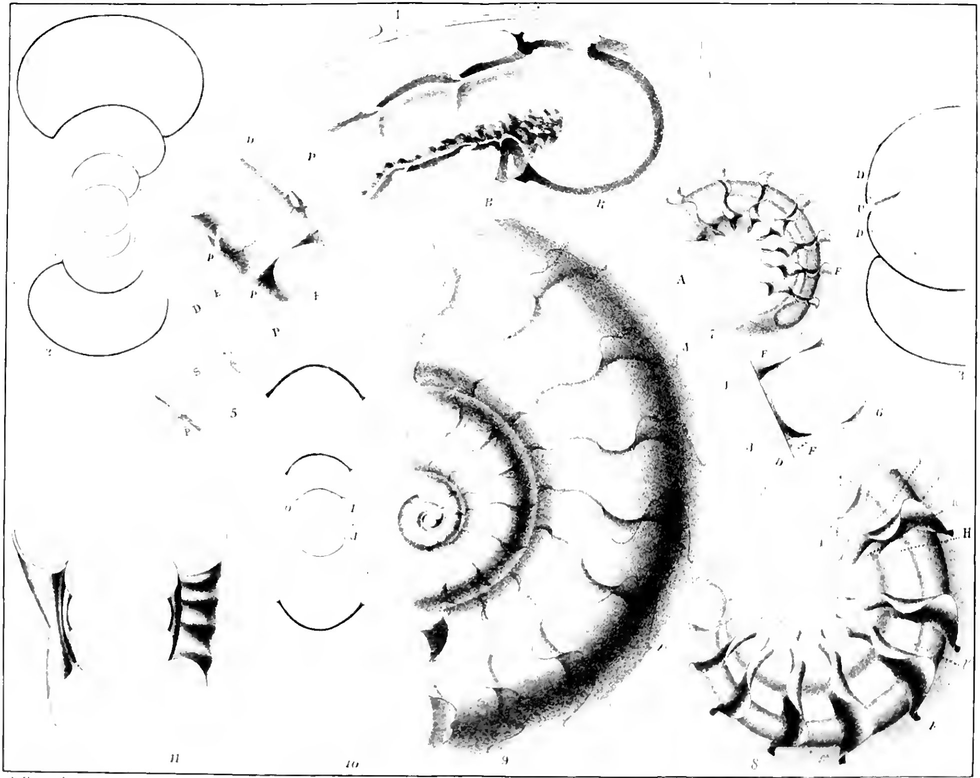
" 9. Side of three and a quarter whorls of an older specimen from the same locality; magnified 21 diameters.

" 10. Front view or projection of the same. O, siphonal fissure; J, abdominal cell; F. abdominal lobe.

Asteroceras obtusum.

Fig. 11. Section of first two whorls and ovisac, magnified 49 diameters. The left side only of this specimen is perfect.

* This section is not exactly at right angles to the siphon, though the variation is not perceptible except when Fig. 3 is drawn. Then the embryonal umbilicus is seen to be absent from one side. This, however, is too slight a deflection to affect materially the truthfulness of the general outline.



A. Hyatt Del. E. ... Lith. New Eng. Lith. Co Boston

Plate III.

NAUTILUS POMPILIUS.

Fig. 1. Front view of the young, showing the cicatrix, and area of attachment of the ovisac, the siphon, portions of the fourth and fifth septa, the siphonal funnel with its abdominal channel or gutter, and part of the side and dorsum of the continuation of the first whorl, which has been left attached to the apex. The shadow cast by the broken edges of the fifth septum on the upper part of the siphon gives the exact outline of the abdominal cell, which is hidden behind the siphon. Magnified 8 diameters.

GONIATITES ATRATUS.

Fig. 2. Section through the centre of the siphonal cœcum and siphon. Loc. Choquier. Magnified 21 diameters.

GONIATITES DIADEMA.

Fig. 3. Front view of the ovisac, with a portion of the first whorl, exhibiting the false abdominal lobe of the first septum, which is formed by the breaking away of the ventral side of the cone of the siphonal cœcum. 1c, first whorl; 1e, first septum; 2e, second septum.

" 4. Side view of the same species. Loc. Choquier. Magnified 74 diameters.

GONIATITES LISTERI.

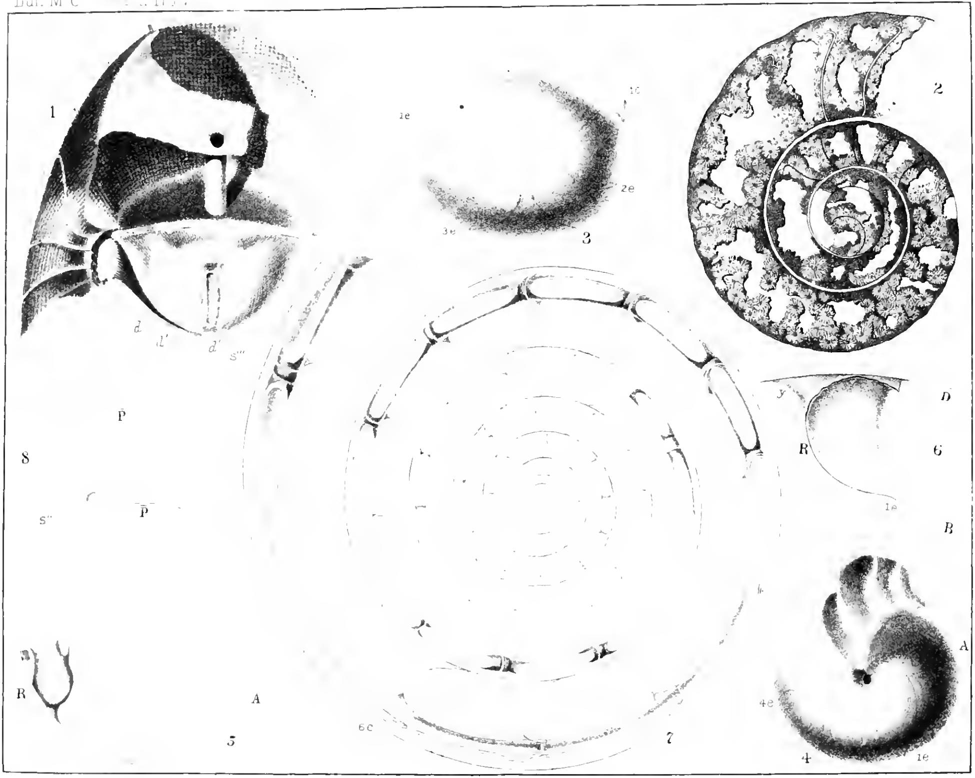
" 5. Section of the ovisac, which has also cut through a portion of the siphonal cœcum. The approximation of the siphonal cœcum and cone to the shell below the first septum is clearly exhibited, and a fragment of the second septum on the abdominal side. Magnified 102.5 diameters.

" 6. The siphonal cœcum after a further reduction of the same section. The neck of the cœcum and remnant of the second septum have broken away, leaving only that part of the cœcum which was formed by the siphonal funnel of the first septum. The cone opens freely into the siphonal cœcum. Magnified 317 diameters. Loc. Choquier.

GONIATITES CRENISTRIA *Phill.*

Fig. 7. Section of six whorls from a specimen of the variety having a flat abdomen. This shows very plainly the eccentricity of the siphon which is cut by the plane of the section at different levels in different parts of the specimen, and entirely cut away in the young. Magnified 15.5 diameters.

" 8. Enlarged view of a siphonal funnel from the same. d′, lining layer of shell; d″, d‴, median and external layers of the shell; P, siphonal funnel; s‴, siphonal sheath. Magnified 104 diameters. Loc. Rudesheim.



A Hyatt Del.   E Konopicky Lith   New Eng Lith Co Boston

Plate IV.

DEROCERAS PLANICOSTA.

Fig. 1. Section showing the imbricated structure of the median and external layers of the shell. The lining layer is not represented. Loc. Wiltshire. From the same block as the specimens of this species previously figured. d″, median layer of the shell; d‴, external layer. Magnified 40 diameters.

" 2. Section of shell transverse to the siphon at the juncture of the side of one whorl with the abdomen of another, from same specimen as Pl. II, Fig. 2. d″, median layer; d‴, outer layer; d′, lining layer. Magnified 104 diameters.

" 3. Enlarged portion from the abdominal side of same section. Magnified 317 diameters.

NAUTILUS POMPILIUS.

Fig. 4. Section of young through the centre of embryonal umbilicus and the siphonal cœcum. d, lining layer of the shell; d″, median layer; d‴, external layer; d +, dark layer deposited by the hood; **X**, the plate which closes the apex of the whorl. Magnified 15 diameters.

NAUTILUS ATRATUS.

Fig. 5. Side view of Saemann's original specimen. 1e, first septum.

" 6. Dorsal side of the same, showing the large dorsal lobe of the second and succeeding septa.

NAUTILUS KONINCKII.

Figs. 7,8,9. Ventral, dorsal, and side views, exhibiting three septa, and absence of the flutings on the apex of the young shell.

NAUTILUS LINEATUS.

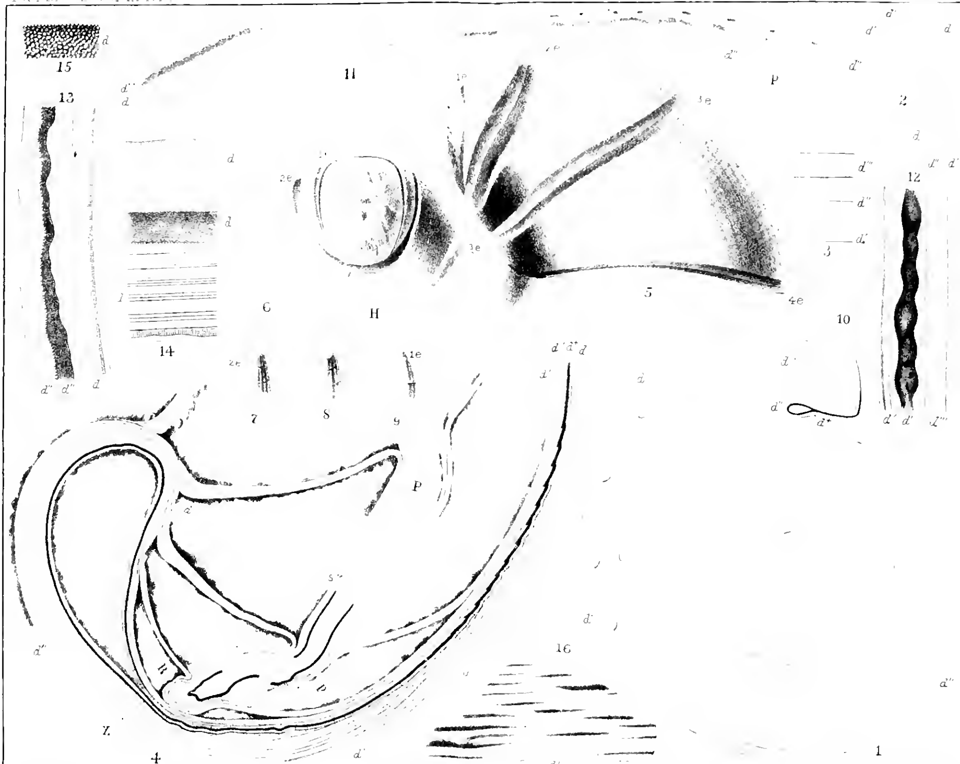
Fig. 10. Section of the young. The external layer of the apex d‴ is too deeply shaded, and consequently seems to fuse with the dark layer of the hood, which begins at d+. whereas it here becomes thinner and passes inside of it, as in N. Pompilius. Fig. 4.

GONIATITES LISTERI.

Fig. 11. Section of shell, which passes through the edge of a former aperture at the end of the first whorl, exhibiting the imbricated structure of the layers. Magnified 40 diameters.

ARGONAUTA ARGO.

Fig. 12. Longitudinal section of shell, but transverse to the fibres of the



A Hyatt del. F. Konopicky Lith. New Eng Eng Co Boston

median layer. d', inner layer; d'', fibrous median layer; d''', external layer. Magnified 104 diameters.

" 13. Transverse section of the shell, but parallel with the fibres of the median layer. Magnified 104 diameters.

" 14. Portion of the last, enlarged 317 diameters.

" 15. Median layer of the same enlarged to 317 diameters, showing the granular aspect of another portion of the same specimen, where the section has cut obliquely through one of the bundles of fibres.

" 16. View of the median fibrous layer from above. Magnified 21 diameters.

No. 6. — *Notes of an Ornithological Reconnoissance of Portions of Kansas, Colorado, Wyoming, and Utah.* By J. A. Allen.

In the following pages are indicated some of the results of field work on the Plains and in the central portions of the Rocky Mountains; these results including more or less complete annotated lists of the birds of nine quite widely separated localities, with a general summary of the whole. Although the region in question presents by no means a new field, the faunal lists here offered form the first special reports that have been made upon the ornithology of any restricted locality within the region referred to at the head of this article. The observations on which the following lists are based were made in 1871 (from May 1 to January 15, 1872), during an expedition sent out by the Museum of Comparative Zoölogy to the Rocky Mountains to obtain specimens of the vertebrated animals of the plains and mountains of the West. The expedition commenced its work at the Missouri River, in the vicinity of Fort Leavenworth, and collected at intervals thence westward to the Great Salt Lake Valley. Mr. Richard Bliss, Jr., of the Museum, accompanied the expedition as ichthyologist; and Mr. C. W. Bennett of Springfield, Massachusetts, as taxidermist. Both of these gentlemen rendered important aid in the ornithological work, Mr. Bennett adding to his zeal the qualifications of an experienced collector and a skilful sportsman. Among the acquisitions of the expedition are over fifteen hundred birds, representing about two hundred species, besides large suites of nearly all the mammals of the region visited, including all the large herbivorous species, large collections of fishes, many reptiles and insects.

An opportunity was thus afforded me of studying many species of birds in the field which I had previously seen only as dried skins, and of examining large series of fresh specimens of many of the puzzling forms of the middle region of the continent. From this has resulted a confirmation of all the general conclusions arrived at in my recent paper on the "Winter Birds of East Florida,"* and the discovery of several well-marked geographical races not previously chronicled. In the woodlands of Eastern Kansas a decided general tendency to a

* Bull. Mus. Comp. Zoöl., Vol. II, No. 3, April, 1871.

greater intensity of color than at the northward was noticed, in accordance with the law of the increase in intensity of color to the southward,* which in several species was especially marked. The males of the common indigo-bird (*Cyanospiza cyanea*) were not only much more than ordinarily lustrous, but the females shared the blue tint of the males to an unusual degree. There was here found also a thick-billed race of the cardinal (*Cardinalis virginianus*), which in the size and form of the bill makes a decided approach to the thick-billed race of this bird found in Lower California (*C. igneus* auct.). The hairy woodpecker begins to noticeably resemble the darker (*Picus Harrisii*) race of the Rocky Mountains, and *Colaptes auratus* has quite commonly a greater or less number of red feathers mixed with the black ones forming the maxillary patches, thus clearly showing a marked tendency to a differentiation towards the *C. mexicanus* of the western half of the continent, at a point some six hundred miles east of the habitat of that species. A well-marked variation is also noticeable in the *Icterus Baltimore*, through the paler colors of the middle wing-coverts, which in Middle Kansas become either pure white or are only faintly tinged with pale yellowish, instead of being orange, as in the eastern form. With this gradual change in the color of the coverts the white edgings of the remiges become greatly broadened, as in the so-called *Parus septentrionalis*, the latter being here less strongly marked in this respect than further westward. The bill of the *Icterus Baltimore* is here slenderer and rather more decurved than in northern specimens. Professor Baird has also recorded a specimen of *Pipilo erythrophthalmus* from Fort Leavenworth, which "has a few white spots on the scapulars only, the wing-coverts without them, exhibiting an approach to *P. arcticus*," † and remarks that other western specimens have more than the usual amount of white on the wings. The Fort Leavenworth specimen he regards as "probably a hybrid," between *P. erythrophthalmus* and *P. arcticus*. While only one of our Fort Leavenworth specimens thus approached *P. arcticus*, all resembled it in the enlarged hind claw, and in a more than the usual amount of white on the wing.‡

* See Bull. Mus. Comp. Zoöl., Vol. II, p. 233.

† Birds of North America, p. 513.

‡ In respect to the claws, I find that in the Pipilos of this group there is a decided enlargement of the claws to the southward, along the Atlantic coast, as well as in the interior and on the Pacific coast, this enlargement reaching its maximum in Lower California, in *Pipilo megalonyx* of this group. Florida specimens have larger claws —

Passing to the Plains proper, the faded aspect of all the birds is strikingly noticeable, especially in the species that range across the continent. The well-known "*neglecta*" type of *Sturnella ludoviciana*, the "*Henryi*" type of *Chordeiles popetue*, the "*rufa*" type of *Eremophila alpestris*, the "*Cassinii*" type of *Peucæa æstivalis*, the "*Parkmanni*" type of *Troglodytes aëdon*, the "*septentrionalis*" type of *Parus atricapillus*, are not only prevalent forms, but corresponding pallid forms are equally marked in *Coturniculus passerinus*, *Spizella socialis*, *Falco sparverius*, *Ægialitis vociferus*, and others; these pallid races prevailing throughout the arid plains to the westward. The same tendency is manifest in the mountains of Colorado, where the *Sitta* "*pygmæa*" forms a similar pale race of *Sitta pusilla*;* *Zonotrichia leucophrys*, through the greater amount of ashy white on the lores, passes into *Z.* "*Gambeli*"; *Geothlypis Macgillivrayi* permanently retains white spots on the eyelids, which appear in *G. Philadelphia* only in the young and in the females. *Pipilo erythrophthalmus*, through an acquisition of white streaks on the back and wings, becomes *P.*

more noticeably that of the hallux — than those from Massachusetts; and in those from Eastern Kansas they are fully as large as in Florida specimens, while the "*P. arcticus*" in Colorado has them still larger. On the Pacific coast the specimens from Oregon have small claws, the size increasing southward to Lower California, where they become excessively enlarged. This increase in the size of the claws to the southward I have traced in several other genera, it corresponding with the increase in the size of the bill in the warmer latitudes, and is doubtless due to a similar climatic cause. See Bull. Mus. Comp. Zoöl., Vol. II, pp. 230, 239.

* *Sitta* "*pygmæa*" differs from *S. pusilla* in being everywhere lighter colored; the head is greenish ashy brown instead of pale hair brown, the back is less deeply blue, and the white markings on the tail and wings are broader and purer. In *S. pusilla* the middle tail-feathers are generally only slightly paler at their bases, but are sometimes distinctly white, as they almost always are in *S. pygmæa*. The oblique white bar on the other tail-feathers is also much broader and more strongly white in *S. pygmæa*. In *S. pusilla* the edge of the wing is generally pale grayish white, but sometimes distinctly white, as are also the basal portions of the inner webs of the greater primary coverts. In *S. pygmæa* the white on the edge of the wing is not only more strongly marked, but covers also a larger portion of the inner vanes of the greater primary coverts, and the concealed basal portion of the primaries also shares the white. The outer edges of the primaries are also more broadly bordered with white than those in *S. pusilla*. The style of markings in the two forms is identical, only that the white is more pronounced and the general tints paler in *S. pygmæa* than in *S. pusilla*, apparently establishing it as a paler race of the latter, co-ordinate with so many other similar examples of pallid races in the interior of the continent.

In like manner the western race of *Sitta carolinensis* (*S. aculeata* Cass.) has less black on the inner secondaries than has the eastern form of this species.

"*arcticus*"; and *Picoides* "*americanus*" becomes *P. dorsalis*, through a somewhat similar increase of white in the dorsal plumage. All the Vireos of the Rocky Mountain plateau are paler races of species that range across the continent, the difference in some of them being so great as to give them the character of strongly marked geographical varieties. Most of the *Empidonaces* are here also similarly represented; and farther southward and westward occur pallid forms of *Myiarchus* and *Tyrannus*; everywhere establishing the law of pallid races in arid regions, which there represent the brighter conspecific forms of the contiguous moister districts. The differences in color between the conspecific forms of arid and of comparatively moist regions is much greater, as a rule, towards the end of the breeding season, or just before the autumnal moult, than after this moult, or in spring specimens, or than is observed between young birds of the two forms; showing most unmistakably the direct influence of the intensely heated dry winds and strongly reflected light upon the colors of birds in semi-desert regions.

Recent investigations show a rather greater tendency to an enlargement of the bill to the southward along the Pacific slope of the continent than that pointed out in my paper on the Florida Birds as existing to so marked a degree among the birds of the Atlantic States.* Instances are seen in the southern forms of the *Chrysomitris psaltria* group, in the *Carpodacus purpureus* group, in the *Cardinalis virginianus* group, in *Curvirostra* "*americana*," in the *rostratus* form of *Passerculus*, in the western forms of *Melospiza melodia*, in *Passerella* "*schistacea*," and in the *Pyranga æstiva* and *P. ludoviciana* groups; it is also well illustrated by *Certhia familiaris*, *Mniotilta varia*, and almost constantly in the *Vireonidæ*, as well as in numerous other families.

From the valley of the Columbia River a comparatively narrow belt extends northward along the Pacific coast, where the annual rainfall is nearly double that of any other portion of the continent; and here the birds (and mammals also), as a general rule, not only reassume the brighter colors of the region east of the Great Plains, but in many cases present a depth of color unequalled eastward in the same latitudes, frequently taking on a peculiar deep plumbeous or dusky brown in replacement of ashy or rufous, with a partial obsolescence of spots and streaks, especially marked in several of the fringilline genera.

* See Bull. Mus. Comp. Zoöl., Vol. II, p. 230.

In respect to the rank and relationships of a great number of forms among North American birds, to which at first was accorded the rank of species, the gradual passage of one form into another, through whole groups of forms that, as it were, cluster about a common type, is an interesting and suggestive fact. Every acquisition of new material from the middle and western portions of the continent but the more fully shows the complete and gradual coalescence of widely differing forms, which reach their typical or maximum development at particular localities, characterized by special climatic conditions, but which intergrade at intermediate points, where the conditions of environment are also of an intermediate character. In illustration of this, the genera *Pipilo*, *Junco*, *Melospiza*, *Passerella*, *Carpodacus*, *Colaptes*, and *Picus* may be cited from among the numerous and more strongly marked examples of longitudinal variation.* In respect to the Pipilos of the United States, the *P. erythrophthalmus* of the East passes southward into a well-marked form in Florida, differing from the northern race in having the white on the wings and tail much more restricted, in its smaller size, larger claws, and longer tail. To the westward it begins at the Missouri River to pass into the *P. arcticus*, through the occasional accession of white streaks on the scapulars and interscapulars, and its larger claws; these characters — especially the development of white in the dorsal plumage — reach their maximum on the dry plateau of the interior; but westward *P. arcticus* merges into another form, *P. oregonus*, towards and on the Pacific coast, in which the white on the wings becomes again reduced, the white streaks on the back (though generally still retained) become narrower and fewer, and at times are either almost or entirely obsolete, and the claws become considerably smaller. To the southward the two forms, in the interior, run into each other, both culminating in Lower California in the *P. megalonyx*, in which the claws have become enormously developed, and the white spotting varies from obsoleteness to the large amount that typically characterizes *P. arcticus*. Further southward, in Mexico, *P. megalonyx* is well-known to grade through *P. macronyx* into *P. maculatus*, which are more or less olivaceous. *Junco* presents three strongly marked forms or "species," that in a similar manner inosculate; *J. hyemalis* being the eastern form, *J. oregonus* the western, and *J. caniceps* occupying an intermediate region at the southward, between the habitats of the others;

* See also Bull. Mus. Comp. Zoöl., Vol. II, p. 237.

but they more or less mix up during winter, and specimens are of frequent occurrence that, from their not being referable to either form, have been assigned to the series of "*hybrids*." *J. caniceps* is the most strongly marked form, in its having the middle of the back reddish, forming a restricted, well-defined patch. *J. oregonus* has the back also reddish, this color occupying a larger area than in *J. caniceps*, more diffused, and involving the secondaries; but its extent and intensity varies greatly in different individuals. The sides are also tinged with a pinkish rufous tint, and the slate of the anterior half of the body is darker than in the other. *J. hyemalis* has the rufous tint present only in young or autumnal specimens, which sometimes strongly approach *J. oregonus*. *J. oregonus*, on the one hand, inosculates with *J. caniceps*, and on the other, with *J. hyemalis*; *caniceps* and *oregonus* both apparently merging into *J. cinereus* of Mexico, through the scarcely distinguishable *J. dorsalis*. *Melospiza melodia* is represented in the interior by a race (*M. fallax*) paler than the eastern, and on the Pacific coast by a darker race, which again divides into a northern (*M. insignis*) and a southern (*M. Heermanni et Gouldii*, etc.), all of which so intergrade as to be but unsatisfactorily definable, though in their extreme stages they present strong points of difference. Few congeneric species, it would seem, need be more distinct than *Colaptes auratus* and *C. mexicanus*, the one occupying the eastern and the other the western side of the continent. Yet a mixed race has been long known to exist in the region where their habitats adjoin, in which every possible combination of the characters of the two birds is presented, and which shade off gradually on the one side into *C. auratus*, and on the other into *C. mexicanus*; these, as it were, engrafted characters not entirely fading out in either direction for a distance of several hundred miles; while to the southwestward is a smaller synthetic race (*C. chrysoides*) partaking mainly of the characters of *C. auratus*.

When but comparatively few instances were known, in which specimens combined in various degrees the characters of two quite distinct species, their synthetic character was generally explained by the theory of hybridity; but the irrefragibility of the evidence now at hand in proof of the gradual intergradation of such forms over large areas, — the transition being so gradual as to occupy hundreds of miles in the passage, — and also coincident with a similarly gradual change in the conditions of environment, together with the demonstrable evidence of the power of climatic influence, seems to furnish a far more satisfactory explanation of these perplexing phenomena. But an advocate of the theory of hybridity might still assume that this gradual transition over a wide area is no objection to the theory, since the gradual fading out of the impression of contact in either direction from the line of junction of the respective habitats of two forms is just the result that would be anticipated from such a sexual intermingling of the forms in question. But the real objection to the theory — granting the possibility of hybridization on such a gigantic scale, which seems really improbable — is, that widely different forms occur also at different points in latitude, between which each successive stage of gradual differentiation can be readily traced, where hybridity can scarcely be supposed to account for the gradual change. Furthermore, a differentiation is now known in so many cases that it amounts to the demonstration of climatic variation as a general law, by means of which a species may be safely predicted to take on a given character under certain specific climatic conditions. If the theory of hybridity be urged to account for the intergradation of forms occurring at localities differently situated in respect to latitude, as has been sometimes done, it evidently falls under the weight it has to support; and yet there seems to be little better evidence in its behalf in cases where the intergrading forms happen to be differently situated in respect to longitude.

In regard to how these well-marked geographical forms shall be recognized, there may be just grounds for a diversity of opinion. Evidently in cases where they are slightly marked or somewhat inconstant, no great harm would result if they were nominally ignored. Practically, most naturalists recognize as species such groups of individuals as are not known to graduate by nearly imperceptible stages into any other similar group; and as varieties, such groups of individuals as occur at certain localities, or over certain areas, which differ more or less from other groups of individuals inhabiting other (generally contiguous) localities, with which there is evidence that they do, more or less fully, intergrade. Convenience seems to demand such a course, in order to enable the naturalist to specify what particular phase or race of a species inhabits a given section of country; the first specific name used for any part of the group being, of course, retained for the longest known form and the other races, when of such prominence as to render naming them advisable, being designated by additional varietal names; as, for example, *A b, var. c.* This method is, indeed, already in more or less common use.

The division of the middle and western portions of North America into faunal areas is still attended with many difficulties, partly from the absence of data, and partly from the peculiarly varied character of the surface. The presence or absence of forests, directly resulting from the peculiarities of climate, seems to be among the most effective influences in the modification of the range of species. If a nearly unbroken forest extended from the Atlantic to the Pacific, with the nearly uniform conditions of humidity that would naturally follow, undoubtedly many species would range across the continent, or at least to the base of the Rocky Mountains, that now extend westward from the Atlantic coast only to the edge of the Great Plains; the western slope of the continent would differ less in its animal life from the eastern than it now does, and the middle region would lack the widely different zoölogical aspect it now presents from that of either the Atlantic or the Pacific coast regions. With the present elevation of the interior, and the resulting climatic conditions, nearly all the woodland species of the East not only range westward to the treeless districts of the interior, but extend up the rivers that descend from the central plateau as far as these streams are skirted to any considerable degree with trees; a few not only reach the base of the Rocky Mountains, but pass around the higher elevations of the chain in Colorado, by means of the northern valleys, and occur on the Pacific coast, while others reach the same coast by gaps in the mountains at the southward. On the other hand, most of the field and prairie species, or those which are but slightly dependent upon woodlands for shelter or sustenance, do not disappear at the edge of the plains, as do the strictly woodland species, but range not only over the plains of the middle region, but also over the plains to the westward of the main chain of the Rocky Mountains, and thence generally to the Pacific coast. In the wooded parts of the Rocky Mountains a few species occur that are peculiar to that region, but the greater part are either but slightly modified forms of eastern species, or forms that, while they differ widely from both the eastern and western, still freely "hybridize" or intergrade with them. These strictly western forms, unless of alpine or subalpine distribution, also generally occur along the streams of the western edge of the Plains, as far as the streams are bordered with trees.

The observations made the past summer (given below in detail) establish the occurrence of a number of eastern species at points several hundred miles to the westward of the westernmost point from which they have been previously recorded; and in like manner other western species were found occurring at points considerably to the eastward of points from which they were before known. Northern species were also found at localities considerably south of their previously known range, both *Anthus ludovicianus* and *Leucosticte tephrocotis* being found breeding above timber-line in the mountains of Middle Colorado. A more extensive overlapping of the habitats of eastern and western species is thus established than there was previous evidence of, which may tend to modify the currently received boundary between the Eastern and Middle Provinces of the North American Region. This boundary has generally been considered as running in the United States near the 100th meridian, or "at the edge of the sterile plains." But the distinctively "Plains species" are nearly all found now to range eastward over the prairies, the others first appearing somewhat to the westward. Thus of about twenty species that are distinctively characteristic of the Plains, fully one third occur on the prairies of Illinois and Wisconsin, another third are met with as far east as Missouri, and the others range more or less regularly into Eastern Kansas. In other words, all the species of the Plains occur in Kansas at points from two hundred to three hundred miles to the eastward of the 100th meridian, and most of the others extend to the woodland districts eastward of the Mississippi. On the other hand, many eastern species follow up the rivers to the most western limit of trees, sometimes to a distance of three hundred miles west of their formerly supposed western limit, where they mix with western species not commonly supposed to occur much to the eastward of the eastern base of the Rocky Mountains.

The faunæ of the middle and western portions of the continent present peculiarly broken and irregular areas, in consequence of the great irregularity of the surface of the country. The more southern faunæ, while occupying the lower table lands, extend also up into the lower mountain valleys, to a limit varying with latitude and the peculiar local conditions of the valleys themselves. Above this basal zone occur several other zones, which are continuous for considerable distances along the main chains, but also embrace distant insular patches in the more isolated groups of mountains. The higher zones are still less regular in their continuity and in their respective areas, the highest having an arctic character and occupying only the partially snow-covered summits that rise above the limit of tree-growth. But at present the data at hand are too few for a satisfactory attempt at an analysis of the characters and limits of the several avian faunæ of the Middle and Western Provinces.

I. *List of Birds observed at Leavenworth, Kansas, from May 2 to May 11, and at Topeka, Kansas, from May 11 to May 21, 1871; with Annotations.*

THE following list embraces one hundred and twenty-one species, of which specimens of nearly all were actually collected. Though an incomplete list of the birds of Eastern Kansas, and based on observations made when many of the species were migrating, it is believed to contain many facts of value, especially since no report has as yet been made of the ornithology of this section of country.* Our collections at Leavenworth were made principally in the heavy timber on the East Leavenworth side of the Missouri River, opposite Fort Leavenworth. A few specimens were collected on the west bank of the river, on the military reservation between the fort and the city, where is also considerable timber. Most of the water birds were obtained about a lagoon on the Missouri side. In the forests the birds were excessively abundant, both in species and individuals. Among them such southern forms as *Helminthophaga pinus*, *Oporornis formosus*, *Wilsonia* (= *Myiodioctes*) *mitrata*, *Thryothorus ludovicianus*, *Icteria virens*, *Cardinalis virginianus*, and *Lophophanes bicolor* were conspicuously numerous, the fauna being emphatically Carolinian.† Although the vegetation was as far advanced the 1st of May as it usually is in Southern New England the 1st of June, very few birds had commenced nesting, and some of the later-arriving species had not yet appeared. By the 10th of May nearly all the trees were in full leaf, and most of them were leafing by the first of the month. The only nests found were those of

* Since the above was written there has appeared a "Catalogue of the Birds of Kansas," by Professor F. H. Snow, of Lawrence, Kansas. The list contains the names of 239 species, yet some of the most characteristic birds of the western half of the State are omitted. The author has attempted to indicate those "known to breed in the State," but it is in this respect very imperfect, though still not without much value as a faunal list. (See Am. Nat., Vol. VI, 1872, p. 350.)

† See Bull. Mus. Comp. Zoöl., Vol. II, p. 3[illegible], 1871.

Harporhynchus rufus, *Pipilo erythrophthalmus*, and *Cardinalis virginianus*, but fledged young of *Thryothorus ludovicianus* were shot May 3d.

At Topeka, about the same number of species were observed as at Leavenworth. Some of those obtained at Topeka, however, were not seen at Leavenworth, and others that were common at Leavenworth were not noticed at Topeka. Yet the general character of the fauna at the two places is quite similar, as would naturally be expected; Topeka being only about sixty miles from Leavenworth, in a southwesterly direction. At Topeka our excursions were mainly confined to the timbered bottom lands of the Kaw River. Though most of the larger trees had been removed, the locality was still tolerably well wooded, and in many places there was a dense undergrowth of hazels, sumachs, and other shrubs. The adjoining prairies were visited a few times, and one excursion was made to the Wakarusa, ten miles to the southward. Here, however, only one species (*Polioptila cærulea*) was taken that was not also seen at Topeka.

At Topeka the birds were even more numerous than at Leavenworth. In the course of half an hour, on the day of our arrival (May 12th), I saw or heard thirty species of birds, by actual count, and in most cases observed a number of individuals of each. This, however, seems to be a feature more or less common to prairie regions, where the timber is restricted to narrow belts along the streams. Especially does this seem to be the case during the season of migration; but it was also observed later in the season at Fort Hays.

Although the forests were in full leaf on our arrival, we noticed that several species of birds became common during the last days of our stay there, that were not met with at first. Among them were such species as *Seiurus aurocapillus*, which usually arrives in New England at the time of the first leafing of the trees. Ripe wild strawberries were abundant as early as May 15th, and the weather was as hot, from this date till we left Topeka, as it usually is in Southern New England in July, the maximum temperature daily increasing from 84° to 94° F. in the shade.

When no locality is mentioned in the remarks that follow, it is to be understood that the species was observed at both Leavenworth and Topeka in about the same numbers. A star is prefixed to the names of those known to breed in Eastern Kansas, whether from personal observation or from their known breeding range including the localities in question.

TURDIDÆ.

1. ***Turdus migratorius.** Only two were seen. Said to be a scarce resident.

2. ***Turdus mustelinus.** Exceedingly abundant. Quite unsuspicious and apparently not yet nesting. Song less melodious and less varied than in the Eastern States. Colors considerably brighter.

3. **Turdus Swainsoni.** Common at Topeka. All of the eight or ten specimens taken were females, the males probably having already gone north. These specimens were also all strongly suffused with rufous. One was shot at Leavenworth, May 8th, and a few others seen.

4. **Turdus Pallasi.** A single female, with the plumage excessively worn and faded, was taken at Topeka, May 18th.

5. ***Harporhynchus rufus.** Abundant. Nest and three eggs obtained May 3d, at Leavenworth. Nest placed in bushes, several feet from the ground. A nest nearly finished was also found May 19th at Topeka, placed on the ground, under a small bush in an open field.

6. ***Mimus carolinensis.** Abundant.

SAXICOLIDÆ.

7. ***Sialia sialis.** Common. Said to be resident.

SYLVIIDÆ.

8. ***Polioptila cærula.** Three specimens were seen and two taken May 22d near Topeka. These were the only ones observed.

SYLVICOLIDÆ.

9. **Parula americana.** Common.

10. ***Helminthophaga pinus.** Not uncommon.

11. **Helminthophaga celata.** Common at Leavenworth.

12. **Helminthophaga ruficapilla.** Common at Leavenworth.

13. ***Dendrœca æstiva.** Moderately common. The streaks on the breast, in the few specimens taken, were very broad and conspicuous, much broader and the colors generally much brighter than they are often seen in specimens from the Eastern States.

14. **Dendrœca pennsylvanica.** Not common. One specimen shot at Leavenworth, and three or four others seen. Not observed at Topeka.

15. **Dendrœca Blackburniæ.** One specimen shot at Leavenworth, May 4th, — the only one seen.

16. ***Dendrœca cærulea.** One specimen taken at Leavenworth, and a number of others seen. Apparently rather common in the forests of the Missouri bottom.

17. **Dendrœca coronata.** One specimen seen May 3d at Leavenworth, the only one observed.

18. * **Dendrœca discolor.** Rather frequent.

19. **Mniotilta varia.** Not common. Two specimens obtained at Leavenworth, and two or three others seen.

20. * **Seiurus aurocapillus.** First observed May 15th; afterwards common.

21. * **Geothlypis trichas.** Common at Topeka; only a few were seen at Leavenworth, where it arrived about May 8th.

22. **Geothlypis philadelphia.** One specimen obtained May 16th at Topeka, where others were seen later.

23. * **Oporornis formosus.** Common. Nest found nearly completed May 16th.

24. * **Wilsonia mitrata.** Rather common at Leavenworth; less so at Topeka.

25. **Setophaga ruticilla.** Common, but only males were taken or observed.

26. * **Icteria virens.** Rather common at Leavenworth. Abundant at Topeka, where three or four males were often seen hovering in the air and singing at the same time.

TANAGRIDÆ.

27. * **Pyranga rubra.** Very abundant. The colors of those obtained were unusually intense, as compared with northern specimens.

PARIDÆ.

28. * **Parus atricapillus.** Abundant.

29. * **Lophophanes bicolor.** Abundant. One of the most numerously represented and most noisy species met with at Leavenworth; not so abundant at Topeka.

SITTIDÆ.

30. **Sitta carolinensis.** Common at Leavenworth.

TROGLODYTIDÆ.

31. * **Troglodytes aëdon.** Common.

32. * **Thryothorus ludovicianus.** Common at Leavenworth. Not seen at Topeka. They apparently breed very early, as we shot a young one fully fledged May 3d.

HIRUNDINIDÆ.

33. * **Hirundo horreorum.** Moderately common.

34. **Hirundo bicolor.** Common, especially at Leavenworth.

35. * **Hirundo lunifrons.** Common at Leavenworth; less numerous at Topeka. At the latter locality several pairs were seen along the bluffs of

the Kaw River, in company with *Cotyle riparia*, entering the holes in the bank in company with that species, and also sitting in the mouths of the holes. One was shot as it left a hole, so that there is no reason for doubting the observation. They had the same appearance of breeding in the banks as *Cotyle riparia* themselves.

36. * **Cotyle riparia.** Exceedingly abundant, especially at Topeka. Hundreds of them were excavating their holes in the bluffs of the Kaw River, May 15th to 20th, but had not yet commenced to lay. At least no eggs were found in any of a considerable number of nests examined.

37. * **Cotyle serripennis.** Common. They appear to breed either singly, or a few pairs together, and not in large colonies like *Cotyle riparia*. They were excavating their holes, but had not yet laid.

38. * **Progne subis.** Common at Topeka, and abundant at Leavenworth, breeding in boxes provided for their use.

VIREONIDÆ.

39. * **Vireo olivaceous.** Common.

40. **Vireo gilvus.** Common.

41. **Vireo flavifrons.** A single specimen was shot at Topeka, and several others were seen.

42. * **Vireo noveboracensis.** Common.

43. * **Vireo Belli.** Exceedingly abundant after May 15th at Topeka; not seen earlier. Commenced pairing immediately after their arrival, and were one of the most numerous and conspicuous species of the smaller birds.

AMPELIDÆ.

44. * **Ampelis cedrorum.** Several small roving flocks were seen at Topeka, May 20th and later.

LANIIDÆ.

45. * **Collurio ludovicianus.** Said to be moderately frequent, but seen only at Leavenworth.*

* Messrs. Dresser and Sharpe, in a paper on "*Lanius excubitor* and its Allies" (Proc. Zoöl. Soc., 1870, p. 595), combine *C. excubitoroides* and *C. elegans* with *C. ludovicianus*, their conclusion being based upon an examination of specimens of each of these so-called species. I am glad to find my own opinion on this point (first partially expressed in Amer. Nat., 1869, p. 579, and more fully reiterated in Bull. Mus. Comp. Zoöl., Vol. II, p. 270, April, 1871) thus confirmed.

The original specimen of the *C. elegans* (*Lanius elegans* of Swainson), now in the British Museum, these gentlemen refer to the *L. lahtora* of Northeastern Africa and Asia, presuming the specimen to have come from some other locality than North America, or that the *L. lahtora* may occur in North America as a straggler from Northern Siberia. In this connection I may add that I have been long impressed with the close resemblance

ALAUDIDÆ.

46. * **Eremophila alpestris.** Common on the prairies.

FRINGILIDÆ.

47. * **Chrysomitris tristis.** Common.

48. * **Coturniculus passerinus.** Common.

49. * **Chondestes grammaca.** Moderately frequent.

50. **Zonotrichia leucophrys.** One specimen seen May 8th at Leavenworth.

51. **Zonotrichia querula.** Exceedingly abundant at Leavenworth. Found almost exclusively in the forests, and generally in company with *Z. albicollis*, which it resembles in habits and somewhat in song.

52. **Zonotrichia albicollis.** Common. Fully as numerous May 11th at Leavenworth as at any time previously. Less numerous at Topeka.

53. * **Spizella pusilla.** Common.

54. * **Spizella socialis.** Obtained one or two at Topeka still in immature plumage, — a condition in which I have never seen this species in the Northern States at this season of the year, although I have handled hundreds of specimens taken in spring at northern localities.

55. * **Spizella pallida.** Common at Topeka. Greatly resembles the specimens of *Spizella socialis* in immature plumage, taken at the same locality, with which they were associated.

56. **Melospiza melodia.** Not common. Only one specimen was observed.

57. **Melospiza palustris.** Not common.

58. **Melospiza Lincolnii.** Common.

59. * **Euspiza americana.** The males were excessively numerous, but only a few females were seen. Not yet breeding.

60. * **Goniaphea ludoviciana.** Only a few observed, which were nearly all males.

61. * **Cyanospiza cyanea.** Common. Not seen till May 8th, but was afterwards abundant. Both sexes unusually brightly colored. One of the females taken at Topeka had a strong shade of blue over the whole throat and breast, and other females were similarly more or less tinged with blue.

62. * **Cardinalis virginianus.** Exceedingly abundant. Young a week old were found May 10th. At the same date other nests were found containing three eggs each, as well as several unfinished nests. All of the

western specimens of *Collurio* (or *Lanius*) *ludovicianus* bear to certain forms of *Lanius* from Northern Africa. On recently comparing two specimens of shrikes, one from California and the other from Algeria, contained in the Lafresnaye collection in the Museum of the Boston Society of Natural History, I was unable to distinguish the Algerian one from the Californian.

half-dozen specimens of this species taken in Eastern Kansas differ from any I have seen from the Atlantic States in having a much larger and more swollen beak. It is a little smaller than that of the Cape St. Lucas form (*C. "igneus"*), in this respect being about half-way between the latter and the race of the Atlantic States. The color of the males is not quite so deep as in specimens from Florida.

63. * **Pipilo erythrophthalmus.** Abundant. Nests with eggs were found about May 6th and later. The song of this species was generally very different from that of the eastern bird, though occasionally it was indistinguishable from that of eastern individuals. Rather more white on the wings than in eastern specimens.

ICTERIDÆ.

64. * **Molothrus pecoris.** Very abundant. Generally seen lurking among the bushes in search of bird's nests in which to deposit its eggs. Plumage appreciably darker than at the north.

65. * **Agelæus phœniceus.** Common.

66. * **Xanthocephalus icterocephalus.** Several times seen around the prairie marshes at Topeka, where it was said to be common.

67. * **Sturnella ludoviciana.** Common. Several very pale-colored specimens were taken. It has here the song and generally the plumage of the so-called *S. neglecta*.*

68. * **Icterus Baltimore.** Common; chiefly frequenting the forests. The notes of the Baltimores here are very peculiar, many of them being entirely unlike any of those of their eastern representative.

69. * **Icterus spurius.** Abundant.

70. * **Quiscalus purpureus.** Abundant.

CORVIDÆ.

71. * **Corvus americanus.** Common. Young full grown taken at Topeka, May 23d.

* Dr. Otto Finsch, in the Proceedings of the Zoölogical Society (1870, p. 573), in speaking of the species of *Sturnella*, says: "The separation of the *Sturnellæ* into five localized species, as Dr. Sclater endeavored to set forth (*Ibis*, 1861, p. 179), in which he was followed by Mr. Cassin (Proc. Ac. Phil., 1866, pp. 23, 24), seems to me to be inadmissible; nobody can distinguish the so-called species from the short diagnoses given as above cited. . . . . Dr. Cabanis (J. f. Orn., 1856, p. 14, *et* 1861, p. 10), after having examined specimens from North America, Cuba, Costa Rica, Venezuela, and Guiana, comes to the conclusion that there is only one species; and I believe this opinion is quite right." These remarks of Dr. Finsch antedate by a few months my revision of this group published in April, 1871 (Bull. Mus. Comp. Zoöl., Vol. II, pp. 288-291), in which I came to the same conclusion. The part of the Proceedings of the Zoölogical Society containing Dr. Finsch's article had not then reached this country, and I am gratified to find that my own opinions on this point coincide with those of such high ornithological authorities.

72. * **Corvus corax.** Frequently seen; apparently common.

73. * **Cyanura cristata.** Abundant. One of the most numerous species met with. It has here a variety of notes I never noticed in the varied vocabulary of the representatives of this species elsewhere.

TYRANNIDÆ.

74. * **Tyrannus carolinensis.** Abundant.

75. * **Myiarchus crinitus.** Abundant.

76. * **Sayornis fuscus.** Common at Leavenworth. Darker colored than at the north.

77. * **Contopus virens.** Common.

78. * **Empidonax Traillii.** Not common.

79. **Empidonax minimus.** Not common.

ALCEDINIDÆ.

80. * **Ceryle alcyon.** Common.

CAPRIMULGIDÆ.

81. * **Chordeiles popetue.** Common.

82. * **Antrostomus vociferus.** A few heard at Leavenworth.

83. * **Antrostomus Nuttallii.** Common at Topeka.

CYPSELIDÆ.

84. * **Chætura pelasgia.** Abundant. Breeds chiefly in hollow trees.

PICIDÆ.

85. * **Picus pubescens.** Common. Darker colored than further north, in this respect resembling Florida specimens, and approaching the so-called *Picus* "*Gairdneri*" of the Rocky Mountains.

86. **Picus villosus.** Probably more or less common, but only one was observed.

87. * **Centurus carolinus.** Common. Those taken were very intensely colored. Some of the males had the whole throat bright red.

88. * **Melanerpes erythrocephalus.** Abundant.

89. * **Colaptes auratus.** Abundant. Several specimens were taken, with the black maxillary patch more or less tinged with red, through the mixture of red feathers with the black ones, thus already showing a tendency to the coloration of *C. mexicanus*, six hundred miles east of the habitat of that species.*

* Since the above was written, a specimen with red feathers in the black maxillary patch has been found in the Florida collection. I have also learned of the capture of a well-marked example of the so-called *C* "*hybridus*" at Topeka, February 13, 1872, by Mr. O. S. George. Mr. Edwin A. Papenoe informs me that in this specimen the quills are "orange red," and that the feathers of the maxillary patch are tipped with "dark blood red," with the other characters nearly as in *C. auratus.*

ARIDÆ.

The *Conurus carolinensis*, Dr. C. A. Logan informed me, was formerly common here, but had not been recently observed.

FALCONIDÆ.

90. * **Falco sparverius.** Abundant.

91. * **Buteo borealis.** Common.

92. * **Buteo lineatus.** Common.

93. * **Circus cyaneus**, var. **hudsonius.** Common.

94. * **Nauclerus furcatus.** Several pairs seen at Topeka, where it arrived about May 15th.

CATHARTIDÆ.

95. * **Cathartes aura.** Common.

COLUMBIDÆ.

96. * **Zenædura carolinensis.** Abundant.

TETRAONIDÆ.

97. * **Cupidonia cupido.** Abundant on the prairies.

PERDICIDÆ.

98. * **Ortyx virginianus.** Abundant.

CHARADRIIDÆ.

99. * **Ægialitis vociferus.** Common.

SCOLOPACIDÆ.

100. **Actodromas maculata.** Common about the lagoons at Leavenworth.

101. **Ereunetes pusillus.** Common on the sand-bars in the Kaw River, at Topeka.

102. **Gambetta flavipes.** Numerous about the lagoons. Ova in the females quite large. Probably breeds. Males considerably darker than the females, with the transverse bars of black broader and much more conspicuous than in the females.

103. **Rhyacophilus solitarius.** Rather common. Probably breeds.

104. * **Tringoides macularius.** Abundant.

105. * **Actiturus Bartramius.** Common on the prairies.

106. **Limosa fedoa.** A few seen.

107. * **Numenius longirostris.** Common on the prairies.

GRUIDÆ.

108. **Grus americanus.** Two individuals were seen on a sand-bar in the Kaw River at Topeka.

ARDEIDÆ.

109. * **Ardea herodias.** One individual seen.

110. * **Butorides virescens.** Common.

111. * **Botaurus lentiginosus.** Common.

RALLIDÆ.

112. * **Fulica americana.** Common.

113. * **Rallus virginianus.** Apparently common.

114. * **Porzana carolina.** Probably common, though but few were seen.

ANATIDÆ.

115. * **Aix sponsa.** Common.

116. * **Querquedula discors.** Abundant.

117. * **Anas boschas.** Abundant.

118. * **Fulix marila.** A single female was killed at Topeka, — the only representative of the species seen.

Two other undetermined species of ducks were seen, but not taken.

PODICIPIDÆ.

119. **Podilymbus podiceps.** Common.

LARIDÆ.

120. * **Hydrochelidon fissipes.** Several seen.

PELECANIDÆ.

121. **Pelecanus erythrorhynchus.** Said to be common. Saw a specimen which was killed about May 10th, which had the crest on the upper mandible remarkably high and thick.

II. — *List of Birds observed in the Vicinity of Fort Hays, Kansas, from May 26 to July 3, 1871; with Annotations.*

The subjoined list of sixty-one species of birds, observed in June at Fort Hays and vicinity, indicates the general character of the summer avian fauna of the eastern border of the Great Plains. The next following list of twenty-five species, observed during three weeks in midwinter, somewhat to the westward of Fort Hays, embraces all the more characteristic species of winter. Many not mentioned in these lists occur in fall and spring, chiefly swimming and wading birds.

Fort Hays is situated on Big Creek, three hundred miles west of the Missouri River, about ten south of the Saline River, and about the same distance north of the Smoky River. The timber here is not only confined to the immediate vicinity of the streams, often to their beds, but generally occurs in thin, irregular belts or scattered clumps, and ceases entirely a few miles to the westward. The Smoky is already quite destitute of trees as far west as Fort Hays, and they soon disappear from the Saline. The observations on which the following notes are based are the result of about thirty-five days spent consecutively in the field, during which time an area of country of from fifteen to thirty miles' radius was quite thoroughly explored. The belt of timber along Big Creek, preserved on the Military Reservation at Fort Hays, afforded by far the richest field, though some species were obtained on the Saline, and during a single day's hunt on Big Timber Creek, that were not met with on Big Creek. A longer time spent on Big Timber would doubtless have added several other woodland species to the list here given. In further description of the locality, it may be added that the trees consist mainly of the white and red elms, the ash-leaved maple, cottonwoods, black-walnut, and ash. Most of these trees assume a spreading form, and grow to a large size. There is little undergrowth, except where the first growth has been removed, as it has been to a large extent on most of the streams within fifteen to twenty miles of the post. The undergrowth consists mainly of sumach, dwarf-plum, and *Amorpha fruticosa*. In proportion to the amount of timber, the tree-nesting species are very abundant, and their nests are easily found, frequently half a dozen pairs of nearly as many species breeding in a single tree.

The "Plains" are here, as usual, somewhat rolling broad level plateaus, being separated by low ridges, or broken by sharp ravines and moist hollows. They are covered with short grass, usually but two or three inches high, except in the hollows and near the streams, where it often grows to the height of one or two feet. On the plateaus and ridges, in consequence of the excessive heat and scanty fall of rain, the grass becomes parched and dry during the latter half of June, and for the rest of the year the landscape wears an arid and forbidding aspect, relieved only by the deep green foliage of the trees along the streams. During May and much of June, however, the fresh young grass is thickly dotted with a variety of showy flowers, which vary the landscape with their respective tints. They are mainly social plants, and, growing thickly, their bright colors are conspicuous, giving their several hues to large areas. Most characteristic among them are *Malvastrum* *coccineum*, and one or two other malvaceous species, *Verbena aubletia*, a *Lippia*, a *Scutellaria*, and an aster-like composite plant, — all low forms and very prolific of large showy flowers. Among the coarser herbs are *Amorpha canescens*, *Echinacea angustifolia*, *Delphinium azureum*, a *Lepachys*, a *Dalea*, two species of *Linum*, *Onosmodium carolinianum*, and *Verbena hastata*, all common in their respective localities, but generally of dwarfed stature as compared with their size on the moister prairies to the eastward. The sensitive brier (*Schrankia uncinata*) was also abundant, and *Rosa lucida* was agreeably frequent along the streams. Two species of *Melocactus* and an *Opuntia* attest by their abundance the dryness of the climate.

The birds found here fall naturally into two groups, in accordance with the situations they most affect, — those of the timber and those of the Plains proper. The former class is much the more numerous in species, only about six being confined strictly to the Plains; these latter are, however, among the most characteristic, being by far the most numerously represented, and almost the only kinds that inhabit the treeless belt which extends thence westward to the Rocky Mountains. They are the horned lark (*Eremophila alpestris*), the chestnut-colored bunting (*Plectrophanes ornatus*), the lark finch (*Chondestes grammaca*), the lark bunting (*Calamospiza bicolor*), the yellow-winged sparrow (*Coturniculus passerinus*), and the meadow lark (*Sturnella ludoviciana*). The Carolina dove (*Zenædura carolinensis*) and the night-hawk (*Chordeiles popetue*) are most numerous about the timber, but are also everywhere common on the open plains, where the dove nests on the ground as readily as it does in trees at the eastward. The killdeer and mountain plovers (*Ægialitis vociferus* and *Æ. montanus*), and Bartram's tattler or field plover (*Actiturus Bartramius*) frequent the plains, chiefly near moist hollows, as well as the neighborhood of streams. About one fifth of the species were strictly western, not regularly occurring east of the Missouri River. Several others, however, as *Chordeiles popetue*, *Sturnella ludoviciana*, *Peucæa æstivalis*, *Troglodytes aëdon*, etc., have received distinctive names, owing to the faded appearance they here exhibit, and others might be thus separated with equal propriety. The bleaching of the plumage is evidently the result of the excessive dryness of the climate, and the lack of shelter from the intense rays of the sun, and in some degree, perhaps, of the wearing off of the edges of the feathers by the almost incessant heavy winds.

During our five weeks stay at Fort Hays, the maximum daily temperature in the shade usually ranged from 90° to 108° F. This temperature is frequently accompanied by parching winds, especially later in the season. The most striking feature of the avian fauna here is the great abundance of more or less strictly woodland species, considering the scantiness of the forest vegetation.

TURDIDÆ.

1. **Harporhynchus rufus.** Common in the narrow timber belts which border the streams.

The habits of this species, in respect to the location of its nest, indicate how greatly it is governed by circumstances. In dry, sandy localities, it is well known to commonly nest on the ground, and to place its nest in low bushes, where the soil is damp and clayey. Along Big Creek, near Fort Hays, we found it nesting in low bushes, and also in trees sixteen to twenty feet from the ground. Big Creek is subject in summer to sudden freshets, the stream, flowing between abrupt banks, sometimes rising ten or twelve feet in a single night, half submerging the trees that grow along its narrow bed. It was under the latter circumstances that the nests of this species were found placed twenty feet above the ground, while but a few yards distant other nests were found in low bushes, the bushes, however, growing on the bluffs, several feet above high-water mark. Other species that generally nest near the ground were also found to place their nests at a similar elevation, when breeding in the trees that grew along the bed of Big Creek. The several species seemed to be well aware of the peculiarities of the stream, and hence placed their nests above the high-water line.

2. **Mimus polyglottus.** Common in the timber along Big Creek. Nest placed in trees fifteen feet from the ground. Fresh eggs obtained June 6th.

3. **Mimus carolinensis.** One or two seen on Big Timber Creek. Not common.

SAXICOLIDÆ.

4. **Sialia sialis.** Not uncommon along the timbered streams.

PARIDÆ.

5. **Parus atricapillus.** Frequent in the timber along the streams.

TROGLODYTIDÆ.

6. **Troglodytes aëdon.** Abundant, nesting in the hollows of trees. Seven fresh eggs taken from one nest June 7th.

In respect to plumage, this species has here all the essential characters of the so-called *T.* "*Parkmanni*," the colors being appreciably paler than in specimens from the Atlantic States.

SYLVICOLIDÆ.

7. **Icteria virens.** Common on Big Timber Creek.

Probably *Dendrœca æstiva* and *D. discolor* occur sparsely along the Big Timber, but none were observed during a day's hunt along that stream.

HIRUNDINIDÆ.

8. **Hirundo lunifrons.** Common at localities. Large colonies breed on the cliffs bordering the Saline River.

9. **Cotyle serripennis.** Not uncommon along the streams, in the banks of which it nests. Nests examined June 7th were not yet completed.

10. **Progne subis.** A few pairs were seen in the vicinity of Fort Hays, where they were breeding in boxes erected for their accommodation.

VIREONIDÆ.

11. **Vireo gilvus.** Rather common in the timber on the "Reservation" at Fort Hays, and along the Saline and Big Timber.

12. **Vireo Belli.** Common along Big Timber, and doubtless more or less frequent along the better timbered portions of the other streams.

ALAUDIDÆ.

13. **Eremophila alpestris.** Abundant; as frequent on the high divides as elsewhere. Very unsuspicious; in this regard its habits contrasting strongly with those of most of the other prairie species, especially *Calamospiza bicolor* and *Plectrophanes ornatus*. It was decidedly the most numerous species in the vicinity of Fort Hays. Resident, breeding very early, and apparently twice in the season. The first brood was fully fledged in May, and before the end of June the young birds were already gathering into flocks. June 11th, we found young in the nest half grown, and the following day young that, although they had left the nest, were still unable to fly. No nests were found containing eggs, the species being a close sitter, and the nest very difficult to find.

The plumage of this species was very much bleached, a large proportion of the specimens observed having the throat either distinctly white, as also the superciliary stripes, or with only the faintest trace of yellow, and the other tints were correspondingly pale.

FRINGILLIDÆ.

14. **Chrysomitris** sp.? A *Chrysomitris* was frequently heard, but all our efforts to procure a specimen were fruitless. It had the restless habits and the notes of *C. pinus*, but this species is not known to frequent so southern a locality in the breeding season. It is hence more likely to have been *C. psaltria*.

15. **Plectrophanes ornatus.** Common out on the plains almost every-

where, it being one of the most interesting and characteristic species of the Plains. It has a short, shrill, but very sweet song, which is often uttered while on the wing. It is very wary for so small a bird, and has the habit of circling round the observer when disturbed for several minutes together, approaching tantalizingly near, with feints of a nearer approach, but generally keeping well out of range. The nest is a very neat, though slight structure, placed of course on the ground, and is composed of dry fine grass and rootlets. The eggs are generally five, blotched and streaked with rusty on a white ground. Full sets of freshly laid eggs were first found about June 3d.

The plumage varies greatly in color in different individuals of even the same sex, the variation being generally in respect to the purity and intensity of the colors. The most highly colored males have the breast and middle of the abdomen more or less strongly tinged with very bright ferruginous; others have these parts pure black; while in others still the black is obscured by the feathers having brownish-white margins. The lesser coverts vary from gray to black. The red tinge on the abdomen seems merely indicative of a high state of plumage; those thus marked also having the lesser coverts black; but they are also black in some specimens that are not tinged with red. *Plectrophanes melanomus* Baird, is merely the ferruginous phase of this species, and not even a local race. The highest colored female (the sex determined by dissection) was nearly as brightly colored as the paler colored males, having the chestnut collar, and the black on the breast nearly as distinct as some of the males. It was also nearly as large, and, until dissected, was supposed to be an immature male. Thirty specimens of the bird were obtained, and three full sets of eggs.

16. **Coturniculus passerinus.** Abundant everywhere on the Plains. Several nests, with full sets of (usually five) fresh eggs were found between June 3d and 10th. In notes and habits it does not differ from the eastern birds, but is paler colored.

On comparing Florida specimens (of which I have thirty before me, from Miami, Florida, collected by Messrs. Maynard and Henshaw) with northern ones, the former are found to be far more brightly colored than the latter. Between northern and southern specimens of the same species greater differences in color are rarely observable than in this, the differences being far greater than occur between many conspecific geographical races to which has been awarded specific rank. The difference consists in the much brighter and blacker tints of the southern form. Massachusetts specimens, though lighter than Florida ones, are still much darker than those from the Plains.

17. **Chondestes grammaca.** Common. Most numerous in the moist ravines and near the streams. Forms a very slight nest on the ground,

about June 1st. The first full set of eggs was found June 3d, and in one instance half-grown young were found June 6th. Generally, however, they appeared to commence laying about June 5th. Quite unsuspicious, and has the most elaborate song of any bird on the Plains.

18. **Peucæa æstivalis, var. Cassinii.** Rather common along the streams, where its low but peculiarly sweet song is heard at morning and evening, beginning with the first approach of dawn, and continuing at evening considerably after nightfall. It is very retiring, and it was only after several attempts that I discovered the author of the sweet notes that at these still hours added greatly to the pleasures of camping on the plains. The plumage is very much paler than that of Florida specimens, agreeing with that of the so-called *P.* "*Cassinii.*"

19. **Calamospiza bicolor.** Common here and there on the plains, living apparently in scattered colonies. Females were obtained from June 5th to 10th, that had evidently commenced incubation, but our long searches for the nest of this species proved always fruitless. The birds are very wary and difficult to shoot. Like most birds of the Plains, they are very tenacious of life, and when shot through vital parts, will generally fly several hundred yards before falling, finally dropping dead. It is a bird of powerful flight, delighting in the strongest gales, which force most other species to lie sheltered in the grass. It has habits that strongly recall the yellow-breasted chat, singing generally on the wing, hovering in the same manner as that bird, while its notes are so similar to those of the chat as to be scarcely distinguishable from them. Hence while collecting, we naturally applied to it the cognomen of the "Black Chat." The plumage of the males varies considerably in color, some being entirely black, except the white wing-patches, while others have the plumage more or less skirted with brownish-white, and in others there is an intermixture of feathers wholly brownish. After the moulting season the males assume the plumage of the female, the change in color being similar to that of the males of *Dolichonyx oryzivora.*

20. **Euspiza americana.** Abundant on Big Timber Creek, and some were seen along the Saline.

21. **Goniaphea melanocephala.** Several pairs seen along Big Creek near Fort Hays. A nest with half-grown young was obtained June 11th. Another nest built by the same pair was found with eggs about June 27th. The song of this species so much resembles that of *G. ludoviciana* that at first we mistook the species for that bird, and were only undeceived by shooting specimens.

No representatives of the genera *Cyanospiza, Spizella,* or *Melospiza* were observed during our five weeks' stay at this locality.

ICTERIDÆ.

22. **Molothrus pecoris.** Common in the timber, and frequent on the plains ten to fifteen miles from the nearest trees.

23. **Xanthocephalus icterocephalus.** A small flock seen at intervals about the corral at Fort Hays during our whole stay there. They probably bred in the vicinity.

24. **Quiscalus purpureus.** Abundant along Big Creek at Fort Hays. Nests with newly hatched young were found June 1st, and others with fresh eggs as late as June 12th. A nest was found in an old woodpecker's hole, the top of which had been broken off, June 8th, containing two eggs, and two young just hatched. A few twigs and rootlets had been laid on the rotten wood to serve for a nest. Mr. William Brewster informs me he has known this species to breed in a woodpecker's hole in Maine, — a rather strange departure from its usual habits, considering its long tail, which would seem to be an impediment to such a mode of nesting.

25. **Icterus Baltimore.** Common in the timber. All the specimens obtained on Big Creek had much more white on the edges of the quills than eastern birds, the middle coverts in the males being entirely white or only faintly stained with yellow, instead of deep yellow or orange as in the eastern birds. The specimens of this bird collected at Topeka and Leavenworth are in this respect about half-way between the Fort Hays specimens and those from the Eastern States. All the Kansas specimens are smaller than average New England ones, and have the bill relatively longer, slenderer, and more decurved. The females were also uniformly without black on the throat and head.

26. **Icterus spurius.** Abundant in the timber on the Reservation at Fort Hays. Full sets of fresh eggs were taken every day from June 6th to 10th.

27. **Sturnella ludoviciana,** var. **neglecta.** Abundant. The eight specimens taken were all very pale, or of the *S. neglecta* type. Song shorter, the notes more guttural and less ringing than those of this bird are on the prairies of Iowa, Northern Missouri, and Eastern Kansas, over which regions the *neglecta* type of plumage also prevails. A single nest found May 30th. It was open at the top, and rather slovenly made.

CORVIDÆ.

28. **Corvus corax.** Only a few pairs seen, though reputed to be common.

29. **Cyanura cristata.** Abundant in the timber.

TYRANNIDÆ.

30. **Tyrannus carolinensis.** Abundant in the vicinity of the timbered streams.

31. **Tyrannus verticalis.** Very numerous along the timbered streams. It has much the same habits as the *T. carolinensis*, nesting in the same manner. The eggs are so much like those of that bird, that they are sometimes actually indistinguishable from them. Nests with fresh eggs obtained June 4th to 10th.

32. **Myiarchus crinitus.** One specimen obtained, which was the only one seen.

No species of *Empidonax*, *Sayornis*, or *Contopus* was observed.

ALCEDINIDÆ.

33. **Ceryle alcyon.** Common.

CUCULIDÆ.

34. **Coccygus americanus.** Common.

PICIDÆ.

35. **Picus pubescens.** A single individual seen.

36. **Melanerpes erythrocephalus.** Abundant wherever there was timber, and no less inquisitive and irrepressible than at the East.

37. **Colaptes auratus.** Rather rare, and very wary. One was several times seen at a distance that seemed nearly red enough to be *C. mexicanus.* Those taken had red in the cheek-patches, as at Leavenworth.

CAPRIMULGIDÆ.

38. **Chordeiles popetue.** Abundant. Most of those taken were very light colored, corresponding with the so-called *C.* "*Henryi*," but some were nearly as dark as the average eastern bird.*

STRIGIDÆ.

39. **Bubo virginianus.** Not seen alive, but a dried carcass was found near Fort Hays.

40. **Athene hypogæa.** A large colony observed near the post, and several small colonies elsewhere, living in the burrows of the prairie-dogs (*Cynomys ludovicianus*).

Different specimens vary greatly in color and in the amount of feathering on the feet. Some have the tarsi densely feathered, while in other specimens the tarsi are nearly bare, a large series presenting every degree of variation between these extremes. The *A. hypogæa*, formerly supposed to be confined to the region east of the Rocky Mountains, as distinguished from the *A.* "*cunicularia*" of the western half of the continent, seems to have been based on specimens with the tarsi quite fully clothed, and hence

* In the synonymy of *C. popetue* given in Bull. Mus. Comp. Zoöl., Vol. II, page 300, foot-note, *C. texensis* was inadvertently included.

mainly on individual variation of this character. The Rocky Mountain form, to which the name of *cunicularia* has generally been restricted, is a little larger than the birds from the Plains, their elevated habitat corresponding to a more northern locality. Specimens were collected the past summer at intervals from Fort Hays to the Salt Lake Basin. After a comparison of these with authentic specimens of both *A.* "*cunicularia*" and *A. hypogæa* of authors, I find no difference that is constant, except the rather larger size of the Rocky Mountain form, — a difference that would *a priori* be expected.

FALCONIDÆ.

41. **Falco peregrinus.** A pair of these birds were found breeding on a high cliff near the Saline River, May 29th, the young being then half grown. The nest was placed on an inaccessible shelf of the cliff, and was composed of sticks. The only other instance that has come to my knowledge in which this bird has used any other nest than the bare ground is that mentioned recently by the Rev. William Jarvis in the "American Naturalist,"* where he speaks of a nest found by him in the White Mountains, which was "made of a few dry sticks placed round a hollow on a shelf of the cliff."

42. **Falco sparverius.** A few pairs observed nesting in hollow trees.

43. **Buteo borealis.** A few pairs seen, and a nest found June 1st, containing three fresh eggs.

44. **Circus cyaneus, var. hudsonius.** Rather common.

CATHARTIDÆ.

45. **Cathartes aura.** Moderately common. Usually seen in small parties of from three or four to a dozen, about the carcasses of recently killed buffaloes. A considerable number were apparently breeding in the vicinity of some high cliffs on the Saline, but a careful search for their nests was unsuccessful.

COLUMBIDÆ.

46. **Zenædura carolinensis.** Common everywhere, but most numerous in the vicinity of timber. Very commonly met with in pairs, many miles from the nearest timber. Many nests were found at Fort Hays, in the timber along Big Creek. Most of them were built in the usual way, forming such slight structures that the eggs could be readily seen through them from the ground. Several pairs, however, were found occupying deserted nests of the purple grackle, which they had slightly repaired. In one case a nest with two eggs was found *on the ground*, only a few yards from shrubs. From the frequency with which I had seen pairs of these birds far out on the plains in the nesting season, I was led to anticipate this method

* Am. Nat., Vol. V, p. 662.

of breeding. I afterwards learned that further west, where the prairies were entirely destitute of timber, and where this bird was very common, they always nested on the ground, as from necessity of course they must. The fact, however, is interesting as showing how readily the bird greatly modifies its breeding habits to suit its surroundings, while other tree-nesting species disappear entirely in regions where there are no trees. The present species, however, seems everywhere but slightly dependent upon trees, as it seeks its food in fields, and not in forests.*

MELEAGRIDÆ.

47. **Meleagris gallopavo.** Common along the timbered portions of the streams, which here form its western limit.

TETRAONIDÆ.

48. **Cupidonia cupido.** Rare. It is every year, however, advancing westward. Was first seen in the vicinity of Fort Hays about two years since, and is apparently fast becoming common.

49. **Pediœcetes phasianellus,** var. **columbianus.** Common along the streams. It is here called the "grouse," in distinction from the prairie-hen; but further west, beyond the range of the true prairie-hen, it is almost universally called "prairie-hen" or "prairie-chicken."

PERDICIDÆ.

50. **Ortyx virginianus.** Occasional, but every year is becoming more common. Like the prairie-hen, it is quite rapidly working westward, following the settlers.

CHARADRIIDÆ.

51. **Ægialitis vociferus.** Common everywhere. To the collector an unmitigated nuisance, from their incessant screaming about his head wherever he goes.

52. **Ægialitis montanus.** Moderately common. Unlike the preceding species, they are quite unsuspicious and retiring, and nearly always silent.

SCOLOPACIDÆ.

53 **Tringoides macularius.** Common.

54 **Actiturus Bartramius.** Not common.

55 **Numenius longirostris.** A few pairs were observed near Fort Hays, where they were breeding.

56. **Numenius hudsonicus.** A single specimen was seen and shot June 15th.

* Since the above was written I have been informed by Professor O. C. Marsh that he has often found the eggs and young of this species on the ground in Western Kansas and in Colorado. He says (in a letter): "Once I flushed a female who was covering a couple of very young birds on the ground, not in a nest, but in a small depression *on the ground*."

ARDEIDÆ.

57. **Butorides virescens.** Occasional.

58. **Nyctiardea grisea, var. nævia.** A single specimen was seen flying along Big Creek.

RALLIDÆ.

59. **Fulica americana.** A single specimen was shot June 8th. Said, however, to be common.

ANATIDÆ.

60. **Aix sponsa.** Not common.

61. **Querquedula discors.** More or less frequent throughout the summer.

III. *List of Birds observed in Northwestern Kansas, December* 25, 1871, *to January* 12, 1872 ; *with Annotations.*

THE following list is based on observations covering a period of nearly three weeks, made during a wagon journey of over two hundred and fifty miles. The area traversed was nearly fifty miles square, extending westward from Park's Fort Station, on the Kansas Pacific Railway, to Grinnell, and from the Smoky River on the south to the head-waters of the Solomon on the north. The opportunity was hence unusually favorable for observing the birds that inhabit the Plains in winter.

The locality does not differ essentially from the country about Fort Hays, except in the greater scarcity of timber, which is limited to a few scanty clumps of bushes and scattered trees on the Saline and Solomon Forks, opposite Coyote Station. The small number of species observed under such favorable circumstances indicates the poverty of the winter avian fauna of the Plains. The only species really numerous were *Eremophila alpestris,* which was met with everywhere, and roving locks of two species of *Plectrophanes* (*P. nivalis* and *P. Maccownii*). As our halts near the timber were necessarily short, a longer stay at hese points might have added a few other species to the list of those observed.

PARIDÆ.

1. **Parus atricapillus.** A few were seen in the shrubs along the streams.

ALAUDIDÆ.

2. **Eremophila alpestris.** Abundant everywhere, but especially numerous along the railroad and near the settlements. Though so numerous, they appeared to suffer considerably from the unusual severity of the winter, as they were frequently found frozen. A number were also obtained that had maimed themselves by flying against the telegraph-wires at Coyote Station.

FRINGILLIDÆ.

3. **Chrysomitris tristis.** One small flock seen.

4. **Plectrophanes nivalis.** Flocks, sometimes of large size, were seen wheeling about over the plains nearly every day, in their usual restless manner.

5. **Plectrophanes Maccownii.** Common in small flocks. Easily approached, and far less erratic in their movements than the preceding species.

6. **Plectrophanes ornatus.** More or less frequent in small flocks, but far less numerous than the preceding, or than they were in summer at Fort Hays.

7. **Spizella monticola.** Frequent along the wooded parts of the streams.

CORVIDÆ.

8. **Corvus corax.** Four or five were seen feeding on some buffalo carcasses on the divide between the North and South Forks of the Solomon, fifteen miles from the nearest timber.

ALCEDINIDÆ.

9. **Ceryle alcyon.** One was seen on the Saline, north of Coyote Station.

PICIDÆ.

10. **Picus pubescens.** One was seen in some timber on the Saline, and one on Big Creek, near Fort Hays.

11. **Colaptes auratus.** Two were observed on the Saline, north of Coyote Station.

FALCONIDÆ.

12. **Falco peregrinus.** Not common.

13. **Falco columbarius.** Occasional.

14. **Astur atricapillus.** A single individual observed.

15. **Buteo lineatus.** Frequent.

16. **Archibuteo lagopus.** Common. Most numerous of the rapacious birds.

17. **Aquila chrysaëtos.** Frequent.

18. **Haliaëtus leucocephalus.** Common.

19. **Circus cyaneus, var. hudsonius.** A single individual seen.

STRIGIDÆ.

20.? **Otus "Wilsonianus."** An owl was heard at one of our camps on the Solomon, supposed to be of this species.

21. **Athene hypogæa.** Several were seen just at nightfall near Buffalo Station. Said to be more or less frequently observed in mild weather throughout the winter.

MELEAGRIDÆ.

22. **Meleagris gallopavo.** Said to be common on the streams as far west as the timber extends.

TETRAONIDÆ.

23. **Cupidonia cupido.** A few occur as far west as Coyote, where they have recently made their appearance from the east.

24. **Pediœcetes phasianellus, var. columbianus.** Common along the streams.

PERDICIDÆ.

25. **Ortyx virginianus.** Not yet common west of Fort Hays, though said to have been observed at Coyote.

IV. *List of Birds observed at Cheyenne, Wyoming Territory, from August* 16 *to August* 28, 1871; *with Annotations.*

CHEYENNE, from its situation in the midst of the Plains, forms a locality possessing peculiar interest ornithologically. Its elevation above the level of the sea is said to be 6,041 feet. The nearest timber is twenty miles distant, but along the bed of Crow Creek — a small stream near the town, consisting, at this season, of little more than a chain of slight pools — were scattered clumps of rose-bushes and low willows. The latter were rarely more than three to six feet in height, grew very much scattered, and were nearly destitute of foliage, their leaves having been devoured by cattle. Although but forty-one species were obtained or observed here, it is probable that even a number considerably less than this would include all that regularly breed here. The abundance of the *Tyrannidæ* found here at this season is one of the most interesting ornithological features of the locality, since they would hardly be expected in very great number or variety at points so remote from timber. Although the greater part were young birds, and may have come from woodlands, probably the greater number and perhaps all the commonly wood-inhabiting species enumerated below, breed sparingly among the low willows that grow along Crow Creek.

TROGLODYTIDÆ.

1. **Troglodytes aëdon.** Frequent.

SYLVICOLIDÆ.

2. **Dendrœca æstiva.** Two or three specimens obtained. Not common.

3. **Wilsonia pusilla.** Several specimens obtained. Rather more frequent than the last.

4. **Icteria virens.** One specimen obtained, which was the only one seen.

HIRUNDINIDÆ.

5. **Hirundo horreorum.** Frequent near the town.

6. **Hirundo lunifrons.** Moderately common.

LANIIDÆ.

7. **Collurio ludovicianus.** Moderately common.

ALAUDIDÆ.

8. **Eremophila alpestris.** Common.

FRINGILLIDÆ.

9. **Chrysomitris tristis.** Several small flocks seen flying over.

10. **Plectrophanes Maccownii.** Abundant. In its notes and mode of flight not readily distinguishable from *P. ornatus*, for which species we at first mistook it. The latter was not observed at this locality.

11. **Chondestes grammaca.** Common.

12. **Poœcetes gramineus.** Abundant. All the specimens obtained were very palely colored, the young of the year as well as the adult.

13. **Passerculus savanna.** Common.

14. **Spizella socialis.** Abundant. Very faintly colored, the young especially, and hardly distinguishable from *S. pallida*.

15. **Spizella pallida.** Common.

16. **Spizella pusilla.** Common.

17. **Calamospiza bicolor.** Common.

18. **Cyanospiza amœna.** Not common.

19. **Goniaphea melanocephala.** Not common.

ICTERIDÆ.

20. **Molothrus pecoris.** Rather common, associating with *Xanthocephalus icterocephalus*.

21. **Xanthocephalus icterocephalus.** Several small flocks met with along Crow Creek.

22. **Sturnella ludoviciana**, var. **neglecta**. Abundant.

23. **Icterus Baltimore**. Frequent. Only young birds seen, which were very palely colored.

TYRANNIDÆ.

24. **Tyrannus carolinensis**. One specimen obtained, and a few others seen.

25. **Tyrannus verticalis**. Very abundant, and somewhat gregarious. Chiefly young birds seen, associating in loose flocks of several dozens. Kept exclusively in the valley of Crow Creek.

26. **Contopus virens**, var. **Richardsonii**. Common.

27. **Sayornis Sayus**. Common.

28. **Empidonax flaviventris**, var. **difficilis**. Common.

TROCHILIDÆ.

29. **Selasphorus platycercus**. Common.

STRIGIDÆ.

30. **Athene hypogæa**. One small colony observed.

FALCONIDÆ.

31. **Falco peregrinus**. A single individual was seen August 20th.

32. **Falco sparverius**. Common.

33. **Buteo** sp.? A very light colored large species of Buteo was common, but none were obtained.

34. **Circus cyaneus**, var. **hudsonius**. Abundant. Nearly all seen were birds of the year, in which the plumage was very red, much more so than in eastern specimens of corresponding age.

CATHARTIDÆ.

35. **Cathartes aura**. Frequent. Six were seen at one time feeding on the carcass of a dog.

COLUMBIDÆ.

36. **Zenædura carolinensis**. Common.

CHARADRIIDÆ.

37. **Ægialitis vociferus**. Common.

SCOLOPACIDÆ.

38. **Actodromas Bairdii**. Common along Crow Creek.

39. **Actodromas minutilla**. Common along Crow Creek.

40. **Rhyacophilus solitarius**. Common with the preceding.

RALLIDÆ.

41. **Porzana carolina**. A single individual observed. Probably not frequent.

V. *List of Birds observed at the Eastern Base of the Rocky Mountains in Colorado Territory, between Colorado City and Denver, in July and August,** 1871; *with Annotations.*

The list given below is based on observations made on a journey from Colorado City to Denver, during the first two weeks of August, supplemented by a few notes made at Denver during the first week of July. Probably five sixths of the species breed at the localities where they were observed. Four days were spent in the neighborhood of Colorado City, two at Lake Pass, and about ten days at Denver. The distance between Colorado City and Denver is nearly one hundred miles. The highest point is at Lake Pass, on the divide between the Arkansas and South Platte Rivers, which is said to be about 7,000 feet above the sea. Though really on the Plains, our road passed quite near the foot-hills, and along the streams there was considerable timber. We found here, as would be naturally anticipated, a fauna in many respects peculiar, — a blending of that of the mountains with that of the Plains. Most of the species found on the Plains extend to the foot-hills, and even into the valleys between them. On the other hand, many, belonging properly to the wooded region of the mountains, follow the timber belts along the streams for some distance into the Plains. We hence have here a far richer bird fauna, through the addition of the mountain species, than is met with on the Plains proper.

TURDIDÆ.

1. **Turdus migratorius.** Tolerably common, especially along the creeks in the foot-hills.

2. **Turdus Pallasi.** Only observed on Monument Creek, at Lake Pass; altitude of the locality about 7,000 feet.

3. **Oreoscoptes montanus.** Common on Dry Creek, ten miles south of Denver.

4. **Mimus carolinensis.** Common along the Fontaine-qui-bouit, near Colorado City. Also seen in the Garden of the Gods, at Lake Pass, at Denver, and on Bear Creek, about fifteen miles southwest of Denver, behind the first foot-hills.

5. **Harporhynchus rufus.** Observed near Colorado City, and obtained on Bear Creek, in the foot-hills southwest of Denver.

* From July 4th to 8th, and August 1st to 13th.

CINCLIDÆ.

6. **Cinclus mexicanus.** Seen on the Fontaine-qui-bouit, at Colorado City, August 1st.

SAXICOLIDÆ.

7. **Sialia mexicana.** One pair observed in the foot-hills west of Denver. There is also a specimen in the Museum, collected near Denver. It is from the late Mr. Cassin's collection, and bears the following label: "*Sialia mexicana*, Clear Creek, Rocky Mts., K. T., July, 1859. W. S. Wood, Jr."

8. **Sialia arctica.** Many seen, and three shot, a few miles north of Colorado City.

SITTIDÆ.

9. **Sitta carolinensis.** A single specimen was seen about twenty miles north of Colorado City, on the Monument.

TROGLODYTIDÆ.

10. **Salpinctes obsoletus.** Obtained in the foot-hills southwest of Denver, on Bear Creek.

11. **Catherpes mexicanus.** Common in the Garden of the Gods, near Colorado City. Seen only on the bare rocks. The vertical sandstone cliffs of the Garden of the Gods seemed to afford them a favorite haunt, over which they flitted to the highest points of the naked cliffs. Their shrill, ringing notes reverberated among the cliffs with almost incredible loudness, it seeming almost impossible that so small a bird should be able to produce such penetrating and startling echoes.

12. **Troglodytes aëdon.** Common everywhere.

A bird supposed to be *Chamæa fasciata* was observed in the foot-hills near Colorado City. Although no specimens were obtained, it was several times seen, and watched at a distance of only a few yards, and I feel confident it was that species, though previously known only from localities as distant as Lower California.

SYLVICOLIDÆ.

13. **Icteria virens.** Common near Colorado City, and also observed near Denver.

14. **Dendrœca Auduboni.** Common along the streams at the foot of the mountains from Colorado City to Denver. Properly a bird of the mountain fauna.

15. **Dendrœca æstiva.** Occasional from Colorado City to Denver.

16. **Setophaga ruticilla.** Common in the foot-hills west of Denver, the first week in July, and also seen at Colorado City.

HIRUNDINIDÆ.

17. **Hirundo horreorum.** Generally dispersed, but not numerous.

18. **Hirundo lunifrons.** Abundant at Denver, common at Colorado City, and frequently seen between these points.

19. **Hirundo thalassina.** Common at the Garden of the Gods, and about Castle Rock, at Lake Pass, *breeding in holes in the rocks*, instead of in hollow trees, as is its usual custom.

20. **Cotyle serripennis.** A few seen along the South Platte at Denver.

VIREONIDÆ.

21. **Vireo gilvus,** var. **Swainsoni.** One was shot on Kettle Creek, near its junction with the Monument, where also others were seen. Paler than eastern specimens, and pertaining to *V. Swainsoni* Baird, which may be recognized as the western paler race of *V. gilvus.*

22. **Viero solitarius,** var. **plumbeus.** Two shot at the same locality as the last, the only point where they were met with. Paler than eastern specimens, with barely a trace of olive above and on the sides, but appears to be merely the pale western race of *V. solitarius.* Other specimens are in the Museum of Comparative Zoölogy from Colorado.

LANIIDÆ.

23. **Collurio ludovicianus.** Rather common in the vicinity of Denver.

TANAGRIDÆ.

24. **Pyranga ludoviciana.** A single specimen was shot near Colorado City, the only one seen.

ALAUDIDÆ.

25. **Eremophila alpestris.** Common.

FRINGILLIDÆ.

26. **Chrysomitris tristis.** Common at Denver and Colorado City, and seen at intervals between these points.

27. **Chrysomitris pinus.** Common at the Soda Springs, near Colorado City, in August, and also observed near Denver. Probably breeds in the mountains, which are here but a few miles distant.

28. **Chondestes grammaca.** Common. Occasionally seen in considerable flocks in company with *Calamospiza bicolor.*

29. **Poœcetes gramineus.** Common.

30. **Spizella socialis.** Common. Seen in large flocks the first week in August.

31. **Spizella pallida.** More or less frequent, associating with *S. socialis,* from which, in nestling plumage, it is scarcely distinguishable.

32. **Melospiza melodia.** A few observed near Colorado City.

33. **Calamospiza bicolor.** Abundant. Moulting the first week in August, when the males were curiously mottled with irregular patches of brown and black.

34. **Euspiza americana.** Frequent near Colorado City.

35. **Goniaphea melanocephala.** Observed at Colorado City and at Denver.

36. **Cyanospiza amœna.** Common at Colorado City, and also observed at Denver. Common in the foot-hills southwest of Denver.

37. **Pipilo erythrophthalmus, var. oregonus.** Numerous among the foot-hills, and more or less frequent along the streams for ten or twenty miles to the eastward.

38. **Pipilo chlorurus.** Common along the streams to some distance east of the foot-hills, though it probably breeds only in the mountains.

ICTERIDÆ.

39. **Molothrus pecoris.** More or less frequent.

40. **Agelæus phœniceus.** Common about Denver.

41. **Sturnella ludoviciana, var. neglecta.** Abundant.

42. **Icterus Baltimore.** Moderately common along the timbered streams. All the specimens examined presented an exceedingly bleached and weathered appearance.

43. **Icterus spurius.** Common in the vicinity of Denver.

44. **Scolecophagus cyanocephalus.** Common near the streams.

CORVIDÆ.

45. **Corvus corax.** Common along the Platte near Denver, and observed at intervals along Plum Creek.

46. **Pica caudata, var. hudsonica.** Seen at intervals along the streams.

47. **Cyanurus Stelleri, var. macrolophus.** The form called *macrolophus* was common along the streams.

48. **Aphelocoma floridana, var. Woodhousei.** A single pair was obtained near Colorado City, the only individuals seen.

49. ? **Picicorvus columbianus.** A small party, probably of this species, seen near Colorado City, but no specimens were obtained. This is the species already referred to as a probably undescribed species of woodpecker.* The colors of this species correspond very closely with the supposed woodpecker, and having since learned that the habits of *Picicorvus columbianus* so closely resembles those of *Melanerpes torquatus* as to render it easily mistaken for a woodpecker, it seems more probable that it may have been this bird than that a large species of woodpecker inhabiting this region should have thus far been overlooked.

TYRANNIDÆ.

50. **Tyrannus carolinensis.** Moderately frequent from the Soda Springs northward to Denver, ranging to the base of the mountains.

51. **Tyrannus verticalis.** Common at Denver, and occasionally southward to Colorado City. Not seen in the mountains, nor in South Park.

* Am. Nat., Vol. VI, p. 350.

52. **Contopus virens**, var. **Richardsoni**. Tolerably frequent.

53. **Sayornis Sayus**. A single individual shot near Colorado City, and one other seen.

54. **Empidonax obscurus**. More or less frequent in the bushes along the streams.

ALCEDINIDÆ.

55. **Ceryle alcyon**. Seen occasionally along most of the creeks.

CAPRIMULGIDÆ.

56. **Antrostomus Nuttallii**. Heard great numbers at our camp near the Garden of the Gods.

57. **Chordeiles popetue**. The paler form, called "*Henryi*," of this species was everywhere common.

CYPSELIDÆ.

58. **Panyptila melanoleuca**. Observed only at the Garden of the Gods, where many pairs were breeding, though sought for at Castle Rocks and other similar places. They breed in holes and crevices in the rocks, usually far above gun-shot. They seemed very shy, and flew mostly near the tops of the highest rocks. Upon ascending the rocks most frequented by them they moved to other points, and thus managed to keep generally out of range. By spending a considerable part of two days, we procured only four specimens, though several others were killed, which fell in inaccessible places. They fly with great velocity and are very tenacious of life. As they swoop down to enter their nests, the rushing sound produced by their wings can be heard to a considerable distance. *Hirundo thalassina* was also breeding here in similar situations.

TROCHILIDÆ.

59. **Selasphorus platycercus**. Common and quite generally distributed.

PICIDÆ.

60. **Picus villosus**, var. **Harrisii**. Shot a single specimen at the Garden of the Gods.

61. **Melanerpes erythrocephalus**. Common at Denver, and frequent southward along Plum Creek and elsewhere where there were many trees.

62. **Melanerpes torquatus**. First seen at Monument Park. Common in the timber along Plum Creek.

63. **Colaptes mexicanus**. Common.

STRIGIDÆ.

64. **Athene hypogæa**. Common near Denver, and also seen near Blake's Mills, on Plum Creek.

FALCONIDÆ.

65. **Falco peregrinus.** Seen at the Garden of the Gods, Castle Rocks, and on Bear Creek, in the foot-hills southwest of Denver.

66. **Falco sparverius.** Abundant everywhere. Very numerous in the Garden of the Gods, *where they appear to nest in holes in the rocks.* The old birds were seen to enter holes in the cliffs, and several broods of newly fledged young seen there were evidently raised in the vicinity, although there were no trees within several miles in which they could have nested. The remarkable pinnacles of rock, rising vertically to a height of from 100 to 300 feet, which occur at this point, abound in holes admirably suited for nesting-sites for these and other birds, while the only timber in the vicinity consists of dwarfed piñons, pines, and cedars, with here and there a cotton-wood along the neighboring creek.

67. **Buteo borealis.** A large red-tailed hawk was frequent everywhere between Colorado City and Denver.

68. **Circus cyaneus, var. hudsonius.** Common and generally dispersed. Next to the sparrow-hawk, the most numerous species of *Falconidæ* observed.

CATHARTIDÆ.

69. **Cathartes aura.** Seen at intervals. Not apparently abundant.

COLUMBIDÆ.

70. **Zenædura carolinensis.** Common.

TETRAONIDÆ.

71. **Pediœcetes phasianellus, var. columbianus.** Said to be abundant, especially near Lake Pass.

CHARADRIIDÆ.

72. **Ægialitis vociferus.** Frequent at Summit Lake (Lake Pass), and common generally along the streams.

73. **Ægialitis montanus.** Not numerous.

SCOLOPACIDÆ.

74. **Actodromas Bairdii.** Common at Summit Lake.

75. **Gambetta flavipes.** A single specimen was shot at Summit Lake, August 5th, — the only one seen.

76. **Gambetta melanoleuca.** A single specimen was shot at Summit Lake, August 5th. No others were seen.

77. **Rhyacophilus solitarius.** Numerous at Summit Lake.

78. **Tringoides macularius.** Common at Summit Lake, and along the streams.

79. **Actiturus Bartramius.** Frequently observed flying over.

ARDEIDÆ.

80. **Demiegretta ? sp. ?** A single heron was seen on the South Platte, apparently a *Demiegretta.*

ANATIDÆ.

81. ? **Anas boschas.** A single specimen of apparently this species was observed at Summit Lake.

VI. *List of Birds observed in South Park, Park County, Colorado Territory, in July,* 1871 ; *with Annotations.*

South Park is an elevated plateau enclosed in the mountains of Colorado Territory, occupying nearly its geographical centre. Its average elevation is a little more than nine thousand feet, its area nearly two thousand square miles. It is situated between the 35th and 36th parallels, about fifty miles west of the eastern base of the Rocky Mountains, and has a length of about sixty miles by a breadth of about thirty. The surface of the Park is somewhat diversified, low nearly parallel ridges running through it in a northwest and southeast direction, dividing it somewhat irregularly into a series of valleys, through which flow the South Platte River and its tributaries. Most of the ridges are scantily covered with pines and aspens, especially their northern declivities, and the streams are fringed with various species of willow and cottonwood. The "bunch grass" generally grows luxuriantly, especially in the vicinity of the streams, but considerable portions of the Park are arid and alkaline, particularly to the eastward, where the vegetation strongly resembles that of the more barren portions of the plains. Here the prevailing plants are low artemisia-like forms, rising to but a few inches, and a few species of *Cactus.*

The avian fauna of South Park is far from rich in species ; the greater part of which are woodland birds, the remainder being such as typically characterize the Plains. During a reconnoissance of two weeks in July, only fifty-four species of birds were observed, many of which were seen but once or twice, and less than half of which were very common. Of the numerous family *Sylvicolidæ*, but two species were observed ; of the *Tyrannidæ*, only representatives of two genera (*Contopus* and *Empidonax*) ; while swimming and wading birds were almost wholly absent. A few others occur in close proximity to the Park, the most of which doubtless frequent to some extent the belts of timber that intersect it.

From the great elevation of the Park, its fauna has a decidedly northern aspect, and may be regarded as at least subalpine, and as representative of the Canadian fauna of the Eastern Province of the continent. The nights are cool even in midsummer, the average sunrise temperature for the summer months being probably little, if any, above 40° F. The midsummer showers are generally accompanied with hail and a great reduction of the temperature. The maximum temperature frequently reaches 80° in the shade, the heat at midday being usually quite oppressive. July 14th may perhaps be taken as an average day, when the temperature at sunrise was 38°; at 2 P. M., 78° in the shade; and at sunset, 60°. Although most of the birds are of a northern type, one or two species, as, for example, *Sturnella ludoviciana* and *Zenædura carolinensis*, are more or less frequent that barely reach the Canadian fauna in the Atlantic States.

In this connection a word or two may be added in respect to the country lying between South Park and the Plains. At Denver (altitude 5,100 feet) the avian fauna is analogous to the Carolinian of the Eastern Province, and extends even into the valleys among the foot-hills. From the base of the mountains up to about 7,500 feet the fauna is more analogous to the Alleghanian, or to that of Southern New England. Thence upward to about 10,500 feet is a zone more resembling the Canadian fauna of the East, or that of Northern New England. From this point upward to the timber-line in the Snowy Range the fauna is more nearly representative of the Hudsonian, or that of the shores of Hudson's Bay and the valley of the McKenzie River. Above this, in the Snowy Range, is a region dotted with snow-fields, where are found several essentially arctic forms.

Following up Turkey Creek, by the stage-road leading from Denver to South Park, we find along this stream the most varied fauna and flora of the middle portion of the Rocky Mountains. Here the rainfall is evidently the greatest, and the vegetation accordingly the most luxuriant. Pines and spruces thickly clothe the slope of the mountains; the streams are densely enclosed with willows, alders, cottonwoods, and other deciduous trees and shrubs, and rosaceous and ranunculaceous plants predominate, giving a flora of a cold-temperate or subalpine type not met with elsewhere between the Rocky Mountains and the Appalachians, and as different from that of the Plains as if it grew on another continent. A profusion of flowers of bright tints meet the traveller at every step, constantly changing in species with the increase of altitude. Gradually, as one approaches the Park, the variety of species diminishes, the timber becomes more scanty, and on every hand there are evidences of increasing aridity in the climate. The birds also decrease in number and in species, till finally we enter South Park at its northern extremity by a pass having an elevation of about 10,500 feet, and an alpine fauna and flora. A few species of birds * were last seen as we entered the mountains, and others disappeared higher up, where still others were for the first time observed.

Between South Park and Pike's Peak the country is much drier than that portion of the mountains between South Park and Denver. Leaving South Park at its southeastern edge, the road thence eastward to Colorado City, at the eastern base of Pike's Peak, passes through a succession of open park-like tracts of country, covered with short grass. The hills are low and rather scantily timbered, and the whole aspect more or less arid and forbidding. The flora and fauna are far from rich, the birds being mainly such as are found in South Park itself, and the herbaceous vegetation also much the same.

TURDIDÆ.

1. **Turdus migratorius.** Common everywhere.

2. **Turdus Pallasi.** Frequent about Fairplay, and also observed at other points.

The Veery (*Turdus fuscescens*), although not observed in or about the Park, was met with at several points between Denver and the Park, especially along the North Fork of the South Platte.

SAXICOLIDÆ.

3. **Sialia arctica.** Common everywhere.

PARIDÆ.

4. **Parus atricapillus.** A small party were met with at Fairplay, representing of course the *septentrionalis* race, characterized mainly by lighter colors, and more especially by a broader edging of white on the quills.

TROGLODYTIDÆ.

5. **Troglodytes aëdon.** Common.

SYLVICOLIDÆ.

6. **Dendrœca Auduboni.** Common along the streams and timbered ridges.

* *Pipilo erythrophthalmus*, var. *arcticus*, *Harporhynchus rufus*, *Mimus carolinensis*, *Icteria virens*, etc.

7. **Wilsonia pusilla.** Abundant in the willows along the streams. Saw sometimes a dozen pairs during a morning's hunt.

The preceding two species were the only *Sylvicolidæ* seen. *Geothlypis philadelphia*, var. *Macgillivrayi*, however, is doubtless more or less frequent, as it was common everywhere in the mountains to the eastward.

HIRUNDINIDÆ.

8. **Hirundo horreorum.** More or less generally distributed throughout the Park, but most numerous in the vicinity of Fairplay.

9. **Hirundo bicolor.** Generally distributed, breeding in woodpecker's holes.

10. **Hirundo lunifrons.** Common at intervals throughout the Park. Found a large colony at Fairplay, nesting under the eaves of buildings. Thirty-eight nests were observed on one house, all within a space of twenty feet.

VIREONIDÆ.

11. **Vireo gilvus.** Rather common.

12. **Vireo solitarius, var. plumbeus.** One shot and others seen at Fairplay.

ALAUDIDÆ.

13. **Eremophila alpestris.** Common throughout the Park.

FRINGILLIDÆ.

14. **Chrysomitris** sp.? A species of *Chrysomitris* was frequently noticed at a distance. *C. pinus* occurs throughout the adjoining region, and doubtless this was the species observed in the Park. *C. tristis* was not met with after entering the mountains.

15. **Carpodacus purpureus.** A few pairs were seen at Fairplay.

16. **Passerculus savanna.** Common along the streams, but far more numerous near the mountains. Very numerous at our camp on Jefferson Creek (July 14), where we found nests with eggs and with young. The numerous specimens obtained here presented great variations in size and in markings, but no decided general differences from summer specimens from Massachusetts.*

17. **Poœcetes gramineus.** More or less common.

18. **Chondestes grammaca.** Not numerous.

19. **Zonotrichia leucophrys.** Exceedingly numerous at Fairplay, and everywhere more or less common. The large number of specimens obtained were, with few exceptions, typically of the *leucophrys* type.

* For remarks on the numerous supposed species of this group attributed, to the middle and western portions of North America, see Bull. Mus. Comp. Zoöl., Vol. II, pp. 272–278, April, 1871.

The others were intermediate between this form and the so-called *Z. Gambeli*.*

20. **Junco "caniceps."** Abundant at Fairplay, and generally common near the borders of the Park.

21. **Melospiza melodia.** Occasionally seen along the streams, but nowhere very common. Song undistinguishable from that of the eastern bird. Nest and eggs similar.

22. **Melospiza Lincolnii.** Abundant along the streams, and especially numerous near the mountains.

23. **Spizella socialis.** Not common. But one specimen obtained, and but few observed. The one obtained is scarcely distinguishable from eastern examples, except in being a little lighter colored.

24. **Calamospiza bicolor.** But few seen in the Park, and only near its eastern border. Numerous at one or two points on the road from South Park to Colorado City.

25. **Pipilo chlorurus.** Common near the streams.

ICTERIDÆ.

26. **Molothrus pecoris.** Moderately frequent.

27. **Sturnella ludoviciana.** Abundant. One of the characteristic species of the open portions of the Park.

28. **Scolecophagus cyanocephalus.** Abundant, keeping mainly near the streams. Young full-fledged, and most of the old birds moulting before the middle of July.

CORVIDÆ.

29. **Corvus corax.** A few pairs observed near Fairplay.

30. **Pica caudata, var. hudsonica.** Frequent along the streams.

* The sole difference which has been supposed to constantly separate *Z. Gambeli* from *Z. leucophrys* consists in the superciliary stripe being continuous to the bill in *Z. Gambeli*, while in *Z. leucophrys* it terminates at the anterior canthus of the eye, being cut off at this point by a black line running from the eye to the black stripe on the head, or by the black extending down, so as to cover the lores. The extension of the black over the lores is, however, quite variable, especially in specimens from the Rocky Mountains. In individuals referable to *Z. leucophrys*, the black covers the lores completely; in others it extends only as low as the middle of the eye, and in others again not as low as the eye, the ash in front of the eye being cut off from the superciliary stripe by a short narrow black line running upward from the anterior canthus. This line is sometimes quite broad and distinct, or it is dotted with ashy feathers, or is reduced to a few black feathers separated by ashy ones; in which case it is difficult to say whether the specimen should be called *Z. leucophrys*, with the black line reduced to scattered feathers, or *Z. Gambeli*, with a few black feathers in the superciliary stripe. Notwithstanding this, the cases are few in which the specimen cannot be referred by this criterion to one or the other series. Yet the irregularity of the extension of the black over the lores in either race, and the evident transition between them, seems to render their specific separation questionable; their true relations being more those of geographical races.

TYRANNIDÆ.

31. **Contopus borealis.** Occasional in the timber along the ridges, but more plentiful in the mountains to the eastward of the Park.

32. **Contopus virens,** var. **Richardsoni.** Common. Found several nests with half-grown young, July 18 to 23, at Fairplay. Nest placed in the fork of small branches, and quite different from that of *C. virens* in the eastern States, as are also its notes.*

33. **Empidonax "obscurus."** Common in the thick willows near the streams. Found a nest July 20th containing young but a day or two old, and another the same day with young nearly ready to fly. Nests placed in the forks of branches in dense willow clumps, and much resembled the ordinary nest of *Dendræca æstiva.* Bird very shy, hiding in the bushes, thus rendering it very hard to shoot. Rarely seen even when but a few yards distant, often stealing away without coming into view.

CAPRIMULGIDÆ.

34. **Chordeiles popetue.** Abundant.

TROCHILIDÆ.

35. **Selasphorus platycercus.** Abundant.

PICIDÆ.

36. **Sphyrapicus varius,** var. **nuchalis.** Common in the mountains near the eastern border of the Park.

37. **Sphyrapicus Williamsoni.** A few seen, chiefly at the eastern side of the Park. Quite common in the mountains further eastward.

38. **Melanerpes erythrocephalus.** Not common. A few pairs observed at Fairplay.

39. **Colaptes mexicanus.** Abundant.

FALCONIDÆ.

40. **Falco peregrinus.** One specimen was shot at Fairplay, a young bird that came about our camp in pursuit of blackbirds.

* Specimens of *Contopus virens* from the Rocky Mountains are considerably darker throughout than those from the Atlantic States. They generally lack the white edge to the outer vane of the first primary, usually seen in the latter, though eastern specimens are often without it. The western specimens are less strongly tinged with yellow beneath, and the axillaries are considerably darker. The greater coverts and secondaries are less broadly edged with white. The lower mandible, instead of being yellow as in eastern summer specimens, appears to be always dusky, — black towards the tip and yellow only at the base. But this feature is also frequently shared by autumnal specimens at the East. The whole difference between the two hence seems to consist in the darker tints of the western form.

The variety *Richardsoni* was the only form seen at Denver and Cheyenne, as well as in the mountains, while the specimens from Eastern Kansas were of the eastern type, differing from Massachusetts specimens only in being somewhat more olivaceous.

41. **Falco sparverius.** Not common.

42. **Buteo** sp.? A large *Buteo* was occasionally seen, but none were procured.

43. **Aquila chrysaëtos.** Occasionally observed.

44. **Circus cyaneus, var. hudsonius.** Seen occasionally throughout the Park. Shot a pair at Fairplay.

CATHARTIDÆ.

45. **Cathartes aura.** Not frequent, and seen only at Fairplay.

COLUMBIDÆ.

46. **Zenædura carolinensis.** Not common. A few pairs were seen at intervals.

TETRAONIDÆ.

47. **Tetrao obscurus.** Apparently not common.

CHARADRIIDÆ.

48. **Ægialitis vociferus.** Common.

49. **Ægialitis montanus.** Not common. Saw newly hatched young July 28th, and full-grown young the day preceding.

SCOLOPACIDÆ.

50. **Gambetta melanoleuca.** A single specimen was shot on the Platte, near the eastern edge of the Park, — the only one seen.

51. **Rhyacophilus solitarius.** A single pair was seen near Hamilton.

52. **Tringoides macularius.** Common along the streams.

ANATIDÆ.

53. **Chaulelasmus streperus.** A single female was shot July 28th on the Platte, near the eastern edge of the Park, — the only one seen.

54. **Querquedula** sp.? A few pairs were seen along the streams, and at some brackish lakes near Hamilton, probably *Q. cyanoptera*.

VII. *List of Birds observed in the Vicinity of Mount Linclon, Park County, Colorado, from July 19th to July 26th*, 1871; *with Annotations.*

The birds mentioned in the following list were all observed during a week spent in the vicinity of Montgomery, at the northeastern base of Mount Lincoln, at the head of the South Platte River. Doubtless all the species mentioned breed at, or near, where they were observed; the list also probably includes nearly all that occur there in summer. The region is strictly alpine in its features. Our camp was in the valley of the Platte, at an altitude of about 12,000 feet, from whence excursions were made every day by some of the party to the region above the timber line, which is here about 13,000 feet above the sea-level. One excursion was made to the top of Mount Lincoln, the height of which is usually given as a little over 14,000 feet. Three species (*Anthus ludovicianus. Leucosticte tephrocotis, Lagopus leucurus*) were obtained above timber line that are truly arctic in their summer distribution, and nearly all the others are known to range to high northern latitudes. Snow remains throughout the year in the gorges nearly down to the forest line, and frosts are of almost nightly occurrence at points considerably below Montgomery, the temperature in July frequently falling to below 30° F. The showers of rain, which were of almost daily occurrence during our visit, are generally attended with heavy thunder, hail, and sleet. Ice is said to form every night at the mining camp on Quandary Peak, about 13,500 feet above the sea.

The timber which thickly covers the lower slopes consists almost exclusively of a single kind of spruce, with here and there representatives of two species of *Populus*. No other conifer was observed higher up than at a point in the Platte valley about five miles below Montgomery, or much above 11,500 feet. Two or three kinds of willow and a small *Betula* occur abundantly in the upper valley of the Platte, and on the declivities of the mountains in places unoccupied by the heavier forest, up to 300 to 500 feet above the limit of trees, becoming more and more diminutive towards their upper limit. For some distance above the forest line are beautiful grassy slopes, and a variety of herbaceous plants, most of them producing a profusion of large, brightly tinted flowers. Many of the species are peculiar to this elevated region, while some are dwarfed or otherwise modified forms of species met with much lower down. Even among the snow-filled gorges are extensive flower-sprinkled grass-plats of great beauty, a variety of diminutive and exquisitely pretty plants ranging even to the summit of Mount Lincoln, wherever there is soil enough to afford them a foothold.

Among the other arctic animals observed are the Little Chief Hare (*Lagomys princeps*), abundant among the loose rocks from a little below timber-line to far above it, and several alpine butterflies.

Nearly all the birds mentioned below were met with as high as the timber line, and many ranged above it. *Wilsonia pusilla*, *Zonotrichia leucophrys*, and *Melospiza Lincolni* were nowhere more abundant than among the dwarfed willows and birches just above the general limit of trees. Three species (*Anthus ludovicianus*, *Leucosticte tephrocotis*, and *Lagopus leucurus*) were met with exclusively above the timber line.

From about 11,500 feet altitude up to the tree limit the fauna appears to be strictly representative of the Hudsonian fauna of the Eastern Province, while that above the tree limit more resembles that of the American arctic fauna.

TURDIDÆ.

1. **Turdus migratorius.** Abundant. Frequently met with far above timber line. Found a nest containing newly hatched young within three hundred feet of the upper limit of trees.

2. **Turdus Pallasi.** Common; ranging upward to the timber line. Its song was heard at all hours of the day at our camp, near Montgomery.

3. **Myiadestes Townsendii.** Several were observed at an altitude of over 12,000 feet, or near the timber line.

CINCLIDÆ.

4. **Cinclus mexicanus.** Common on the Platte above Montgomery.

SAXICOLIDÆ.

5. **Sialia arctica.** Abundant. More numerous here than we found it at any other point. It was seen by Mr. Bennett on the top of Mount Lincoln, and it breeds up to the limit of trees. Saw a brood of newly fledged young at the extreme upper edge of the timber.

SYLVIIDÆ.

6. **Regulus calendulus.** Common as high as the timber line. Shot a female feeding her newly fledged young.

PARIDÆ.

7. **Parus montanus.** Common. Collected full-grown young, July 23d.

SITTIDÆ.

8. **Sitta carolinensis**, var. **aculeata**. A single individual.

TROGLODYTIDÆ.

9. **Salpinctes obsoletus.** Observed several pairs among the rocks near the timber line.

MOTACILLIDÆ.

10. **Anthus ludovicianus.** Common among the snow-fields above timber line. Saw young birds scarcely able to fly, July 20th.

SYLVICOLIDÆ.

11. **Dendrœca Auduboni.** Common up to the limit of trees.

12. **Wilsonia pusilla.** Abundant. Most numerous among the low willows above the limit of trees.

HIRUNDINIDÆ.

13. **Hirundo horreorum.** Common at Montgomery. In clear weather flies to the tops of the mountains.

14. **Hirundo bicolor.** Common about Montgomery, and seen far above timber-line.

15. **Hirundo lunifrons.** A few seen in company with the preceding.

FRINGILLIDÆ.

16. **Leucosticte tephrocotis.*** Common above timber line on Mount Lincoln, breeding among the snow-fields. The common form of *L. tephrocotis* appears to be abundant in winter throughout the mountains of Colorado, whence I have seen specimens collected near Denver. I also met with it in December on the plains of Wyoming Territory, near the Medicine Bow Mountains.

17. **Carpodacus purpureus.** Common at Montgomery.

18. **Chrysomitris pinus.** Common up to the limit of trees.

19. **Passerculus savanna.** Common in the valley of the Platte, and also numerous on the mountains above timber line.

20. **Poœcetes gramineus.** Common, ranging considerably above timber line.

* The specimens (4♂ 2♀) of *Leucosticte* obtained on Mount Lincoln differ very much in color from winter specimens of *Leucosticte tephrocotis*, as well as from any figure or description of any form of *Leucosticte* I have seen. Whether they represent more than the breeding plumage of *L. tephrocotis* or a well-marked southern form of that species I am at present uncertain, being without summer specimens of that species. The following is a description of the Mount Lincoln specimens: *Male.* Bill entirely black, or in some specimens with a faint trace of yellow at the base of the lower mandible. Nasal feathers whitish; front of head black, fading to sooty brown on the mentum; no ashy nuchal collar as in winter specimens of *L. tephrocotis*; above umber brown, each feather broadly edged with bright red, fading to rosaceous on the rump and upper tail-coverts; throat sooty brown, tinged slightly with red; breast umber brown; rest of under parts crimson, fading to bright rosaceous posteriorly; wings and tail dusky, tinged with crimson, especially on the basal portions; lesser wing-coverts bright rosaceous. Length 6.25 to 6.75; alar extent, 11.75 to 12.60; wing, 4.05 to 4.20; tail, 2.60 to 2.87. *Female* similar, but duller colored and smaller. Different specimens vary considerably in the intensity and amount of red. Besides wanting the gray nuchal collar, these specimens have the rosaceous of winter specimens replaced by bright red, and the bill black instead of yellow.

Since writing the above, I have had an opportunity of examining several specimens of *Leucosticte* killed at Central City, Colorado, in March, 1869, by Mr. F. E. Everett, and

21. **Zonotrichia leucophrys.** Exceedingly numerous, even to a considerable distance above timber line.

22. **Junco "caniceps."** Common, ranging considerably above timber line.

23. **Spizella socialis.** Frequent about Montgomery.

24. **Melospiza Lincolnii.** Very numerous along the Platte, and also common for some distance above timber line.

ICTERIDÆ.

25. **Scolecophagus cyanocephalus.** Common at Montgomery, and ranges to the tops of the mountains.

CORVIDÆ.

26. **Perisoreus canadensis.** Common.

27. **Cyanura Stelleri, var. macrolopha.** More or less frequent.

TROCHILIDÆ.

28. **Selasphorus platycercus.** Common. Repeatedly seen about the flowers far above timber line.

PICIDÆ.

29. **Picus villosus.** The variety *Harrisii* was more or less frequent up to the timber line.

30. **Picoides americanus, var. dorsalis.** Common up to the timber line.

31. **Colaptes mexicanus.** Common up to the timber line.

FALCONIDÆ.

32. **Buteo sp.?** A large *Buteo* was frequently observed.

by him presented to the Boston Society of Natural History. Of three males, one (marked "young male") differs but little from the Mount Lincoln specimens, it having no ash on the head. Another corresponds very nearly in color with the so-called *L. griseinucha*, and another nearly as well with the so-called *L. littoralis*. Although these birds may have been born at widely separated localities, it seems probable that some of the differences whereon certain species of *Leucosticte* have been founded may be only individual variations. It is to be noticed, however, that the amount of ash on the head, and the intensity of the colors, vary with locality from the north southward; the most southerly form having no ash on the head, the bill black instead of yellow, and the red of a brighter tint than those from more northern localities. The type of *L. tephrocotis* was a male, killed on the Saskatchewan in May (see Faun. Bor.-Am., II, p. 266), in which the ash formed a narrow nuchal band. In *L. griseinucha*, a more northern form, the gray involves nearly the whole head and the throat; and in *L. littoralis* and *campestris* there is more gray on the head than in *tephrocotis*, and they also appear to be more northern in their distribution. In view of these facts, it seems probable that the Mount Lincoln specimens above described represent the smaller, brighter-colored southern race, in which the ash on the head has entirely disappeared.

TETRAONIDÆ.

33. **Tetrao obscurus.** Apparently more or less common. One was shot in the upper edge of the timber.

34. **Lagopus leucurus.** Common above timber line. Said to descend into the timber in winter, when many are killed by the miners for food.

SCOLOPACIDÆ.

35. **Tringoides macularius.** Common along the Platte to its source. Its nest and eggs were found at Montgomery, July 24th.

ANATIDÆ.

36. **Mergus merganser.** A pair seen at Montgomery.

VIII. *List of Birds collected in the Vicinity of Ogden, Utah Territory, from September* 1*st to October* 8*th*, 1871 ; *with Annotations.*

The region to which the following remarks refer embraces the northeastern portion of the valley of the Great Salt Lake, including a portion of the lake shore near the mouth of the Weber River, the lower portion of the Weber valley, Ogden Cañon, and the mountains north of Ogden. It thus includes a great variety of surface, including the sage-covered plains that form the eastern border of the lake, the numerous lagoons and marshes about the mouth of the Weber River, the thickets of willow and cottonwood that border both this river and the Ogden, and the scantily wooded or almost naked slopes of the adjoining mountains. From the lateness of the season, a few of the summer residents had already migrated, and many others that pass the summer in the mountains or to the northwards had become common. The higher parts of the Wahsatch Range, which bounds the Great Salt Lake Valley to the eastward, doubtless form the summer haunts of most of the land birds observed here, which leave the valley in summer, since the higher peaks of the range rise to the snow line.

The great abundance of aquatic birds that frequent the vicinity of the Great Salt Lake has long been known as one of the characteristic ornithological features of this interesting locality, especially the abundance of pelicans, gulls, cormorants, avocets, stilts, ducks, and other wading and swimming birds, many of which regularly pass the summer here, and breed on the islands of the lake. Yet the bird fauna of this peculiar region has not as yet been fully explored, and hence still offers a highly attractive and promising field to the collector. The only special report that has as yet appeared respecting the ornithology of the Great Salt Lake Valley is a list of thirty-one species contained in Stansbury's Report,* prepared by Professor Baird from the collections made by Captain Stansbury during his admirable survey of this region in 1849 and 1850. Since that time the region immediately under consideration has undergone important changes. Through the industry and energy of the Mormon emigrants, large portions of the arid plains that surround the lake have been transformed, by irrigation, from a desert to productive farms, abundantly provided with orchards and shade-trees. So great a modification of the flora has, of course, induced a corresponding change in the fauna, so that now many birds are common that were formerly rare, especially among the granivorous and fruit-eating kinds. At the same time the water-fowl have greatly decreased, and have acquired the wildness characteristic of their tribe in the older settled portions of the country. Ducks are still abundant, but, being subject to constant persecution from juvenile and other sportsmen, their numbers are said to be annually appreciably decreasing.

The present list contains one hundred and thirty-seven species collected or observed by Mr. Bennett and myself during five weeks spent almost constantly ornithologizing. As almost every excursion added to our collection one or more species we had not previously seen, it is presumably more or less deficient for even the single month (September) during which most of our observations were made.

TURDIDÆ.

1. **Turdus migratorius.** Common. Said to have been very rare in the Great Salt Lake Valley when it was first settled, but having been carefully protected, it has gradually increased in numbers till it is now a common bird. Doubtless the successful cultivation of the smaller fruits has also done much towards increasing its numbers, by attracting them from less favoring localities. Many are said to remain here all the year, though it is much more numerous in fall and spring than during either summer or winter. Most of the specimens taken by us are much paler than the robin of the East, some of them presenting an exceedingly pallid aspect.

2. **Turdus Pallasi.** One shot September 11th.

3. **Mimus carolinensis.** Common. As numerous in the dense thickets along the Weber River as I ever saw it at the East.

* Stansbury's Exploration and Survey of the Valley of the Great Salt Lake of Utah, 1852, pp. 314 – 325.

4. **Oreoscoptes montanus.** Common. Called "Gray-Bird," and also "Mocking-Bird." Very destructive to the fruit, even the peach not escaping its rapacity.

SAXICOLIDÆ.

5. **Sialia arctica.** Common in spring and fall.

CINCLIDÆ.

6. **Cinclus mexicanus.** Common along the Ogden and Weber Rivers. Shot fourteen in Ogden Cañon in the course of an hour or two, October 2d, and saw several others.

SYLVIIDÆ.

7. **Regulus calendulus.** Shot September 11th and later. Probably not uncommon in fall and spring.

PARIDÆ.

8. **Parus atricapillus**, var. **septentrionalis.** Abundant.

TROGLODYTIDÆ.

9. **Salpinctes obsoletus.** Abundant in the Wahsatch Mountains as far down as the first "bench." About the first of October we saw them several times on the shore of Salt Lake, near the mouth of the Weber River, twelve or fifteen miles from the mountains. Its preference for rocks even here was manifested by one which had chosen a heap of stones as a temporary resting-place.

10. **Cistothorus stellaris.** Abundant in the marshes everywhere.

MOTACILLIDÆ.

11. **Anthus ludovicianus.** Abundant after September 15th.

SYLVICOLIDÆ.

12. **Geothlypis trichas.** Common.

13. **Geothlypis philadelphia**, var. **Macgillivrayi.** Apparently not uncommon.

14. **Icteria virens.** Moderately common.

15. **Helminthophaga ruficapilla.** One shot September 20th, and others seen. Apparently common.

16. **Helminthophaga celata.** First seen September 11th. Common later.

17. **Dendrœca Auduboni.** Common after the 15th of September.

18. **Dendrœca Blackburniæ.** Not common. A few specimens obtained.

19? **Dendrœca nigrescens.** A bluish warbler was once or twice seen which was probably of this species.

20. **Dendrœca æstiva.** Common.

21. **Wilsonia pusilla.** Common.

22. **Setophaga ruticilla.** One seen September 8th.

HIRUNDINIDÆ.

23. **Hirundo horreorum.** Common.

24. **Hirundo lunifrons.** But few were seen, owing probably to the lateness of the season. Their nests were very numerous on the cliffs of Weber and Echo Cañons.

25. **Hirundo thalassina.** A few seen September 11th.

26. **Cotyle serripennis.** Moderately common.

VIREONIDÆ.

27. **Vireo olivaceus.** More or less common.

28. **Vireo gilvus.** Rather common.

29. **Vireo solitarius.** Rather frequent. Somewhat paler colored than in the Eastern States, but much brighter than those obtained in July in Colorado.

AMPELIDÆ.

30. **Ampelis cedrorum.** Rather common.

LANIIDÆ.

31. **Collurio ludovicianus.** Quite common. Said to breed.

TANAGRIDÆ.

32. **Pyranga ludoviciana.** Frequent.

ALAUDIDÆ.

33. **Eremophila alpestris.** Common.

FRINGILLIDÆ.

34. **Carpodacus purpureus.** Not numerous.

35. **Chrysomitris tristis.** Abundant.

36. **Chrysomitris psaltria.** Apparently common, associating with the preceding.

37. **Passer domesticus.** Recently introduced and apparently flourishing.

38. **Passerculus savanna.** Common.

39. **Poœcetes gramineus.** Abundant.

40. **Coturniculus passerinus.** Common.

41. **Zonotrichia leucophrys,** var. **Gambeli.** Abundant. Mainly of the form called "*Gambeli*," but a typical *leucophrys* was also taken.

42. **Junco "oregonus."** Common after about October 1st. The specimens taken scarcely differ from fall specimens of *J. hyemalis*, except in the rufous on the sides.

43. **Poospiza Belli.** Common on the Plains among the sage-brush.

44. **Spizella socialis.** Abundant.

45. **Spizella pallida.** Abundant.

46. **Melospiza melodia.** Very abundant. A little paler than specimens from the Atlantic States, but not so markedly so as is the case in some other species. From the locality it should, however, be referable to the *M. fallax*, a name applied to the paler form of *M. melodia* from the Rocky Mountain region.

47. **Melospiza Lincolnii.** Exceedingly abundant.

48. **Passerella iliaca, var. schistacea.** Not numerous. First obtained September 10th.

49. **Goniaphea melanocephala.** Common in summer. Leaves about the first week of September. Called "Pea Bird," it being very fond of young peas, and is hence regarded as obnoxious.

50. **Cyanospiza amœna.** Not common.

51. **Pipilo erythrophthalmus, var. arcticus.** Common.

52. **Pipilo chlorurus.** Common after September 20th.

ICTERIDÆ.

53. **Dolichonyx oryzivorus.** Common. Said to breed here.

54. **Agelæus phœniceus.** Exceedingly abundant. Flocks of thousands seen about the marshes. In color, especially in respect to the shoulder-patch, it closely resembles the form prevailing in the Atlantic and Gulf States. A few specimens were taken that had very small spots of black on the ends of the middle coverts, but in none were they so well developed as to typically represent the so-called *A. gubernator*. One specimen was taken which had the exposed portions of the *greater* coverts of the same color as the middle ones, thus forming a very broad conspicuous brownish-yellow patch on each wing.

55. **Xanthocephalus icterocephalus.** Abundant, occurring in large flocks about the marshes, associating more or less with the preceding. The colors vary exceedingly in different individuals, from some young females that are only tinged with pale yellowish on the throat, to some males that have the whole throat and breast intense orange red.

56. **Sturnella ludoviciana, var. neglecta.** Abundant, typically representing the so-called *S. neglecta*. The notes of some individuals, however, were scarcely different from those of the eastern bird, though generally the song is dissimilar and much richer.

57. **Icterus Bullockii.** Said to be common in summer. Saw only stuffed specimens in collections at Salt Lake City, said to have been taken in the vicinity.

58. **Scolecophagus cyanocephalus.** Very abundant.

CORVIDÆ.

59. **Corvus corax.** Common.

60. ? **Corvus americanus.** None were seen, but it was said to be more or less frequent.

61. **Pica caudata**, var. **hudsonica.** Common.

62. **Cyanura Stelleri**, var. **macrolopha.** Common in the mountains, and occasional in the thickets along the streams; called "Mountain Jay."

63. **Aphelocoma floridana, var Woodhousei.** Common.

TYRANNIDÆ.

64. **Tyrannus carolinensis.** One obtained and two or three others seen.

65. **Tyrannus verticalis.** Not common.

66. **Contopus borealis.** Not common. Several seen among the cottonwoods along Weber River.

67. **Contopus virens**, var. **Richardsonii.** Not common; seen in the same localities as the last.

68. **Empidonax flaviventris**, var. **difficilis.** Not uncommon in favorable localities.

69. **Empidonax "obscurus."** Common.

ALCEDINIDÆ.

70. **Ceryle alcyon.** Common.

CAPRIMULGIDÆ.

71. **Antrostomus Nuttallii.** Abundant in the mountains near Ogden. One was seen October 7th, half-way up the mountains, during a severe snow-storm, the snow being already several inches deep.

72. **Chordeiles popetue.** Abundant till nearly October 1st.

TROCHILIDÆ.

73. **Selasphorus platycercus.** Common.

PICIDÆ.

74. **Picus** sp.? A small spotted woodpecker was seen a few times, near the mouth of Ogden Cañon, which was apparently *P. pubescens.*

75. **Colaptes mexicanus.** Rather common along the Ogden and Weber Rivers. They were accustomed to frequent a high clayey bank near the town, in which were a number of holes. These the woodpeckers entered, and we repeatedly saw them sitting in them, with their heads thrust out at the entrances. About a dozen individuals were quite regularly seen around the place, especially early in the morning. We found

on examining these holes that they entered horizotnally but a few inches, and then turned abruptly downward, having about the size and form of the holes the *Colaptes auratus* is accustomed to make in decayed trees. They appeared much attached to the spot, and from all the circumstances we were led to believe that they had nested in the holes which we saw them frequenting, as there were no trees within several miles that could have served them as nesting sites.

STRIGIDÆ.

76. **Otus vulgaris**, var. **Wilsonianus**. One specimen taken.

77. **Bubo virginianus**. Occasional. Said to be quite frequent in winter.

78. **Athene hypogæa**. Several colonies were met with in the vicinity of Ogden, living chiefly in holes made by coyotes and other *Canidæ*, no pecies of *Cynomys* occurring here.

FALCONIDÆ.

79. **Falco peregrinus**. Common about the marshes of Salt Lake preying upon the water-fowl.

80. **Falco columbarius**. Moderately frequent.

81. **Falco sparverius**. Exceedingly numerous. Along the Weber River, below Weber Cañon, a dozen or more were frequently seen in the air at the same instant, catching grasshoppers.

82. **Buteo borealis**. Not uncommon.

83. **Circus cyaneus**, var. **hudsonius**. Abundant. Especially numerous about the marshes, where they were constantly seen pursuing the blackbirds, but apparently with indifferent success.

84. **Aquila chrysaëtos**. Said to be occasionally killed.

85. **Haliaëtus leucocephalus**. More or less frequent.

86. **Pandion haliaëtus**. A few seen. Said to be common in summer.

CATHARTIDÆ.

87. **Cathartes aura**. Common.

COLUMBIDÆ.

88. **Zenædura carolinensis**. Abundant. Said to breed generally on the ground.

TETRAONIDÆ.

89. **Tetrao obscurus**. Reported to be common in the mountains.

90. **Centrocercus urophasianus**. Common. Much less numerous than formerly. A few years ago it is represented to have been exceedingly abundant, but less than a dozen were seen by us during a quite thorough reconnoissance of the northeastern portion of the Great Salt Lake Valley, they having never been known to be so scarce there before.

91. **Pediœcetes phasianellus**, var. **columbianus**. Common, but said

to be much less numerous the present season than usually. In the Great Salt Lake Valley we have of course the paler or light-colored form of the Plains, to which Mr. D. G. Elliot has restricted the name *P. columbianus*,* the darker form of the more heavily wooded regions of the north being considered by him to be the true *P. phasianellus* (= *P. Kennicottii* Suckley).†

92. **Bonasa umbellus.** The ruffed grouse is said to occur sparingly in the mountains.

PERDICIDÆ.

93. **Ortyx virginianus.** A few pairs of the common quail were introduced from the East last year, and are said to have each raised a brood of young.

94. **Lophortyx californicus.** A few pairs were introduced a short time since, and are said to have raised young the present year (1871).

CHARADRIIDÆ.

95. **Ægialitis vociferus.** Abundant.

SCOLOPACIDÆ.

96. **Gallinago Wilsoni.** Very abundant.

97. **Macrorhampus griseus.** Abundant September 25th and later; perhaps breeds here.

98. **Pelidna americana.** Common.

99. **Actodromas minutilla.** Not common.

100. **Gambetta melanoleuca.** Abundant.

101. **Gambetta flavipes.** Not common.

102. **Rhyacophilus solitarius.** Not common.

103. **Tringoides macularius.** Not common. Only two or three were seen.

PHALAROPODIDÆ.

104. **Phalaropus Wilsoni.** Abundant. Said to breed in great numbers on the islands in the lake.

RECURVIROSTRIDÆ.

105 **Recurvirostra americana.** Very abundant. Flocks of several thousands seen on the shores of the lake. Said to breed on the islands.

106. **Himantopus nigricollis.** Common, but far less numerous than the preceding, with which it freely associates. Both this and the preceding species are known locally as "White Snipes."

GRUIDÆ.

107. **Grus canadensis.** Occasional in fall and spring.

* Proc. Acad. Nat. Sci. Philad., 1862, p. 403.

† Ibid., 1861, p. 361.

TANTALIDÆ.

108. **Ibis falcinellus**, var. **Ordii**. Common in summer. Leaves early in September. Obtained five specimens out of the seven we saw. Called "Black Snipe." Said to have become numerous only during the last two or three years.

109. **Ibis alba**. Only a few seen. Said to be frequent in summer.

ARDEIDÆ.

110. **Ardea herodias**. Rather common.

111. **Botaurus lentiginosus**. Common.

112. **Nyctiardea grisea**, var. **nævia**. Common.

RALLIDÆ.

113. **Rallus virginianus**. Common.

114. **Rallus crepitans**. Said to be common.

115. **Porzana carolina**. Common.

116. **Fulica americana**. Abundant.

ANATIDÆ.

117. **Anser hyperboreus**. Common in fall and winter, appearing about October 1st. Called "White Brant."

118. **Bernicla canadensis**. Abundant. Exceedingly numerous in the fall. A few said to breed.

119. **Anas boschas**. Common.

120. **Dafila acuta**. Abundant.

121. **Nettion carolinensis**. Abundant.

122. **Querquedula cyanoptera**. Abundant.

123. **Spatula clypeata**. Common.

124. **Chaulelasmus streperus**. Abundant.

125. **Mareca americana**. Common.

126. **Aix sponsa**. Common.

127. **Fulix marila**. Common.

128. **Aythya ferina**, var. **americana**. Abundant.

129. **Erismatura rubida**. Common.

130. **Mergus merganser**. Common.

PELECANIDÆ.

131. **Pelecanus erythrorhynchus**. Leaves about September 1st. Stansbury found it breeding on the islands in immense numbers.*

GRACULIDÆ.

132. **Graculus dilophus**. Common. Called "Black Swan"!

* See Stansbury's Report, pp. 179 and 188.

LARIDÆ.

133. **Larus delawarensis.** Abundant. Has the singular habit of feeding on grasshoppers, which it captures in the air. Breeds in large numbers on the islands.

134. **Chrœcocephalus philadelphia.** First seen about October 1st. Three specimens were taken, which differ from average eastern examples in having a much shorter, relatively thicker, and less decurved bill. The difference is so great as to be quite striking.

135. **Xema Sabini.** A single specimen was taken September 28th, the only one seen.

PODICIPIDÆ.

136. **Podiceps cornutus.** One specimen taken. Perhaps common.

137. **Podilymbus podiceps.** Common.

IX. *Summary List of Birds observed in Kansas, Colorado, Wyoming, and Utah, in* 1871.

THE preceding lists being more especially a record of observations respecting the character of the avian fauna of particular localities, the following general summary is appended to show at a glance the area over which the different species were respectively met with, and to indicate the vertical range of those observed in the mountains of Colorado. It is to be understood that the species are summer residents at the localities named, unless otherwise stated. Some were seen only during migration, and unless known to breed at the localities where they were observed, the season of observation is stated. The altitudes given are of course only approximate, though believed to be in the main correct. The list has some negative value, as it is probable that at most of the localities cited few, if any, other species were characteristically common.

TURDIDÆ.

1. **Turdus mustelinus.** Eastern Kansas.

2. **Turdus Pallasi.** Topeka, Kansas (one specimen); mountains of Colorado, from about 8,000 feet to timber line; Ogden, Utah.

3. **Turdus Swainsoni.** Eastern Kansas (May).

4. **Turdus fuscescens.** Mountains of Colorado, up to about 8,500 feet.

5. **Turdus migratorius.** Eastern Kansas (rare); mountains of Colorado up to timber line; Ogden, Utah.

6. **Harporhynchus rufus.** Eastern Kansas; western edge of the Plains of Colorado, and in the mountains up to about 7,500 feet.

7. **Oreoscoptes montanus.** Western edge of the Plains of Colorado; Ogden, Utah.

8. **Mimus polyglottus.** Eastern and Middle Kansas.

9. **Mimus carolinensis.** Eastern and Middle Kansas; western edge of the Plains in Colorado, and in the foot-hills up to about 7,500 feet; Ogden, Utah.

CINCLIDÆ.

10. **Cinclus mexicanus.** Mountains of Colorado from the Plains up to timber line; Ogden, Utah.

SAXICOLIDÆ.

11. **Sialia sialis.** Eastern Kansas, west to Fort Hays.

12. **Sialia arctica.** Mountains of Colorado, from the Plains up to timber line; Ogden, Utah.

13. **Sialia mexicana.** Foot-hills west of Denver, Colorado.

SYLVIIDÆ.

14. **Regulus calenaulus.** Mountains of Colorado, from about 8,000 feet to timber line; Wahsatch Mountains, near Ogden, Utah.

15. **Polioptila cærulea.** Eastern Kansas.

CHAMÆIDÆ.

16.? **Chamæa fasciata.** Mountains of Colorado, west of Colorado City.

PARIDÆ.

17. **Parus atricapillus**, var. **septentrionalis.** Eastern and Middle Kansas; mountains of Colorado, up to about 11,000 feet; Green River, Wyoming Territory; Ogden, Utah.

18. **Parus montanus.** Mountains of Colorado, from 8,000 feet up to timber line.

19. **Lophophanes bicolor.** Eastern Kansas.

SITTIDÆ.

20. **Sitta carolinensis.** Eastern Kansas; var. **aculeata,** mountains of Colorado up to timber line.

21. **Sitta pusilla**, var. **pygmæa.** Mountains of Colorado, up to about 8,000 feet.

TROGLODYTIDÆ.

22. **Troglodytes aëdon.** Eastern and Middle Kansas; Cheyenne; western edge of the Plains in Colorado, and in the mountains of Colorado, up to about 10,000 feet.

23. **Salpinctes obsoletus.** Mountains of Colorado, from the Plains up to timber line; Ogden, Utah.

24. **Catherpes mexicanus.** Near Colorado City.

25. **Cistothorus palustris.** Ogden, Utah.

26. **Thryothorus ludovicianus.** Eastern Kansas.

MOTACILLIDÆ.

27. **Anthus ludovicianus.** Mountains of Colorado, above timber line; Ogden, Utah (Sept.); Wahsatch Mountains, probably breeding above timber line.

SYLVICOLIDÆ.

28. **Mniotilta varia.** Eastern Kansas (May).

29. **Parula americana.** Eastern Kansas (May).

30. **Helminthophaga pinus.** Eastern Kansas.

31. **Helminthophaga celata.** Eastern Kansas (May); Ogden, Utah (Sept.): Wahsatch Mts.

32. **Helminthophaga ruficapilla.** Eastern Kansas (May); Ogden, Utah (Sept.); Wahsatch Mts.

33. **Dendrœca coronata.** Eastern Kansas (May).

34. **Dendrœca Auduboni.** Mountains of Colorado, from the Plains up to timber line; Ogden, Utah.

35. **Dendrœca Blackburniæ.** Eastern Kansas (May); Ogden, Utah (Sept.).

36. **Dendrœca pennsylvanica.** Eastern Kansas (May).

37. **Dendrœca cærulea.** Eastern Kansas.

38. **Dendrœca discolor.** Eastern Kansas.

39. **Dendrœca æstiva.** Eastern Kansas; Denver, and western edge of the Plains, Colorado; Cheyenne, Wyoming; Ogden, Utah.

40. **Seiurus aurocapillus.** Eastern Kansas.

41. **Geothlypis trichas.** Eastern Kansas; Ogden, Utah.

42. **Geothlypis philadelphia.** Eastern Kansas; var. **Macgillivrayi,** mountains of Colorado, below 9,000 feet.

43. **Oporornis formosus.** Eastern Kansas.

44. **Icteria virens.** Eastern and Middle Kansas; Cheyenne; Colorado, at the base of the mountains; Ogden, Utah.

45. **Wilsonia mitrata.** Eastern Kansas.

46. **Wilsonia pusilla.** Mountains of Colorado, from the Plains to above timber line; Cheyenne; Green River, Wyoming (Oct.); Ogden, Utah.

47. **Setophaga ruticilla.** Eastern Kansas; mountains of Colorado, up to about 8,000 feet; Ogden, Utah.

TANAGRIDÆ.

48. **Pyranga rubra.** Eastern Kansas.

49 **Pyranga ludoviciana.** Mountains of Colorado, from the Plains up to about 8,000 feet.

HIRUNDINIDÆ.

50. **Hirundo horreorum.** Eastern Kansas to Ogden, Utah; in the mountains of Colorado up to timber line.

51. **Hirundo lunifrons.** Eastern Kansas; Ogden, Utah; in the mountains of Colorado up to timber line.

52 **Hirundo bicolor.** Eastern Kansas (May); in the mountains of Colorado up to timber line.

53. **Hirundo thalassina.** Mountains of Colorado, from the Plains up to about 8,000 feet; perhaps to timber line.

54. **Cotyle riparia.** Eastern Kansas.

55. **Cotyle serripennis.** Eastern Kansas; western edge of the Plains; Ogden, Utah.

56. **Progne subis.** Eastern Kansas.

VIREONIDÆ.

57. **Vireo olivaceus.** Eastern Kansas; mountains of Colorado up to 11,000 feet; Ogden, Utah.

58. **Vireo gilvus.** Eastern Kansas; western edge of the Plains of Colorado; Ogden, Utah.

59. **Vireo solitarius,** var. **plumbeus.** Western edge of the Plains of Colorado, and in the mountains up to about 10,000 feet; Ogden, Utah.

60. **Vireo noveboracensis.** Eastern Kansas.

61. **Vireo Belli.** Eastern and Middle Kansas.

AMPELIDÆ.

62. **Ampelis cedrorum.** Eastern Kansas.

63. **Myiadestes Townsendii.** Mountains of Colorado, up to timber line.

LANIIDÆ.

64. **Collurio ludovicianus.** Eastern Kansas; western edge of the Plains of Colorado; Cheyenne; Ogden, Utah.

ALAUDIDÆ.

65. **Eremophila alpestris.** Eastern, Middle and Western Kansas; South Park, Colorado; Laramie Plains; Ogden, Utah.

FRINGILLIDÆ.

66. **Carpodacus purpureus.** South Park, Colorado; Ogden, Utah.

67. **Chrysomitris tristis.** Eastern Kansas; western edge of the Plains of Colorado; Ogden, Utah.

68. **Chrysomitris pinus.** Mountains of Colorado, from the Plains up to timber line.

69. **Chrysomitris psaltria.** Middle Kansas (?); Ogden, Utah.

70. **Leucosticte tephrocotis.** Mountains of Colorado, above timber line; Carbon County, Wyoming (in December).

71. **Plectrophanes nivalis.** Western Kansas (winter).

72. **Plectrophanes ornatus.** Middle Kansas.

73. **Plectrophanes Maccownii.** Cheyenne; Western Kansas (in winter).

74. **Passer domesticus.** Great Salt Lake Valley (introduced).

75. **Passerculus savanna.** Western edge of the Plains to above timber line.

76. **Poœcetes gramineus.** Western edge of the Plains to above timber line.

77. **Coturniculus passerinus.** Kansas; western edge of the Plains; Ogden, Utah.

78. **Chondestes grammaca.** Kansas; South Park; Cheyenne; Laramie Plains; Ogden, Utah.

79. **Zonotrichia querula.** Fort Leavenworth, Kansas.

80. **Zonotrichia albicollis.** Eastern Kansas (May).

81. **Zonotrichia leucophrys.** Eastern Kansas (May); mountains of Colorado up to above timber line; var. **Gambeli,** Ogden, Utah (Sept.); Wahsatch Mountains.

82. **Junco "caniceps."** Mountains of Colorado, from about 7,500 feet up to above timber line.

83. **Junco "oregonus."** Ogden, Utah (Sept.); Wahsatch Mountains.

84. **Poospiza Belli.** Ogden, Utah

85. **Spizella monticola.** Western Kansas (in winter).

86. **Spizella socialis.** Eastern Kansas; western edge of the Plains; mountains of Colorado up to timber line; Ogden, Utah.

87. **Spizella pallida.** Eastern Kansas; western edge of the Plains; Ogden, Utah.

88. **Spizella pusilla.** Eastern Kansas; western edge of the Plains.

89. **Melospiza melodia.** Eastern Kansas; western edge of the Plains; South Park; Ogden, Utah.

90. **Melospiza palustris.** Eastern Kansas (May).

91. **Melospiza Lincolnii.** Eastern Kansas (May); mountains of Colorado, from about 8,000 feet to above timber line; Ogden, Utah.

92. **Peucæa æstivalis,** var. **Cassinii.** Middle Kansas.

93. **Passerella iliaca,** var. **schistacea.** Ogden, Utah (Sept.); Wahsatch Mountains.

94. **Calamospiza bicolor.** Middle Kansas; western edge of the Plains; South Park, and mountains to the eastward; Cheyenne.

95. **Euspiza americana.** Kansas; Colorado City.

96. **Goniaphea ludoviciana.** Eastern Kansas.

97. **Goniaphea melanocephala.** Middle Kansas; Denver; Cheyenne; Ogden, Utah.

98. **Cyanospiza cyanea.** Eastern Kansas.

99. **Cyanospiza amœna.** Western edge of the Plains, and mountains of Colorado up to about 8,000 feet; Cheyenne; Ogden, Utah.

100. **Cardinalis virginianus.** Eastern Kansas.

101. **Pipilo erythrophthalmus.** Eastern Kansas; var. **arcticus,** western edge of the Plains of Colorado, and in the mountains up to about 8,000 feet; Ogden, Utah.

102. **Pipilo chlorurus.** Mountains of Colorado from about 8,000 feet up to timber line; Ogden, Utah.

ICTERIDÆ.

103. **Dolichonyx oryzivorus.** Ogden, Utah.

104. **Molothrus pecoris.** Kansas; mountains of Colorado up to 11,000 feet; Cheyenne; Ogden, Utah.

105. **Agelæus phœniceus.** Eastern Kansas; mountains and western edge of the Plains of Colorado: Ogden, Utah.

106. **Xanthocephalus icterocephalus.** Eastern and Middle Kansas; western edge of the Plains; Ogden, Utah.

107. **Sturnella ludoviciana,** var. **neglecta.** Kansas; Plains of Colorado and Wyoming; South Park; Ogden, Utah.

108. **Icterus Baltimore.** Kansas; Cheyenne; western edge of the Plains in Colorado.

109. **Icterus Bullockii.** Ogden, Utah.

110. **Icterus spurius.** Kansas; western edge of the Plains in Colorado.

111. **Scolecophagus cyanocephalus.** Western edge of the Plains; mountains of Colorado, to above timber line; Ogden, Utah.

112. **Quiscalus purpureus.** Eastern and Middle Kansas.

CORVIDÆ.

113. **Corvus corax.** Kansas; Colorado; Wyoming; Utah.

114. **Corvus americanus.** Eastern and Middle Kansas; Utah?

115. **Picicorvus columbianus.** Near Colorado City? Medicine Bow Mountains, Wyoming.

116. **Pica caudata,** var. **hudsonica.** Western Kansas; Plains and mountains of Colorado, up to at least 11,000 feet; Wyoming; Utah.

117. **Cyanura cristata.** Eastern Kansas.

118. **Cyanura stelleri,** var. **macrolopha.** Mountains of Colorado, up to timber line; Medicine Bow Mountains, Wyoming; Wahsatch Mountains, Utah.

119. **Aphelocoma floridana**, var. **Woodhousei.** Near Colorado City; Ogden, Utah.

120. **Perisoreus canadensis.** Mountains of Colorado, above 12,000 feet; Medicine Bow Mountains; Wahsatch Mountains.

TYRANNIDÆ.

121. **Tyrannus carolinensis.** Eastern and Middle Kansas; Denver; Cheyenne; Ogden, Utah.

122. **Tyrannus verticalis.** Middle Kansas; Denver; Cheyenne; Ogden, Utah.

123. **Myiarchus crinitus.** Eastern Kansas.

124. **Sayornis fuscus.** Eastern Kansas.

125. **Sayornis Sayus.** Western edge of Plains in Colorado; Cheyenne.

126. **Contopus borealis.** Mountains of Colorado up to 12,000 feet; Ogden, Utah (Sept.); Wahsatch Mountains.

127. **Contopus virens.** Eastern Kansas; var. **Richardsoni**, western edge of Plains, and mountains of Colorado, up to about 12,000 feet; Ogden, Utah.

128. **Empidonax minimus.** Eastern Kansas (May).

129. **Empidonax Traillii** Eastern Kansas.

130. **Empidonax "obscurus."** Mountains of Colorado up to 12,000 feet; Ogden, Utah.

131. **Empidonax "Hammondi."** * Fort Fred. Steele, Wyoming (Oct.); Ogden, Utah (Sept.).

132. **Empidonax flaviventris**, var. **difficilis.** Ogden, Utah.

ALCEDINIDÆ.

133. **Ceryle alcyon.** Kansas; Plains of Colorado and mountains up to 9,000 feet; Plains of Wyoming; Ogden, Utah.

CAPRIMULGIDÆ.

134. **Antrostomus Nuttallii.** Eastern Kansas; mountains of Colorado, up to about 8,000 feet; Ogden, Utah.

135. **Antrostomus vociferus.** Eastern Kansas.

136. **Chordeiles popetue.** Eastern Kansas; var. **Henryi**, Middle Kansas, and generally westward to Utah; in the mountains of Colorado up to 12,000 feet.

* Dr. Elliott Coues being at present engaged in a revision of the *Tyrannidæ*, all the specimens of *Empidonax* collected during the present expedition have been sent to him for examination, and the names here provisionally adopted are given with his approval. Since the preceding pages were put in type, I have learned that specimens of the so-called *Empidonax* "*Hammondi*" were among those collected at Ogden, Utah, and at Fort Fred. Steele, Wyoming.

CYPSELIDÆ.

137. **Chætura pelasgia.** Eastern Kansas.

138. **Panyptila melanoleuca.** Garden of the Gods, near Colorado City.

TROCHILIDÆ.

139. **Trochilus colubris.** Eastern Kansas.

140. **Selasphorus platycercus.** Western edge of the Plains, and mountains of Colorado to above timber line; Cheyenne; Ogden, Utah.

CUCULIDÆ.

141. **Coccygus americanus.** Eastern Kansas.

PICIDÆ.

142. **Picus villosus.** Eastern Kansas; var. **Harrisii**, mountains of Colorado.

143. **Picus pubescens.** Eastern and Middle Kansas.

144. **Picoides americanus**, var. **dorsalis.** Mountains of Colorado, from about 8,000 feet to timber line.

145. **Sphyrapicus varius**, var. **nuchalis.** Mountains of Colorado, from 7,000 to 12,000 feet.

146. **Sphyrapicus Williamsoni.** South Park and the mountains to the eastward.

147. **Centurus carolinus.** Eastern Kansas.

148. **Melanerpes erythrocephalus.** Kansas; mountains of Colorado, from the Plains to about 11,000 feet.

149. **Melanerpes torquatus.** Western edge of the Plains up to about 10,000 feet.

150. **Colaptes auratus.** Eastern Kansas.

151. **Colaptes mexicanus,** Western edge of the Plains and mountains of Colorado up to timber line; Ogden, Utah.

STRIGIDÆ.

152. **Otus vulgaris**, var. **Wilsonianus.** Ogden, Utah.

153. **Athene hypogæa.** Middle Kansas; western edge of the Plains; Cheyenne; Ogden, Utah.

FALCONIDÆ.

154. **Falco peregrinus.** Middle Kansas; South Park; Plains of Wyoming; Ogden, Utah.

155. **Falco columbarius.** Ogden, Utah (Sept.); Wahsatch Mountains.

156. **Falco sparverius.** Eastern and Middle Kansas; western edge of the Plains, and mountains of Colorado; Ogden, Utah.

157. **Buteo borealis.** Eastern and Middle Kansas; Colorado.

158. **Archibuteo lagopus**, var. **Sancti-Johannis.** Western and Middle Kansas (winter); Carbon County, Wyoming (winter, abundant).

159. **Nauclerus furcatus.** Eastern Kansas.

160. **Circus cyaneus**, var. **hudsonius.** Kansas; Colorado; Wyoming; Utah.

161. **Aquila chrysaëtos.** Colorado; Wyoming; Utah.

162. **Haliaëtus leucocephalus.** Kansas; Colorado; Wyoming; Utah.

CATHARTIDÆ.

163. **Cathartes aura.** Kansas; Plains of Colorado; South Park; Wyoming; Utah.

COLUMBIDÆ.

164. **Zenædura carolinensis.** Kansas; western edge of the Plains; mountains of Colorado up to about 11,000 feet; Laramie Plains; Ogden, Utah.

MELEAGRIDÆ.

165. **Meleagris gallopavo.** Eastern and Middle Kansas; along the streams as far as timbered; not much to the westward of Middle Kansas.

TETRAONIDÆ.

166. **Tetrao obscurus.** Mountains of Colorado (up to timber line); Wyoming and Utah.

167. **Centrocercus urophasianus.** Laramie Plains; Carbon County, Wyoming: Salt Lake Valley.

168. **Pediœcetes phasianellus**, var. **columbianus.** Middle and Western Kansas; Plains of Colorado and Wyoming; Great Salt Lake Valley.

169. **Cupidonia cupido.** Eastern and Middle Kansas, spreading westward.

170. **Bonasa umbellus.** Mountains of Colorado, Wyoming, and Utah.

171. **Lagopus leucurus.** Mountains of Colorado, above timber line.

PERDICIDÆ.

172. **Ortyx virginianus.** Eastern and Middle Kansas, spreading westward; Great Salt Lake Valley (introduced).

173. **Lophortyx californicus.** Great Salt Lake Valley (introduced).

CHARADRIIDÆ.

174. **Ægialitis vociferus.** Kansas; Plains of Colorado and Wyoming; South Park; Great Salt Lake Valley.

175. **Ægialitis montanus.** Middle Kansas; Plains of Colorado and Wyoming; South Park.

SCOLOPACIDÆ.

176. **Gallingo Wilsoni.** Ogden, Utah (Sept.).

177. **Macrorhampus griseus.** Shores of Great Salt Lake (Sept.).

178. **Pelidna alpina**, var. **americana**. Great Salt Lake Valley (Sept.).

179. **Ereunetes pusillus**. Eastern Kansas (May).

180. **Actodromas maculata**. Fort Leavenworth, Kansas (May).

181. **Actodromas Bairdii**. Western edge of the Plains (August).

182. **Actodromas minutilla**. Colorado (August 3d); Cheyenne (August); Laramie Plains (August); Ogden, Utah (September).

183. **Gambetta melanoleuca**. Eastern Kansas (May); Lake Pass, Colorado (August 3); Cheyenne (August); Laramie Plains (August); Great Salt Lake (September).

184. **Gambetta flavipes**. Lake Pass, Colorado (August); Ogden, Utah (September).

185. **Rhyacophilus solitarius**. Eastern and Middle Kansas; Colorado (August); Wyoming (August).

186. **Tringoides macularius**. Kansas; Colorado, up to 13,000 feet; Wyoming; Utah.

187. **Actiturus Bartramius**. Kansas; Colorado.

188. **Numenius longirostris**. Kansas.

189. **Numenius borealis**. Middle Kansas (June 20th, one individual).

PHALAROPODIDÆ.

190. **Phalaropus Wilsoni**. Great Salt Lake.

RECURVIROSTRIDÆ.

191. **Recurvirostra americana**. Laramie Plains; Great Salt Lake.

192. **Himantopus nigricollis**. Great Salt Lake.

GRUIDÆ.

193. **Grus americanus**. Eastern Kansas (May).

TANTALIDÆ.

194. **Ibis falcinellus**, var. **Ordii**. Great Salt Lake.

195. **Ibis alba**. Great Salt Lake.

ARDEIDÆ.

196. **Ardea herodias**. Eastern Kansas; Great Salt Lake Valley.

197. **Ardetta exilis**. Eastern Kansas.

198. **Botaurus lentiginosus**. Eastern Kansas; Great Salt Lake Valley.

199. **Butorides virescens**. Eastern Kansas.

200. **Nyctiardea grisea**, var. **nævia**. Eastern Kansas; Great Salt Lake Valley.

RALLIDÆ.

201. **Rallus crepitans**. Great Salt Lake Valley.

202. **Rallus virginianus**. Eastern Kansas.

203. **Porzana carolina.** Eastern Kansas; Great Salt Lake Valley.

204. **Fulica americana.** Eastern and Middle Kansas; Great Salt Lake Valley.

ANATIDÆ.

205. **Anser hyperboreus.** Great Salt Lake (October).

206. **Bernicla canadensis.** Great Salt Lake Valley.

207. **Anas boschas.** Eastern Kansas; Great Salt Lake Valley.

208. **Dafila acuta.** Great Salt Lake Valley (September).

209. **Nettion carolinensis.** Kansas. Great Salt Lake Valley.

210. **Querquedula discors.** Eastern Kansas.

211. **Querquedula cyanoptera.** Great Salt Lake.

212. **Spatula clypeata.** Great Salt Lake.

213. **Chaulelasmus streperus.** South Park, Col. Great Salt Lake.

214. **Mareca americana.** Great Salt Lake.

215. **Aix sponsa.** Kansas; Great Salt Lake.

216. **Fulix marila.** Eastern Kansas (May); Great Salt Lake (Sept.).

217. **Aythya ferina,** var. **americana.** Great Salt Lake.

218. **Erismatura rubida.** Great Salt Lake (September).

219. **Mergus merganser.** Great Salt Lake (September); Wahsatch Mountains; Fort Fred. Steele, Wyoming (October).

220. **Lophodytes cucullatus.** Fort Fred. Steele, Wyoming (Oct.).

PELECANIDÆ.

221. **Pelecanus erythrorhynchus.** Eastern Kansas. Great Salt Lake.

GRACULIDÆ.

222. **Graculus dilophus.** Great Salt Lake.

LARIDÆ.

223. **Larus delawarensis.** Great Salt Lake.

224. **Chrœcocephalus philadelphia.** Great Salt Lake (October).

225. **Xema Sabini.** Great Salt Lake (October).

226. **Hydrochelidon fissipes.** Eastern Kansas (May).

PODICIPIDÆ.

227. **Podiceps cornutus.** Great Salt Lake Valley.

228. **Podilymbus podiceps.** Great Salt Lake Valley.

CAMBRIDGE, July 10, 1872.

No. 7. — *Interim Report of the Hydroids collected by* L. F. de Pourtalès *during the Gulf Stream Exploration of the United States Coast Survey.* By George T. Allman.

(Published by permission of Prof. B. Peirce, Supt. U. S. Coast Survey.)

Setting aside a very few whose imperfect state of preservation rendered their determination impossible, the whole of the specimens forming the collection may be distributed among seventy-three species. Of these species sixty-three are undescribed, two have been already described by M. de Pourtalès, and, like the undescribed species, have not yet been obtained beyond the area of the Exploration; while the remaining eight, so far as the diagnosis of specimens in almost every case destitute of gonosome can be relied on, occur also on the eastern side of the Atlantic. It must be borne in mind, however, that the identification of specimens in which the gonosome is wanting cannot be regarded as absolute.

Eleven species belong to Gymnoblastic genera. Of these one has been already described by M. de Pourtalès. Of the remaining ten, seven have their hydranths sufficiently well preserved for description; while the remaining three, retaining nothing but the tubular perisarc with at most the included cœnosarc, can be referred only provisionally to definite species or even to definite genera.

Only one of the Gymnoblastic Hydroids admits of being referred with any degree of probability to a species occurring on the eastern shores of the Atlantic. This is a large, simple-stemmed form, which cannot be distinguished from *Tubularia indivisa*; but as nothing remains of it beyond the stems, it would be rash to assert positively that it is identical with the *Tubularia indivisa* of the European shores.

Of the Calyptoblastic forms there are sixty-two species in all. Of these fifteen belong to the Campanularinæ, while forty-seven must be referred to the Sertularinæ.

Of the fifteen species referable to the Campanularinæ one has been already described by M. de Pourtalès, while two others cannot be distinguished from the *Filellum immersum* and the *Halecium muricatum* of the European shores. In the absence of hydranths and gonosome, however, it would be unsafe to insist on the identity of these with the European species.

Among the Sertularinæ, nineteen species belong to the Sertularidæ and twenty-eight to the Plumularidæ. Of the nineteen species of Sertularidæ sixteen have not yet been met with beyond the area investigated by the Explorers, while three are undistinguishable from the following European species: *Sertularella Gayii* and its variety, *robusta*; *Sertularella polyzonias*; and *Sertularella tricuspidata*.

The collection is especially rich in the Plumularidæ, no less than twenty-eight out of the seventy-three species of which the collection is composed belonging to this beautiful family. Two of these would seem to be common to both sides of the Atlantic; for though it is true that no gonosome is present in either of them, their trophosomes are undistinguishable from those of the *Antennularia ramosa* and *Plumularia catharina* of the European shores.

Among the Gymnoblastea contained in the collections, the gonosome is present in a large proportion of species. So also a large proportion of the Plumularidæ are provided with their gonosomes and present some interesting and beautiful modifications of this part of the hydroid colony. It is remarkable, however, that the gonosome is absent in almost every instance from the other Calyptoblastic forms. Among the fifteen species of Campanularinæ the gonosome occurs in only one; while among the nineteen species of Sertularidæ it is present in only two, unless a remarkable structure, which will be described in the detailed report, is rightly referable to this part of the colony, and then a third species must be included among those Sertularidæ in which the gonosome is preserved.

The two species of Sertularidæ in which the gonosome is undoubtedly present are common to both sides of the Atlantic, while not only those, but the single example of the Campanularinæ, in which it also occurs, are from some of the deepest dredgings made.

January, 1873.

No. 8. — *The Echini collected on the Hassler Expedition.* By ALEXANDER AGASSIZ.

(PUBLISHED BY PERMISSION OF PROF. PEIRCE, SUPT. OF THE U. S. COAST SURVEY.)

THE following preliminary notice of the Sea-urchins collected by Professor Agassiz and Mr. Pourtalès during the voyage of the Hassler, contains a description of the most interesting of the new species collected.

The most valuable collection was made off the Barbadoes, at a depth of one hundred fathoms: a very fine specimen of Asthenosoma hystrix was dredged at that point, three young specimens of Cœlopleurus floridanus, — the anal plates of two of the specimens of Cœlopleurus were preserved, (there are four of them, as in the Arbaciadæ,) — and a remarkable Spatangoid (Paleopneustes cristatus A. AG.), noticed in one of the letters of Professor Agassiz to Professor Peirce; this proves to be another of these remarkable cretaceous types already noticed in the Report of the Echini of the Straits of Florida. A very good series of specimens of Hemiaster Philippii and of Echinus margaritaceus were collected on the east coast of Patagonia. In the Straits of Magellan the common species are Arbacia Dufresnii and Echinus Magellanicus; Schizaster Philippii was also found. No Goniocidaris was collected. Along the west coast of South America no novelties were found, and nothing of special importance was brought home except a very fine specimen of Astropyga pulvinata collected at Panama by Lieutenant Cutts. During the stay at the Galapagos a few species of Echini were collected, which leave no doubt that the Galapagos form a part of the Panamic District. The following species were collected there: Cidaris Thouarsii, Strongylocentrotus gibbosus, Toxopneustes semituberculatus, Encope micropora, Rhynchopygus pacificus. None of the East Indian types often credited to those islands were found at the Galapagos, namely, no Amblypneustes nor Temnopleurus. But we must be careful not to judge from negative evidence, as, notwithstanding the Hassler visited so many parts of the west coast of South America, it is quite remarkable that only single specimens of the two most common species of Echini of that coast, Strongylocentrotus albus and Arbacia nigra, were brought home.

No species hitherto not noticed from the west coast of Central America, Mexico, or the Gulf of California, or San Francisco, were collected.

During the visit made to Juan Fernandez a few Echini were collected; among them specimens of a small Spatangoid (Nacospatangus gracilis A. Ag.) allied to Micraster and Spatangus. Small specimens of Echinus margaritaceus were also collected there; other specimens of the same species were obtained off Cape Dos Bahias, on the east coast of Patagonia. A fine specimen was in the Museum collection previously, from Cape Horn.

A full description and figures of the most interesting species will be given in the Zoölogical Results of the Hassler Expedition.

Paleopneustes cristatus A. Ag. (nov. gen. et sp.)

Seen in profile this species has a remarkable resemblance to some of the forms of Ananchytes ovata. Like it, it has neither peripetalous nor anal or subanal fascioles. The actinal surface is nearly flat, the anterior extremity rounded, with no trace of indentation for the anterior ambulacrum, which consists, as in Ananchytes, of slightly diverging zones, with a pair of pores piercing the centre of each ambulacral plate. The abactinal system is, however, compact, as in Spatangus, and the lateral ambulacra form imperfect petals, diverging, extending half-way from apex to edge of the test, terminating abruptly, and very slightly depressed below the level of the test. The vertex corresponds to the apical system, and is nearly central. The anal system is large, circular, and placed close to the edge of the test in the truncated posterior extremity of the test. The lateral petals are continued by distant pairs of pores in the centre of the ambulacral plates to the actinostome. The actinal ambulacra form broad avenues on each side of the triangular elongate plastron. The actinostome is transverse, narrow, with a very prominent posterior lip. The upper part of the test is covered by distant tubercles of uniform size, arranged in regular horizontal lines; they are more closely packed and larger on the actinal surface. On the upper part of the test the spines are straight, short, comparatively stout. They are large, slightly curved at the base, and spatulate at the actinal sides The apical part of the anterior interambulacrum carries a cluster of longer spines closely packed together, forming a sort of tuft. The spines of the abactinal part of the test resemble at first glance much more those of the regular Echini than those of the Spatangoids, standing out from the test in all possible directions, and not having a general direction as is usually the case in Spatangoids. The color when alive was of a dark violet.

This genus differs from Asterostoma only in the absence of actinal ambulacral furrows and in having a labiate actinostome instead of the pentagonal sunken mouth represented in the poorly preserved specimens of Asterostoma.

100 fathoms off Barbadoes.

Nacospatangus gracilis A. Ag. (nov. gen. et sp.)

Off Juan Fernandez in 65 fathoms was dredged a small Spatangoid (17 m.m. long), which will form the type of a subgenus of Spatangus intermediate between Maretia and Micraster. It has the high test of Maretia alta, vertex posterior; in the anterior lateral ambulacral petal the abactinal part of the anterior poriferous zone is obliterated, the posterior petals are as in Maretia. The anal extremity of the test resembles that of Spatangus proper, but the whole test is covered, as in Micraster, with uniform tubercles: the genus resembles those species of Micraster which have a subanal fasciole. In this genus the subanal fasciole is heart-shaped, and sends off an anal branch. The whole surface of the test is covered by silvery-gray short curved spines, somewhat longer on the actinal side, especially towards the posterior extremity of the actinal plastron.

A very fine series of Hemiaster Philippii A. Ag. (Lovén's Abatus Philippii MS. taken by Kinberg off La Plata). This is extremely interesting, as showing how with increasing age the lateral ambulacra, which in young stages (18 mm. long) are slightly depressed, gradually become more and more sunken, till in specimens measuring 40 mm. in length the lateral ambulacra, especially the anterior, are deeply sunken, much as in Tripylus. The peripetalous fasciole does not vary greatly in outline or breadth, and this species is readily distinguished from H. australis by the short posterior lateral ambulacra, and the narrow peripetalous fasciole.

Very small specimens show this species to go through changes similar to those of Brissopsis. They are quite cylindrical when measuring about 75. mm. in length.

Lat. 37° 42′ S.	Long. 56° 20′ W.	44 fathoms.	
Lat. 51 26	" 68 56	55 fathoms.	
Off Cape Dos Bahias		55 fathoms.	E. coast of Patagonia.

CAMBRIDGE, January, 1873.

No. 9.— *Catalogue of the Terrestrial Air-breathing Mollusks of North America, with Notes on their Geographical Range.* By W. G. Binney.

In connection with my friend, Mr. Thomas Bland, I have collected many facts relating to the North American Land Shells since the publication of our Monograph.* The following pages give a synopsis of the more important of these, especially such as throw light upon their classification, synonymy, and geographical distribution.

As regards classification, I have followed the arrangement proposed by Mr. Bland and myself in the Annals of the Lyceum of Natural History of New York, Vol. X. p. 158.

As regards synonymy, I have followed our Monograph referred to, except in a very few cases where more ample opportunities of study have caused me to reconsider our decisions. Future study will, no doubt, eliminate as synonymes several species of the present catalogue. I have added the species described since our Monograph was printed. Happily but two synonymes have been added to our list since then,— *Vertigo tridentata* and *Helix ptycophora.*

As regards geographical distribution, it must be borne in mind that the data are very imperfect on which I base my views. Future research will, no doubt, greatly modify them. I have omitted the species of Lower California as belonging to the fauna of Mexico. San Diego is the lowest point from which we have truly Californian species.

PULMONATA GEOPHILA.

OLEACINIDÆ.

Glandina Vanuxemensis, *Lea.*
truncata, *Gmel.*
parallela, *W. G. B.*
Glandina decussata, *Desh.*
bullata, *Gld.*
Texasiana, *Pfr.*

* Land and Freshwater Shells of North America, Part I. Pulmonata Geophila. By W. G. Binney and Thomas Bland, Washington, Smithsonian Institution, 1869.

HELICIDÆ.

(Vitrininæ.)

Macrocyclis Vancouverensis, *Lea.*
sportella, *Gld.*
concava, *Say.*
Voyana, *Newc.*
Duranti, *Newc.*

Zonites kopnodes, *W. G. B.*
fuliginosus, *Griff.*
friabilis, *W. G. B.*
caducus, *Pfr.*
lævigatus, *Pfr.*
demissus, *Binn.*
ligerus, *Say.*
intertextus, *Binn.*
subplanus, *Binn.*
inornatus, *Say.*
sculptilis. *Bland.*
Elliotti, *Redf.*
cerinoideus, *Anth.*
cellarius, *Müll.*
Whitneyi, *Newc.*
nitidus, *Müll.*
arboreus, *Say.*
viridulus, *Mke.*
indentatus, *Say.*
limatulus, *Ward.*
minusculus, *Binn.*

Zonites milium, *Morse.*
Binneyanus, *Morse.*
ferreus, *Morse.*
conspectus, *Bland.*
exiguus, *Stimpson.*
chersinellus, *Dall.*
capsella, *Gld.*
fulvus, *Drap.*
Fabricii, *Beck.*
Gundlachi, *Pfr.*

*

gularis, *Say.*
suppressus, *Say.*
lasmodon, *Phillips.*
significans, *Bland.*
internus, *Say.*
multidentatus, *Binn.*

Vitrina limpida, *Gould.*
Angelicæ, *Beck.*
Pfeifferi, *Newc.*
exilis, *Mor.*

Limax maximus, *Lin.*
flavus, *Lin.*
agrestis, *Müll.*
campestris, *Binn.*
Hewstoni, *J. G. Cooper.*

(Helicinæ.)

Arion fuscus, *Müll.*
Andersoni, *J. G. Coop.*
foliolatus, *Gld.*

Ariolimax Columbinaus, *Gld.*
Californicus, *J. G. Coop.*
niger, *J. G. Coop.*

Prophysaon Hemphilli, *Bl. & Binn.*

Binneia notabilis, *J. G. Coop.*

Hemphillia glandulosa, *Bl. & Binn.*

Patula solitaria, *Say.*

Patula strigosa, *Gld.*
Hemphilli, *Newc.*
Cooperi, *W. G. B.*
Idahoensis, *Newc.*
Haydeni, *Gabb.*
alternata, *Say.*
Cumberlandiana, *Lea.*
tenuistriata, *Binn.*
perspectiva, *Say.*
striatella, *Anth.*

Patula pauper, *Mor.*
Horni, *Gabb.*
asteriscus, *Morse.*
incrustata, *Pfr.*
vortex, *Pfr.*
Helix lineata, *Say.*

*

labyrinthica, *Say.*
Hubbardi, *Brown.*

*

Yatesii, *J. G. Coop.*

*

auriculata, *Say.*
uvulifera, *Shuttl.*
auriformis, *Bld.*
Postelliana, *Bld.*
espiloca, *Rav.*
avara, *Say.*
ventrosula, *Pfr.*
Hindsi, *Pfr.*
Texasiana, *Moricand.*
triodontoides, *Bld.*
Mooreana, *W. G. Binn.*
tholus, *W. G. Binn.*
hippocrepis, *Pfr.*
fastigans, *L. W. Say.*
Jacksoni, *Bld.*
Troostiana, *Lea.*
Hazardi, *Bld.*
oppilata, *Moricand.*
Dorfeuilliana, *Lea.*
Ariadnæ, *Pfr.*
septemvolva, *Say.*
cereolus, *Muhlf.*
Carpenteriana, *Bld.*
Febigeri, *Bld.*
pustula, *Fer.*
pustuloides, *Bld.*
leporina, *Gld.*
Harfordiana, *J. G. Coop.*

*

Helix polygyrella, *Bld. & J. G. Coop.*

*

spinosa, *Lea.*
labrosa, *Bld.*
Edgariana, *Lea.*
Edvardsi, *Bld.*
barbigera, *Redf.*
stenotrema, *Fer.*
hirsuta, *Say.*
maxillata, *Gld.*
monodon, *Rack.*

*

palliata, *Say.*
obstricta, *Say.*
appressa, *Say.*
inflecta, *Say.*
Rugeli, *Shuttl.*
tridentata, *Say.*
Mullani, *Bld. & J. G. Coop.*
fallax, *Say.*
introferens, *Bld.*
Hopetonensis, *Shuttl.*
vultuosa, *Gld.*
loricata, *Gld.*

*

major, *Binn.*
albolabris, *Say.*
divesta, *Gld.*
multilineata *Say.*
Pennsylvanica, *Green.*
Mitchelliana, *Lea.*
elevata, *Say.*
Clarki, *Lea.*
Christyi, *Bld.*
exoleta, *Binn.*
Wheatleyi, *Bld.*
dentifera, *Binn.*
Roëmeri, *Pfr.*
thyroides, *Say.*
clausa, *Say.*
Columbiana, *Lea.*

Helix germana, *Gld.*
Downieana, *Bld.*
jejuna, *Say.*
devia, *Gld.*
profunda, *Say.*
Sayii, *Binn.*
*
harpa, *Say.*
*
pulchella, *Müll.*
*
hispida, *L.*
rufescens, *Penn.*
*
Berlandieriana, *Mor.*
griseola, *Pfr.*
*
fidelis, *Gray.*
infumata, *Gld.*
Hillebrandi, *Newc.*
*
arrosa, *Gld.*
Townsendiana, *Lea.*
tudiculata, *Binn.*
Nickliniana, *Lea.*
Ayresiana, *Newc.*
redimita, *W. G. Binn.*
intercisa, *W. G. Binn.*
exarata, *Pfr.*
ramentosa, *Gld.*
Californiensis, *Lea.*
Carpenteri, *Newc.*
Mormonum, *Pfr.*
sequoicola, *J. G. Coop.*
Diabloensis, *J. G. Coop.*
Traski, *Newc.*
Dupetithouarsi, *Desh.*
ruficincta, *Newc.*
facta, *Newc.*
Gabbi, *Newc.*
*

Helix Newberryana, *W. G. Binn.*
*
Kelletti, *Fbs.*
Tryoni, *Newc.*
*
hortensis, *Müll.*
*
aspersa, *Müll.*
*
varians, *Mke.*

Holospira Roemeri, *Pfr.*
Goldfussi, *Pfr.*

Cylindrella Poeyana, *Pfr.*
jejuna, *Gld.*

Macroceramus Kieneri, *Pfr.*
Gossei, *Pfr.*

Bulimulus multilineatus, *Say.*
Dormani, *W. G. B.*
Marielinus, *Pfr.*
Floridanus, *Pfr.*
patriarcha, *W. G. B.*
alternatus, *Say.*
Schiedeanus, *Pfr.*
dealbatus, *Say.*

Cionella subcylindrica, *L.*
acicula, *Müll.*

Stenogyra decollata, *L.*
subula, *Pfr.*
octonoides, *Ad.*
gracillima, *Pfr.*

Pupa muscorum, *L.*
Blandi, *Morse.*
Hoppii, *Müll.*
variolosa, *Gld.*
pentodon, *Say.*
decora, *Gld.*
corpulenta, *Morse.*
Rowelli, *Newc.*
Californica, *Rowell.*
fallax, *Say.*
modica, *Gld.*

Pupa Arizonensis, *Gabb.*
hordeacea, *Gabb.*
armifera, *Say.*
contracta, *Say.*
rupicola, *Say.*
corticaria, *Say.*
pellucida, *Pfr.*
borealis, *Mor.*
Strophia incana, *Binn.*
Vertigo Gouldi, *Binn.*
Bollesiana, *Morse.*
milium, *Gld.*
ovata, *Say.*
ventricosa, *Morse.*
simplex, *Gld.*

(*Orthalicinæ.*)

Liguus fasciatus, *Müll.*
Orthalicus zebra, *Müll.*
Orthalicus undatus, *Brug.*
Punctum minutissimum, *Lea.*

(*Succininæ.*)

Succinea Haydeni, *W. G. B.*
retusa, *Lea.*
Sillimani, *Bld.*
ovalis, *Gld.*, not *Say.*
Higginsi, *Bld.*
Haleana, *Lea.*
Mooresiana, *Lea.*
Grosvenori, *Lea.*
Wilsoni, *Lea.*
Concordialis, *Gld.*
luteola, *Gld.*
lineata, *W. G. Binn.*
avara, *Say.*
Succinea Stretchiana, *Bld.*
Verrilli, *Bld.*
aurea, *Lea.*
Groenlandica, *Beck.*
obliqua, *Say.*
Totteniana, *Lea.*
campestris, *Say.*
Hawkinsi, *Bd.*
rusticana, *Gld.*
Nuttalliana, *Lea.*
Oregonensis, *Lea.*
effusa, *Shuttl.*
Salleana, *Pfr.*

PHILOMYCIDÆ.

Tebennophorus Caroliniensis, *Bosc.*
Pallifera dorsalis, *Binn.*

VERONICELLIDÆ.

Veronicella Floridana, *Binn.*
Veronicella olivacea, *Stearns.*

During the many years in which my attention has been devoted to the Terrestrial Pulmonata of North America, I have lost no opportunity of adding to the knowledge of their geographical distribution, presented by my father in the first volume of his work.* The result of

* A. Binney, Terr. Moll. U. S., I. Chaps. V.-IX.

this accumulation of facts is here briefly offered. It must be studied in connection with the chapters referred to, and also with the text-book of our land shells, prepared for the Smithsonian Institution by my friend, Mr. Bland, and myself.*

The regions west of the Rocky Mountains have become known since the publication of my father's work, and much additional information received from the eastern portion of the continent. It becomes necessary, therefore, somewhat to modify the limits of the sections which he indicated. I have already suggested † that, in regard to the geographical distribution of the Terrestrial Pulmonata of North America, there appear to be three distinct faunas, which I have called, —

I. THE PACIFIC PROVINCE.
II. THE CENTRAL PROVINCE.
III. THE EASTERN PROVINCE.

The boundaries of these provinces and the subdivisions which appear to exist in them will be given below, as well as lists of their peculiar species. It must be distinctly understood, however, that future researches, especially at the South and Southwest, may greatly modify the views here presented.

I. THE PACIFIC PROVINCE comprises a narrow strip between the Sierra Nevada and Cascade Mountains on the east, and the Pacific Ocean on the west. Its southern limit is San Diego, from whence it extends northerly into Alaska.

Over this province the following species range : —

Macrocyclis Vancouverensis.
sportella.
Helix Columbiana.
germana.
tudiculata.
Ariolimax Columbianus.
Prophysaon Hemphilli.
Succinea rusticana.
Oregonensis.
Nuttalliana.

Over the whole of this province we find also the following species, common to Eastern North America. They also extend over the whole northern portion of the continent, where the mountains have ceased to

* Land and Freshwater Shells of North America, Part I. Pulmonata Geophila. By W. G. Binney and Thomas Bland, Washington, 1869.

† Proc. Bost. Soc. Nat. Hist., IX. 177, 1863.

be barriers to distribution. It is, no doubt, from these regions that they have spread through the Pacific Province, and not westward over the Rocky Mountains. Had other eastern species extended over the boreal regions, we should, no doubt, have found them also spreading into the Pacific States. They are especially found along the Sierra Nevada.

Zonites arboreus.	**Limax campestris.**
indentatus.	**Patula striatella.**
minusculus.	**Helix lineata.**
milium.	**Punctum minutissimum.**

In the Pacific Province we also find several species common to the circumpolar regions of Asia, Europe, and America. They have likewise spread southward along the Sierra Nevada and on either side of it. They have also spread southward over the Central and Eastern Provinces, and now inhabit most, if not all, of North America. They are

Zonites fulvus.	**Cionella subcylindrica.**

Other species will probably be added to this list by further search; among them *Helix pulchella.*

In dealing with the species from the North in Eastern North America (see below, p. 204), the question of their distribution will be more fully discussed.

In addition to the species already enumerated as common to the whole Pacific Province, there are many more restricted in their range. It appears that the Pacific Province is divided into two regions, (*a*) the Oregonian and (*b*) Californian, the two intermingling slightly or overlapping in the extreme north of California, near Humboldt Bay. The faunas of these regions are nearly allied.

(*a.*) The Oregon Region lies between the Cascade Mountains and the Pacific Ocean, extending northerly through British Columbia into Alaska. The following species are peculiar to it: — *

Helix devia.	**Arion foliolatus.**
fidelis.	**Hemphillia glandulosa.**
Townsendiana.	**Succinea Hawkinsi.**

There seems to be here some overlapping of the Pacific and Central Provinces, as *Helix Townsendiana*, *Helix devia*, and *Macrocyclis Van-*

* I omit *Onchidella borealis*, Dall, from Sitka, being doubtful whether the genus should be treated as American.

couverensis extend along the mountains southeasterly into Idaho and Montana. The former two become much dwarfed in size at their most eastern range.

(*b.*) The Californian Region extends from Humboldt Bay to San Diego, between the Sierra Nevada and Cascade Mountains on the east, and the Pacific Ocean on the west.

The following are the species peculiar to it: —

Macrocyclis Voyana.
Duranti.
Vitrina Pfeifferi.
Zonites Whitneyi.
conspectus.
chersinellus.
Limax Hewstoni.
Binneia notabilis.
Ariolimax Californicus.
niger.
Arion ? Andersoni.
Helix Yatesii.
Harfordiana.
loricata.
infumata.
Hillebrandi.
arrosa.
Nickliniana.
Ayresiana.
redimita.
intercisa.
Helix exarata.
ramentosa.
Californiensis.
Diabloensis.
Carpenteri.
Mormonum.
sequoicola.
Traski.
Dupetithouarsi.
ruficincta.
Gabbi.
facta.
Kelletti.
Tryoni.
Newberryana.
Pupa corpulenta.
Rowelli.
Californica.
Succinea Sillimani.
Stretchiana.

Of the above, several species extend beyond the limits of the region. Thus, *Vitrina Pfeifferi*, *Zonites Whitneyi*, *Pupa corpulenta*, *Succinea Sillimani*, *Succinea Stretchiana*, and *S. rusticana* are found also on the western slope of the Sierra Nevada in the Central Province. *Helix infumata* and *Macrocyclis Voyana* are also found outside the bounds of the Region, in the Oregonian Region.

With the fauna of Lower California there seems no connection, unless *Helix Stearnsiana* proves identical with *H. Kelletti*, in which case the former must be considered as belonging to the Lower California fauna rather than to that of our Pacific Province. Another species, *H. Carpenteri*, is included in the above list, having been quoted from San Diego and Tulare Valley, California. It may, however, belong rather to the Lower California fauna,* having been described from that region under the name of *H. Remondi*, and from Guaymas. *Veronicella olivacea*, Stearns, a Nicaraguan species, is also said to extend into California.

From the list of California species are omitted *Columna Californica*, actually collected at Marmato, New Granada, by Mr. Bland, and

* The peninsula of Lower California forms a distinct molluscous province of itself, extending nearly to San Diego. The following species are peculiar to it: —

Cœlocentrum irregulare, *Gabb.*
Helix Stearnsiana, *Newc.* (*Kelletti*, Fbs. ?)
areolata, *Sowb.* (*Veitchii*, Tryon
Pandoræ, *Forbes.*
levis, *Pfr.*
Rowelli, *Newc.* (*Lohri*, Gabb.)
Berendtia Taylori, *Pfr.*
Bulimus spirifer, *Gabb.*
Gabbi, *Crosse.*
Bulimulus pallidior, *Sowerby.*
excelsus, *Gould.*
inscendens, *W. G. Binn.*
sufflatus, *Gould.*
pilula, *W. G. Binn.*
proteus, *Brod.*
Xantusi, *W. G. Binn.*
artemisia, *W. G. Binn.*
Onchidium Carpenteri, *W. G. Binn.*

Veronicella olivacea, Stearns, a Nicaraguan species, is also found in Lower California. Of the above list one only has been found near San Diego, *H. Stearnsiana*. Another, *H. Rowelli*, has been referred to Arizona, but with doubtful accuracy. *H. Pandoræ* and *areolata* have also erroneously been referred to California. *Helix Remondi* (*Carpenteri*) is omitted from the list, as it also occurs in the California Region. It is the only species common to the peninsula and mainland of Mexico. The most interesting fact in the fauna of Lower California is the presence of *Bulimulus proteus* and *B. pallidior*, — species described originally from South America, the former from Chili. Such facts can only be accounted for by a theory of former connection of the two points.

Though still more remotely connected with the subject of this paper, it will be interesting to add here a list of species found at and north of Mazatlan, on the Pacific coast of Mexico.

Glandina turris, *Pfr.*
Albersi, *Pfr.*
Holospira Remondi, *Gabb.*
Helix Mazatlanica, *Pfr.*
Carpenteri, *Newc.*
anilis, *Gabb.*
Behri, *Gabb.*
Helix acutedentata, *W. G. Binn.*
ventrosula, *Pfr.*
Bulimulus Ziegleri, *Pfr.*
Californicus, *Rve.* ?
Orthalicus undatus, *Brug.*
Pupa chordata, *Pfr.*
Succinea cingulata, *Forbes.*

Of the above, *H. Mazatlanica* has lately been quoted from San Francisco, confounded probably with some allied species.

H. Mormonum is omitted from this list, its presence in Sonora not having been confirmed, although asserted, doubtfully, by Messrs. Fischer and Crosse.

Zonites cultellatus, probably an accidentally introduced European shell. *Bulimus Californicus* is also omitted, belonging, no doubt, to the region of Mazatlan. Also *Glandina Albersi*, which we know to live in the Sierra Madre.

Separate lists of species peculiar to the several regions of the Pacific Province are given above. There now follows a complete list of all the species hitherto observed in the entire Province.

Macrocyclis Vancouverensis.
sportella.
Voyana.
Duranti.
Zonites Whitneyi.
arboreus.
indentatus.
minusculus.
milium.
conspectus.
chersinellus.
fulvus.
Vitrina Pfeifferi.
Limax campestris.
Hewstoni.
Prophysaon Hemphilli.
Ariolimax Columbianus.
Californicus.
niger.
Arion? follolatus.
Andersoni.
Binneia notabilis.
Hemphillia glandulosa.
Patula striatella.
Helix lineata.
Yatesii, *J. G. C.*, not *Pfr.*
Harfordiana.
loricata.
Columbiana.
germana.
devia.
fidelis.
infumata.
Hillebrandi.
Helix arrosa.
Townsendiana.
tudiculata.
Nickliniana.
Ayresiana.
redimita.
intercisa.
exarata.
ramentosa.
Californiensis
Carpenteri.
Mormonum.
sequoicola.
Diabloensis.
Traski.
Dupetithouarsi
ruficincta.
facta.
Gabbi.
Kelletti.
Tryoni.
Newberryana.
Cionella subcylindrica.
Pupa Rowelli.
Californica.
corpulenta.
Succinea Sillimani.
Stretchiana.
Hawkinsi.
rusticana.
Nuttalliana.
Oregonensis.
Punctum minutissimum.
Veronicella olivacea.

Several of the above will eventually prove to be synonymes, but the total number of species is small in comparison with the great size of the Pacific Province. An equal extent of territory in the Mississippi Valley, or even on the Atlantic coast, would show a larger number; and the comparatively small regions of Texas, Florida, and the Cumberland Mountains would each show an equal number of species peculiar to itself, independent of what they have in common with the rest of Eastern North America. This disparity in number is still more plainly shown in the separate region of Oregon. Thus it appears that the Pacific Province is not rich in the number of its species, but it is peculiarly favored in their size and beauty, — in this respect strikingly in contrast with the Central Province and Eastern Province.

From the Central Province the Pacific Province is quite distinct. A few species have been shown above to inhabit both slopes of the Sierra Nevada, and a few of the Oregon species have passed the barrier of the Cascade Mountains on the north, but the peculiar Pacific forms, such as *Arionta* and *Aglaia*, are unknown in the Central Province. On the other hand, the only form which has any development in the Central Province, *Patula*, is scarcely known in the Pacific Province.

Compared with Eastern North America, or the Eastern Province, as it is designated below, the Pacific Province is remarkable for the absence of all the larger *Zonites*. The presence of the smaller species, also, may perhaps be accounted for by migration from the north, so that the genus *Zonites* cannot be considered as characteristic of the Province. The genus *Pupa* is less common. The genera *Tebennophorus* and *Pallifera*, so universally distributed in Eastern North America, are unknown, and so are the southern genera *Glandina*, and *Bulimulus*. On the other hand, we find the genus *Macrocyclis* much more developed, and meet several genera unknown in the Eastern Province, such as *Ariolimax*, *Binneia*, *Prophysaon*, and *Hemphillia*. The genus *Helix* is proportionally more developed in the Pacific Region, and is represented by quite dissimilar subgenera. The sections so peculiar to the Eastern Province, *Polygyra*, *Stenotrema*, *Triodopsis*, *Mesodon*, are scarcely represented. In their place we find *Aglaia* and *Arionta*, forms unknown in the Eastern Province. The latter, though feebly represented in Europe, is the form of *Helix* characteristic of California. It is prolific of species and also of varieties to a degree which has caused some confusion in the synonymy. The section to which *Helix Newberryana* belongs, *Glyptostoma*, is also peculiar to California.

From Lower California and Mexico the Pacific Region has been shown to be equally distinct, wanting entirely the *Holospira*, *Glandina*, *Bulimulus*, and *Zonites* of those regions.

Failing on the north, east, and south, the west alone is left fo us from whence to trace the pulmonate fauna of the Pacific Region, and here the secret of its origin lies buried under the Pacific Ocean.*

II. The Central Province extends from Mexico to the British Possessions, between the Rocky Mountains on the east, and the Sierra Nevada and Cascade Mountains on the west.

The following are the species peculiar to the province: —

Patula strigosa.
Cooperi.
Haydeni.
Idahoensis.
Hemphilli.
Patula Horni.
Helix polygyrella.
Mullani.
Pupa Arizonensis.
hordeacea.

The first two of these species, perhaps identical, are also found on the eastern slope of the Rocky Mountains, in Wyoming and Dakota.

To the above must be added, as inhabiting the province, but not peculiar to it, the following species from the Pacific Province, inhabiting either slope of the Sierra Nevada: *Vitrina Pfeifferi*, *Zonites Whitneyi*, *Pupa corpulenta*, *Succinea Sillimani*, and *Succinea Stretchiana*. The following, also, from the Oregonian Region of the Pacific Province, *Helix devia*, *Helix Townsendiana*, and *Macrocyclis Vancouverensis*, are found at its most northern point, though the former two species are reduced in size. We find, also, over the Central Province the following species, whose derivation can readily be traced to the north; † *Zonites*

* A subsidence of eight hundred feet in the continent of North America would leave on its eastern shore a strip of land of about equal size of our Pacific Region, equally distinct in its terrestrial mollusca from the balance of the continent. In this case, however, we should have a distant island of the Appalachian chain on which we should find all the species of the eastern coast of the mainland. This would give us a proof of what we can now only suspect as regards the Pacific Province, — of former more wide distribution of its pulmonate fauna. From wherever the fauna may have originated, we can easily explain its present condition. The physical and climatic features of the Pacific Region are such as readily to account for its richness in terrestrial mollusks in comparison with the less favored Central Province, and even with the Eastern Province.

† See remarks on the distribution of these species over Eastern North America, p. 204.

minusculus, fulvus, indentatus, Helix pulchella, H. lineata, Patula striatella, Cionella subcylindrica.

Helix Rowelli, a Lower California species, is omitted from the list, its presence in Arizona not being well authenticated.

The fauna of the Central Province is quite distinct from that of the Pacific Province, but is nearly allied to that of the Eastern Province, its genera and subgenera being the same, excepting *Polygyrella*, its only peculiar subgenus of *Helix*. It may therefore be of the same origin as the fauna of the Eastern Province.

The paucity of species over this large province is owing to the nature of its climate and soil, — causes in equal force on the western border of the Eastern Province.

In order to avoid mistakes in the study of the geographical distribution of North American Land Shells one must constantly bear in mind the changes in the names and boundaries of the trans-Mississippi States and Territories.*

III. The Eastern Province comprises the remaining portions of the continent north of Mexico. The species by which it is inhabited have been derived partly from the north, partly from the interior, and partly from the south. It may, therefore, be divided into the (*a*) Northern Region, (*b*) the Interior Region, and (*c*) the Southern Region.

(*a*.) The Northern Region † comprises the whole northern portion of the continent, including Greenland and Alaska. Its southern boundary is not perfectly known, and probably not exactly marked; it may, however, be indicated in general terms as the same with the political division between the British Possessions and the United States to the northeast corner of New York, where it runs southwesterly along the Appalachian chain of mountains to Chesapeake Bay, thus including all New England, and the portions of New York, New Jersey, Pennsylvania, and Maryland lying east of those mountains. Into this

* Thus, *Helix Mullani* was described in Land and Freshwater Shells of North America, I. 131, from points in Washington Territory and Oregon. Both localities are now in Idaho.

† For a description of this Region, see A. Binney, l. c. pp. 124, 125, under sections 5 and 6. The American land shells, especially those of the Interior Region, are forest species; they become rare towards the northern region of the continent as the deciduous trees become rare.

southern extension of the Region we find the Interior Region overlapping, as will be shown below while treating of the Interior fauna. At other points in the Region, also, have been found species from the Interior Region,* especially small *Zonites*, which are able to bear the severe climate of the north.

The following are the species of the Northern Region: —

Vitrina limpida.	**Helix pulchella.**
Angelicæ.	**Cionella subcylindrica.**
exilis.	**Pupa muscorum.**
Zonites fulvus.	**Blandi.**
nitidus.	**Hoppii.**
viridulus.	**decora.**
Fabricii.	**borealis.**
milium.	**Vertigo Gouldi.**
Binneyanus.	**Bollesiana.**
ferreus.	**simplex.**
exiguus.	**Punctum minutissimum.**
multidentatus.	**Succinea Haydeni.**
Patula striatella.	**Verrilli.**
asteriscus.	**Higginsi.**
pauper.	**Groenlandica.**
Helix harpa.	**Totteniana.**

Of the above, several are circumpolar species, common to the three continents of Europe, Asia, and America. There being no mountain-barriers in these regions, they are not restricted in their range across America. In their progress southward, also, they have met with no transverse mountain-barriers, but have spread equally on the east and west of the Rocky Mountains and Sierra Nevada. Hence we find them common to the whole of North America.† Such are: —

* See Proc. Phila. Acad., N. S., 1861, p. 330, for the northern range of species from the Interior Region.

† In the same way we can account for the distribution of the small eastern species over the Central and Pacific Provinces. They have not crossed the mountain-barriers, but spread southward from their wider range in the north. Such are: —

Zonites arboreus.	**Limax campestris.**
indentatus.	**Patula striatella.**
minusculus.	**Helix lineata.**
milium.	**Punctum minutissimum.**

These northern species, both indigenous and circumpolar, may have been assisted

Zonites viridulus.
fulvus.
nitidus.
Helix harpa.
Helix pulchella.
Cionella subcylindrica.
Pupa muscorum.

This list will be increased should it be proved that Mr. Gwyn Jeffreys* is correct in referring the following American species to those of Europe. Vitrina limpida = V. pellucida, Punctum minutissimum = Helix pygmæa, Drap., Limax campestris = L. lævis, Müll., Vertigo Gouldii = V. alpestris, Ald., Vertigo Bollesiana = V. pygmæa, Drap., V. ovata = V. antivergo, Drap., V. ventricosa = V. Moulinsiana, V. simplex = V. edentula, Drap., Succinea ovalis = S. elegans, Risso, S. Totteniana = S. putris, Drap. var.

From Asia have come into Alaska the following: *Vitrina exilis*, *Patula pauper*, *Pupa borealis*.

The species peculiar to Greenland are *Vitrina Angelicæ*, *Zonites Fabricii*, *Pupa Hoppii*, and *Succinea Groenlandica*. Of these, *Pupa Hoppii* has, however, also been found on Anticosti Island.

Into this Northern Region have also been introduced by commerce from Europe the following: *Zonites cellarius*, at most of, if not at all of, the ports from New York to Halifax; *Limax flavus*, *L. agrestis*, and *Arion fuscus*, which follow man over the whole United States, living around his habitations; and *L. maximus*, also around human habitations, but noticed only in Newport, R. I., New York City, and Philadelphia; *Helix hispida* at Halifax, *Helix rufescens* at Quebec, *Helix hortensis* on the islands off the coast of New England and the British Provinces, and on the mainland in Canada and Greenland.

Of the species referred above to the Northern Region, several have spread beyond its limits. *Vitrina limpida* has been found in Central New York; *Zonites viridulus* extends to Mexico; *Z. milium* to San Francisco; *Z. fulvus* and *Helix pulchella* all over the United States; *Zonites nitidus*, *Z. multidentatus*, and *Punctum minutissimum* to Ohio, the last to Texas and to California; *Cionella subcylindrica* to the States south of the Great Lakes and into California and New Mexico; *Patula striatella* to Virginia, as well as into Oregon and Nevada.

in their migration southward by glacial agencies. There is a wide field for speculation here.

* Ann. and Mag. N. H., 1872, 245, 246.

The Northern Region does not differ in the characteristics of its fauna from that lying south of it, but its climate is too severe for any but the more hardy forms. Thus, we find only the small *Zonites* and *Helix*, with the genus *Vitrina*. Compared with the balance of North America, the Region is peculiar for the great distribution of its species east and west, owing to the mountain-ranges having here lost the great elevation which they have farther south, and thus ceasing to be barriers to distribution. The Region is also interesting as being the source from whence have spread southward over the whole continent several small species now found in Florida and Texas, and even in Mexico and the West Indies.

(*b*.) The Interior Region lies to the south of the Northern Region, but extends only as far as the Rocky Mountains * on the west. Southerly it extends to the alluvial regions of the Atlantic and Gulf coasts, the dividing line here not being sharply defined.

This is the only portion of the continent where we have evidence of the origin of our land mollusks in former geological times. In the Post-pleiocene deposits along the Ohio and Mississippi Rivers are found immense beds of shells, "proving that our existing species were living at a period which, though recent in a geological sense, was anterior to the last geological revolution, when the surface of this portion of the earth was brought to its present condition, and to the existence of the higher order of animals which now inhabit it, and even to that of the extinct mammalians which are known only by their gigantic remains." †

From the evidence gathered from these deposits, it appears that the fauna of this Region can be traced to Indiana and Ohio. From this centre the species have extended over the Region; some of them also have passed the barrier of the Appalachian chain into the Northern Region, and some have spread, with the enlargement of the continent, into the Southern Region.

The following species have actually been found fossil in the Post-pleiocene deposits: — †

Zonites arboreus.	**Zonites intertextus.**
fuliginosus.	**ligerus.**
inornatus.	**gularis.**

* This is the extreme limit, but before reaching it the land shells have become very rare, owing to the nature of the soil. For a description see A. Binney, l. c.

† A. Binney, Terr. Moll. U. S., I. 185.

Macrocyclis concava.
Patula solitaria.
alternata.
perspectiva.
Helix lineata.
labyrinthica.
auriformis.
stenotrema.
hirsuta.
monodon.
palliata.
obstricta.
appressa.
Helix inflecta.
albolabris.
elevata.
exoleta.
thyroides.
clausa.
profunda.
Pupa armifera.
contracta.
Succinea obliqua.
Helicina* orbiculata.
occulta.

Of the above all are now living and are equally numerous, excepting *Helicina occulta*, a species most abundant in Post-pleiocene days, but now almost extinct.† The other species of *Helicina* is now confined to more southern limits.

In addition to the above, the following species, now living in the Interior Province, probably had their origin in Post-pleiocene times, and will, no doubt, be found fossil in the "bluffs": —

Zonites friabilis.
lævigatus.
suppressus.
indentatus.
internus.
minusculus.
limatulus.
Helix Dorfeuilliana.
leporina.
multilineata.
Pennsylvanica.
Mitchelliana.
dentifera.
Helix bucculenta.
Sayii.
tridentata.
fallax.
Pupa pentodon.
fallax.
rupicola.
corticaria.
Vertigo milium.
ovata.
Succinea avara.
ovalis.

* Though not *Pulmonata*, these two species are strictly terrestrial in their habits, and are here introduced from their value on the question of the permanence of the Post-pleiocene species. One of them is almost extinct, the other more restricted in its range at present.

† See A. Binney, Terr. Moll. U. S., I. 183, 184; Bland and Binney, Ann. Lyc. N. H. of N. Y., IX. 289.

Tebennophorus Caroliniensis, *Pallifera dorsalis*, and *Limax campestris* probably have also come down from Post-pleiocene times. From their nature they could leave no record of their presence in the "bluffs."

There are also found in the Interior Region several forms of *Succinea* which have been described as

Succinea retusa.
Grosvenori.
lineata.
Succinea aurea.
Mooresiana.

The following is a complete list of those species of the Interior Region which have spread beyond it by passing the barriers of the Appalachian chain, and are now found over New England and the whole southern extension of the Northern Region, described on p. 203, as well as over the whole Southern Region. They may, therefore, be said to inhabit all of the Eastern Province.

Macrocyclis concava.
Zonites fuliginosus.
inornatus.
suppressus.
indentatus.
arboreus.
minusculus.
Limax campestris.
Patula alternata.
Helix lineata.
labyrinthica.
hirsuta.
monodon.
palliata.
tridentata.
Helix fallax.
albolabris.
thyroides.
Pupa pentodon.
fallax.
armifera.
contracta.
rupicola.
corticaria.
Vertigo milium.
ovata.
Succinea avara.
obliqua.
Tebennophorus Caroliniensis.
Pallifera dorsalis.

Helix Sayii and *Helix dentifera* have spread into New England only from the Interior Region. They have not been found in more southern latitudes on the Atlantic slopes of the Appalachian chain, nor in the Southern Region.

The geographical range of these species is very great, forming one of the most striking features of the North American fauna. Still more widely distributed are those minute species which have been mentioned above as spreading southwardly from the Northern Region equally on both sides of the Sierra Nevada and Rocky Mountains. These species may be said to inhabit the whole continent of North America as far south as Mexico. The range of some is still greater. Thus, *Zonites minusculus* has been found from British Columbia to Labrador on the north to Yucatan and Florida on the south, and still farther in Cuba, Jamaica, Porto Rico, and Bermuda. *Helix labyrinthica* also is found over all Eastern North America, and perhaps in Mexico (as *H. Strebeli*, see Fischer and Crosse, Moll. Mex. et Guat., 267). It is also by some considered identical with an Eocene fossil of France and England. (See Land and Freshw. Shells N. A., I. 84.) *Zonites arboreus* ranges from Labrador to New Mexico, and in Nevada and California, and from British Columbia to Florida, Cuba, and Guadaloupe. *Vertigo ovata* is found from Maine to Mexico and in Cuba.

The character of the soil and climate, with, perhaps, the gradual elevation, is such as to render the land shells rare, if not quite extinct, before the Rocky Mountains are reached, the western boundary of the Interior Region. But one species, *Patula solitaria*, seems to have passed this mountain-barrier into the Central Province. This is found with *P. Cooperi* in Montana and Idaho, very difficult to distinguish from forms of the last species. It is, however, oviparous (from Salmon River, Idaho), while *P. strigosa*, *Cooperi*, *Hemphilli*, and *Idahoensis* are viviparous. It has been suggested by Dr. H. Dohrn that this characteristic is connected with the fact of the great dryness of the soil in the Central Province. The young shell is ready to protect itself from the moment of its birth, while, if deposited as an egg by the parent, it might perish from drought.

The following list contains the names of all the species inhabiting the Interior Region, including those which have spread into it from the Northern Region: —

Macrocyclis concava.
Zonites fuliginosus.
friabilis.
lævigatus.
ligerus.
intertextus.
inornatus.
nitidus.
arboreus.
viridulus.
Zonites indentatus.
limatulus.
minusculus.
fulvus.
gularis.
suppressus.
internus.
Limax campestris.
Patula solitaria.
alternata.

Patula perspectiva.
striatella.
Helix lineata.
labyrinthica.
Dorfeuilliana.
leporina.
auriformis.
stenotrema.
hirsuta.
monodon.
palliata.
obstricta.
appressa.
inflecta.
tridentata.
fallax.
albolabris.
multilineata.
Pennsylvanica.
Mitchelliana.
elevata.
exoleta.
dentifera.
thyroides.
clausa.
Helix profunda.
Sayii.
harpa.
pulchella.
Pupa muscorum.
pentodon.
fallax.
armifera.
contracta.
rupicola.
corticaria.
Vertigo milium.
ovata.
Succinea retusa.
Grosvenori.
Mooresiana.
ovalis.
lineata.
avara.
aurea.
obliqua.
Totteniana.
Tebennophorus Caroliniensis.
Pallifera dorsalis.

The above list shows the Interior Region to be remarkable for the development of the section of *Zonites* familiar by the European *Z. olivetorum* (*Mesomphix* of Alb. ed. 2). In the genus *Helix* the section or subgenus *Mesodon* is most developed. This is almost exclusively a North American subgenus, as is also *Triodopsis*, which is also greatly developed in the Interior Region.

In addition to the species included in the above list as inhabiting all of the Interior Region, there is a large group of species found within its limits, but having a more restricted range. They are found in what may be called the Cumberland Sub-Region. This is comprised in the southern portion of the Appalachian chain, situated in Eastern Tennessee and the adjoining counties of North Carolina, with an offshoot into the mountains of West Virginia.*

* For a description of its physical and climatic characters, see Dr. A. Binney, Terr. Moll. U. S., I. 122. It is there designated as the Southern Interior Section, and is given a wider western range.

The following species are peculiar to this Sub-Region: —

Zonites kopnodes.	Helix spinosa.
subplanus.	labrosa.
sculptilis.	Edgariana.
Elliotti.	Edvardsi.
demissus.	barbigera.
capsella.	maxillata.
lasmodon.	Rugeli.
Patula Cumberlandiana.	introferens.
tenuistriata. ?	Clarki.
Helix fastigans.	Christyi.
Troostiana.	Wheatleyi.
Hazardi.	Downieana.

Of these, several have spread beyond the limits given above for the Sub-Region. Thus, *Zonites lasmodon* and *Helix spinosa* have been found in Northern Alabama. *Helix Hazardi* has also spread into Northern Alabama, and equally into Georgia and Kentucky. *Helix labrosa* and *Helix Edgariana* in Alabama, and in one case have been collected in Arkansas. *Helix barbigera*, *Helix maxillata*, and *Zonites kopnodes* have found their way into Alabama and Georgia; *Helix Clarki* into Georgia. *Zonites subplanus* has been found even in Pennsylvania, having, no doubt, crept along the mountain chain; but no other of the species of the Cumberland Sub-Region has been found as far north, excepting *Z. demissus*. This last-named species is found in a highly developed state in Eastern Tennessee, and has extended into Western Pennsylvania, North Carolina, Georgia, Alabama (near Mobile), and Arkansas in a much dwarfed condition.

If to the twenty-four species catalogued above as peculiar to the Sub-Region are added the sixty-six species which inhabit it as a portion of the Interior Region (see p. 209), it will be seen that in the Cumberland Sub-Region we find the largest number of species of any other portion of North America. The Sub-Region is equally prolific in individuals, and the individuals are highly developed. These facts are partially explained by the nature of the country. Low mountains, thickly shaded, well watered, and with a genial climate and proper soil, offer in their thickets and ravines innumerable safe breeding-grounds for the land shells.*

* See A. Binney, Terr. Moll. U. S., I. pp. 122, 123. Being less adapted for cultivation than the balance of Eastern North America, we may hope for the preservation

There seems also to be in this Sub-Region conditions peculiarly conducive to testaceous variation. Six (or twenty-five per cent) of its peculiar species are carinated, and here also the following species of the Interior Region show the same tendency to carination, — *Zonites ligerus, intertextus, Patula alternata, Helix appressa* and *palliata.* Here, also, we first notice the variation of *Patula alternata* towards heavy ribs upon its shell; which is still more apparent as the species extends towards the southwest.*

The Cumberland Sub-Region is peculiar for the development of *Zonites*, and in the genus *Helix* for the development of the section or subgenus *Stenotrema*, almost peculiar to these narrow limits.

(*c.*) The Southern Region comprises the peninsula of Florida, with the adjacent islands, together with the alluvial regions of the Atlantic and Gulf coasts. It includes, therefore, the eastern portion of North Carolina, South Carolina, Georgia, all of Florida, the southern part of Alabama, Mississippi, Louisiana, extending into Texas.† Its boundaries, however, are but imperfectly known, and probably not accurately defined. Many of the species from the Interior Region and Cumberland Sub-Region have spread into its northern portion, and the following have extended over the larger portion of it: —

Macrocyclis concava.
Zonites fuliginosus.
inornatus.
suppressus.
indentatus.
arboreus.
minusculus.
Limax campestris.
Patula alternata.
Helix lineata.
labyrinthica.
hirsuta.
monodon.
palliata.
tridentata.
Helix fallax.
albolabris.
thyroides.
Pupa pentodon.
fallax.
armifera.
contracta.
rupicola.
corticaria.
Vertigo milium.
ovata.
Succinea avara.
obliqua.
Tebennophorus Caroliniensis.
Pallifera dorsalis.

of our land shells in this Region, while they decrease rapidly before the advance of civilization elsewhere. See *Ibid.*, pp. 132, 133.

* This heavily ribbed form was common in Post-pleiocene days.

† See A. Binney, Terr. Moll. U. S., I. 120, for a description of the Region.

Equally wide over the Region has been the distribution of those minute species whose origin has been traced to circumpolar regions (see p. 205). Such are: *Zonites viridulus*, *fulvus*, and *Helix pulchella*.

In addition to these species derived from the north, are found the following species peculiar to the Region, whose origin can be traced to the south, in the peninsula of Florida, from whence, indeed, many of them have not yet spread over the whole Region: —

Glandina truncata.
Zonites cerinoideus.
Helix auriculata.
uvulifera.
Postelliana.
espiloca.
avara.
cereolus.
septemvolva.
Carpenteriana.
Febigeri.
pustula.
pustuloides.
Helix Hopetonensis.
major.
jejuna.
Bulimulus Floridanus.
Dormani.
dealbatus.
Cylindrella jejuna.
Pupa variolosa.
modica.
Succinea effusa.
campestris.
Wilsoni.
Veronicella Floridana.

Of the more widely spread species, *Helix septemvolva* is represented by various forms over the whole southern littoral region, both of the Atlantic and Gulf. So is *Glandina truncata*, *Helix jejuna*, *pustula*, *pustuloides*, and *Pupa modica*. *Helix Hopetonensis* and *major* extend only along the Atlantic alluvial Region. *Bulimulus dealbatus* is also distributed over the whole Region, from North Carolina to Texas, and has spread northward to Arkansas and Kentucky. *Succinea campestris* extends along the Atlantic coast as far as South Carolina, as does also *Zonites cerinoideus*, even into North Carolina. *Helix espiloca* and *Postelliana* have been noticed thus far in the southeastern corner of Georgia. The former also at New Orleans and Indianola. *Succinea Wilsoni*, at Darien, Ga.

The following European species have been introduced by commerce into this Region, and still exist at the points named: *Stenogyra decollata*, Lin., and *Helix aspersa*, Müll., at Charleston, S. C.; *Acicula acicula*, Müll., Florida.

From the list of species peculiar to the Southern Region it will be seen that the prevailing form is *Polygyra*, a group or subgenus peculiarly American, represented in the Interior Region indeed, but meeting its greatest development here. The presence of *Glandina* and *Veronicella* shows, also, the more southern character of land-shell fauna. But the Region, and especially that portion of it from whence the fauna was distributed, i. e. the southern extremity of Florida, is still more peculiar in showing the connection between the land shells of the continent of North America and those of the West India Islands and the Spanish Main. Of the species given above (p. 213), *Cylindrella jejuna* was, perhaps, introduced from Cuba, and *Bulimulus Dormani* may prove identical with *B. maculatus*, Lea. of Carthagena. The following species have evidently been introduced* from the West India fauna: — †

Zonites Gundlachi, Cuba, etc.	**Bulimulus Marielinus**, Cuba.
Patula vortex, Cuba, etc.	**Strophia incana**, Cuba.
Helix varians, New Providence.	**Stenogyra subula**, Cuba, etc.
Cylindrella Poeyana, Cuba.	**gracillima**, Cuba, etc.
Macroceramus Kieneri, Cuba.	**Liguus fasciatus**, Cuba.
Gossei, Cuba.	**Orthalicus undatus**, Cuba.

From Yucatan one species has been introduced, *Helix oppilata*. *Orthalicus zebra*, found in several of the Florida keys, is, no doubt, of foreign origin, though from what point introduced it is difficult to say. It has been found in Mexico in the Sierra Madre, and in Maranhon. *Bulimulus multilineatus* was introduced ‡ from the continent of South America, where it has been found at St. Martha, N. Granada, and at Maracaibo and Pto. Cabello in Venezuela.

Florida has not only received several of its species from the West Indies, but also from its southern extremity it has contributed in return to the fauna of those islands. From hence, no doubt, *Zonites arboreus* has passed into Cuba and Guadaloupe; *Zonites minusculus* to Cuba, Jamaica, Porto Rico, (Bermuda?) *Pupa fallax* to Cuba; *Vertigo ovata* to Cuba; *Zonites indentatus* to San Domingo?

* Either by oceanic currents since the formation of the peninsula of Florida, or else from some island of the West India group, now enclosed in the peninsula. It is interesting in this connection to refer to the discovery, by Mr. Conrad, of a Tertiary fossil at Tampa Bay, *Bulimus Floridanus*, Conr. See also below, p. 217.

† Also several non-pulmonate species, as *Helicina subglobulosa*, Cuba; *Ctenopoma rugulosum*, Cuba; *Chondropoma dentatum*, Cuba.

‡ See note † to p. 216.

From the various sources indicated above the southern extremity of Florida has become inhabited by about seventy species of land shells, a number small in comparison with those found in the Cumberland Sub-Region (see p. 211), but large when compared with those found in the great Interior Region.

In addition to those species apparently originating in the peninsula of Florida and thence spreading over the whole Southern Region, there is found within its limits a number of species confined to its southwestern portion. These seem restricted to the southern part of Texas, which may be considered an offshoot of the Mexican fauna as shown by the presence of the genera characteristic of that country, such as *Holospira*, *Bulimulus*, and *Glandina*. Within the region, however, are many species peculiar to it, but belonging to the subgenera characteristic of North America, such as *Polygyra* and *Mesodon*. It seems, therefore, best to consider Texas as belonging equally to the fauna of North America and of Mexico, being the point where the two overlap. As the limits of the region are ill defined, several species extralimital to the State of Texas are included in the following catalogue of the Texan Region: —

Glandina Vanuxemensis.
decussata.
parallela.
bullata.
Texasiana.
Zonites significans.
caducus.
Patula incrustata.
Helix Hubbardi.
ventrosula.
Hindsi.
Texasiana.
triodontoides.
Mooreana.
tholus.
hippocrepis.
Jacksoni.
Ariadne.
Helix vultuosa.
divesta.
Roemeri.
Berlandieriana.
griseola.
Bulimulus patriarcha.
alternatus.
Schiedeanus.
Macroceramus Gossei.
Holospira Goldfussi.
Roemeri.
Stenogyra octonoides.
Pupa pellucida.
Succinea Haleana.
concordialis.
luteola.
Salleana.

Of the above *Helix Jacksoni* and *Zonites significans* are included with great hesitation. They are found at Fort Gibson, in Indian Territory.* They are more related to the fauna of the Cumberland Sub-Region than that of Texas.

Besides the species characteristic of the North American fauna which Texas has as a portion of the Southern Region of the great Eastern Province, we find in the above list two species peculiar to it of the characteristic American subgenus *Mesodon*, *Helix Roemeri* and *H. divesta*.†

Several species on the list have been introduced from other regions,‡ such as *Helix Hubbardi*,§ a Jamaica species, as well as *Macroceramus Gossei*, a Cuban species, which is also found on the Florida Keys. *Patula incrustata* from Cuba, as well as *Pupa pellucida* and *Stenogyra octonoides*.

Of the remaining species on the list, sixteen have actually been found in Mexico; probably all will be, as there seems no well-defined boundary here between the North American and Mexican fauna.

Bulimulus serperastrus, Say, although actually found in Texas, is evidently a member of the Mexican fauna, and is therefore omitted from my list.

The characteristic of Texas appears to be the great preponderance of the subgenus *Polygyra*, of the type of *H. Texasiana*, while the type of Florida, the *septemvolva*, is quite wanting. The great abundance of individuals is also remarkable, showing the Region to be peculiarly adapted to pulmonate life. In the number of its species, also, the Texas Region is favored; by adding to the above list of peculiar species those which it has in common with all of the Eastern Province, and also those of the Southern Region, we find a total of seventy species, the same number as found in Florida.

* A. Binney, Terr. Moll., I. 122, gives the limits of the corresponding "Southern Interior Section" such as would include these species. Several of the species of East Tennessee, also, have been found in Arkansas, — a fact also favoring a wider limit to the Cumberland Sub-Region.

† This species has not actually been found within the limits of the State of Texas, but in the neighboring State of Arkansas and in Mississippi. To it may be applied the remarks on *Zonites significans* and *Helix Jacksoni* on p. 215.

‡ Either by commerce, by oceanic currents, or from some former molluscous fauna of which these now isolated localities were offshoots.

§ Since the above was written, this species has been found by Dr. Newcomb near Savannah, Ga. It may therefore prove a widely distributed American species. In Jamaica it is known as *H. Vendryesiana*, Gloyne.

On the accompanying map the Pacific Province is colored pink, the Central Province* blue; the Eastern Province (of which the northern portions are not shown) is uncolored. The subdivisions, or regions, of the Eastern Province are also indicated by colored lines. The red line marks the division between the Northern and Interior Regions. From this line the last-named region extends (its Sub-Region of the Cumberland shown by green lines) to the brown and yellow lines, which, taken together, mark the northern boundary of the Southern Region, the yellow separately indicating the Texan Sub-Region, the brown the Floridan Sub-Region.

In the above pages I have simply stated the facts now known regarding the actual distribution of our land shells, scarcely attempting to explain it. I will here venture to make a few suggestions on this subject.

Even at the present stage of our knowledge, we are justified in believing that North America has received a group of small species from the circumpolar regions. These species are common to the three continents, Europe, Asia, and America. A great duration of time has been required to effect their wide distribution over the continent, even into Mexico. I believe, therefore, that they are no recent acquisition to our fauna. They may even antedate the creation of our strictly American species.†

Again, in the Southern Region we have evidence of immigration from other faunas; Florida possessing West Indian and South American species, Texas many from Mexico. We have, however, at the same time, equal evidence of a distinct creation for a large portion of the fauna of our Southern Region, so peculiar is it to the region.

By a distinct creation only can I account for the origin of our peculiarly American fauna of the Eastern Province. I have traced it to

* On the map the dividing line between the Central and Eastern Provinces is carried more easterly, above Lat. 40°, than described in the text. This is done on account of the Central Province overlapping the Eastern at this point, as indicated by the distribution of *Patula strigosa*.

† Of these minute species common to the three continents, I find two at least, *Helix pulchella* and *Cionella subcylindrica*, giving somewhat similar proof of great antiquity by their distribution in Europe and Asia, and especially by their presence in Madeira.

Post-pleiocene times,* since when scarcely any change has occurred in the fauna.

Of the origin of the fauna of the Central Province, little can be said with our present knowledge. The same applies to the Pacific Province, though the peculiarity of its species surely indicates a distinct creation of its fauna.

Finally, we have in the list of American land shells several species, purely local in their distribution, imported through the more or less direct agency of man. Of these, *Helix aspersa* was no doubt introduced as an article of food by foreign residents of Charleston, S. C., and seems to have established a hold there.† *Zonites cellarius* was introduced by foreign shipping, probably around water-casks. It is also well known to have been introduced into other countries. The *Limaces* are found around human habitations; they seem to follow the English to all their colonies. The other foreign species mentioned on pp. 205, 213 have probably been introduced around the roots of plants, as have been other species which are from time to time sent me from greenhouses, gardens, etc. They are only local except *Helix hortensis*, which may have been accidentally introduced in some other manner,

* I suggested on p. 206 that the region of Ohio and Indiana was the point from whence the fauna was distributed. Another theory might suggest that the Cumberland Sub-Region was the point of origin of all the species, those still restricted to that sub-region not being adapted to the wider distribution which the other species have obtained. Any one familiar with the habits of snails is well aware how much they differ in this respect. Some are much more disposed to migrate than others. Thus, *Helix appressa* is content to remain within a radius of a few feet under a decaying log. *Helix thyroidus* is more restless, travels much, and climbs trees. *Helix nemoralis* has no local attachments, migrating far and wide. These facts I have verified in my own garden during many years. The *H. Nappressa* spoken of are descendants of Illinois specimens given me fifteen years ago by the lamented Kennicott.

† I have been asked what authority I have for this opinion, so think it worthy of statement that Charleston specimens belonging to the cabinet of the late General Totten still retain a strong odor of the garlic which seasoned them for the foreign palate. I have myself had specimens given me by French residents of the town where I reside, who had bought them as food in Philadelphia. The species has also been imported into Havana, Rio Janeiro, St. Iago, Chili, and other ports as an article of food. I received living specimens from a garden in Charleston, S. C., within the last twelve years, and in 1871, Professor Featherman sent me specimens from Baton Rouge.

since the discovery of America by Europeans, and owe its present distribution in the northeast to its being peculiarly adapted to colonization. I have elsewhere related my successful attempt to colonize the allied *H. nemoralis.**

BURLINGTON, N. J., June, 1873.

* Before closing I will continue the note to p. 202, which suggests some of the changes which would be caused in the pulmonate fauna of Eastern North America by a subsidence in the continent of eight hundred feet. In the Southern Region the change would be still greater. All the species peculiar to it, catalogued on p. 213, would perish, excepting *Bulimulus alternatus*. This species would still be found in Kentucky, restricted to a small area; all record of its former wide distribution being at the same time destroyed.

The West Indian and South American species, catalogued on p. 214, would no longer be found on the North American Continent, nor would any record be preserved of the former connection of the regions. Indeed, no one would then suspect that the tropical genera *Glandina, Veronicella,* and *Cylindrella* had ever been represented on this continent.

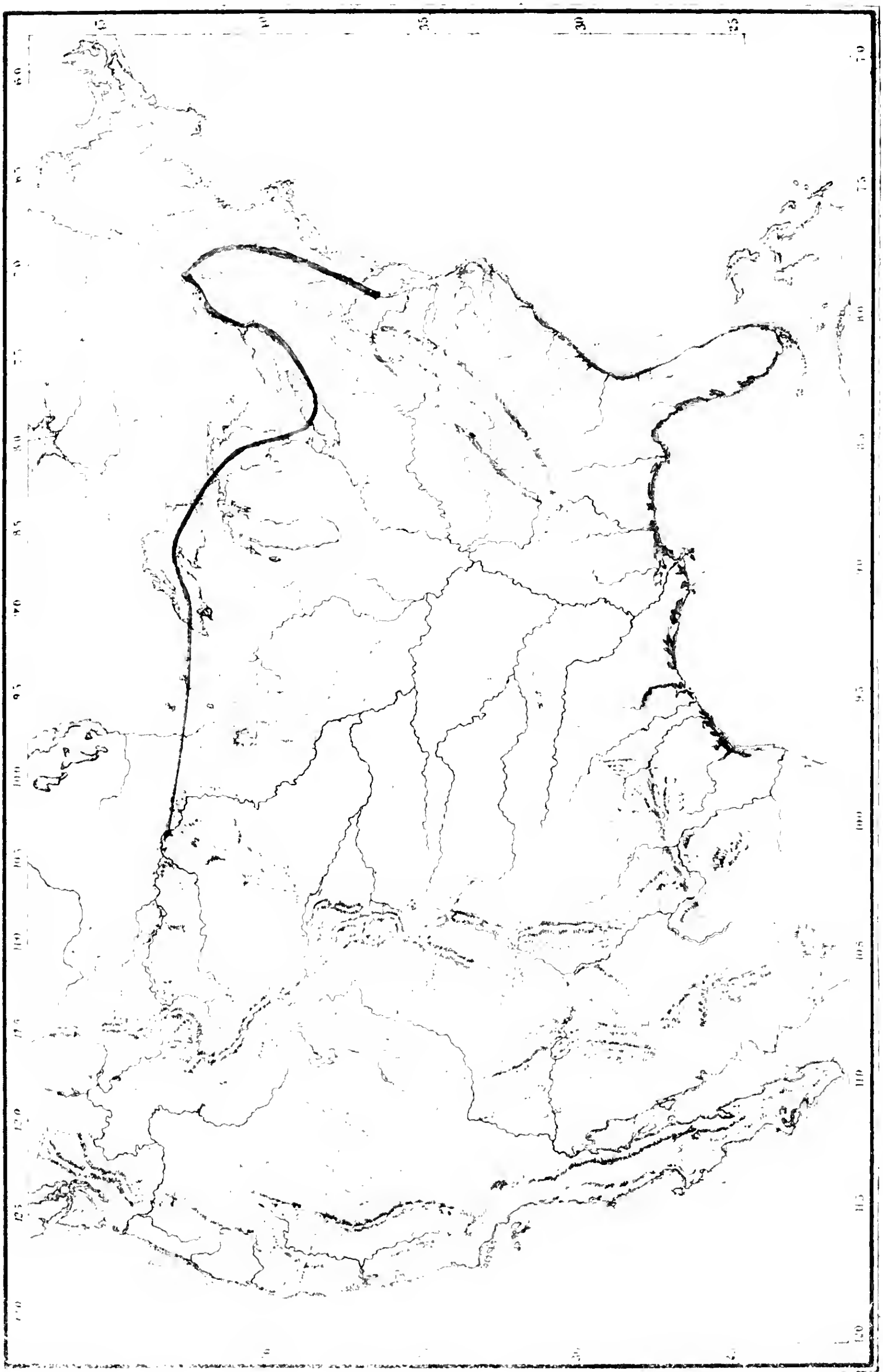
The West India Islands being much more widely separated from North America, the presence among them of the small American species (catalogued on p. 214) would be still more difficult to explain.

Again, the supposed subsidence would destroy most of the species peculiar to the Sub-Region of Texas (see p. 215), and remove the evidence of the present intermingling of the North American and Mexican faunas in that Sub-Region.

Another effect would be to remove from our reach all evidence of the origin of our species in Post-pleiocene days, the fossil deposits in the bluffs being rendered inaccessible. Thus one would not be able to have correct impressions of the origin and distribution of certain species. The non-pulmonate *Helicinæ* give the best instance of this. Finding *Helicina orbiculata* and *occulta* confined to the narrow limits of the Appalachian Island, one would have no reason to suspect their past history has been so much more interesting than that of many of the species of *Stenotrema,* etc., found with them, which never had had a larger distribution. It would be impossible to know that *Helicina orbiculata* and *occulta* flourished greatly in Post-pleiocene times; that later, one of them, *occulta*, became comparatively rare and restricted in range, while *orbiculata* became very numerous in individuals over a vast extent of territory; and finally, that our supposed subsidence gradually restricted them to the Appalachian Island.

This supposition of subsidence might be carried still further, till we should have in certain islands of the Appalachian chain the sole resting-places of the now widely distributed Eastern North American fauna. The more southern of these islands would alone retain the species of the present Cumberland Sub-Region, and thus be much richer in species than the more northern islands. On the other hand, these more northern islands would possess species derived from the present northern regions which would not be found in the southern islands.

Still more instructive is the supposition of a subsidence in Eastern North America which would leave above the level of the sea only two groups of islands formed by the White Mountains of New Hampshire, and Mount Mitchell and Black Mountain of North Carolina. On the latter we may suppose would be preserved all the species given in the lists on pp. 209, 210, 211. Of these species all would be peculiar to the island, except such as are named in the list on p. 208, which would all be found also in the White Mountains, where we should also find the following species peculiar to the islands, *Helix Sayii, dentifera, Vitrina limpida, Zonites milium, Binneyanus, ferreus, exiguus, multidentatus, Patula striatella, asteriscus, Pupa decora, Vertigo Gouldi, Bollesiana, simplex, Succinea Totteniana.* Of the former distribution of these species nothing could be known, but a former connection of the two groups of islands would be surely indicated by the presence of so large a proportion of species common to each. A former connection of the two groups of islands with Europe and Asia would be as surely indicated by the presence on each of *Zonites fulvus, nitidus, viridulus, Helix harpa, pulchella, Cionella subcylindrica,* and *Pupa muscorum.* Nor could it escape the attention of conchologists that these and other small species, *Z. arboreus,* &c. (see p. 204, note,) proved that a former connection must have existed between these groups of islands and the far-off Central and Pacific Provinces.



No. 10. — *Ophiuridæ and Astrophytidæ, Old and New.* By Theodore Lyman.

Ophiopeza Peters.

Ophiopeza fallax *Pet.* is well distinguished from *O. Yoldii* Ltk., as I satisfied myself by examination of the originals at Berlin and Copenhagen. Two specimens of the same size differed as follows: *O. fallax:* diameter of disk 9 mm.; grains on disk, 26 in a mm. long; eighteen mouth-papillæ to each angle; eight nearly equal, crowded arm-spines. *O. Yoldii:* diameter of disk, 9 mm.; grains on disk, 13 in a mm. long; five spaced arm-spines, the middle one longest. *Ophiopeza* does not differ from *Pectinura* Fbs., except in having small supplementary mouth-shields, and *O. fallax* even has such pieces as an occasional accident.

Pectinura Forbes.

Lütken (Addit. ad Hist. Oph., III. pp. 31 and 105) correctly separated from *Ophiarachna* Mull. and Tr. those species which had spines arranged along the outer edge of the side arm-plates, and placed them with *Pectinura* (Forbes, Linn. Trans., XIX. 143). The original *P. vestita* of Forbes is only known by the figure (Pl. XIII., Figs. 1 – 7), which is apparently that of a young animal. In *Ophiarachna* only two species are left, *O. incrassata*, the largest known Ophiuran, having four arm-spines, and pores between the under arm-plates nearly to the tip of the arm; and *O. affinis*, with six arm-spines and pores only between the first and second under arm-plates. With *Pectinura* should be included *Ophiopezella* Ljn. and *Ophiochasma* Grube, which are only extreme forms of this genus. Its species may then be tabulated as follows: —

Disk covered, under its granulation, with coarse scales, or swollen plates.	No pores between under arm-plates.	Radial shields, granulated, 13 – 15 arm-spines		*P. spinosa* Lym.
		Radial shields naked; also some other disk-plates; 9 arm-spines.		*P. infernalis* Ltk.
	Pores betwen first and second under arm-plates.	Arms cylindrical at their insertion in the disk, which is puffed.		*P. gorgonia* Ltk.
		Arms widened at their insertion in the disk, which is flat.	10–11 arm-spines.	*P. marmorata* Lym.
			5–6 arm-spines.	*P. stellata* Lkt.*

* By comparing the originals I found Grube's *Ophiochasma adspersum* was the *Ophiarachna stellata* of Ljungman.

Disk, under its granulation, covered with minute and smooth scales.	10 thin equal arm-spines; under arm-plates encroached on by side arm-plates.	. . . .	*P. vestita* Fbs.
	Pores only between first and second under arm-plates.	. . . .	*P. maculata* Vll.
	Pores between the under arm-plates continued for some distance along the arm.	7–8 conical arm-spines, the lowest one a little the longest	*P. septemspinosa* Ltk.
		8–9 flat, pointed arm-spines; the lowest one very long and flat, often equal to two joints in length.	*P. rigida* Lym.*

Pectinura (*Ophiarachna M. T.*) **infernalis.** The original at Leyden is lost: but among the unsorted specimens of the Museum Godeffroy at Hamburg I found a specimen from near Sumatra. It was unmistakable, and is figured, Plate VII., Fig 1. I found another specimen from the Philippines, by Semper.

Pectinura septemspinosa. The original of Müller and Troschel from the Moluccas is yet at Leyden, and remains unique. Diameter of disk 25 mm. Arms stiff, thick, cylindrical. Disk closely and evenly granulated, with a *smooth* surface not indicating the scales below; six grains in a mm. long. Radial shields small, oval, brown and very distinct. Usually seven arm-spines, but, on the inner joints, eight; they are conical, not so long as a side arm-plate; the lowest one a little the longest, and having its base covered by one of the tentacle-scales. The under arm-plates within the disk have pores between them. Supplementary mouth-shield small. Color, yellow-brown. On Plate VI., Figs. 10–13, are shown the peculiar broken upper arm-plates of this species; an angle of the mouth; and a row of arm-spines.

Pectinura marmorata sp. nov.

Plate V., Figs. 1–7.

Special Marks. — Pores only between the first and second under arm-plates. Arms somewhat widened at their insertion in the disk. Eleven arm-spines.

Description of a Specimen. — Diameter of disk 20 mm. Length of arm about 105 mm. Width of arm at disk 4.7 mm. Height of the same 4.7 mm. Fourteen small, close-set, tooth-like mouth-papillæ to each mouth-angle, of

* Mr. F. W. Hutton (Catalogue of the Echinodermata of New Zealand, 1872) has described an *Ophiura* (*Ophiarachna* ?) *cylindrica*. It is earnestly to be desired that general zoölogists, who have not large collections for comparison, should abstain from describing species. For such persons, thus situated, to give useful diagnoses is simply *impossible*. They only add to the confusion already existing. Zoölogy, so far as concerns genera and species, has now passed into the hands of specialists; and they alone can treat such subjects.

which the outermost one is widest. Outside this, and continuous in the row, is a long papilla which stretches upward into the mouth-slit, and embraces the second mouth-tentacle; its base rests on the side mouth-shield and on the first under arm-plate. This same piece is seen in other genera, *Ophiocoma*, *Ophiura*, etc., and is usually reckoned among the true mouth-papillæ. In *Ophioglypha* it takes on a great development, and is the piece which carries the scales of the mouth-tentacle, and which gives the forked look to the mouth-slit. In the species under consideration it may carry a sort of lobe or articulated scale. Five short, flat, rounded teeth, the uppermost one a little longer and sharper. Mouth-shields rounded heart-shape; rather wider than long, standing close to the mouth-papillæ; length to breadth 2.5 : 3. Supplementary mouth-shields semicircular and about half the size of the mouth-shields. Side mouth-shields very small and wedged between the first under arm-plate and the mouth-shield. Under arm-plates strongly overlapping, bounded without by a broken curve and by a re-entering curve within; length to breadth, within disk, .6 : .8. The first plate has a broad diamond shape, and, between it and the second, are two large pores. The side arm-plates cover nearly one half the height of the arm at its base, the rest being occupied by the upper arm-plates, which there are considerably arched, have a wavy outer side, and a length to breadth as .6 : 3. A little farther out, the upper arm-plates are lower and less arched. Disk flat and round, but embracing the base of each arm by a forked projection. With the exception of the radial shields and shields of the mouth, it is closely granulated; about eight grains in the length of a mm. This granulation is, however, easily rubbed off, and then the coarse swollen scales of the disk may be seen; among which there are along the edge of the disk, in each interbrachial space, about six imbricated plates, making a close row between outer ends of the radial shields, which are large and conspicuous, oval in shape, and having a length to breadth of 4 : 2. Arm-spines near disk, ten or eleven, small, slightly tapering, somewhat flattened, a little rounded, about two thirds of the length of a side arm-plate; the lowest one scarcely longer than the rest. Two flat, oval tentacle-scales; the one which lies at the base of the lowest arm-spine is smaller, as usual, but has its end rounded and not cut square off.

Color, in alcohol, light yellowish brown above, with lines and patches of darker, and with darker specks on the upper arm-plates; below, the under arm-plates and mouth-region are white.

This species, by its conspicuous radial shields and its arms widened next the disk, stands near *P. stellata*, from which it is easily distinguished by more numerous arm-spines and differently shaped under arm-plates.

C. Semper; Philippines.

Pectinura rigida sp. nov.

Special Marks. — Very large, with cylindrical arms; disk closely granulated and smooth. Very small sunken radial shields; pores between under arm-plates far out on arm. Nine or ten much flattened arm-spines, the lowest one much the longest and largest.

Description of a Specimen.—Diameter of disk 36 mm. Length of arm 175 mm. Width of arm near disk 5.5 mm.; height 6 mm. Ten flat, close-set, rough-edged mouth-papillæ to each mouth-angle, of which the two under the teeth are a little higher than the rest. There is also a small additional papilla, nearly covered by the outermost mouth-papilla, which stretches upward and embraces the second mouth-tentacle. Six short, broad, flat teeth with a curved cutting edge; the lowest one often split in two. Under arm-plates, within the disk broader than long, bounded without by a curve, and within and on the sides by re-entering curves; length to breadth 1.8 : 2.8. Farther out on the arm they are as broad as long, with rounded corners, and they everywhere are thick and even swollen, and have pores between them, nearly to the end of the arm. Side arm-plates flat, and occupying nearly the whole height of arm. Upper arm-plates regular, not broken, and with a wavy outer margin; they occupy most of the upper surface; length to breadth 2 : 4. Mouth-shields large and lying close to the mouth-papillæ, roundish with a small point within, and a re-entering curve without; length to breadth 4 : 4.5. Supplementary mouth-shields small, roundish, about 2 mm. in length and width. Side mouth-shields minute and wedged between the first under arm-plate and the mouth-shield. Disk, except small sunken radial shields about 2 mm. long, and the shields of the mouth, closely and smoothly granulated with about eight grains to 1 mm. long. The underlying scale-coat is of delicate, smooth scales, not more than .4 mm. wide, and difficult to distinguish. Arm-spines nine or ten, much flattened, about three fourths the length of the side arm-plate, except the lowest, which is much stouter, and whose length equals two under arm-plates. The upper spines are somewhat shorter and notably wider than the lower, and all taper to a blunt point. Two tentacle-scales, of a rounded oval shape; the one which covers the base of the lowest arm-spine often larger than the other.

Color, in alcohol, purplish brown, with black radial shields.

Variations. — Another specimen, of about the same size, had the lowest arm-spine even longer, and often with a thickened end.

This species stands nearest to *P. septemspinosa*, from which it is distinguished by more numerous and more flattened arm-spines, and by the great length of the lowest one.

Zanzibar; Mr. Cooke.

Ophiocoma brevipes Peters, **insularia** Lym., and **ternispina** v. Mart.

I have examined great numbers of these, especially in the Museum Godeffroy and the Museum of Comparative Zoölogy, and do confess myself much puzzled. They all agree in being completely and closely granulated, above and below, and in having very regular, cleanly cut arm-plates. The variation in color is from dark brown, through gray, and reticulated in patterns, to pure white. It would seem that *O. brevipes* (originals at Berlin) has five spines on the first eight joints, and then four, and that the upper are the *longest*. *O. insularia* has four spines at the base of the arm, and the upper are the *shortest;* the disk granulation is coarser, only six or seven in the length of a mm. *O. ternispina* has but three spines, which are tapering, cylindrical, and often bent. A number of specimens, supposed to be *O. brevipes*, from the Philippines, had only four arm-spines at the base of the arm; there were from nine to twelve grains in the length of a mm. On present evidence it will not do to bring these three under one head. As to *O. squamata* M. T. the original at Paris is lost, and nobody can now tell what it was, though it might have been *O. brevipes.*

Ophiocoma alternans (von Martens, Oph. Ind. Oc., p. 251). I found, by the Berlin original, that this is only the young of some species, probably *O. scolopendrina.*

Ophiarthrum pictum.

Ophiocoma picta Mull. and Trosch., Syst. der Asteriden.

Plate VII., Figs. 2-4.

Special Marks. — Disk ornamented with meandrine brown lines; a dark line along the upper arm. Three ringed arm-spines, the upper one longest.

Description of an Individual. — Diameter of disk 15 mm. Width of arm without spines 3 mm. Distance from outer side of mouth-shield to inner points of mouth-papillæ to that between outer corners of mouth-slits, 3 : 4. Mouth-papillæ four (rarely three) on each side, the outer one tapering and pointed; the next wider than long and rounded; the two innermost as broad as long, and bead-like. Tooth-papillæ (including as such all those under the teeth) fifteen to seventeen, of nearly equal size, bead-like; arranged in two outer vertical rows of four or five each, with a more irregular central row, and two or three odd papillæ below. Teeth four, upper one largest and broadest; all stout and thick, with rounded corners and a straight cutting edge. Mouth-shields nearly round, faintly pointed within; length to breadth 2 : 2. Side mouth-shields thick, nearly joining their neighbor of the next mouth-shield; within, running to a point, but not meeting. Under arm-plates about as broad as long, clearly defined and regular, with outer side slightly curved and lateral sides re-enteringly curved; length to breadth

(4th plate) 1.4 : 1.4. The first plate is minute, being nearly crowded out by the side mouth-shields. Side arm-plates forming only a small ridge for the arm-spines. Upper arm-plates hexagonal, with the outer and inner sides shorter than the others; length to breadth 1.4 : 2. Skin of disk quite smooth, above and below. Arm-spines three, cylindrical, stout, gently tapering, blunt; lengths to that of upper arm-plate (7th joint) 5, 3, 2.7 : 1.4. They are essentially smooth, although, under the microscope, the points look minutely thorny. One large tentacle-scale, longer than broad, and flat. Ground-color of disk and upper arms purplish brown. Disk, above and below, ornamented with patterns in dark brown lines. Above, there are straight lines from arms to centre, and, in interbrachial spaces, above and below, meandrine patterns, which are filled with white, yellowish, or purplish brown. A dark stripe along upper arm; arm-spines with three to five dark rings.

The original specimen of Müller and Troschel at Leyden, brought from Java by Kuhl and Van Hasselt, remained for a long time a unique specimen. Within a few years the Leyden Museum has obtained others from islands near New Guinea, and Professor Semper also got very fine ones from the Philippines and the Pelews. This species, by its well-marked upper arm-plates and regular arm-spines, approaches nearer than *O. elegans* to the genus *Ophiocoma*, from which it differs only by its naked disk.

Ophiomastix flaccida sp. nov.

Plate VI., Figs. 14, 15.

Special Marks. — No tentacle-scales. Disk smooth, except a few short spines above. Upper and side arm-plates obscured by thick skin.

Description of an Individual. — Diameter of disk 15 mm. Length of arm 100 mm. Width of arm 3 mm. Height of arm 2 mm. Distance from outer side of mouth-shield to inner points of tooth-papillae, compared with that between outer corners of mouth-slits, 3 : 2.5. Mouth-papillae four on each side, small and bead-like, except the outer one, which is pointed. Tooth-papillae similar, usually nine, arranged in three regular rows, of which the lowest is on a level with the mouth-papillae. Teeth five or six, the upper ones longest, with a square cutting edge; the lowermost smaller and rounded, or partly split. Mouth-shields small, of a much rounded heart-shape, length to breadth 2 : 1.8. They are close against the outer mouth-papillae, leaving little space for the minute side mouth-shields, which do not meet within, and are obscured by thick skin. Under arm-plates squarish, with rounded corners; length to breadth 1.5 : 1.5. Side arm-plates obscured by thick skin, as also are the upper ones, except in dry specimens, where their form is seen to be rounded hexagonal. Disk wholly covered by smooth skin, sparsely set above with short, slender, rounded spines, about 1.2 mm. long. Arm-spines three; the two lowest slender, rounded, pointed, often bent, and in length about 1.5 mm. On every second or fourth joint, and on alternating sides, the upper spine is much thickened, and has the clove-shape characteristic of the genus; its length is about 2.5 mm. Towards the end of arm there are no such spines, but the upper one is usually the longest and stoutest. No tentacle-scale; the tentacles are rather long and thick and without papillæ. Color, in alcohol, disk dull greenish brown; arms yellowish brown.

Philippines; C. Semper.

Ophioplocus Esmarki sp. nov.

Plate V., Figs. 12-14; Plate VI., Fig. 6.

Special Marks. — Color, in alcohol, uniform dull purplish above, and light brown below. Arms decidedly flattened, having the width to the height 3.5 : 2. Arm-spines not tapering, and of nearly equal length.

Description of a Specimen. — Diameter of disk 16 mm. Length of arm 53 mm. Width of arm 3.5 mm. Distance from outer side of mouth-shield to inner point of teeth to that between outer corners of mouth-slits, 3 : 3.2. Mouth-papillæ five on each side, or rarely six, stout, irregular, or squarish; the two outer ones rest on the side mouth-shield, the others on the mouth-frames. Teeth five or six, the upper ones short, stout, broader than long, with a curved cutting edge; the lowest one smaller, nearly on a level with mouth-papillæ, and resembling them. Mouth-shields heart-shaped, with a curve without and an angle within; length to breadth 1.2 : 1.2. Side mouth-shields long triangular, somewhat swelled, not quite meeting within; length to breadth 1.3 : 1. Under arm-plates broad pentagonal, with the odd angle inward; length to breadth, close to disk, 1 : 1.5. The upper arm-plate is simple only at the tip joint of the arm; at the next joint a longitudinal crease of division appears; at the next the upper arm-plate is completely divided, and there appear two supplementary pieces on the median line, of which the outer one partly separates the two halves of the plate. Farther down the arm the two halves are wedged apart by the supplementary pieces, whose number has increased to six or seven. Close to the disk most of the upper surface is occupied by thirteen supplementary pieces, of which three, of an irregular hexagonal form, lie on the median line. This development of pieces is quite as in *O. imbricatus*. Side arm-plates small, and crowded mostly to the under side of the arm. Scales of disk, above, irregularly imbricated and thickened; the longest 1 mm. long; below they are thinner, finer, and more regular. Along edge of disk run half a dozen larger rounded, swelled scales. Radial shields small, about 2 mm. long. Genital slits 3 mm. long and starting close to mouth-shields. Arm-spines three, nearly of equal lengths, stout, rounded, blunt, and not tapering. Lengths to that of under arm-plate, near disk, .8, .9, 1 : 1. Tentacle-scales two, flat, nearly oval, and placed closely side by side. On outer side of tentacle-pore is a semicircular rim or lip. Color, in alcohol, dull uniform purplish above.

This species is of high interest as the first from the Pacific coast of North America, which represents a genus peculiarly characteristic of the great ocean. *Ohioplocus imbricatus*, described thirty years ago by Müller and Troschel, has been brought in plenty from such diverse localities as Zanzibar, Mauritius, New Caledonia, the Philippines, and the Kingsmill Islands. It long remained the sole representative of a genus which was confined to these faunal limits. *O. Esmarki* differs from it in the precise way in which, on the theory of Agassiz, species should differ within their genus, namely, in the proportion of their parts. It will be therefore proper to briefly note these differences. *O. imbricatus* is a thicker animal; not only is the disk thicker, but the arm is higher, having a width to height of 3.5 : 3, from which it follows that the arm-spines are less crowded, having more room; they also taper more, and the undermost is much the longest, having a length of 1.3 : 1 as compared with the under arm-plate. The scaling of the interbrachial space below is coarser and more uneven, having four or five scales in the length of a mm., while in *O. Esmarki* the smallest number is five or six. The genital slit begins at some distance from the mouth-shield, and is very short, while in *O. Esmarki* it begins close to the mouth-shield, and is longer. The minute lip or rim outside the tentacle-pore is barely to be seen, while in the American species it is conspicuous. These differences are all the more instructive from the fact that *O. imbricatus* is a singularly steady species, and shows none of the variations offered by *Ophiocoma scolopendrina* and *O. erinaceus* in the same fauna. In examining great numbers of individuals from many and distant localities, I have found no essential variations in *O. imbricatus*, except three specimens from Japan and one from Java, in the Leyden Museum, in which the genital opening ran as far as the mouth-shield.

Professor Esmark found numerous specimens at San Diego, California, among stones in shallow water.

Amphiura (*Amphipholis*) **planispina** v. MARTENS (Monatsber. König. Akad., Berlin, 1867, p. 347). This species is originally described, perhaps by a misprint, as having only *one* mouth-papilla on each side, like *Hemipholis*. The originals, however, show three mouth-papillæ on each side. In color it is just like *Ophiophragmus Wurdemani*, which, however, has a marginal fence of jointed scales round the disk, and its innermost mouth-papillæ are thickened, and run upwards towards the teeth.

Amphiura lævis sp. nov.

Plate IV., Figs. 18-21.

Special Marks. — Disk flat and thin, not lobed, covered with small thin scales. Radial shields narrow and closely joined. Eight mouth-papillæ to each angle. A light line along upper side of arm.

Description of an Individual. — Diameter of disk 6.5 mm. The arms (which were broken) were flattened, not very wide (1.2 mm.), gradually tapering, and seemed to have been not less than eight times the diameter of disk. Eight mouth-papillæ to each angle, of which the two outer on either side are scale-like and larger than the others, which are stout and blunt; the outer papilla rests on the side mouth-shield; the others are supported by the mouth-frames. Mouth-shields spear-head shaped; length to breadth .6 : .4. Side mouth-shields long triangular, meeting within, and closely joined to mouth-shields. Under arm-plates wide pentangular, with the odd angle inward; slightly separated by side plates; length to breadth (8th plate) .4 : .6. Side arm-plates meeting below and encroaching above; forming but a slight crest laterally. Upper arm-plates wider than long; bounded by a wide curve within, but nearly straight without; length to breadth (2d plate) .5 : .9.. Disk unusually thin and flat, with a fine line of juncture along its rim, between the scaling of upper and lower surfaces. Scales very thin and fine, without central rosette of primary plates; near edge of disk nine or ten scales in 1 mm. long; half-way to centre, four; and in the interbrachial spaces below, seventeen. Radial shields rather long, narrow, closely joined except at the inner tips, which are separated by three little scales; length to breadth of each 1.2 : .3. Arm-spines three, nearly equal, cylindrical, tapering, rather slender; lengths to that of an upper arm-plate .4, .5, .4 : .5. Tentacle-scales two, wide and thin with a curved free edge; they are set at right angles, one on the side arm-plate, the other on the side of the under arm-plate, beyond which it projects. Color, in alcohol, brown-gray, with a light line along upper arm, and obscurer light cross-lines between joints.

This species approaches nearest to *A. gracillima, subtilis, Januarii*, and *pulchella*, but differs in several respects, especially in having eight mouth-papillæ to each angle.

Philippines; C. Semper.

Ophionephthys phalerata sp. nov.

Plate VI., Figs. 7-9.

Special Marks. — Arm-spine, next the lowest one, much stouter than the rest and with thorns at the end. Disk naked, except a belt of fine scales round each pair of radial shields. No tentacle-scales.

Description of a Specimen. — Diameter of disk 9 mm. Arms very long.

One which was broken near the end was 145 mm. Width of arm 1.3 mm. Distance from outer side of mouth-shield to inner point of mouth-papillæ compared with that between outer corners of mouth-slits 1.4 : 1.4. Mouth-papillæ four to each angle; namely, two large wedge-shaped ones, just under the teeth, and one, small and slender, sitting on each side mouth-shield. Mouth-shields small, broader than long, nearly oval; length to breadth .5 : .7. Side mouth-shields curved and united at their ends so as to form a continuous ring. Under arm-plates broader than long, squarish, with a peak within and a re-entering angle without; length to breadth, within the disk, .4 : .5. Side arm-plates nearly meeting above and making only a slight ridge, on which stand the spines. Upper arm-plates irregular oval, rather small, not covering the upper side of arm; length to breadth .4 : .7. The plates next the disk are narrower and more irregular. Radial shields long and narrow; joined for about half their length, which is to their breadth as 2 : .6. Their free sides are edged with two or three parallel rows of minute scales. The rest of the disk is puffed, deeply wrinkled, and quite naked. Arm-spines on the basal and middle portions of the arm five, of which four are short, cylindrical, and tapering; but the one next the lowest is flattened, much thickened, and thorny at its end. Its length is about .4 mm. No tentacle-scales. Color, in alcohol, brownish gray.

The true *Ophionephthys* of Lütken, which includes but one species as yet (*O. limicola*), has lines of fine scales not only round the radial shields, but thence extending towards the centre of the disk and along its edges; also the mouth-papillæ may be either four or six to each angle of the mouth. I prefer, however, to leave the new species in this genus, because the groups which centre about *Amphiura* are not yet very clearly established.

One specimen from Philippines; C. Semper.

Ophiocnida echinata?

Ophiophragmus echinatus? Ljungman.

Ophiocnida longipeda Lym. M. S.

Plate IV., Figs. 22, 23.

Special Marks.— Upper disk, and a triangular patch in each interbrachial space below, beset with minute sharp spines. Radial shields narrow, wholly separated, naked. Three arm-spines, except close to disk. Four mouth-papillæ on each side. Arms very long.

Description of an Individual.— Diameter of disk 10 mm. Length of arm 200 mm. Width of arm 2.2 mm. Four mouth-papillæ on each side, of which the innermost is bead-like, the two next of about the same size but more flattened, and the outer one smallest and tooth-like. Distance from outer side of mouth-shield to inner point of mouth-papillæ to that between outer corners of mouth-slits 2.2 : 2.2. Mouth-shields oval, with outer end cut off; length to breadth 1.2 : .8. Side mouth-shields broad and thick, widely touching within; they directly join the neighboring side mouth-shields; a continuous ring is thus formed, and the usual rudimentary under arm-plates are not interposed. Under arm-plates squarish with clearly rounded outer corners; length to breadth (2d plate) 1 : .7. Side arm-plates only slightly prominent. Upper arm-plates much broader than long, four-sided, bounded without by a gentle curve, within by a shorter and re-entering curve, and on the sides by straight converging lines; length to breadth (2d plate) .7 : 1.8. Disk flat, but soft and a little wrinkled; pretty evenly beset above with minute, short, tapering spines, the longest about .2 mm.: below, a triangular patch of similar spines. Radial shields long, narrow, pointed within; diverging and completely separated: length to breadth 2.8 : .6. Under the spines, the scaling of the disk is obscurely visible, especially between each pair of radial shields. Arm-spines short, cylindrical, tapering; the lowest usually longest: on the first four or five joints outside disk, usually four; on all beyond, only three: lengths to that of an upper arm-plate .6, .7, .8 : .7. Tentacle-scales two (on first joint only one), small, not over one third as long as an under arm-plate, and disposed at right angles to each other. Color, in alcohol, pale gray. A young one with a disk of 4 mm. had the primary plates in the centre of the disk, naked; and often only three mouth-papillæ on a side.

I deem it best to leave this species under its present name, although it differs from *Ophiophragmus echinatus* Ljn. as follows: *O. longipeda* has no spines on radial shields, which also are wholly separated; mouth-shields oval and not four-sided; four mouth-papillæ on each side: three arm-spines, except on a few first joints. Vide Ljn. Oph. Viven., p. 316.

Philippines; C. Semper.

Ophiopsammium* gen. nov.

Teeth: tooth-papillæ numerous and arranged in a vertical, oval clump, as in *Ophiothrix*. No mouth-papillæ. Disk and arms naked below, but closely granulated above. Arm-spines stout and thorny, mounted on a crest-like side arm-plate, as in *Ophiothrix*. Tentacles long, covered with papillæ, and issuing, not from the under surface, but from the side of the arm.

This genus is nearest *Ophiothela*, but differs in having the whole upper surface closely granulated, as also in the side arm-plates.

* ὄφις, a snake; ψαμμίον, a granule.

Ophiopsammium Semperi sp. nov.

Plate IV., Figs. 11-17.

Special Marks. — Six or seven stumpy arm-spines, of which the lowest is flattened and hooked: two or three little spines on the edge of the disk in the interbrachial space: granulation of upper surface fine and even; finer on the disk.

Description of an Individual. — Diameter of disk 6.5 mm. Length of arm 23 mm. Width of arm, without spines, 1.7 mm. Mouth-shields small, rounded, broader than long, much obscured by being closely soldered with surrounding parts and covered by thick skin. Tooth-papillae about twenty-five, of nearly equal size and length, crowded into a short oval clump. Teeth three: the uppermost longest, the lowest touching the mouth-papillae. Under surface, and part of the sides, of arms, covered by smooth skin, through which may be obscurely seen the outlines of the under arm-plates, which, near base of arm, are wide, short triangles with the apex inward; and, near point of arm, have an angular heart-shape. Side arm-plates covered with thick skin, and forming a well-marked crest, at right angles to the arm, conspicuous from below, but little projecting as seen from above. Upper side of arm densely covered by a granulation, of about fourteen grains in the length of a mm. This granulation descends partly down the side of arm. The terminal joints are naked, with a minute rudimentary upper arm-plate: those which follow have a few scattered grains, and these grow soon into a continuous stratum. Disk, below and on sides, covered with smooth skin; above, with a continuous granulation, finer than that of arms: on edge of disk between the arms, a pair of sharp spines, about .6 mm. long. Genital scales wide, with their outer edge showing on each side of the arm. Arm-spines, near disk, usually seven; short, stout, blunt, minutely thorny, often much swelled at the base; the lowest one flattened and armed on one edge with a double hook, the next one or two also flattened. Length of third and longest spine .8 mm.: length of lowest and shortest .4 mm. At tip of arm, three spines, of which the upper is smallest and pointed; the second pointed or forked; and the third is a sharp double hook. The long tentacles, of an elongated club-shape, issue from the side of the arm just below, and in front of, the middle arm-spine; there is no tentacle-scale. Color, in alcohol, of arms, straw yellow: disk more gray.

A younger specimen had a disk of 4.5 mm., and arms of 16 mm.; there were only six arm-spines.

This singular species has rather flat and little tapering arms, which have a tendency to roll on themselves, as in *Ophiochondrus*.

Philippines; C. Semper.

Ophiomaza cacaotica Lym., and **Ophiocnemis obscura** Ljn., which have been considered as perhaps the same, are, on comparing the originals, quite different. The two specimens of *O. obscura* at Stockholm have the interbrachial spaces on the back of the disk, covered by four or five very irregular radiating lines of elongated scales, covered by a thick skin so as to obliterate their outlines; in the centre, a great number of similar but rounded scales. The upper arm-plates are as wide at the base of the arm as beyond, and there is scarcely any notch in the margin above the arm. The specimen at Copenhagen, which Dr. Lütken took to be *O. obscura* (Addit. ad Hist. Oph. 40), is really *O. cacaotica*, which has in each interbrachial space above, only one, or at most two, radiating rows of plates, which are naked, swollen, and clearly defined. Furthermore, however, there is in the Museum Godeffroy (No. 6258) a dried specimen of *Ophiomaza*, considerably like *O. cacaotica*, but with a fine scaling imbricated on the interbrachial spaces below. It may be this scaling always exists, but is usually hidden by the extremely thick skin. As to *Ophiomaza* being separated generically from *Ophiocnemis* by the absence of granulation on the disk, I can only say that the same distinction is allowed to separate *Ophiarthrum* from *Ophiocoma*.

Ophiocnemis marmorata, see *Ophiothrix clypeata*.

Ophiothrix comata Müll. & Tr. has not been since found and is generally ignored. The originals in the Vienna Museum are dry and nearly ruined by time. It is therefore well to note that the species belongs to the division of the genus which has long needle-like spines, a thin disk, and slender rounded arms. *O. Suensonii* is its type, and *O. comata* resembles it considerably. The sketches (Plate IV., Figs. 27, 28) show that the shapes both of upper and under arm-plates are different; and whereas *O. Suensonii* has a purple arm-stripe above and below, *O. comata* has, along the upper arm, a central white stripe bordered by a purple line on each side, and no stripe at all below.

Ophiothrix fumaria Müll. & Tr. (Plate IV., Figs. 33–36). Originals at the Garden of Plants; dry, and in bad condition. Diameter of disk 9.5 mm. Length of arm 42 mm. Disk-scales conspicuous and bearing thorny cylinders (Fig. 36), which are scattered over the disk, as shown in Fig. 33. Arm-spines seven, rounded, the second and third longest, 2.5 mm, and slightly club-ended. They are opaque and feebly thorny (Fig. 35). Under arm-plates wider than long, of an angular oval shape (Fig. 34). It resembles *O. aspidota*, but has coarser disk-stumps and much shorter arms. I have an Ophiuran from Banka Strait which resembles it closely but has narrower under arm-plates.

Ophiothrix ciliaris Müll. & Tr. (Plate IV., Figs. 29–32). Originals at the Garden of Plants; belonging with *O. fumaria*, and in similar condition. Diameter of disk 5 mm.; length of arm 35 mm. Seven or eight flattened, delicate, glassy arm-spines with sharp thorns, along their edges only (Fig. 32); the second, third, and fourth are longest, and about equal. Disk closely beset with minute stumps (Fig. 29), which are larger and fluted near the edges of the disk and below (Fig. 30). The radial shields have a less number, and are small. The under arm-plates (Fig. 31) are bounded by a curve without, and have sides which converge. The upper arm-plates are broader than long, overlapping, diamond-shape, and slightly keeled. Color pink. *O. ciliaris* and *O. fumaria* are likewise originals of Lamarck. With them I found *Ophiomaza cacaotica*, which marks their locality as the region of the Indian Ocean. No. 128, Museum Godeffroy, seems to be *O. fumaria*.

Ophiothrix aspidota MÜLL. & TR. Original at Berlin, No. 1,108, East Indies, by Schoenlein. Diameter of disk 10 mm. Radial shields naked; rest of disk closely beset with minute scarcely thorny conical stumps, which are smaller below. Upper arm-plates have a microscopically granular surface. Arm-spines glassy with very feeble thorns. Dr. von Martens agrees that No. 1,966, from Makassar, is this species. I also have it from the Celibes; and there are young ones — often with a few stumps on the radial shields — in the Museum Godeffroy.

Ophiothrix propinqua LYM. The Ophiurans described by Dr. Lütken (Addit. ad Hist. Oph., III. 56) as the young of *O. longipeda* are not that, but the adult *O. propinqua*, and have *naked* radial shields. The tendency of young *Ophiothrices* is to have thorny radial shields, even when these are naked in the full grown.

(Ophiothrix) clypeata LJN., is the young of an *Ophiocnemis*, almost certainly of *O. marmorata*. In the Garden of Plants are specimens brought in 1842 by Hombron and Jaquinot from Trincomalee, Ceylon.

Ophiothrix Martensi sp. nov.

Plate IV., Figs. 9, 10.

Special Marks. — Seven stout arm-spines; the upper ones with thorny, club-shaped ends; the lowest having the shape of a triple or quadruple hook. Disk naked above, with short, conical, scattered spines on the edge and in interbrachial spaces below. Color, above, bright indigo, with a darker blue line along the arm, and, along the under side of arm, a white line.

Description of an Individual. — Diameter of disk 14 mm. Length of arm 63 mm. Width of arm, without spines, 2 mm. Four thick teeth; below them, two pairs of stout tooth-papillæ; and, below these, the usual oval of small, crowded, tooth-papillæ about thirty-two in number, of which about seventeen form the margin, and the rest are arranged in two or three irregular lines. Mouth-shields rather broader than long, of a rounded diamond shape. Under arm-plates covered by a thick skin; squarish, with rounded corners. Side arm-plates rather small; although, below, they make a well-marked ridge for the arm-spines. Upper arm-plates much wider than long, six-sided but with much rounded angles; the lateral corners pointed; length to breadth, near disk, .7 : 1.7. Close to tip of arm, the shape is wholly different; longer than broad, wider without than within, the outer side curved; length to breadth .5 : .4. Disk covered by thick skin which obscures the outline of the radial shields, and nearly hides the scaling. Near the edge are a few scattered spines, about .5 mm. long, stout and conical, and which are more numerous on the under side. Radial shields quite smooth; length to breadth 3.5 : 2.5. Arm-spines near the disk, seven; the upper ones short, stout, with a nearly smooth shaft, and a club-shaped end bearing strongly curved thorns; the lowest one keeps the form of a triple or quadruple hook quite to the base of the arm. Lengths, to that of an upper arm-plate, 1.8, 1.9, 1.8, 1, .6, .4, .4, : .7. Close to tip of arm only three spines, of which the uppermost is longest; the lowest is a hook, the other two having a rounded shaft and about six curved thorns at the end. Tentacle-scales small, scale-like, usually serrated. Color, above, bright indigo, with a darker line along the arm, bounded by a lighter one on either side; below, paler indigo, with a white line along the arm.

A smaller specimen with disk of 6.5 mm. had a thinner skin, so that the various plates were better defined, and the ends of the arm-spines seemed more thorny. In the interbrachial spaces between the radial shields could be distinguished four irregular radiating rows of oval scales. Below, the short disk-spines were more numerous than in the full grown, and were a little thorny at their ends. The blue lines along the arms were continued to the centre of the disk, but were not margined by lighter lines. Under arm-plates thick and conspicuous; squarish, with rounded corners; length to breadth (7th plate) .6 : .6. Chewing apparatus the same as in the adult, except that the oval of small tooth-papillæ has only twenty-one, of which eight papillæ form an irregular double or single line.

Philippines; by Semper.

Specimens also in Garden of Plants; at Berlin, and at Stockholm.

Ophiothrix pusilla sp. nov.

Plate III., Figs. 21-30.

Special Marks. — Upper arm-plates swelled, narrow, covering only part of the arm. Side arm-plates with a projecting point running toward the upper arm-plate. About nine short arm-spines, of which the lowest continues as a hook quite to base of arm. Disk densely beset, radial shields and all, with very short, even, forked stumps.

Description of an Individual. — Diameter of disk 5 mm. Length of arm 16 mm. Width of arm 1 mm. Tooth-papillæ of usual form, arranged in an oval, whose border is made up of about eleven papillæ with a central, single line of three or four papillæ. Mouth-shields small, indistinct; of a rounded diamond shape. Under arm-plates as long as broad, squarish, with a notch in their outer side; they are obscured by thick skin, and are somewhat separate. Side arm-plates stout and pretty strongly projecting; each one has a triangular piece projecting towards and near the upper arm-plate. Upper arm-plates swelled and very distinct, longer than broad, narrow, of an oval diamond shape. Near the base of arm they touch, but near the end they are separated, and, the side-plates being very projecting, there appear considerable naked spaces on the arm. Disk densely and evenly beset, above and below, with minute, forked stumps about .4 mm. high, so that no trace of radial shields is seen. These stumps are very short, and consist of a little trunk with a diverging crown of three, four, or five sharp, slender prongs. Those of the interbrachial spaces below are somewhat longer in the trunk, and a few, towards the mouth, have only short blunt thorns. Genital scales at outer end of openings very broad, and nearly meeting over the arm. Arm-spines short; near base of arm, nine; of which the lowest is a triple hook. Lengths, to that of an upper arm-plate, .7, 1, 1, 1, .8, .6, .5, .4, .3 : .6. The five upper are tapering, rather slender and glassy, with three to six sharp, not very long, thorns on each side. The three lower are blunt, with two to five blunt thorns at their tip. Close to tip of arm there is only a large triple hook, above which is a short and very feeble spine. Tentacle-scale none, or so feeble as to be scarcely visible. Color pale blue, in alcohol.

Philippines; by Semper. Specimens also in Garden of Plants.

Ophiothrix exigua sp. nov.

Plate IV., Figs. 24-26.

Special Marks. — Upper arm-plates thick, distinct; as broad as long; curved without. About seven short arm-spines, of which the lowest continues as a hook to the base of the arm. Disk above densely beset, radial shields and all, with very short, even, forked stumps, but naked *below*.

Description of an Individual. — Diameter of disk 5 mm. Length of arm 17 mm. Width of arm 1.1 mm. Tooth papillæ arranged in an oval whose border is composed of about eleven papillæ, with a central line of three. They are more pointed and less crowded than in *O. pusilla*. Mouth-shields much wider than long, and of a diamond shape, with rounded angles. Under arm-plates about as long as broad, with a strong notch on their outer side and a curve within; they are somewhat separated. Side arm-plates stout, not projecting, and completely covering the space between upper and under plates, so that the arm, without its spines, has a pretty regular, rounded form. Upper arm-plates slightly broader than long; length to breadth, near the disk, .6 : .7 : distinct, rather thick, of a much rounded diamond-shape, with the outer side curved, and the two laterals converging inward nearly to a point. Disk, above, densely beset with very short, minute stumps, each bearing a crown of two, three, or rarely four, sharp, diverging prongs, each stump about .4 mm. high, on the average. Below, the interbrachial spaces are naked. Genital scales, at outer end of openings, very broad, and arching partly over the arm. Seven rather short arm-spines flattened, not much tapering; the longest with seven to nine rather strong thorns on each edge and three blunt thorns at the tip; the lowest has a hooked form even at the base of arm. Lengths to that of an upper plate (7th joint) .8, 1.2, 1.2, .5, .3, .2 : .6. Tentacle-scales minute, pointed. Color, in alcohol, pale blue, with darker markings on upper arm.

It differs from *O. pusilla* in having the disk nearly or quite naked below, in different upper arm-plates, and in wider arm-spines.

Philippines, by Semper. Specimen also in Garden of Plants.

Ophiothrix stelligera sp. nov.

Plate III., Figs. 15-20.

Special Marks. — Disk, above, closely beset with minute, stout stumps, each with a crown of five or six short, not much diverging prongs; there are also a few short spines. Below, interbrachial spaces, near mouth, naked; but near edge of disk, beset with small cylindrical spines. Under arm-plates with a clean curve, without.

Description of a Specimen. — Diameter of disk 5.5 mm. Length of arm 28 mm. Width of arm 1.5 mm. About twenty-one tooth-papillæ, of which fifteen form the border of the oval, and six are arranged in an irregular line in the centre. Mouth-shields as broad as long, of a rounded diamond-shape. Under arm-plates a little broader than long; 7th plate, length to breadth, .6 : .8, bounded, without, by a gentle curve, and by laterals which converge moderately, giving the whole plate a nearly oval look. Side arm-plates only moderately projecting, covering completely the space between the upper and under plates. Upper arm-plates thickened and with a slight longitudinal ridge; a little broader than long; length to breadth .6 : .8, near disk; bounded without by a curve; on the sides by re-entering curves, which converge to a blunt point. Disk, above, closely beset with minute, stout stumps, each with a crown of five or six short, not much diverging prongs; the outline of the radial shields may be distinguished, because they bear fewer stumps. Under the microscope the disk has a look of being sprinkled with little glass stars, among which appears, very rarely, a short spine. Below, the interbrachial spaces are naked at their inner angle, but towards the margin are beset with cylindrical spines which are about $\frac{1}{3}$ mm. long, while the stumps are not over $\frac{1}{7}$ mm. Genital plates wide, at outer end of the openings. Arm-spines about eight, short, glassy, flattened, and rather blunt, about as in *O. exigua*: the longer ones have six to nine well-marked thorns on each edge, and three minute thorns at the tip; lengths to that of an upper arm-plate (7th joint) 1.8, 2, 2, 1.8, 1, .8, .6, .5 : .6. The lowest spine retains the form of a triple hook quite to base of arm. Tentacle-scales blunt, small but distinct. Color, above, disk indigo round margin, paler towards centre; upper arm-plates mottled blue and white, with an ill-marked central line: lower surface paler.

This stands near *O. carinata* v. Mart., but the disk-stumps with their star-like crowns, the disk-spines below, the more numerous arm-spines, and different upper arm-plates, will separate it from this, as well as from *O. exigua* and *O. pusilla*.

Philippines, by Semper; also from Borneo, in the Hamburg Museum.

Ophiothrix plana sp. nov.

Plate IV., Figs. 1 - 8.

Special Marks. — Disk smooth and covered by a thick epidermis, through which the scaling and the outlines of radial shields are seen vaguely. Near edge and on interbrachial spaces below, short thorns covered with so thick an epidermis as often to be bead-like in form. Color of disk pale blue, with minute darker rings. Seven arm-spines, all, usually, with widened ends, except the upper one, and covered with a thick epidermis.

Description of an Individual. — Diameter of disk 6.5 mm. Length of arm 32 mm. Width of arm 1.5 mm. Tooth-papillæ eighteen, of which fifteen form the border of the oval, and three much shorter ones a single line in the centre; all the papillæ, except lowest, quite stout. Mouth-shields small, oval, with a peak within, and closely soldered with surrounding parts. Under arm-plates squarish, with rounded corners and a re-entering curve without; length to breadth (8th plate) .6 : .7. Side arm-plates well marked, but small, and lying close to arm. Upper arm-plates small and swelled, bounded without by a wide curve; on the sides by slightly re-entering curves which converge strongly, leaving the inner side very short: length to breadth (8th plate) .6 : 1. At the very tip of arm, the side arm-plates meet above, but not below. Disk nearly smooth, with radial shields rather small and on a level with the rest of the surface; the centre occupied by a rosette of thin scales, nearly obscured by epidermis; a large, round, primary scale in the centre, surrounded by two and part of a third rather irregular concentric rings of smaller ones; from this central rosette radiate interbrachial bands, each consisting of a line of three or four larger elongated scales, with a line of about five narrower and smaller ones on each side; the whole variable, irregular, and much obscured by a thick epidermis. Along edge of disk, outside radial shields, a cross line of about five large scales. Radial shields smooth and flat; separated by a line of two or three scales; length to breadth 2 : 1. Interbrachial spaces below beset with minute spines, which are encased in such a thick epidermis as sometimes to have a bead-like form: they continue to the edges of the upper surface, but there are none in the centre. Arm-spines seven; a little out on the arm, six; flattened, glassy: the upper one slender, tapering, and with five or six thorns on each edge; the lowest one formed like a stout double hook; the rest with a smooth shaft much flattened at the end, where it has five to seven long thorns on each edge, giving a wide brush-like shape to the tip, which is increased by the thick epidermis investing the whole; lengths to that of an upper arm-plate (4th joint) 1.8, 1.8, 1, .6, .5, .4 : .6. At the very tip of arm, only three spines, of which two are needle-like and the lowest one is a slender double hook. Tentacle-scale well marked, with a sharp point. Color, above, pale purplish blue with minute spots, or rings, of darker on the disk.

Another specimen with disk of 7 mm. had the arm of 27 mm. The disk-thorns were confined to the interbrachial spaces below.

This species is easily recognized by its smooth, shiny disk, with little dark rings, and its broad-ended arm-spines.

Philippines, by Semper. Specimens also in Garden of Plants; and, from Makassar, at Berlin.

Ophiothrix rudis sp. nov.

Plate III., Figs. 11-14.

Special Marks. — Disk, above, except radial shields, closely set with short, very thick cylinders, jointed at their base, and having rounded ends. Seven stout, rounded, blunt, nearly smooth arm-spines; the two upper ones much the longest.

Description of a Specimen. — Diameter of disk 9 mm. Length of arm 62 mm. Width of arm 2.2 mm. About thirty-five crowded tooth-papillæ, whereof twenty-one form the border of the oval, and are much more projecting than the fourteen central ones. Mouth-shields wider than long, of a broad, rounded diamond shape. Under arm-plates closely soldered to each other; near base of arm, broader than long, of an irregular oval shape, with a decided depression or re-entering curve within; length to breadth (8th plate) 1 : .8. Side arm-plates stout and well marked, but not very prominent. Upper arm-plates, near base of arm, wider than long, with sharp lateral angles, and bounded without by a strong curve, on the sides by re-entering curves converging inwards, and within by a very short line; length to breadth (8th joint) .8 : 1.2. Disk naked below, but the upper surface is closely set with short, even, very stout, nearly smooth cylinders having rounded ends. These cylinders are .5 mm. high, jointed at their base, so that they can lie flat to the disk, and their ends under the microscope are seen to be slightly thorny. Radial shields completely naked, small, separated partially by a single line of little cylinders; length to breadth 3 : 1.5. Seven stout, gently tapering, blunt, rounded, slightly flattened, nearly smooth arm-spines, which are wholly opaque, and only present feeble terminal thorns under the microscope. The two upper ones are much the longest, and usually a little crooked; lengths to that of an upper arm-plate (8th joint) 2.6, 2.8, 1.2, 1, .6, .3 : .8. Tentacle-scales none, or very minute and rounded. Color dull indigo, lighter below, with arm-spines mottled with yellowish.

San Diego, California. Many specimens from shallow water, by Professor Esmark. *O. magnifica* is somewhat near, but has very thorny arm-spines.

On the Species of Ophiothrix from the Waters of Western Europe and of the Mediterranean.

The genus *Ophiothrix* is usually the most perplexing in respect of the identification of its species. Those of Europe make no exception, as may be seen by the following list of names taken from the principal writers on echinoderms : —

Stella scolopendroides : Rosula scolopendroides, Linck de Stel. Mar., p. 52, Pl. XXVI., Fig. 42, 1733.

Asterias fragilis ABILDGAARD (O. F. Müller), Zool. Dan., p. 28, Pl. XCVIII., 1789.

Asterias pentaphyllum : varia : aculeata ; hastata : fissa ; nigra PENNANT, Brit. Zoöl., IV. 54, 55, 1812.

Ophiura fragilis LAMK., Hist. des An. sans Verteb., II. 546, 1816.
" *tricolor* " " " " " "

Asterias tricolor DELLE CHIAJE, Memorie, III. 78, Pl. XXXIV., Fig. 9, 1823.
" *echinata* " " " " "
" *pentagona* " " " " "
" *Cuvieri* " " " " 79.
" *Ferussacii* " " " " "
" *quinquemaculata* " " IV. 197.

Ophiocoma rosula FORBES, Brit. Starfishes, 60, 1841.
Ophiothrix fragilis MÜLL. & TROSCH., Syst. d. Asterid., 110, 1842.
" *echinata* " " " " 111, "
" *alopecurus* " " " " " "
" *tricolor* " " " " 112, "
" *Ferussacii* " " " " " "
" *quinquemaculata* " " " " "
" *Rammelsbergii* " " " 113, "
" *fragilis* (*var. tenuispina*) SARS, Middelhavets Littoral Fauna, II. p. 74, 1857.
" *alba* (?) GRUBE, Wiegmann's Archiv., 1857, 344.
" *rosula* LYMAN, Illust. Catalogue, 154, 1865.
" *echinata* LÜTKEN, Addit. ad Hist. Oph., III. 52 and 104, 1869.
" *quinquemaculata* " " " " " "
" *fragilis* " " " " " "
" " LJUNGMAN, Vestindiska och Atlantiska Oph., 623, 1871.
" *lusitanica* " " " " " 625, "
" *pentaphyllum* " " " " " 622, "
" *rubra* " " " " " 624, "
" *maculata* " " " " " 623, "
" *echinata* " " " " " 653, "
" *Lütkeni*, WYV. THOMSON, Depths of the Sea, 100, 1873.

Do all these names refer to one species or to many? I have tried to throw some light on this question by bringing together for study as many originals and as great a number of specimens as possible.

In this way I had, side by side, in Paris: —

Ophiothrix echinata. Original of Mull. & Trosch.; by courtesy of Professor Peters.

Ophiothrix Rammelsbergii. Original of Müll. & Trosch.; by courtesy of Professor Peters.

Ophiothrix alba. Original of Grube; by courtesy of Professor Grube.

Ophiothrix fragilis. Originals, as identified by Ljungman with Abildgaard's *Asterias*; by courtesy of Professor Lovén.

Ophiothrix Lusitanica. Original of Ljungman; by courtesy of Professor Lovén.

Ophiothrix pentaphyllum. Originals as identified by Ljungman with Pennant's *Asterias*; by courtesy of Professor Lovén.

Besides these were great quantities of specimens from the coasts of Denmark and Sweden, the Isle of Wight, the northwest coast of France, coast of Portugal, Madeira (?), Algeria, Spezia, Naples, the northern Adriatic, and the coast of Egypt.

At Stockholm, Professor Lovén permitted me to examine the whole of that great collection, and Mr. Ljungman showed me the originals of his *O. rubra* and *O. maculata*.

At Copenhagen, Dr. Lütken personally set before me the very rich collection of the University, and showed me the original of Wyville Thomson's *O. Lütkeni*. I received like marks of kindness from Mr. Schmeltz of the Museum Godeffroy at Hamburg; from Professor Richiardi at Pisa; Professor Panceri at Naples; Sig. Trois at Venice; Dr. von Martens at Berlin, and from Professor Schlegel at Leyden.*

All these *Ophiothrices* (with one exception presently to be mentioned) have certain features in common. They have arms rather short, narrow, and rounded, being from four to six times the diameter of the disk; their lower arm-plates have a notch or re-entering curve in their outer side; the upper arm-plates are more or less broad diamond-shaped or rhomboidal, and overlap one another. The arm-spines, eight or nine in number, stout, blunt, but never club-ended, somewhat rounded, feebly translucent, the side thorns not very distinct and from eleven to seventeen on each edge; the disk beset with grains, stumps, or short spines, except the radial shields, which are usually naked, but sometimes have a few stumps which are merely the persistence of a character of the young.

Among these characters the plates of the arms furnish no clew whatsoever; nor yet do the arm-spines, which present a wide range as to length, thickness, and the number of thorns on their edges. A careful microscopic study of the *armature of the disk*, its grains, stumps, or spines, is the best guide to the specific differences; to which may be added a consideration of the *absolute size* attained by these specimens. Some hints, too, may be gained from the *pattern of color*: but this must be taken with great caution. It is true that writers, notably Grube, have successfully distinguished *Ophiothrices* almost wholly by their coloration; but this coloration is that which appears *after immersion in alcohol*, and is not to be confounded with that of the living animal. Thus *Ophiothrix angulata* has the most varied sets of hues,† but in alcohol all these turn to pale blue. The pigment patches are arranged in certain lines or patterns, which are brought out by the alcohol, and which usually are characteristic. In this way, a stripe along the arm (*O. Suensonii*) or regular spots on the disk (*O. plana*) are good guides to species. In the European species this guide is often dubious, because many of the specimens,

* To Professor Deshayes a special acknowledgment is due. Whenever I have been in Paris he has taken me into his own laboratory at the Jardin des Plantes, given me free access to the collections, and treated me, not as a stranger, but as one who had a claim on his attention.

† Illustrated Catalogue I., Pl. II., Figs. 1, 2, 3.

although brilliant in life, fade to a dull straw-color in alcohol, while others present a mottled and varied look without any special pattern.

Beginning with northern waters, we find, on the shores of Denmark and Sweden, a type which is without question the *Asterias fragilis* of Abildgaard. It is large, and has a fleshy disk swelling into lobes in the interbrachial spaces; a diameter of 15 or 16 mm. is a common size, and specimens with a disk of 9 mm. have still young characters. Here it may be observed that the *upper arm-plates*, at the base of the arm, furnish the best test of the animal having taken on its adult form. For example, in the group under discussion, these plates have a length to breadth about as 2 : 3; whenever, therefore, the length of these plates, near the disk, is greater than, or equal to, the breadth, it is safe to assume that the creature is still in its young stage. The arm-spines of *O. fragilis* vary more than those of any other European type; they may be found very short, and so thickened that the edge thorns, of which there are only 14, are nearly obliterated; or quite long, flattened, and glassy, with as many as 22 well-marked thorns on each edge. Often, or perhaps generally, the upper arm-plates, instead of being decidedly angular, have the outer side cleanly curved. The radial shields are somewhat sunken in the swelled disk, and are a little bent near their small end. The armature of the disk consists of a great variety of short, stout, stumps, accompanied or not by a few slender cylindrical spines (Plate II., Fig. 42). A very common form of stump is with a crown of four thorns, either cylindrical or else spread like a partly opened fan (Fig. 38); some, too, may have only three thorns, whereof the middle one may be flattened and elongated (Fig. 39). There may be near the centre of the disk a quantity of conical grains covered with minute points (Fig. 43), with which the preceding shapes mingle, especially near the edge. In the young we get the simpler shapes from which are produced the full-grown stumps. Thus, a little one having a disk only 5.5 mm. in diameter exhibited minute, very stout stumps which were simply clavate, or else had a crown of three strong thorns (Fig. 41). When the disk was increased to 7 mm. the same shapes presented themselves, but more elongated (Figs. 37, 40); and there were added a few true spines (Fig. 42), slender, cylindrical, and with very feeble thorns at the tip and along the sides. The same shapes again occurred on a larger disk, 9 mm., with an increased number of spines; and, near the edge, a much elongated modification of the clavate stump (Fig. 44).

Ophiothrix Rammelsbergii, Mull. and Trosch., is a half-grown specimen of *O. fragilis*, in which the disk stumps were encased in thick wrappers of skin, giving them the look of smooth papillæ. It is a variety always to be borne in mind while studying this genus, and is illustrated in Figs. 10, 11; in one of which the skin-bag is left on, and in the other partly torn off.

I could not find in *O. alba* Grube any characters to distinguish it from a half-grown *O. fragilis*, although it is said to have been brought from the Pacific by Escholtz.

It will be best next to speak of the European *Ophiothrix* most unlike that just described. In Naples, Dr. Gasco showed me a large number of living *Ophiothrices*, and called my attention to their great differences. One sort was blue with a swelled body, short arms, and rather stout arm-spines; the other was reddish-brown, with a flat rounded disk and slender spines on it, and long arms, by whose rapid worm-like motion the animal slid briskly over the bottom of a basin filled with sea-water. This latter is the species identified by Lütken as *Asterias quinquemaculata* of Delle Chiaje. Here it is proper to say that the descriptions and plates of that Italian author, so far as concerns Ophiurans, are utterly unrecognizable; the figures, in fact, portray animals that do not exist anywhere. However, to avoid multiplying names, there is no objection to taking the nomenclature of Delle Chiaje and applying it arbitrarily to Mediterranean species. Unlike most Ophiurans, this species is better marked as young than as adult, when it bears some resemblance to *O. pentaphyllum* (to be described further on). With a disk of 3.5 mm. the arm was already 25 mm. long, or in proportion of 7 : 1, which is greater than I have usually found, even in the full grown of other European species. The disk was flat and circular, little lobed, and had its surface regularly sprinkled with minute, equal, slender, trifid stumps, with sometimes none on the radial shields and sometimes as many as four (Pl. II., Fig. 46), also there were long, thin, cylindrical spines, as long nearly as those of the arm, having very small thorns on the sides and tip; these spines were all *articulated* on little mamelons, on which they have a free motion (Fig. 47), a character I have not observed in the other European species. There were but six arm-spines, the two upper ones longest, viz. 2.7, 2.5 mm., with a glassy look and nineteen thorns on each edge. A specimen, whose disk was 7.5 mm. in diameter, had stouter forked and trifid stumps on the centre (Fig. 52); stouter articulated spines; and, on the edge of the disk, much elongated forked stumps (Fig. 53). An individual with a disk of 9 mm. resembled the young one first mentioned, except that the disk spines were of several sizes, and the upper arm-plates, of course, proportionally wider. There were six or seven arm-spines, whereof the longest was 4.5 mm., with as many as twenty-five or even twenty-seven thorns on each edge. A large specimen had the disk 14 mm. in diameter, flat and circular, with large smooth radial shields, resembling in these respects *O. pentaphyllum*; besides the long articulated spines (Fig. 51), there were in the centre numerous short, thick stumps, with crowns of three or four long thorns (Figs. 49, 50), or conical grains with thorns on top (Fig. 48); while near the edge and below were very elongated clavate stumps (Fig. 54). This was the usual armature in a large number of adults, some with the disk as large as 16 mm.; the differences were in the proportion and closeness of the various stumps and spines mentioned above; there also was sometimes a much elongated form of 49 (Fig. 55). Among the young, the arm is from five to seven times the disk; among the adult, from six and a half to ten times.

The blue species, already mentioned as living beside *O. quinquemaculata*, is that identified by Müller & Troschel with *Asterias echinata* Dell. Ch. One of their originals at Berlin has the disk 11 mm. and the arm about 40 mm. The upper arm-plates are rhomboidal, overlapping, and with a slightly thickened lobe without; length to breadth .9 : 1.2. There are nine short, stout, little, tapering arm-spines, the longest 2.1 mm., and with a dozen blunt, feeble thorns on each edge. The disk is evenly set with larger and smaller trifid stumps (Pl. II., Figs. 2, 3), with very few small cylindrical spines (Fig. 1). This is as large a specimen as I have seen, for the species is small; it has a puffed disk, in which the radial shields' are somewhat sunken, and are therefore not conspicuous. The arms are always short; in five adult specimens the average of the arm to the disk was as 5 : 1. Already, with a disk of 7 mm., the adult characters are taken on; the upper arm-plates are broader than long, as 1 : .6; while a specimen of *O. quinquemaculata*, of the same size, had them of equal dimensions, .9 : .9. The arm-spines vary little; they are even, short, stout, and little tapering, and are from seven to nine in number. The smallest specimen (Naples) had a disk of 2.5 mm., and the arm 13 mm.; the scaling was very distinct, each scale usually bearing a slender, trifid stump (Pl. II., Figs. 12, 13); on the upper surface their character was the same, but some were simply forked; on the radial shields were a few similar but smaller stumps, which, in the adult, wholly or nearly disappear. Another had a disk of 7 mm., which carried on its upper surface, evenly set, two and three forked stumps (Figs. 5, 9) and a few short spines (Fig. 4), there being, on the radial shields, some little trifid ones (Fig. 6). The lower interbrachial spaces were closely set with long stumps and short spines (Figs. 7, 8); between the radial shields of the same pair there was a single line of stumps. Another specimen — disk 10 mm. — was evenly set with little forked stumps, covered with a thick envelope of skin (Figs. 10, 11). An individual from Algeria had a few forked stumps so elongated as more properly to be called spines (Fig. 14), but the greater part of the armature consisted of forms similar to 6, 11, and 12. Four specimens from the Adriatic and one from Egypt presented no new features. It will be noted of this species: first, that it is small; secondly, that the disk-stumps are fine, and never have more than two or three thorns as a crown, while longer spines are wanting, or very rare; thirdly, that the arms are short, being from three and a half to six times the disk.

Heller * has recalled attention to the Adriatic species *O. alopecurus* Müll.

* Zooph. und Echinod. des Adriatischen Meeres, 63, 1868.

& Trosch.,* but without recognizing any specimens, and in his description seems to have included this and *O. echinata* under the name of *O. fragilis*. In the collections of Professors Grube and Richiardi, and at the museum of the Palazzo Ducale in Venice, I found nearly a dozen specimens, collected chiefly near Trieste; and there are others in the museums at Copenhagen and at Stockholm. They present pretty uniform characters, and attract attention by the close-set crop of long, glassy, or silvery spines, by which the disk is almost hidden; closer examination shows that there are no stumps at all on the disk, and that the radial shields are either absolutely naked, or have only a few extremely minute spines. Moreover, the animal is distinguished usually by its dark green color, with which the spines contrast, like spun glass. A specimen with a disk 12 mm. in diameter, and arms 96 mm. long, was dark green, with lighter mottlings on the radial shields, which were naked. The upper arm-plates were rhomboidal, overlapping, and with a well-marked lobe without. The arm-spines were nine, flat and regular; longer, more tapering, and more glassy than in *O. echinata*, and with sixteen or seventeen thorns on an edge. The longest one (usually the second) was to the upper arm-plate as 3.2 : 1. The disk-spines were uniform in shape, being stout at the base, tapering, somewhat flattened, forked at the tip, and with a few very minute thorns on their sides; their length on the back of the disk was 1.2 mm., near the edge longer. Other specimens did not vary essentially from this, except in the comparative length and slenderness of the disk and arm-spines; the former having sometimes a regular fluted form (Pl. III., Fig. 1) and a maximum length of 3 mm. The radial shields are usually wholly naked, but may have a few minute spines, not over .2 mm. long (Pl. III., Figs. 2, 3). One specimen had a light-colored disk, with a black spot on each radial shield, and dark upper arm-plates.

There seems no question as to the distinction of the four species just noticed; there are now to be considered some whose claims are less clear. The *Asterias pentaphyllum* of Pennant is an inhabitant of the English coast; Lütken considers it a variety of *O. fragilis*, while Ljungman regards it as a good species. Those I have seen were from the Isle of Wight and from Madeira (?); they were readily distinguished from *O. fragilis*, but, as there were no young forms, I am unable to speak with a full knowledge. The disk is flat and round, and not puffed; radial shields naked and conspicuous; upper arm-plates with a well-developed peak on the outer side. The disk-stumps and spines seem in their young state to be thorny grains (Pl. II., Fig. 30) and not forked stumps, as is usual; from this form develop larger grains and thick stumps (Figs. 31–33) and even columnar spines (Figs. 34, 35); the more pointed spine (Fig. 36) was found only on two specimens, said to come

* The original examined by Troschel no longer exists at Leyden, but the present identification of *O. alopecurus* seems a reliable one.

from Madeira. As to arrangement, the thick stumps and thorny grains, of which the most numerous are 32, 33, are concentrated in the centre of the disk, while the coarse spines are sparsely distributed from the centre towards the periphery.

Next comes *O. lusitanica*, the commonest species, or variety, of some parts of the coasts of France and Portugal, and even extending into the Mediterranean. Somewhat larger than *O. echinata*, it is at once distinguished by the greater absolute size and thickness of the disk-stumps, and by the more numerous thorns at their ends; for, whereas *O. echinata* commonly has stumps simply forked, and never with more than three terminal thorns, *O. lusitanica* has them with a crown of four, five, and even six thorns (Pl. II., Figs. 15, 16, 22). A young one whose disk was 5.5 mm. in diameter, had clavate or trifid stumps, and some with four terminal thorns (Figs. 16 – 18); a still smaller one, with a disk of 5 mm., had clavate stumps (Fig. 23) also on the radial shields, where they are scarcely ever seen in the adult. On a specimen from Naples, disk 8 mm., the stumps were chiefly stout cylinders with a crown of five thorns (Fig. 15); but there were, besides, a few stout spines, some columnar with two side thorns and six terminal (Fig. 19), others with a swelled cluster of numerous thorns at the tip (Fig. 20). It should here be added that spines are so rare in this species as almost to be accidents; while the stumps are of so even a height and so closely set as to give to the upper disk the figure of a regular five-rayed star, in which the radial shields are sharply defined. Of many examined, one from St. Va-est la Houge, France, had an occasional spine of a type like that found in *O. echinata* and *O. fragilis*, but much thicker (Fig. 29: compare Figs. 1, 42). To continue among rare forms, an individual from the Iles Chausés had small toothed grains and others more elongated, derived from them (Figs. 25, 26); and 26 may be still further elongated by the shooting up of the three central thorns, and thus take on the character of a small spine; this was found in one specimen from the Iles Chausés (Fig. 27). Among stumps, Figs. 21, 24, are rare eccentric shapes derived from 15. Fig. 28 is an elongated clavate stump, comparable to 9 in *O. echinata*, 44 in *O. fragilis*, and 53 in *O. alopecurus*, and like them found near the edge of the disk. Of eighteen specimens examined with special care, viz. two from Naples, one Portugal, eight St. Va-est la Houge, seven Iles Chau-és (France), ranging from 5 to 13 mm. in diameter of the disk, there were five specimens in which the disk-stumps had not developed beyond the two or three forked forms, but, as before mentioned, larger and stouter than in *O. echinata* of the same size. The other thirteen had more or less cylindrical stumps with crowns of four to seven thorns, and two of them had also thorny grains (Figs. 25, 26). Among five adult specimens, the average of the arm to the disk was as 5 : 1. The upper arm-plates are decidedly angular; the arm-spines about as in *O. echinata*, little variable, and with thirteen to seventeen thorns on an edge.

Of *Ophiothrix rubra* Ljn., there exists only a single specimen, from near Lisbon, at Stockholm. The disk is 7 mm. in diameter, and is crisp, with thorny stumps on it, as well as on the radial shields. Arm-spines stout and thick. Without more material to judge from, I am not satisfied that this differs from *O. lusitanica*. Dr. Ljungman thinks it may be *O. echinata*.

There are at Stockholm two specimens of *Ophiothrix maculata* Ljn., from 120 fathoms on the Josephine bank, near the coast of Portugal. They have disks of 12 mm. diameter and somewhat resemble *O. pentaphyllum*, but have only seven arm-spines, and bear a reddish spot on each upper arm-plate. The fewness of arm-spines is important, though I have seen an *O. quinquemaculata* with a disk of 9 mm. that had no more. The red spots are not of so much consequence, since *O. pentaphyllum* is variously mottled in alcohol, *O. alopecurus* has sometimes banded arms or spots on its radial shields, and *O. echinata* occasionally carries a large five-sided patch on the back of the disk. Dr. Ljungman considers it a well-defined species, and it should at least be provisionally admitted on such excellent authority.

Ophiothrix Lütkeni is a deep-sea form, dredged by Wyville Thomson in 374 fathoms S.W. of Ireland. I examined the original at Copenhagen. It differs from others of which *O. fragilis* is the type by having high rounded arms, short, thin arm-spines, and minute spines on the upper arm-plates. The individual was large, and, in its dried state, was light-colored with red mottlings.

This completes the list; and it remains to consider its proper divisions. Dr. Lütken * admits (1) a northern species, *Asterias fragilis* Abgd., of which he has specimens from Iceland, North Norway, Denmark, North Sea, Spithead, and British Channel. With this he includes, as a variety, *O. pentaphyllum*; and as a variety of the *young*, *O. echinata* Müll. & Trosch. from Naples. (2) *Ophiothrix quinquemaculata*, also from Naples, the same which has just been noticed. (3) *Ophiothrix alopecurus* (*echinata* Ltk.), from Trieste, also noticed and illustrated above. (4) *Ophiothrix Lütkeni*, dredged by Professor Thomson in 374 fathoms, off Ireland. On *O. lusitanica*, *maculata*, and *rubra* Dr. Lütken has no opinion to offer. In support of his view that all the northern forms are one species, he says pertinently, "That the animals living in the North Sea should afford such differences — that one form should belong to Scandinavia, the other to Britannica — is hardly credible. That would be in opposition to all analogy from all other inhabitants of that sea, which are of course the same on both sides."

I have but one objection to this division: it is not possible to include *O. echinata* as a variety of *O. fragilis*. An examination of the upper arm-plates in two specimens of equal size will satisfy the observer that *O. echinata* is an adult, while an *O. fragilis* of the same diameter is not even half grown.

Dr Ljungman, who is naturally more inclined to see specific differences,

* In a letter, December, 1872.

recognizes a greater number, as follows: * (1) *Ophiothrix fragilis*, the same as understood by Lütken, but in a narrower limit; Denmark, Norway, etc. (2) *Ophiothrix quinquemaculata*, as distinguished by Lütken; Naples. (3) *Ophiothrix alopecurus* Müll. & Trosch. from Trieste, which Mr. Ljungman identifies with *O. fragilis* M. T., *tenuispina* Sars, and *echinata* Ltk. (4) *Ophiothrix maculata* Ljn.; Josephine Bank, 120 fathoms. (5) *Ophiothrix pentaphyllum*, common on south coast of England and west coast of France; identified with *Asterias pentaphyllum* of Pennant, and included by Lütken in his *O. fragilis*. (6) *Ophiothrix lusitanica* Ljn.; as already described above; Portugal. Dr. Ljungman had not seen *O. Lütkeni*, and therefore does not refer to it. It is sufficient to prove the difficulty of the subject, that, of the two European authors best qualified to judge, one recognizes four and the other seven species.

Combining the information from these authorities with personal observation, I am inclined to divide the species as follows: —

1. **Ophiothrix fragilis** Dub. & Kor.
   Asterias fragilis Ablg.
   Ophiothrix Rammelsbergii Müll. & Trosch.
   Ophiothrix alba (?) Grube.
   Ophiothrix fragilis Sars, Ltk. (pars). Denmark, Norway, Iceland, Faro Isl's.
2. **Ophiothrix quinquemaculata** Müll. & Trosch.
   Asterias quinquemaculata Dell. Ch.
   Ophiothrix quinquemaculata Ltk.
   Ophiothrix echinata (?) Ljn. (*non* Müll. & Trosch. *nec* Ltk.). West Coast of Italy.
3. **Ophiothrix echinata** Müll. & Trosch. (*non* Ltk. *nec* Ljn.).
   Asterias echinata Dell. Ch.
   Ophiothrix fragilis (*var.* mediterranea, *juv.*) Ltk.
   Ophiothrix rubra (?) Ljn. Algeria, west coast of Italy, Adriatic, Egypt.
4. **Ophiothrix alopecurus** Müll. & Trosch.
   Ophiothrix fragilis (?) Müll. & Trosch. (*non Asterias* Ablg.).
   Ophiothrix fragilis (*var. tenuispina*) Sars.
   Ophiothrix echinata Ltk. (*non* Müll. & Trosch. *nec* Ljn.). North Adriatic.
5. **Ophiothrix pentaphyllum** Ljn.
   Asterias pentaphyllum; *varia*; *aculeata*; *hastata*; *fissa*; *nigra*; Pennant (*teste* Ljungman).
   Ophiothrix rosula Forbes.
   Ophiothrix fragilis Ltk. (pars). South coast of England, west and north coast of France, Madeira (?).
6. **Ophiothrix lusitanica** Ljn.
   Ophiothrix rubra (?) Ljn. Northwest coast of France, Portugal, Naples.

* Letter, March, 1873.

7. **Ophiothrix maculata** Ljn. Josephine Bank, 120 fathoms, off Portugal.
8. **Ophiothrix Lütkeni** Wyv. Thoms. Southwest of Ireland, 374 fathoms.

Of these species, I consider the first four and the last as well marked; the remaining three, perhaps, need to be illustrated by more specimens and localities.

It may be proper to add, that the foregoing critique is simply intended as a guide to the naturalist who has sufficient specimens of these species for study.

Astrophyton cacaoticum sp. nov.

Plate VI., Figs. 1-3.

Special Marks. — Disk and arms essentially smooth with only a few microscopic grains. Radial ribs high, narrow, and well-marked. Arms unusually slender and forking close to the disk; with hook-bearing ridges feebly raised above the general surface. Five madreporic bodies.

Description of a Specimen (dried). — Diameter of disk 30 mm. Arm forked close to disk. Width of arm 6 mm.; of each fork 3 mm. Each then continues as a slender, slowly tapering main trunk, throwing out side branches on alternate sides, and these branches in like manner throw out side twigs.

Distance	from	first	fork	to	second	17 mm.
"	"	second	"	"	third	20 "
"	"	third	"	"	fourth	21 "
"	"	fourth	"	"	fifth	20 "
"	"	fifth	"	"	sixth	20 "
"	"	sixth	"	"	seventh	25 "
"	"	seventh	"	"	eighth	25 "
"	"	eighth	"	"	ninth	25 "
"	"	ninth	"	"	tenth	27 "
"	"	tenth	"	"	eleventh	20 "
"	"	eleventh	"	"	twelfth	22 "
"	"	twelfth	"	"	thirteenth	12 "
"	"	thirteenth	"	"	end	32 "
		Total,				286 "

Along the upper surface of the arm are scattered microscopic granules, which are still fewer and more minute than those of the disk; on an alcoholic specimen these granules would doubtless be invisible. Beginning near the mouth there are two pointed tentacle-spines, .5 mm. long, on each pore, beyond the first fork usually three; and these continue nearly to the tips of the arm, where they are replaced by the hook-bearing ridges, here composed of a double ring of large prominent grains encircling the arm, and with but a short space from one ridge to the next. Each grain bears a minute simple hook. Except at the tip of arm, the hook-bearing ridges are small and low, and separated from each other by a considerable smooth space. The hooks are found in greater or less number quite to the base of arm. Disk absolutely naked in the interbrachial spaces, except along its edge above, where, as well as on the high narrow radial ribs, there are minute grains, about five in the length of a mm. In the space round the mouth, below, there are a few scattered microscopic granules, which in an alcoholic specimen must be invisible. Five small, narrow madreporic bodies, placed one in the inner angle of each interbrachial space and close against the line of separation between the under and upper surfaces. Mouth and tooth-papillæ sharp and spiniform, arranged in an irregular clump, above which appear three or four teeth, irregularly superimposed, with a striated surface and a rather wide curved cutting edge. Genital openings 2.5 mm. long, situated 1.5 mm. inside the outer end of the radial rib. Color, chocolate-brown.

Guadeloupe; 20 fathoms. A specimen in the Garden of Plants and another, by exchange, in the Museum of Comparative Zoölogy.

Astrophyton nudum sp. nov.

Plate VI, Figs. 4-5.

Special Marks. — No tentacle-scales on pores. Disk and arms quite smooth; the latter ringed with faint lines, which, magnified, are seen to be rows of minute conical papillæ. One large madreporic body.

Description of a Specimen. — Diameter of disk 44 mm. Length of arm about 375 mm., as follows:

Distance	from	first	fork	to	second	10 mm.
"	"	second	"	"	third	12 "
"	"	third	"	"	fourth	16 "
"	"	fourth	"	"	fifth	16 "
"	"	fifth	"	"	sixth	17 "
"	"	sixth	"	"	seventh	20 "
"	"	seventh	"	"	eighth	20 "
"	"	eighth	"	"	ninth	19 "
"	"	ninth	"	"	tenth	22 "
"	"	tenth	"	"	eleventh	20 "
"	"	eleventh	"	"	twelfth	20 "
"	"	twelfth	"	"	thirteenth	20 "
"	"	thirteenth	"	"	fourteenth	20 "
"	"	fourteenth	"	"	fifteenth	19 "
"	"	fifteenth	"	"	sixteenth	20 "
"	"	sixteenth	"	"	seventeenth	20 "
"	"	seventeenth	"	"	eighteenth	20 "
"	"	eighteenth	"	"	nineteenth	14 "
"	"	nineteenth	"	"	twentieth	17 (tip broken).
			Total,			342

Width of arm at disk 16 mm.; width of first fork at its base 6 mm.; at the fifth branch 3.3 mm.; at the fifteenth branch 1.7 mm.; at the twentieth branch 1.2 mm. General surface of arm smooth, without spines or grains; a lens shows a fine network of cross-lines which make an ill-defined mosaic. Each joint is marked by a minute ridge placed in a sunken line and running over the top of the arm and ending on either side near the tentacle-pore. These ridges (about 2 mm. apart at base of arm) consist of minute papillæ not more than .3 mm. long, sometimes in a single row, but more often in zig-zag or alternating order, so as to make an almost double row. Each papilla consists of a hook covered with a thick sheath of skin, and either mounted on a very small base, or else sitting directly on the arm. Approaching the tip of arm, the hook-rows become more and more annular, till, on the fine twigs, they completely encircle the arm in a single row. In this way one or two hooks nearest the tentacle-pores often are prominent, so as to appear like tentacle-scales, though really there are none. Disk essentially naked, although, when partially dry, scattered microscopic grains are seen. Radial ribs regular, rather high, with the outer end cleanly cut off; they are covered with a smooth, close, fine granulation; about eight grains in the length of a mm. Mouth-papillæ, teeth, and tooth-papillæ all flat, spiniform, and similar; about twenty-one in all; those that represent teeth are about three, and are longer than the others. One large madreporic body at the inner angle of interbrachial space, close against the line of separation between upper and lower surfaces. Genital slits 5 mm. long, and lying under outer ends of radial ribs. Color, in alcohol, above, yellowish brown; below and at ends of twigs, much lighter.

A specimen from Philippines, by Semper.

CATALOGUE OF THE OPHIURIDÆ AND ASTROPHYTIDÆ, COLLECTED BY PROF. C. SEMPER, AND NOW BELONGING TO THE MUSEUM OF COMPARATIVE ZOÖLOGY.

	Number of specimens.	
Ophiomastix annulosa Müll. Tr.	5	Philippines.
" "	2	Pelews.
" mixta Ltk.	1	Pelews.
" flaccida sp. nov.	13	Philippines.
Ophiocoma scolopendrina Agas.	4	Pelews.
" "	1	Pelews ?
" "	14	Philippines.
" erinaceus Müll. Tr.	8	Philippines and Pelews.
" brevipes ? Peters.	4	Philippines.
" "	5	Pelews.
Ophioplocus imbricatus Lym.	9	Philippines.

	Number of specimens.	
Ophiarachna incrassata Müll. Tr.	1	Pelews.
" "	2	Philippines.
Pectinura marmorata sp. nov.	5	Philippines.
" stellata Ltk.	2	Philippines.
" infernalis Ltk.	1	Philippines.
" " "	1	Pelews.
" gorgonia Ltk.	2	Pelews.
" spinosa Lym.	1	Philippines.
Ophiolepis annulosa Müll. Tr.	1	Philippines.
" cincta Müll. Tr.	1	Pelews.
Ophiothrix Galateæ Ltk.	1	Philippines.
" " var. ?	1	Philippines.
" longipeda Müll. Tr.	7	Philippines.
" "	1	Pelews.
" " var. ?	3	Pelews.
" " var. ?	1	Philippines.
" hirsuta Müll. Tr.	1	Philippines.
" aspidota Müll. Tr.	1	Philippines.
" " ?	1	Philippines.
" Martensi sp. nov.	15	Philippines.
" cataphracta v. Martens	2	Philippines.
" purpurea v. Martens	1	Philippines.
" exigua sp. nov.	12	Philippines.
" striolata Grube	9	Philippines.
" plana sp. nov.	4	Philippines.
" stelligera sp. nov.	1	Philippines.
" pusilla sp. nov.	2	Philippines.
" elegans ? Ltk.	1	Pelews.
" triloba ? v. Martens	1	Philippines.
Ophiogymna elegans Ljn.	13	Philippines.
Ophiarthrum elegans Peters	4	Pelews and Philippines.
" pictum Lym.	3	Pelews.
" "	2	Philippines.
Ophiocnemis marmorata Müll. Tr.	13	Philippines.
Ophiactis sexradia Ltk.	38	Philippines.
" "	1	Pelews.
Ophionephthys phalerata sp. nov.	1	Philippines.
Amphiura (Amphipholis) depressa Ljn.	8	Philippines.
" lævis sp. nov.	7	Philippines.
Ophiocnida (Ophiophragmus Ljn.) echinata ?	4	Philippines.
Ophiopeza fallax Peters	1	Philippines.

	Number of specimens.	
Ophioglypha sinensis, Lym. var.?	10	Philippines.
Ophionereis dubia? Lym.	2	Philippines.
Ophiopsammium Semperi sp. nov.	12	Philippines.
Ophiothela isidicola Ltk. (young)	20	Philippines.
Astrophyton asperum Agas. (young)	1	Singapore.
" "	3	Philippines.
" nudum sp. nov.	1	Philippines.

In all, forty-five species, whereof eleven are new. These possess great value as illustrating the fauna of the shallower waters about the Philippine group, because Professor Semper passed several years in that region, and searched diligently for animals of all sorts. On the whole, this collection faithfully represents the fauna of the great ocean, although some rather common species, notably *Ophiocoma Valenciæ* and *O. pica*, are missing. This well may be, because species are often thus lacking in corners of faunal regions, e. g. *Ophiura brevicauda*, abundant at St. Thomas, is almost wanting in Florida. Of *Astrophyton*, besides *A. asperum*, there is a new and beautiful species, *A. nudum*, which, with *A. clavatum* and *A. verrucosum*, make four for the great ocean. To these may perhaps be added *A. exiguum*, in the Garden of Plants, brought by Peron and Lesueur, in 1803, from the South Sea. It is apparently a young one, having a disk of only 8 mm. in diameter, which, with the upper surface of the arm, is granulated finely, and has larger rounded grains among the smaller. Dr. von Martens need have no doubt as to the occurrence of this genus in the limits of the Indian Ocean. We have *A. asperum* not only from China and the Philippines, but also from the Straits of Malacca, brought to the Garden of Plants by Eydoux, in 1832. *A. verrucosum* rests on the authority of a specimen from "Indian seas," in the Garden of Plants, which may well be good, since such species as *Ophiocnemis marmorata* are found from Port Natal on the south to the Philippines on the north. It seems in every way probable that deep dredging will bring up not only plenty of these species, and of others like *Trichaster palmiferus*, but also additional forms, in the neighborhood of *Astromorpha*.

Homologies of Chewing Apparatus in Ophiuridæ.

The skeleton of an Ophiuran within the circle of the disk (Pl. VII.) consists of the line of arm-bones, jointed one on the other, like vertebræ; the genital plates (Fig. 13, *o*); the radial shields (*l*); of certain irregular pieces arranged along the margin of the disk (Figs. 5 and 18, *s*); and, finally, of the strong forked pieces (Figs. 5, 11, 13, 18, *f*) which form the five angles of the mouth, support the teeth, and thus make up the chewing apparatus. It is agreed that these forked pieces (f) are in some way made from the division of an arm-bone on its median line, and the swinging of each half sideways till it meets and is soldered with the corresponding half of the neighboring

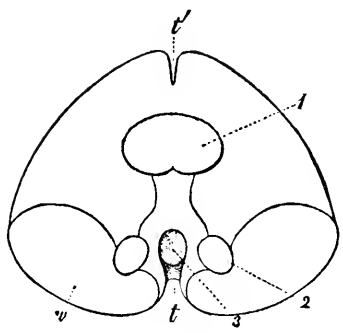


Fig. A.

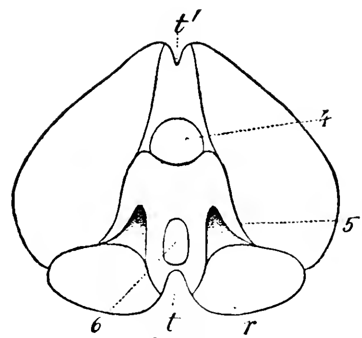


Fig. B.

arm-bone. To understand this, an arm-bone must be described in some detail. Each one then is, near the base of the arm, essentially the same as its fellows. Its inner surface (Fig. A) has, above, a broad umbo (1), below

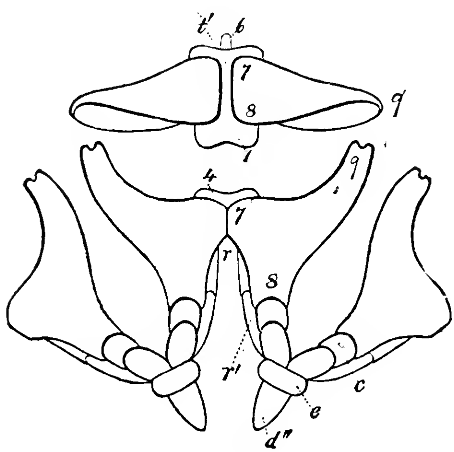


Fig. C.

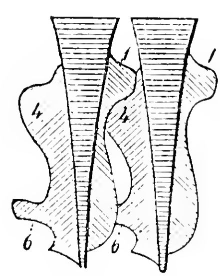


Fig. G.

which are two smaller knobs (2) standing on each side of a socket (3); still lower, and quite on the sides, are two large depressions (v) for attachment of muscles; above (t') and below (t) are notches for the upper and lower canals, of which the latter has been more studied and is known to carry a nerve and a water-tube. The outer surface of the arm-bone (Fig. B) presents, above, a hollow (4) in which rests the umbo (1) of the next piece beyond it; below are two depressions (5) into which fit the knobs (2), and between which is a peg (6) fitting in the socket (3). On each side of the lower edge is a triangular swelling (*r*), which is the outer wall of the tentacle-socket. Seen from above (Fig. C), the upper longitudinal canal (*t'*) divides the piece in two, leaving on either side an elongated triangular surface on which rest the upper arm-plates. On the outer side may be seen the upper surface of the hollow (4) and the articulating peg below it (6); and within is the upper surface of the articulating umbo (1). A view from below (Fig. D) shows the lower longitudinal canal (*t*); then without is the articulating peg (6) and the two sockets of the tentacles (*r*); within are the great lower muscle-fields (*w*), the two articulating knobs (2), and the socket (3) for the articulating peg. (For detailed views see Pl. VII., Figs. 7 – 10.) From the way in which the

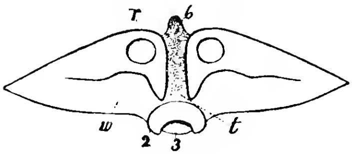


Fig. D.

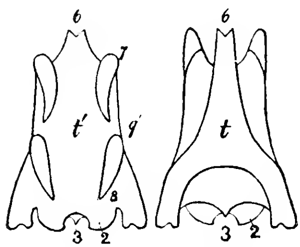


Fig. E. Fig. F.

joint is held by the umbo above and the peg below, a vertical motion of the arm upward is difficult where these parts are well developed, while the lateral motion is comparatively a free one. As a fact, the chief motion in the living is a lateral one, and only certain species roll their arms in a vertical plane, and this rolling is downward and not upward; the umbo must then slip outward and downward, while the peg must press deeper in its socket (Fig. G, lettered like the others).

A great modification is to be seen in the bones near the tip of the arm, which are much elongated, and are quite different in detail of structure. Along the upper surface runs a very wide and deep longitudinal canal (Fig. E, *t'*); from the outer end projects a forked process, which is the articulating peg (6); at the inner end may be recognized the articulating knobs (2), and the socket (3). On the lower surface may be seen the same parts (Fig. F) and the corresponding canal (*t*), which is slightly marked. (See also Pl. VII., Figs. 16, 17).

To return now to the chewing apparatus, each angle of the mouth has a supporting skeleton (Fig. C) in the form of a V, at whose apex is the jaw-plate (*e*). As has already been said, each side of this V is composed (wholly or in part) of the halves of one or more arm-bones greatly modified, and called collectively mouth-frames (Pl. VII., Fig. 5, *f*.). It has generally been assumed that there was only one modified arm-bone in each half of a mouth-frame, but plainly there must be *two*, because there are two tentacle-sockets (*r*, *r'*), in which are lodged the so-called mouth-tentacles; and in no Ophiuran or Astrophyton is there ever more than one tentacle, on each side, to every joint or arm-bone. When the mouth-frames are carefully examined, especially if boiled in potash, there is seen to be a line or suture between the wide outer part (*f*) and the narrow inner point (*c*). The suture runs nearly vertically through, or a little outside, the hollow for the nerve-ring (*n*), and, in some genera, as *Ophioglypha*, this inner point (*c*), called the jaw, is easily detached from the outer portion (*f*), which is more properly the mouth-frame.* This jaw has no tentacle, and is regarded by Müller as an interambulacral piece, which is soldered with its fellow from the side; and on the angle or point thus made is fixed the jaw-plate (*e*), which belongs to the skin formation, and which in turn supports the teeth (*d''*). It is in *Ophiothrix* that the homology of mouth-frames with the innermost arm-bone may most clearly be seen. In Fig. C, which is a diagram of the innermost arm-bone and of the mouth-frames seen from above, it is evident that the former is split nearly to its outer edge, and that its halves are turned sideways to meet their fellows from the next arm. The angles 7, 8, 9, correspond in the two pieces. This upper portion of the mouth-frame must be considered the first arm-bone having its own tentacle-socket (Pl. VII., Fig. 13, *r'*). The second arm-bone must be placed directly *below* the first, and so intimately soldered with it as to form one: it is provided with its tentacle (*r*), which is the second mouth-tentacle. On this view, each side of a mouth-frame would consist of three pieces, to wit, the first and second arm-bones and an interambulacral piece. All, however, is a theory, based on the position of the tentacles, and needs demonstration from embryology.

The skin formation remains to be considered. It is usual to make two distinct divisions, namely, the skin proper, which includes the arm-plates and the plating or scaling of the disk; and the skin appendages, which are spines, grains, and stumps. Great weight is therefore given, in classification, to these parts; but, morphologically, they are all *the same*, — a fact which may be

* See J. Müller über den Bau der Echinodermen, 1854, Plate VII., Fig. 6, *f*. This paper, with that of Gaudry, Pièces Solides chez les Stellérides, Annales des Scien. Nat., 1851, p. 339, are the most important for the subject.

illustrated by the arm-plates and spines. If we examine the broken end of an arm which is repairing, and where new joints are rapidly forming, we shall see that the tip is a mere tube (Plate V., Figs. 1, 2, 3, 4. Compare, also, the figures of young Ophiurans given by Müller). This tube is a calcareous network, filled and covered by the secreting tissue, or, as it may be termed, the skin. There seems, then, to be no beginning of an internal arm-bone, — nothing but this open calcareous tube. Immediately, however, there appear annular strictures round the arm, marking the future joints, with a sunken longitudinal line, or even slit, above and below, dividing the tube into two side arm-plates. This embryonic stage is partly persistent in some genera; e. g. species of *Ophiomusium*, which have no under arm-plates on most of the joints. Then appear on the central point of juncture, above, clusters of grains, which, in time, grow into upper arm-plates, and a similar process follows for the lower arm-plates. On the lower surface may be seen (Fig. 1), on the terminal joints, a little flap on each side; this flap grows more acute and rounded, becomes separated from the side arm-plate, and ends as a true arm-spine. So that, in this species of *Pectinura*, beginning with a tube of calcareous network, covered by its secreting skin, we end, at the base of the arm, by the complex assemblage shown in figures 5, 6, 7; and all these parts are merely different growths and divisions of this same network.

The same is true of the various divisions of the upper arm-plates and their supplementary pieces, explained in Plate V. The network may send its branches from its edges or from its upper surface, and these branches may remain connected, and thus enlarge the plate; or they may be separated, and make spines, tentacle-scales, and supplementary plates. It is the same with other Echinodermata, and the process is simply illustrated by the growth of a young spine in *Ophiothrix* (Pl. III., Figs. 4 – 7). The mouth-parts make no exception. The jaw-plate (Pl. I., Fig. 4, *c*) is a skin-plate, and supports *another* skin-plate, the tooth (*d''*), which has been separated from it. The peculiar papillæ of *Ophioglypha*, which embrace the second mouth-tentacle (*q''*), are, on one side, carried by a peculiar piece attached to the innermost under arm-plate. This piece is only an enlarged outer mouth-papilla (so called), on whose edge have formed these additional papillæ (see the mouth-papillæ described under *Pectinura marmorata*). A similar process gives all the variety in the lamellæ of the stony Polyps. What is true of the arm-plates is true of the skin of the disk, whose scales may be traced from the six primary plates first formed on the back. On these scales may be developed spines, grains, or stumps, just as on the arm-plates. The strict morphological connection of all these parts should warn us not to distinguish them too emphatically, and not to give them too great a value in generic distinctions, especially those minute papillæ which form the armature of the mouth. As to what is provisionally called the skeleton, it is well to remark that Gaudry is right in considering the arm-bones or disks as parts whose homology is obscure; certainly they are not properly ambulacral plates, as Joh. Müller thought, because the tentacles, with their water-system, lie *above* the ambulacral plates in starfishes, whereas in Ophiurans they lie *below* the arm-bones and above the under arm-plates, which latter are plainly the true ambulacral plates, not only from their position, but from their early formation, which corresponds to that of the same parts in the starfishes.

EXPLANATION OF PLATES.

NOTE. — Of these seven plates, all printed by photolithography, the two first are by the Heliotype process of Boston; the five last by the Alberttype, of New York. Although they have the advantage of giving exactly the outlines of the original india-ink drawings, they are very inferior to the drawings themselves; and not only these, but all similar plates I have seen, are faulty in their blurred outlines and their uneven and spotted shading. Their general effect is that of a lithograph from a worn stone. Doubtless the process will, before long, be perfected; but at present it lacks much.

PLATE I.

DIAGRAMS.

To make clear the terms commonly used in describing Ophiurans, and to show the varied forms of the parts to which these terms apply, there are given two diagrams, Figs. 1 and 2, representing the under and the upper surface of a disk, with the bases of arms. Each surface is divided into five equal sections, exhibiting the types of as many genera; while the bases of the arms may either correspond, or may belong to others; so that, in the two diagrams, there are nine genera, as follows: A, *Ophiura*; B, *Ophiocoma*; C, *Ophiomyxa*; D, *Ophiothrix*; E, *Ophioglypha*; F, disk of *Amphiura*; G, arm of *Ophiopsammium*; H, arm of *Hemieuryale*; I, arm of *Ophiomusium*.

Fig. 3 is a diagram of one of the five angles of the mouth, seen diagonally from below, to show the relations of the chewing apparatus, mouth-tentacles, mouth-shields, and jaws.

Fig. 4 is a diagram of the mouth parts in *Ophioglypha*, showing half of an angle, with the under arm-plates of two joints.

To these figures the same lettering is applied.

a. Scutum buccale; mouth-shield; mundschild; plaque buccale. This plate is always present, though sometimes quite shrouded by a thick skin (*Ophiomyxa*). Sometimes it takes on a great development, running far out into the interbrachial space (some species of *Ophioglypha*); in *Ophiarachna* it has a small supplementary piece lying outside of it. One of the five shields is the madreporic, and is connected with the stone-canal.

b. Scutella adoralia; side mouth-shields. These are lettered in Figs. 3, 4, and will be seen inside the point of the mouth-shield in Fig. 1. Often they may be covered either by thick skin (*Ophiomyxa*) or by granulation (*Ophiura*). Their size is considerable in *Ophioglypha* (Fig. 1, E), but in *Ophiothrix* they are small and narrow (Fig. 1, D). Usually their outer end rests against the innermost side arm-plate; but in some species of *Ophiactis* they extend farther, and touch their outer ends at the outer corner of each mouth-slit; thus forming an unbroken ring round the mouth.

c. Scutella oralia; jaws; mundeckstück (sometimes included in mouth-frames). These are the only pieces of the skeleton not covered by the tegument or its plates. They are lettered in Figs. 3, 4, and may be seen in Fig. 1, within the side mouth-shields, against which they usually press, though in *Ophiothrix* they are separated by an indentation. Sometimes they are covered by the skin or by granulation (*Ophiomyxa*, *Ophiura*).

d. Papillæ orales vel marginales; saumpapillen; papilles calcaires de la bouche; mouth-papillæ. These run along the lower edge of each mouth-angle, and the greater part, or the whole, rest directly on the mouth-frames; in a whole group of genera they are wanting (*Ophiothrix*, *Ophiocnemis*, etc.). *Ophiomyxa* has them under the form of little comb-like lobes. They are close and numerous in some genera (*Ophiocoma*), and confined to a single papilla on each side in others (*Hemipholis*). They run diagonally upward in some species of *Ophioglypha*. See also under *tentacle-scales.*

d'. Papillæ dentales: zahnpapillen; tooth-papillæ. (Fig. 3, *d'*, and the point of the mouth-angle of *Ophiothrix* in Fig. 1.) This group of papillæ, lying just under the teeth, is most developed in *Ophiothrix*, well marked in *Ophiocoma*, but quite wanting in *Ophiura*.

d''. Dentes; zähne; teeth. (Figs. 3, and 4 *d''*, and the point of the mouth-angle in *Ophioglypha* and *Ophiura* in Fig. 1.) These, like the tooth-papillæ, are always carried by the jaw-plate, and are never wanting among true Ophiurans. In some genera, they descend to the level of the lower margin of the jaw-frames (*Ophioglypha*, *Ophiura*, *Ophiopeza*), in others they are supplemented by tooth-papillæ (*Ophiocoma*, *Ophiomastix*, *Ophiothrix*); and in *Ophiomyxa* they have the form of comb-like lobes, resembling the rest of the chewing apparatus.

e. Torus angularis: maxiller; jaw-plate. (Figs. 3 and 4.) This is a narrow calcareous plate, running vertically along the inner point of the jaws, with little hollows in its surface, to which the teeth are bound by small muscles. It is a part which always exists, and is made up of several pieces, which are often separable.

h. Scutella ventralia; bauchschilder; plaques ventrales du bras; under arm-plates. (Figs. 1 and 4, *h.*) They differ extremely in size and form; being always minute and more elongated at the tip of the arm, and in some genera they continue subordinate (*Ophioglypha*, *Ophiomusium*), while in others they widen and make a broad continuous strip (*Ophiura*, *Ophiarachna*, *Ophiocoma*). Some genera have them covered by a thick skin (*Ophiopsammium*, *Ophioscolex*), as also *Ophiomyxa*, where they divided, lengthwise, in two.

i. Scutella lateralia; plaques laterales du bras; side arm-plates. These may be considered the fundamental covering of the arm, for they alone surround it at the tip; and in one genus (*Ophiomusium*) they so continue nearly to its base, almost wholly excluding the upper and under plates (Fig. 2, I *i*). Other genera, like *Ophioglypha* (Fig. 1, E *i*), have them persistent on the lower surface of the arm, but replaced above by the upper arm-plates. Coming to forms like *Ophiocoma*, they are widely separated (Fig. 1, B) above and below. Finally, in the extreme case of *Hemieuryale* (Fig. 2, H *i*) the side arm-plates are reduced to small bead-like projections. Then there are two different forms, — the *ridge*, which stands out free of its neighbors, and bears the spines nearly at right angles to the axis of the arm (Fig. 1, B D), (*Ophiocoma*, *Ophiothrix*, *Ophiacantha*); and the *flat*, which clings close to the surface and overlaps the next plate beyond (Fig. 1, A E; Fig. 2, A I), (*Ophiura*, *Ophioglypha*, *Pectinura*). These bear the spines on their outer edge, and lying close to and parallel with the arm. In consequence of two such modes of structure, Ophiurans are divided into supple-armed and stiff-armed. The ridge-like plates give space for a more or less free lateral motion, while the flat and overlapping ones impart rigidity. If a living *Ophiothrix* be placed side by side with an *Ophiura*, the former will wriggle briskly along the bottom, while the latter may lie quite torpid, or only slightly bend its rigid arms. Dr. Graeffe told me that one of the most singular spectacles he had seen was an *Ophiothrix longipeda* swimming free, and with its five immensely long arms in rapid and perplexing motion. *Ophioglypha* has more mobility than *Ophiura*, but its way of lifting itself along by two of its arms, as described by Professor Mobius,* is very different from the lively squirming of the arms of an *Ophiothrix*. Even in genera which are clothed by a thick skin, such as *Ophiomyxa*, the side arm-plates will be found well developed underneath.

j. Scutella dorsalia; rückenschilder; plaques dorsales du bras; upper arm-plates. Like those of the lower surface, they may either remain very small, as when they first appear at the arm-tip (*Ophiomusium*, Fig. 2, I *j*), or may develop into wide scales, covering the whole upper surface (*Ophiura*, Fig. 2, A *j*; *Ophiarachna*). It is these plates that are specially liable to multiplication, either by breaking up mechanically, or by the addition, in various ways, of supplementary pieces (see p. 267). The extremest case is furnished by *Hemieuryale*, where the original plate becomes lost in a mosaic of additional pieces (Fig. 2, H *j*).

l. Scutella radialia; radialschilder; plaques radiales; radial shields. Not properly a part of the general scale covering of the disk, and belonging rather to the interior skeleton through their connection with the genital plate, these shields are an exceptional feature, and one that never is wanting, although sometimes hidden by thick skin (*Ophiomyxa*, Fig. 2, C), or by scales and granules (*Ophiura*, Fig. 2, A); sometimes very large, with their inner portion buried by scales (*Ophiothrix*, Fig. 2, D; *Ophioglypha*, Fig. 2, E), or, again small and narrow (*Amphiura*, Fig. 2, F).

m. Radial scales sometimes exist as large scales just next the outer end of the radial shield. In *Ophioglypha* they serve to support an arm-comb of small papillæ (Fig. 2, E *m*).

n. Genital scales are largely developed in some genera, where they bound a part of the body wall of the genital opening (*Ophioglypha*, Fig. 1, E *n*), and even pass upwards and arch over the base of the arm (*Ophiothrix*, Fig. 1, D *n*).

p. Spinæ brachiales; arm stacheln; piquants; arm-spines. It has already been

* Schriften des Naturw. Vereins für Schleswig-Holstein, I. 179, 1873.

shown that these spines may stand either on ridges at right angles to the length of the arm (Fig. 1, B C D) or on the outer edges of the side arm-plates, parallel to it (Fig. 1, A E). In the former case the wider diameters of the spines are upward, like the paddles on a wheel (*Ophiothrix*); in the latter, the spine has its edge upward as if it had been revolved 90° on its own axis. The variations in these little organs are almost endless; extremely long, thin, glassy, and thorny (*Ophiothrix Suensonii*), very small, thick, opaque, and smooth (*Ophiomusium eburneum*); rounded and tapering (*Ophiocnemis marmorata*); flat and of even width (*Ophiura cinerea*); covered with thick skin (*Ophiomyxa flaccida*); naked (*Ophiocoma echinata*); club-ended (*Ophiomastix annulosa*); armed with hooks (under spine in some species of *Ophiothrix*). The importance of the arm-spines depends partly on their length, thickness, and number, and partly on the extent of the side arm-plates. When these last occupy a large part of the circumference, and the spines also are long and numerous, the arm proper is almost hidden and resembles a round bristle-brush (*Ophiomyces frutectosus*).

q. Papillæ ambulacrales; tentakel schuppen; papilles tentaculaires; tentacle-scales. Although these small organs are strictly homologous with, and even sometimes similar to, the arm-spines (*Ophioglypha*), they nevertheless have a different function, to wit, that of covering the tentacle drawn in; and usually they differ in form and position from the nearest arm-spine. Thus in *Ophiothrix*, while the lowest spine is often hooked, the tentacle-scale is minute and tooth-like; in *Ophiopsila* it is like a spatula; *Ophionereis* has a single circular one; *Ophiocoma* one, or two, of a shape more or less oval. In *Ophiura* the upper scale laps over the base of the lowest arm-spine, though in most genera the two are separated. One of the tentacle-scales is often carried by the under arm-plate, either on its lateral edge (*Amphiura*) or on its surface, making a continuation of the line of arm-spines (*Ophiomyces*). Although some species of *Amphiura* have two scales, one on the edge of the under arm-plate and the other at right angles on the edge of the side arm-plate, others have no scale at all, — a want shared by many species (*Ophioscolex glacialis*, *Ophiomyxa*, *Ophiopsammium*). The two pairs of mouth-tentacles are not neglected in this respect (Figs. 3, 4, *q′ q″*); but, in almost all genera, are furnished with one or more tentacle-scales (*q q*). That of the first, or upper, tentacle sits on a little ridge of the jaw. It is this, when largely developed (as in some species of *Amphiura*), that has been described as a peculiar papilla situated *high up in the mouth*. *Ophiothrix* is one of the few genera that lacks this scale, which exists even in *Ophiomyxa*. While these scales are closely homologous, on the one side, with arm-spines, they also are, on the other, with certain mouth-papillæ. Of this there is an illustration in *Ophioglypha* (Fig. 4), where the tentacle has a row of scales on either side of it, one row carried on the edge of the side arm-plate (*i*), the other on that of the under arm-plate (somewhat displaced in the figure). It is a greater development of what occurs in the *Amphiuræ* with two scales (Pl. IV. Fig. 20). The homologue of the side arm-plate which belongs to the innermost under plate is the side mouth-shield; and this not only in *Ophioglypha* (*b*), but in most other genera, bears one or more tentacle-scales, under the form of outer mouth-papillæ; while what may exactly be called mouth-papillæ (*d*) are apt to stand on the mouth-frames. This distinction, however, is only one of convenience as applied to parts really homologous. Thus in *Ophioglypha* the two rows of scales belonging to the second pair of mouth-tentacles stand respectively on a plate which is really an overgrown outer mouth-papilla (see under *Pectinura marmorata*), and on the side mouth-shield (partly, also, on the mouth-frames ?). The first pair of mouth-tentacles, in the same genus, are duly furnished with their own scales, which stand, as usual, on a ridge of the jaw. All the complex arrangement just described may be most clearly seen in *O. Lymani*.

The integument which encloses the disk is, properly speaking, covered, or beset, with calcareous plates, which, in the young, are six in number, to wit, the largest in the centre and the other five in a close circle round it, one opposite the base of each arm. In some genera the secretion of lime is stopped in the disk integument at an early period; and, in the adult, nothing is to be found but a few minute grains buried in the skin, while the general surface of the disk is smooth and fleshy. Such genera are said to be *naked* (*Ophiomyxa*, *Ophiarthrum*, Figs. 1, 2, C). Others are equally called naked where a thick skin covers a regular scaly coat (*Ophiopsila*). In many genera the disk is plainly covered with plates, which may be finely imbricated scales (*Amphiura*, Fig. 2, F) or coarser and thicker ones irregularly arranged (*Ophioglypha*, Figs. 1, 2, E), or thick angular pieces set side by side on the same level, like a mosaic (*Ophiolepis*, *Ophiomusium*). Then there are genera in which the scale coat is beset, or even hidden, by appendages. These may be spines (*Ophiothrix*, Figs. 1, 2, D); or scattered grains (*Ophiocoma*, Fig. 1, B); or grains so closely set as to completely hide the disk, radial shields and all, except the mouth-shields (some species of *Ophiura*, Figs. 1, 2, A). There is one genus (*Ophiopsammium*) in which the disk and upper surface of the arms are covered, first by a smooth integument, and this again by a close granulation. The radial shields are to be seen in all species in which the scale coat is visible, and the mouth-shields are never hidden except in a few species which have a very thick, naked integument.

PLATE II.

Spines and Stumps of the Disk of Ophiothrix.

All the figures are enlarged about thirty diameters.

Figs.	1 – 14	*Ophiothrix echinata.*
"	15 – 29	" *lusitanica.*
"	30 – 36	" *pentaphyllum.*
"	37 – 44	" *fragilis.*
"	45 – 55	" *quinquemaculata.*

1, 2, 3, a spine and two stumps, *O. echinata*, original of Müll. & Trosch. 4 – 9, Naples. 10 – 11, showing a stump covered by skin, and another with the skin partly torn off: Naples. 12 – 13, stumps from lower interbrachial space of a young, having a disk of 2.5 mm. The scales of the disk are then visible, and Fig. 13 shows how one stump stands on each scale: Naples. 14, a short spine from the interbrachial space below: Algeria.

15 – 20, *O. lusitanica*, Naples; 16 – 18 being from the young; 15, 19, 20, from an adult; the last (20) is a very rare spine. 21 – 29, N. W. coast of France; of these 22 is the common form; the rest are more or less rare; 28 is found near the edge of the disk.

30 – 35, *O. pentaphyllum*, Isle of Wight; of these 30 – 33 are the characteristic grains and stumps of the centre of the disk; 34, 35, are its thick columnar spines; 36, a disk spine: Madeira?

O. fragilis. 41, stump from a young, with a disk of 5.5 mm. 37, 40, 42, two stumps and a spine from a disk 7 mm. in diameter. 44, an elongated stump from the edge of a disk 9 mm. in diameter. 38, 39, stumps from a large specimen (disk 16 mm.); 39 is rare: Denmark. 43, rough grain from centre of disk; large specimen: Sweden.

O. quinquemaculata. 46, 47, stump and articulated spine from a young, with a disk of 3.5 mm.: Naples. 52, 53, short and elongated stumps from a disk 7.5 mm. in diameter; the latter from the edge. 51, articulated spine from a large specimen. 45, irregular, thickened spine from an adult. 48, 49, 50, short stumps from the centre of a large disk. 54, an elongated stump from the edge of the same. 55, a large stump like 49, much elongated: Spezia.

PLATE III.

Growth of Spines, Hooks, and Stumps.

Ophiothrix alopecurus Müll. & Trosch. *Ophiothrix rudis* sp. nov. *Ophiothrix stelligera* sp. nov. *Ophiothrix pusilla* sp. nov.

Fig. 1. The fluted form of the long spines which cover the upper surface of the disk, except the radial shields, in *O. alopecurus*. These usually are more slender, with smaller side thorns and only slight appearance of fluting; $\frac{30}{1}$.

Figs. 2, 3. Minute spines, simple and forked, which sometimes are found sparsely on the radial shields; $\frac{30}{1}$.

Fig. 4. A young arm-spine from near tip of arm, showing a central shaft with thorns forming on either side, and the holes, along the two lines of juncture, not yet filled up; $\frac{70}{1}$.

Fig. 5. A similar spine with the side thorns broken off to show more distinctly the central shaft; $\frac{70}{1}$.

Fig. 6. Tip of a similar spine more magnified, to show the holes along the lines of juncture, holes of growth; $\frac{140}{1}$.

Fig. 7. Fragment of a very young spine much magnified, to show the soldering of a thorn with the central shaft, and the holes of growth.

Fig. 8. Base of an adult arm-spine, showing the development and close soldering of the side thorns to each other and to the central shaft; $\frac{20}{1}$.

Fig. 9. Tip of an adult spine magnified, to show the central shaft and side thorns beginning to form.

Fig. 10. Hook from near tip of arm, corresponding to Fig. 4. At its base are seen the holes of growth; $\frac{70}{1}$. For its position with its three arm-spines, see Pl. VII., Fig. 16.

Fig. 11. *Ophiothrix rudis.* A disk-stump; $\frac{20}{1}$.

Figs. 12, 13. Under and upper arm-spines from the eighth joint; the latter has a blue belt round the middle; $\frac{20}{1}$.

Fig. 14. Under arm-plate of the eighth joint; $\frac{20}{1}$.

Fig. 15. *Ophiothrix stelligera.* Under arm-plates of the seventh, eighth, and ninth joints, with one of the hooks; $\frac{10}{1}$.

Fig. 16. Upper arm-plate, near the disk; $\frac{10}{1}$.

Fig. 17. Common form of disk-stump; $\frac{120}{1}$.

Fig. 18. A similar one from above; $\frac{120}{1}$.

Fig. 19. Rare form of disk-stump; $\frac{120}{1}$.

Fig. 20. Spine from the interbrachial space below; $\frac{100}{1}$.

Figs. 21, 23, 25. *Ophiothrix pusilla.* Unusual forms of disk-stumps; $\frac{60}{1}$.

Fig. 22. The common form of stump on the back of the disk; $\frac{60}{1}$.

Fig. 24. Stump from interbrachial space below; $\frac{60}{1}$.

Fig. 26. Stump from interbrachial space near mouth; $\frac{60}{1}$.

Fig. 27. Side arm-plate of seventh joint with its eight spines and hook; $\frac{10}{1}$.

Fig. 28. Part of an under and a side arm-plate close to tip of arm, showing the one small arm-spine and the large hook; much magnified.

Fig. 29. Upper arm-plates of sixth, seventh, and eighth joints, with two side arm-plates, to show the triangular projection from the latter; $\frac{10}{1}$.

Fig. 30. Upper arm-plates, near end of arm, with spines and side arm-plates, showing the triangular projection from the latter.

PLATE IV.

Ophiothrix plana sp. nov. *Ophiothrix Martensi* sp. nov. *Ophiopsammium Semperi* gen. et sp. nov. *Amphiura laevis* sp. nov. *Ophiocnida* (*Ophiophragmus* Ljn.) *echinata* (?) (*longipeda* Lym. MS.). *Ophiothrix exigua* sp. nov. *Ophiothrix comata* Mull. & Trosch. *Ophiothrix ciliaris* Mull. & Trosch. *Ophiothrix fumaria* Müll. & Trosch.

Fig. 1. *Ophiothrix plana.* Portion of upper surface of disk; at the centre and left the skin is partly dried to exhibit the underlying scales which on the right are covered by the epidermis; $\frac{5}{1}$.

Figs. 2, 4. Different forms of the third arm-spine. Fig. 4 has its epidermis; $\frac{20}{1}$

Fig. 3. An upper arm-spine; $\frac{20}{1}$.

Fig. 5. A short disk-stump covered by a thick epidermis ; $\frac{20}{1}$.

Fig. 6. Three disk-stumps, one with and two without epidermis ; $\frac{20}{1}$.

Fig. 7. Edge of a side arm-plate near tip, carrying two spines and a double hook ; $\frac{40}{1}$.

Fig. 8. Under arm-plates ; $\frac{5}{1}$.

Fig. 9. *Ophiothrix Martensi.* Hook and arm-spine next above it, with its epidermis ; $\frac{30}{1}$.

Fig. 10. Upper arm-spine and upper arm-plates close to disk ; showing the central blue line with a white line on each side.

Fig. 11. *Ophiopsammium Semperi.* Twelfth joint, seen diagonally from below, showing, on the further side, an extended tentacle and the lowermost arm-spines ; and, on the nearer portion, a side arm-plate and its spines, foreshortened, and with the tentacle omitted ; $\frac{20}{1}$.

Fig. 12. Part of upper surface of disk, showing the base of an arm, and the pairs of spines in the interbrachial space ; $\frac{5}{1}$.

Fig. 13. Tooth-papillæ and teeth seen from within ; $\frac{10}{1}$.

Fig. 14. Longest arm-spine (third) near base of arm ; $\frac{10}{1}$.

Fig. 15. Under arm-plates, as they may be distinguished near tip of arm ; $\frac{10}{1}$.

Fig. 16. Joints, seen from above, close to end of arm, showing the beginning of the granulation, and the embryonic upper arm-plates ; each side arm-plate is furnished only with two little arm-spines and a strong double hook ; $\frac{20}{1}$.

Fig. 17. Granulation of the upper arm near its base ; $\frac{20}{1}$.

Fig. 18. *Amphiura lævis.* A portion of the disk, from above, with the base of an arm ; $\frac{10}{1}$.

Fig. 19. An angle of the mouth, showing the four mouth-papillæ on each side, with mouth-shield and side mouth-shields ; $\frac{10}{1}$.

Fig. 20. Two joints of arm, near the disk, seen from below ; $\frac{10}{1}$.

Fig. 21. *Ophiocnida echinata ?* Part of a side arm-plate with its spines ; $\frac{5}{1}$.

Fig. 22. A portion of the disk, from above, with the base of an arm ; $\frac{5}{1}$.

Fig. 23. An angle of the mouth, with a mouth-shield and the first two under arm-plates ; $\frac{5}{1}$.

Fig. 24. *Ophiothrix exigua.* Upper arm-plates and bases of the arm-spines, near the disk ; $\frac{10}{1}$.

Fig. 25. The common form of disk-stump ; $\frac{50}{1}$.

Fig. 26. Hook, standing below the arm-spines ; $\frac{35}{1}$.

Fig. 27. *Ophiothrix comata* (from the original in the Vienna Museum). An under arm-plate, with its tentacle-scale ; $\frac{10}{1}$.

Fig. 28. Two upper arm-plates, with the bases of arm-spines ; $\frac{10}{1}$.

Fig. 29. *Ophiothrix ciliaris* (from the original at the Garden of Plants). A portion of upper surface of disk and two upper arm-plates, showing the distribution of the fine disk-stumps ; $\frac{8}{1}$.

Fig. 30. A disk-stump, from near the edge ; $\frac{18}{1}$.

Fig. 31. Two under arm-plates.

Fig. 32. Second arm-spine; $\frac{15}{1}$.

Fig. 33. *Ophiothrix fumaria* (from the original in the Garden of Plants). A portion of upper surface of disk, with some upper arm-plates. On either side of the points of the radial shields appear the upper corners of the genital scales; $\frac{4}{1}$.

Fig. 34. Under arm-plates, with tentacle-scales.

Fig. 35. Arm-spines, near base of arm; $\frac{8}{1}$.

Fig. 36. A disk-stump on its scale, much magnified.

PLATE V.

Formation of Arm-spines, Arm-plates, and Supplementary Pieces.

Pectinura marmorata sp. nov.; *Hemieuryale pustulata* v. Mart.; *Ophioplocus Esmarki* sp. nov.; *Ophiura squamosissima* Lym.; *Ophiura cinerea* Lym.; *Ophiopholis aculeata* Müll. & Trosch.; *Ophionereis dubia* Lym.

Fig. 1. *Pectinura marmorata.* The tip of an arm undergoing repair. The point is only a tube of calcareous network, covered by the secreting membrane. Farther in, this tube is widened and cut transversely by furrows into joints, which have lobes at their outer edge; and these lobes grow more sharp and rounded, and finally become the lowermost arm-spine, *p*. There are no under arm-plates at this stage of growth; $\frac{40}{1}$.

Fig. 2. The same from above. Almost the entire surface is occupied by the side arm-plates, at whose central point of juncture appear little collections of granules, *j*, which are to be separated later as upper arm-plates; $\frac{40}{1}$.

Fig. 3. The same seen from the side. One joint has two partly formed arm-spines, *p*, and the next joints have one each; $\frac{40}{1}$.

Fig. 4. The broken arm under repair, showing the old portion, and eighteen new joints; of which the last five are represented in Figs. 1, 2, 3; $\frac{10}{1}$.

Figs. 5, 6, 7. Two joints, close to the disk, seen from below, from above, and from the side, to compare the perfect plates and spines with the young; $\frac{10}{1}$.

Fig. 8. *Hemieuryale pustulata.* Tip of the arm, magnified, showing the tubular point, the side arm-plate, *i*, and the young upper arm-plate, *j*.

Fig. 9. A joint near the tip, seen from above. *p*, arm-spine; *i*, side arm-plate; *j*, upper arm-plate; *k*, supplementary piece.

Fig. 10. Joint farther inward. *i*, side arm-plate; *j*, upper arm-plate; *k*, supplementary piece, in addition to which there are now numerous others, smaller.

Fig. 11. Joint about one third out on the arm. *k*, the great supplementary piece, which now is larger than the side arm-plate, *i*, and forms the little cushion characteristic of the genus. The upper arm-plate can no longer be distinguished among the numerous irregular supplementary pieces. This is an instance of great changes in the relative importance of parts in the process of growth.

Fig. 12. *Ophioplocus Esmarki.* Tip of arm showing the very short tubular point, followed by a joint which has a small upper arm-plate. The corresponding plate of the next joint has a longitudinal furrow; the same is fairly separated in

two parts on the succeeding joint, and has a couple of supplementary pieces within. The two parts are still more diverging on the next joint, *j*; the large side arm-plate, *i*, comes up toward the median line, and the upper arm-spine *p* is prominent; $\frac{40}{1}$.

Fig. 13. A joint near the middle of the arm. The two parts of the upper arm-plate, *j*, are now completely separated by the intrusion of supplementary pieces, which have increased to seven; *p*, arm-spine; *i*, side arm-plate; $\frac{40}{1}$.

Fig. 14. A joint at the base of the arm. The two parts of the upper arm-plate *j*, instead of occupying the top, have been wedged apart by supplementary pieces, until they are on each margin. The side arm-plates, *i*, have become small as compared with the supplementary pieces, and the arm-spines, *p*, are no longer conspicuous; $\frac{40}{1}$.

Fig. 15. *Ophiura squamosissima.* Piece of arm near its tip, enlarged. The outer joint bears a small, simple upper arm-plate; the innermost one has also a simple plate, *j*, outside which are two supplementary pieces, *k*; on either side is a large side arm-plate, *i*, bearing a short spine.

Fig. 16. A joint near the base of the arm. The upper arm-plate still occupies the median line, *j*; but the two supplementary pieces, *k*, have moved from a position beyond, to one on either side of the upper arm-plate, and still another supplementary piece has been formed in a line with the rest and lying on the margin. The side arm-plate has become comparatively small, *i*, and has been crowded down on the side of the arm.

Fig. 17. *Ophiura cinerea.* A joint near base of arm, showing the upper arm-plate broken in several pieces, as is usual; $\frac{8}{1}$.

Fig. 18. *Ophiopholis aculeata.* Two joints near end of arm showing the upper arm-plate, *j*, with a row of grains or small supplementary pieces, only along their outer margin; $\frac{4}{1}$.

Fig. 19. Two joints near the base, showing the same plates, *j*, completely encircled by a close row of small pieces, which may be double on the sides; $\frac{4}{1}$.

Fig. 20. *Ophioncreis dubia.* A joint near end of arm showing the simple upper arm-plate, *j*; $\frac{20}{1}$.

Fig. 21. A joint near base of arm, with a small supplementary piece, *k*, on each side of the upper arm-plate, *j*; $\frac{20}{1}$.

PLATE VI.

Astrophyton caecoticum sp. nov.; *Astrophyton nudum* sp. nov.; *Ophioplocus Esmarki* sp. nov.; *Ophionephthys phalerata* sp. nov.; *Pectinura septemspinosa* Müll. & Trosch.; *Ophiomastix flaccida* sp. nov.

Fig. 1. *Astrophyton caecoticum* (from a dried specimen). A part of the disk, from below, with outline of one fork of the arm, showing the distance of the branches with approximate accuracy; $\frac{1}{1}$.

Fig. 2. Part of upper side of disk, showing the slender radial ribs, and the first fork of the arm ; $\frac{4}{1}$.

Fig. 3. The head of a radial rib and part of the interbrachial margin, enlarged to show the granulation along the edge ; $\frac{4}{1}$.

Fig. 4. *Astrophyton nudum*. Tip of a twig, seen from below, showing the continuous line of hooks covered by a thick skin ; and, in front of them, two short, conical tentacles ; $\frac{60}{1}$.

Fig. 5. Three hooks, from the double alternating rows of the branches near the base of the arm. From one, the skin has been stripped, showing the naked hook ; $\frac{40}{1}$.

Fig. 6. *Ophioplocus Esmarki*. Two joints near base of arm, seen from the side ; $\frac{16}{1}$.

Fig. 7. *Ophionephthys phalerata*. Two angles of the mouth, the base of the arm, and a part of two interbrachial spaces ; $\frac{7}{1}$.

Fig. 8. Portion of upper surface of disk, with base of an arm, and radial shields surrounded by their peculiar wreath of scales ; $\frac{7}{1}$.

Fig. 9. An upper arm-plate, with a side arm-plate and its spines, showing the peculiar thickened spine ; $\frac{30}{1}$.

Fig. 10. *Pectinura septemspinosa* (from the original at Leyden). Upper arm-plates and spines, near disk, showing how the former are usually broken ; $\frac{4}{1}$.

Fig. 11. An angle of the mouth enlarged, exhibiting the mouth-shield with its small supplementary piece and the surrounding granulation.

Fig. 12. Arm-spines, near disk, with the lowest one somewhat longest, and having its base covered by a tentacle-scale ; $\frac{4}{1}$.

Fig. 13. Two under arm-plates within the disk, with the pairs of pores between them ; $\frac{4}{1}$.

Fig. 14. *Ophiomastix flaccida*. An angle of the disk and base of an arm, seen from above, where are seen the peculiar upper spines thickened in different degrees ; $\frac{5}{1}$.

Fig. 15. Two joints from below, showing two tentacles having no tentacle-scales ; $\frac{5}{1}$.

PLATE VII.

Pectinura infernalis. Mull. and Trosch. ; *Ophiarthrum pictum* Lym. : Homologies of the skeleton of the arm and mouth-parts in *Ophiothrix*, *Ophiura*, *Ophioglypha*, and *Ophiomyxa*.

Fig. 1. *Pectinura infernalis*. Part of upper surface of disk, to show the characteristic arrangement of the naked plates ; $\frac{4}{1}$.

Fig. 2. *Ophiarthrum pictum*. A corner of the disk and three upper arm-plates, with the pattern lines and arm-stripe ; $\frac{4}{1}$. Specimen from Pelew Islands.

Fig. 3. A tentacle and its scale ; $\frac{40}{1}$.

Fig. 4. Side arm-plate (third joint from the disk) with its spines, and a corner of the upper arm-plate; $\frac{5}{1}$.

Fig. 5. *Ophiura lævis* (Mediterranean). The skeleton of the mouth-parts, and of the arm as far as the edge of the disk, with the genital plates, *o*, *o*, in position, seen from above; $\frac{5}{1}$. *c*, jaws; *e*, jaw-plate; *d″*, teeth; *u*, circular canal for the nerve-ring of the mouth; *r*, *r′*, sockets of the second and first pairs of tentacles; *q*, tentacle-scale of the first pair; *f*, mouth-frames; *r*, *r* (on the arm-bones), places for the tentacles; *s*, one of the supplementary pieces lying along the margin of the disk, under the skin; *t′* upper arm-canal. On the left are a few scales of the disk, in position, with their coat of grains. The radial shields are removed.

Fig. 6. Jaws, one mouth-frame, and two arm-bones in profile, the latter are separated and turned so as to show part of the top; lettering as above; $\frac{5}{1}$.

Fig. 7. *Inner* side of first arm-bone, showing its points, which articulate with the outer side of the mouth-frames (compare Fig. 6); *t*, lower arm-canal; *h*, under arm-plate; *w*, lower muscle-field; $\frac{5}{1}$.

Fig. 8. Fifth arm-bone, *outer* side, with tentacle-sockets, *r*, upper and lower canal, articulating peg, and depression to receive the umbo of the next arm-bone; $\frac{5}{1}$.

Fig. 9. *Inner* side of same bone, with the lower muscle-field, *w*, the articulating umbo, and the depression below it to admit the articulating peg; $\frac{5}{1}$.

Fig. 10. Same bone from below, with the muscle-field, *w*, on the inner side, and the tentacle-socket, *r*, on the outer, where also is the articulating peg; on the median line runs the lower arm-canal, *t*; $\frac{5}{1}$.

Fig. 11. *Ophioglypha ciliata* (Mediterranean). Skeleton of arm and mouth-parts, to edge of disk, seen from above, with a genital plate, *o*, in position on one side, and on the other a radial shield, *l*, turned aside to show the underlying parts. On the middle line is the first upper arm-plate, *j*; on one side of it is the lower arm-comb, *m′*; and, on the other, the upper arm-comb or radial scale, *m*. Other letters as above; $\frac{5}{1}$.

Fig. 12. Three innermost side arm-plates, *i*, forming one wall of the genital opening. The upper corner of the side mouth-shield, *b*, supports the inner end of the genital plate, *o*, here seen in profile, with the under arm-comb, *m′* (compare Fig. 11), *q*, tentacle-scales; $\frac{5}{1}$.

Fig. 13. *Ophiothrix quinquemaculata* (Mediterranean). Skeleton of mouth-parts and arm, as far as edge of disk, with a radial shield and genital plate arranged and lettered as in Fig. 11, except that the mouth-frames are separated from the innermost arm-bone; $\frac{5}{1}$.

Fig. 14. Outer articulating surface of mouth-frames (compare Fig. 13); $\frac{5}{1}$.

Fig. 15. Inner articulating surface of the arm-bone next the mouth-frames; $\frac{5}{1}$.

Fig. 16. *Ophiothrix alopecurus* (Adriatic). An arm-bone close to the tip of the arm, seen from above, with a side arm-plate in position, and bearing a hook and the bases of three young spines; $\frac{35}{1}$.

Fig. 17. The same bone from below; $\frac{35}{1}$.

Fig. 18. *Ophiomyxa pentagona* (Mediterranean). Skeleton of mouth-parts and arm, as far as edge of disk, seen from above. The radial shields, *l*, are turned upwards and *outwards*, so as to expose the peculiar forked genital plates, *o*. *r*, stout triangular pieces covering the trench of the nerve-ring. These in *Ophioglypha ciliata* appear only as thin plates. *j*, little rudimentary upper arm-plates, split in two. *s*, supplementary pieces lying within the skin, along the disk margin ; $\frac{5}{1}$.

CAMBRIDGE, February 15, 1874.

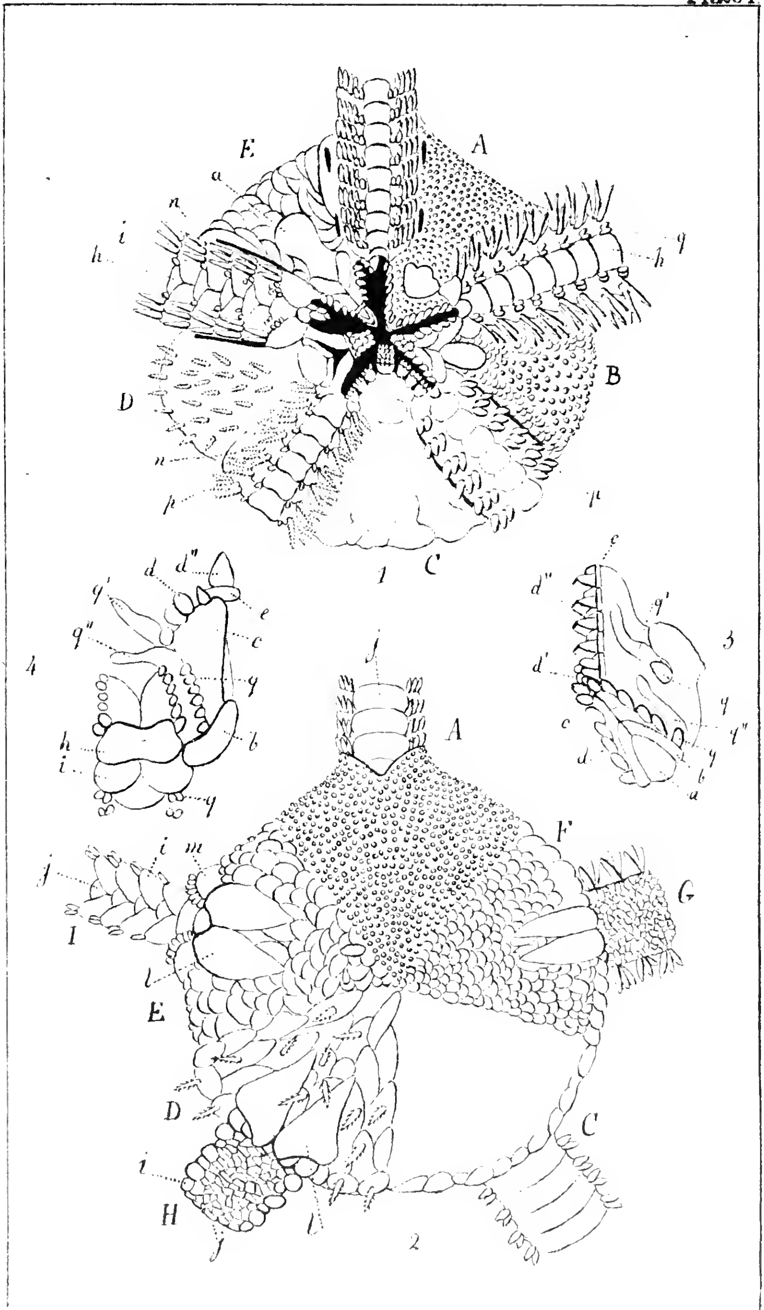
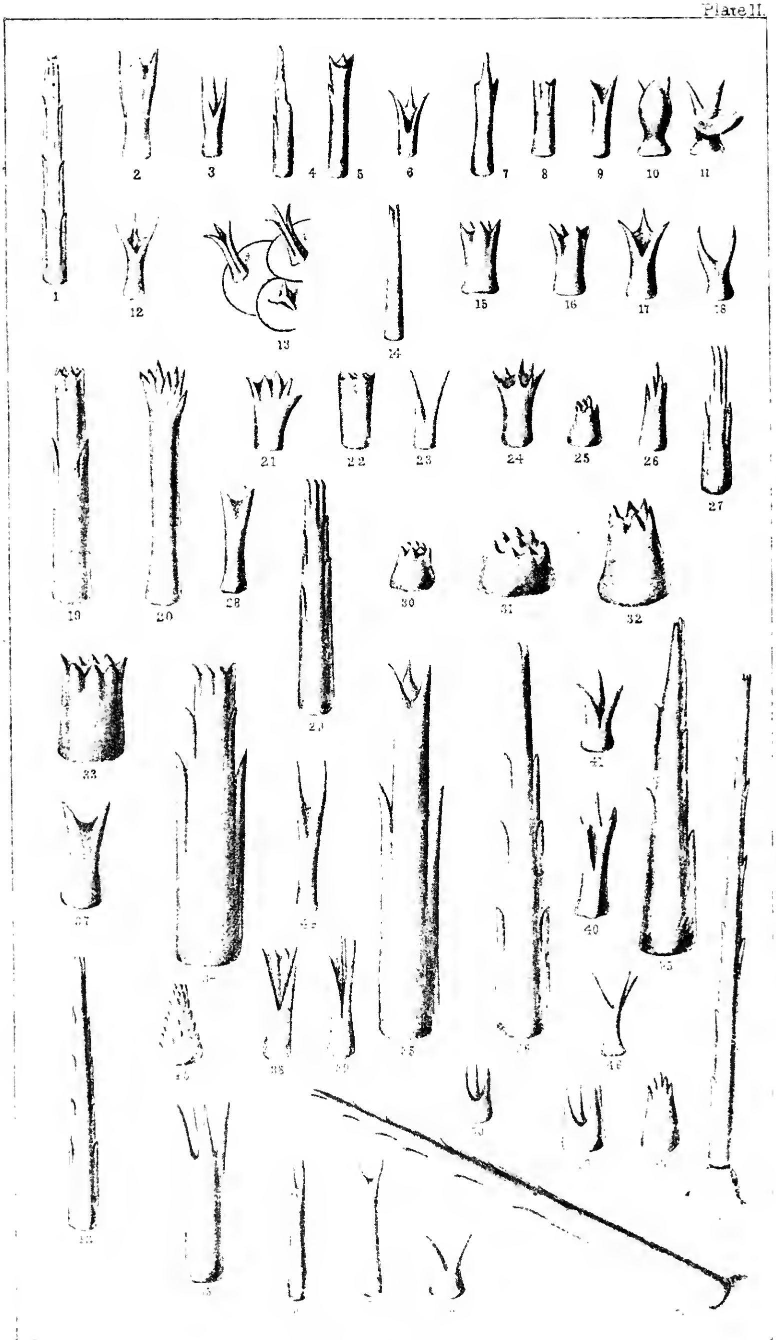
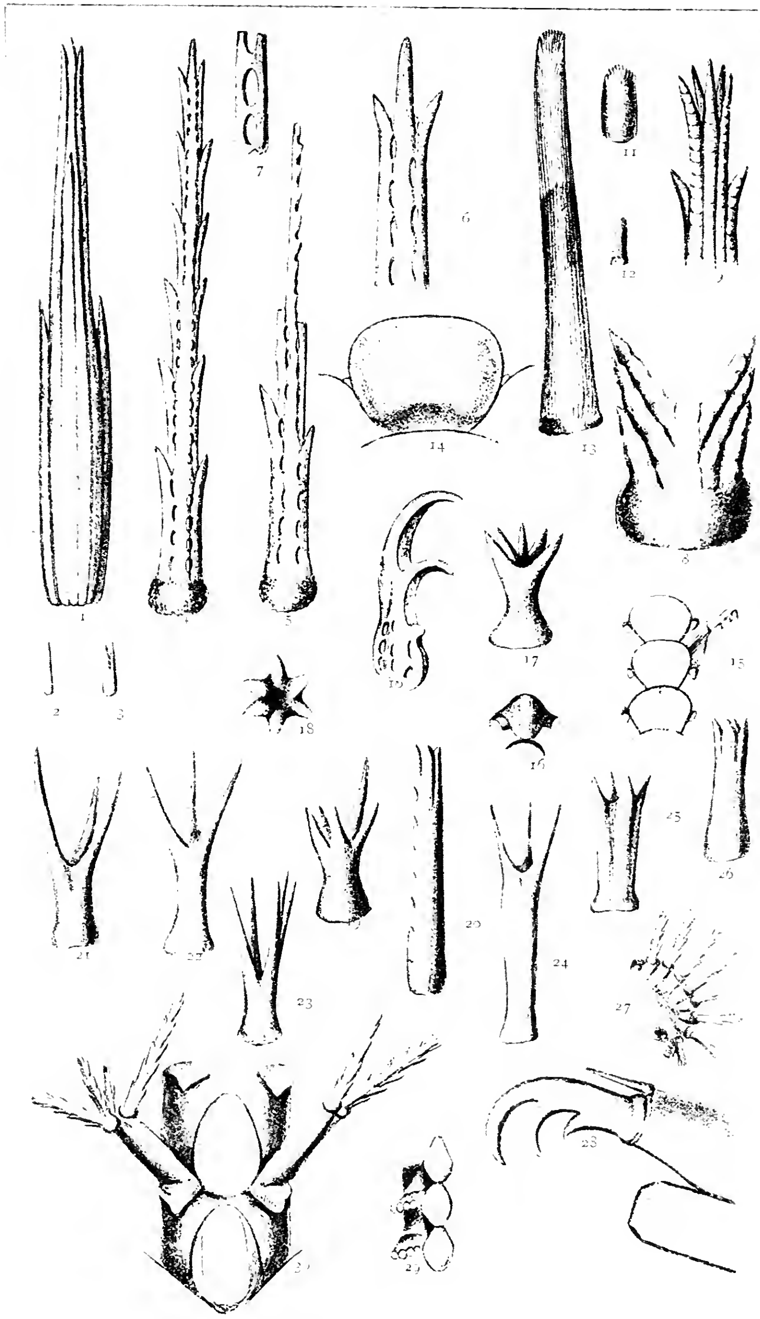


Plate II.





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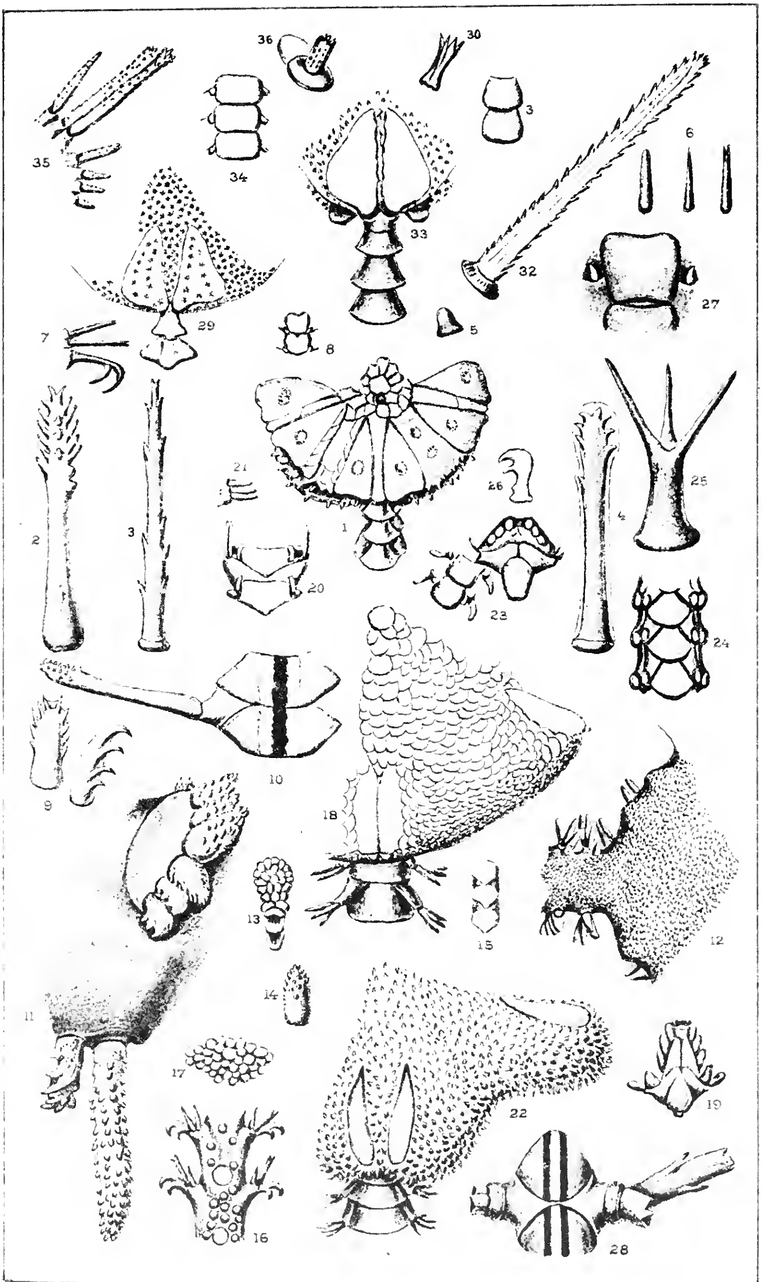
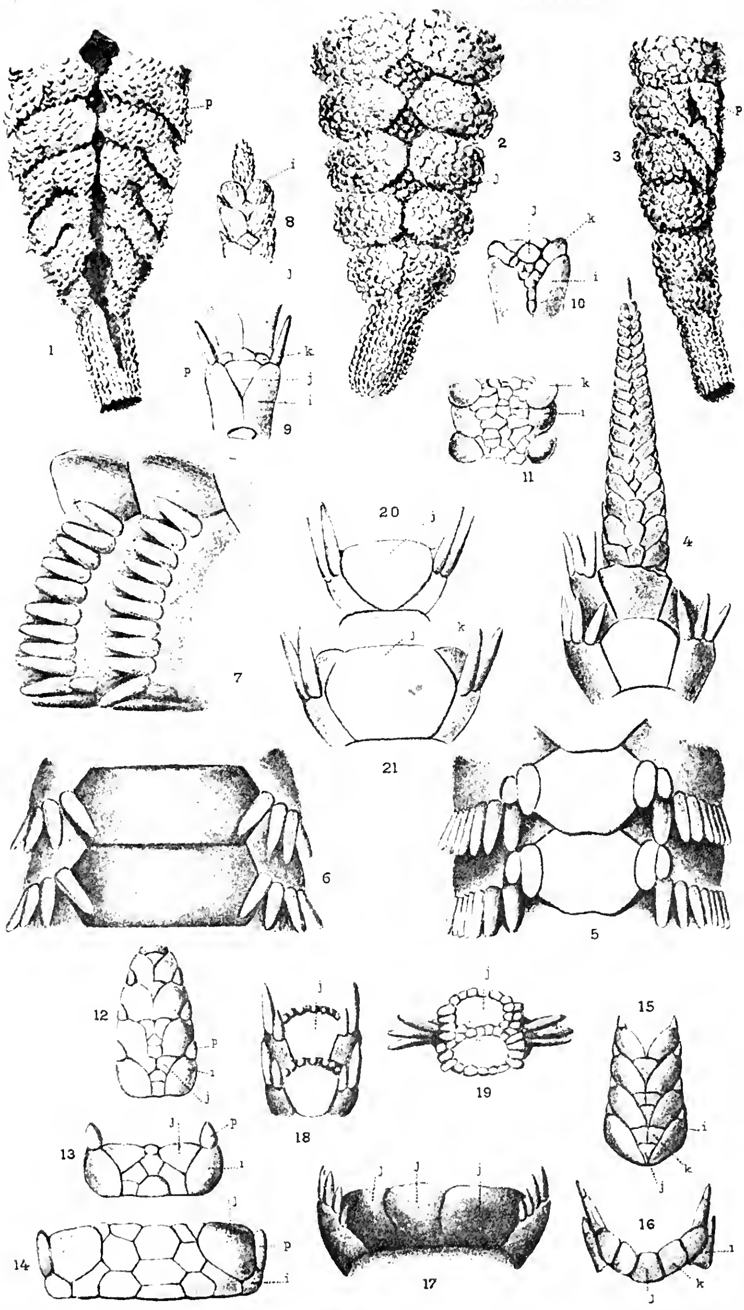


Lyman & Roetter ad nat.

Plate V.



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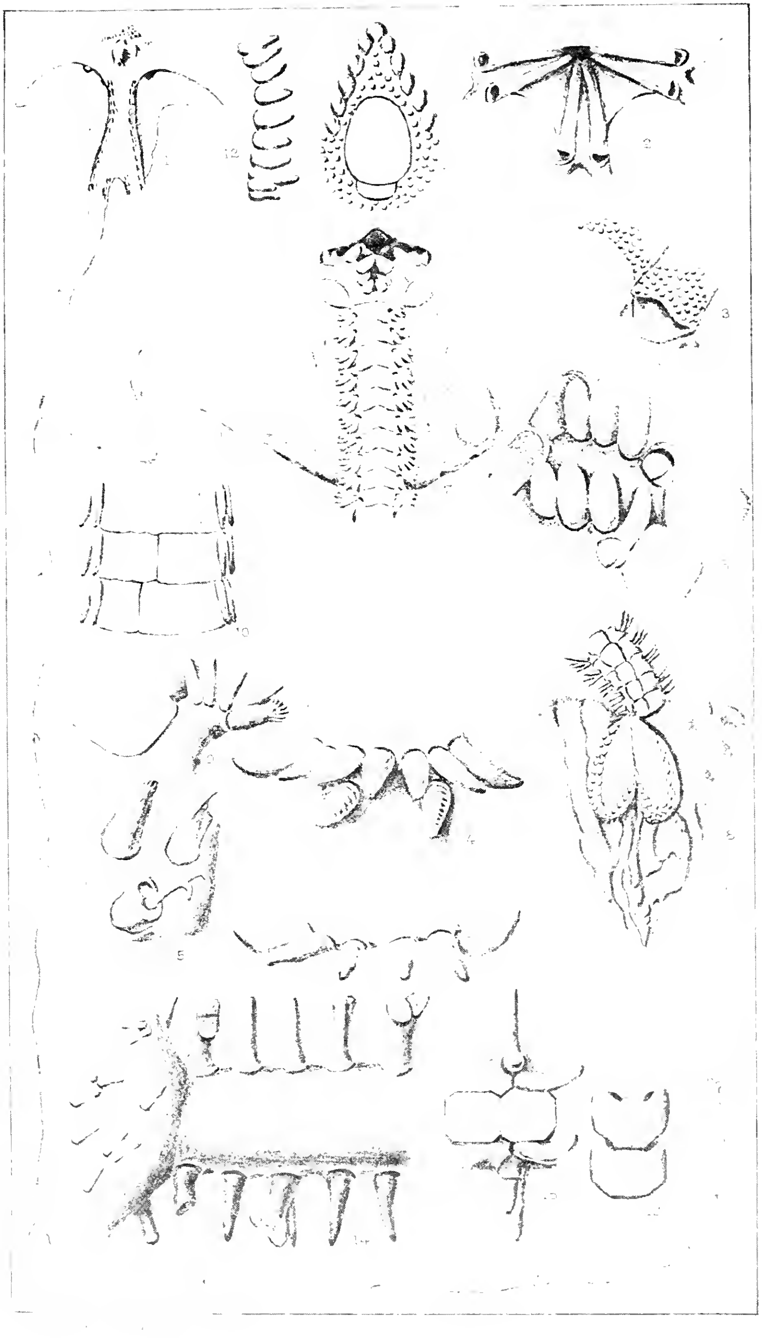
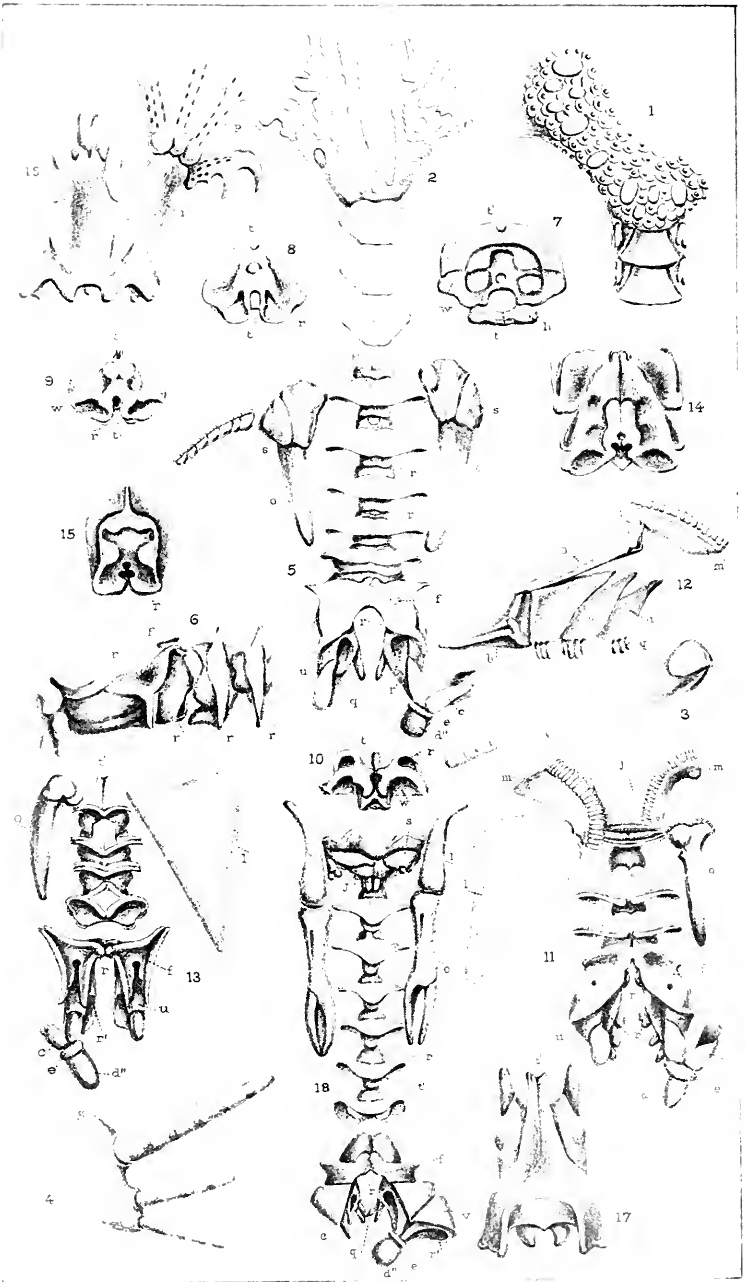




Lyman & Roetter ad nat.

No. 11. — *Exploration of Lake Titicaca, by* ALEXANDER AGASSIZ *and* S. W. GARMAN.

I. *Fishes and Reptiles.* BY S. W. GARMAN.

FISHES.

THE fishes of Lake Titicaca present but little variety. Only two genera are represented. A month of search and inquiry discovered but one species of Trichomycterus, a siluroid, and five of Orestias, a cyprinodont. Though found in great numbers and easily taken, on account of their inferior quality these fishes form but a small proportion of the food of the people living on the shores. The successful introduction of some superior food-fish would be of very great advantage to the inhabitants of the valley. A more inviting opportunity for a grand experiment in fish-culture can hardly be imagined than is offered here in this extensive sheet of pure water, with its numerous mountain streams, complete isolation, abundance of vegetation, and vast numbers of animals. The siluroids are more prized by the natives and are tolerably common in the markets. They are too oily to be considered good. Specimens that weigh a pound are large. As is usual with the Siluridæ, they are carnivorous and most active by night. The cyprinodonts are much more numerous, but have little to recommend them for the table except the absence of better. Their small size and numerous strong bones make them very unsatisfactory articles of food. It is their worthlessness, no doubt, that has fastened upon several species the epithet Carache as a common name. Immense schools of these fishes are found in their feeding-places, the great fields of rushes ("totora") and the beds of weeds which cover the bottom in the shallower portions of the lake. When young, they are preyed upon by other fishes and the thousands of birds frequenting their places of resort; as they grow older their structure and size give them immunity. The many bones and scales brought up in the dredge from the deeper waters along these localities were those of adults. All the species of this genus are small; we saw none weighing more than eight ounces.

Angling and spearing are not practised. The fishing is done with pounds, nets, and pots. When compared with the complicated structures on the coast of the United States, these primitive traps hardly deserve the name of pounds. They are mere fences, with an opening near the middle for the pocket, placed across the course travelled by the fishes. The fence is made of rushes tied close together by one end along a line of the required length; this line is fastened on the bottom by means of stakes, and the buoyancy of the rushes keeps them upright.

The pot is a short cylinder of open basket-work with one end rounded and closed, and with a gate in the other, like that of the lobster-pot, which admits the fishes but prevents their egress. Considerable ingenuity is displayed in the structure of these baskets. The warp is of single stems of a smooth, stiff, wiry grass; the woof is made by wrapping several small stems with split straws, making rolls which are bound to the stems of the warp, on the outside, by passing one of the straws which bind the roll around each stem at its proper distance from each other. The spaces in the warp are determined by the size of the fishes desired; those in the woof by the strength of the materials. Such traps are used as are lobster-pots.

The net in common use is a small dip-net with a long handle. Armed with this the Indian glides back and forth along the beach, late in the evening when the hungry siluroids come close to the water's edge to feed, occasionally dropping the net quietly down so as to cut off its retreat and then with a jerk throwing an unwary fish far out of the water. It is said that these nets are also used in fishing by torchlight from balsas.

Eight species of the genus Orestias were described by Cuvier and Valenciennes (Hist. Nat. d. Poiss., Vol. XVIII, p. 221) as occurring in this lake. Of these Cuvieri and Humboldti are synonymous, the latter being the young of the former, as shown by Dr. Günther; Mülleri and luteus are doubtless to be referred to one species; and, from the variations in proportions exhibited by our specimens, it appears likely that one of the stouter forms of Agassizii served as the type of Jussiei. The description and figure of Agassizii given by Cuv. and Val., from the common form of a half-grown animal, represents the species most accurately; for this reason the name is retained and Jussiei placed as a synonyme. Here also is the place for the O. Owenii of Günther.

O. Owenii of Cuv. and Val. agrees with albus, in its large muzzle and colors, rather than with Agassizii; the description is very indefinite; the type was taken in Lake Urcos.

In the following list of the fishes obtained notes in reference to value, abundance, etc. are given under the name of each species.

Trichomycterus dispar GÜNTH.

Called Suche or Maure by the natives.

It is found in all parts of the lake and the streams entering it. In the stomachs of a number dissected small molluscs, crustacea, and fishes were found. One specimen of fourteen inches contained another of six. The color is generally brown, reticulated with many narrow irregular white lines; sometimes with spots like trout or uniform.

Adults of less than seven inches were taken; the largest specimen measured sixteen. The Indians distinguish between small and large, calling the former Maure, the latter Suche. They are higher priced in the market than the other fishes of the lake.

Orestias Cuvieri CUV. et VAL.

The full grown is called Omanto and the young Peje Rey. Its market value is less than that of O. Pentlandi. The bare space on each side of the dorsal row of scales occurs in all adults.

Dead ones with the stomach everted were frequently met with on the shores of Titicaca Island. Ten and a half inches is the measurement of the largest specimen.

O. Pentlandi CUV. et VAL.

Apparently not so abundant as the preceding. This species ranks next to the Suche for the table. With the bare space on each side of the dorsum. One specimen shows the entire top of the head covered by a single large scale; others have the vertex bare. The largest secured was nine and a quarter inches in length. Bova is the common name of this fish.

O. Agassizii CUV. et VAL.

One of the several species to which the name Carache is applied. The most abundant fish in the lake. It is valued less than either of the preceding.

There is much variation in the proportions of different individuals; the depth of body varies from a third to a fourth of the length, exclusive of the caudal fin. In the adult the colors are uniform dark brown above, lighter below; the young are spotted or banded. Longest specimen eight inches.

The names Bova and Carache suggest a possible likening of the fishes to cattle. A scabby sheep is called Carache, though the term is properly the name of the scab itself.

O. Mülleri Cuv. et Val.

Common name Carache. Not so plentiful as the preceding. Its angular head and shoulders, the great width of the latter compared with that of the body, and the strongly granulated scales serve to distinguish this species from Agassizii, and the narrow muzzle and small mouth from albus.

In some individuals the angles of the head are less pronounced than in others. The colors in different specimens vary from quite light to very dark. None obtained were longer than six inches and a half.

O. albus Cuv. et Val.

Less numerous than the other Caraches. The muzzle is wider, the mouth larger, and the head longer than in the species preceding. The head has the aspect of that of Cuvieri. Color light brown, often reddish or yellowish. None of the few examples taken exceeded six inches in length. In the young of all the species the striation of the scales is plainly visible; the granulation on the anterior part of the body in several appears later. A number of small fishes, less than half grown, which are considered the young of this species were obtained at Moho. These differ somewhat from the adult; the back has a dorsal and two lateral series of spots; the belly is of salmon color and is closely covered with scales. The Indian from whom they were purchased called them Silgo.

The collection from which the foregoing list is made was said by the fishermen to contain specimens of each of the different fishes found in the lake.

Batrachians.

Cyclorhamphus marmoratus Dum. et Bibr.

Specimens were taken at Arequipa and at Vincocaya on the summit, 14,538 feet above the sea-level. The adult from the higher regions is about half the size of that from nearer the coast, though similar in all other respects.

Cyclorhamphus culeus (nov. sp.) Pl. I.

Body large, depressed. Head rounded in front, wide, flattened. Skin smooth, very loose and baggy, of the entire upper surface glandular, giving off, when the animal is held in the hand for a little time, a secretion similar to that of the Amblystomæ. Fingers free. Toes rather more than half-webbed. First cuneiform bone forming a slight prominence. Tympanum hidden. Eustachian tubes not apparent. No vocal sac. Tongue broader forward, free posteriorly. Vomerine teeth, generally present, in two very small groups between the inner nares. Internal nostrils large, anterior very small. Color varying in different individuals from uniform olive brown to brown irregularly spotted with white or so thickly sown with white dots as to appear gray.

Average length of body about three inches. Two very large specimens were secured; the bodies of these measure a little more than four inches, from snout to anus. One of them is smooth, as is usual; the other has numerous prominent nipple-like warts on the flanks from the tympanum backward.

The young of this species and those of marmoratus are very similar. The adult, however, instead of being erect and trim with prominent palmar and plantar tubercles as the latter, is much depressed and flattened, and carries itself more like Pipa; it has a great baggy skin which hangs in loose folds about it and the tubercles are slightly developed or absent.

The vomerine teeth are reduced to a minimum; often they are absent on one side or altogether.

As might be expected from the exclusively aquatic habits of culeus, its skeleton is weaker and less perfectly ossified than that of marmoratus. In the latter the skull and its processes are strong and the foramina and fontanel very small; in the other the skull is thin and shell-like, the processes are more slender and the foramina and fontanel larger. Large specimens of culeus are here compared with much smaller ones of the other species.

These animals are very abundant in the extensive beds of weeds which occur on the bottom of Lake Titicaca. They feed on the molluscs, crustacea, worms, etc., and are fed upon by the birds and fishes. Marmoratus was found in little creeks and marshy places, in situations indicating habits similar to the common Ranæ; during the two months of the observations culeus was only to be found in the lake, crawling lazily about among the weeds or half hidden by them, watching for prey. The latter was the only one found in this vicinity; the former was secured on the summit and the western slope. These animals are able to remain under water for great lengths of time without coming up for air; hours of watching in clear water, where many could be seen, failed to detect any approaching the surface. It is possible they are more lively at night, when their enemies are less active. Numbers were brought up in the trawl at more than four miles from the shore. None were found on the land. The natives were positive they never left the water. All stages of the animal are represented by the specimens in the collection. On Pl. I. are given figures from above and in profile (natural size).

Pleurodema Bibroni Tschudi.

Abundant at Puno, on the lake. Colors varying.

Leiuperus marmoratus Dum. et Bibr.

From Vincocaya and Puno.

Leiuperus sagittifer Schmidt.

Many specimens. From Arequipa, Juliaca, and Puno. From these examples a regular series leading from the one species to the other may be selected. The existence of so many intermediates suggests that sagittifer may be no more than a variety.

Bufo chilensis Tschudi.

Many toads were collected under the impression that several species were represented; a careful examination and comparison includes them all in one. The toad of the Titicaca Valley and the mountains differs from that of the coast; those of these localities are smaller, and have the black blotches narrowed down to mere spots which makes them appear much whiter. There is much variation in the coloration; some have few spots and small, others many, and others are so dark as to render the marks obsolete. Many are rough with small spines, others are smooth. In some cases the warts are greatly developed, in others the skin is quite free and glossy. With the cutaneous fold on the tarsus; the very young are dark colored and have yellow feet. From Arequipa, Vincocaya, Puno, and Carapata.

REPTILES.

Saurians.

Phyllodactylus gymnopygus Dum. et Bibr.

Taken from beneath rocks on the plains near Arequipa, Peru.

Leiolaemus signifer Dum. et Bibr.

Very common on the plains around Vincocaya and Colca, at an altitude of 14,500 feet.

L. maculatus Gray.

Abundant on the hills around Lake Titicaca. None were found on the summits, where signifer was so very plentiful.

L. Belli Gray.

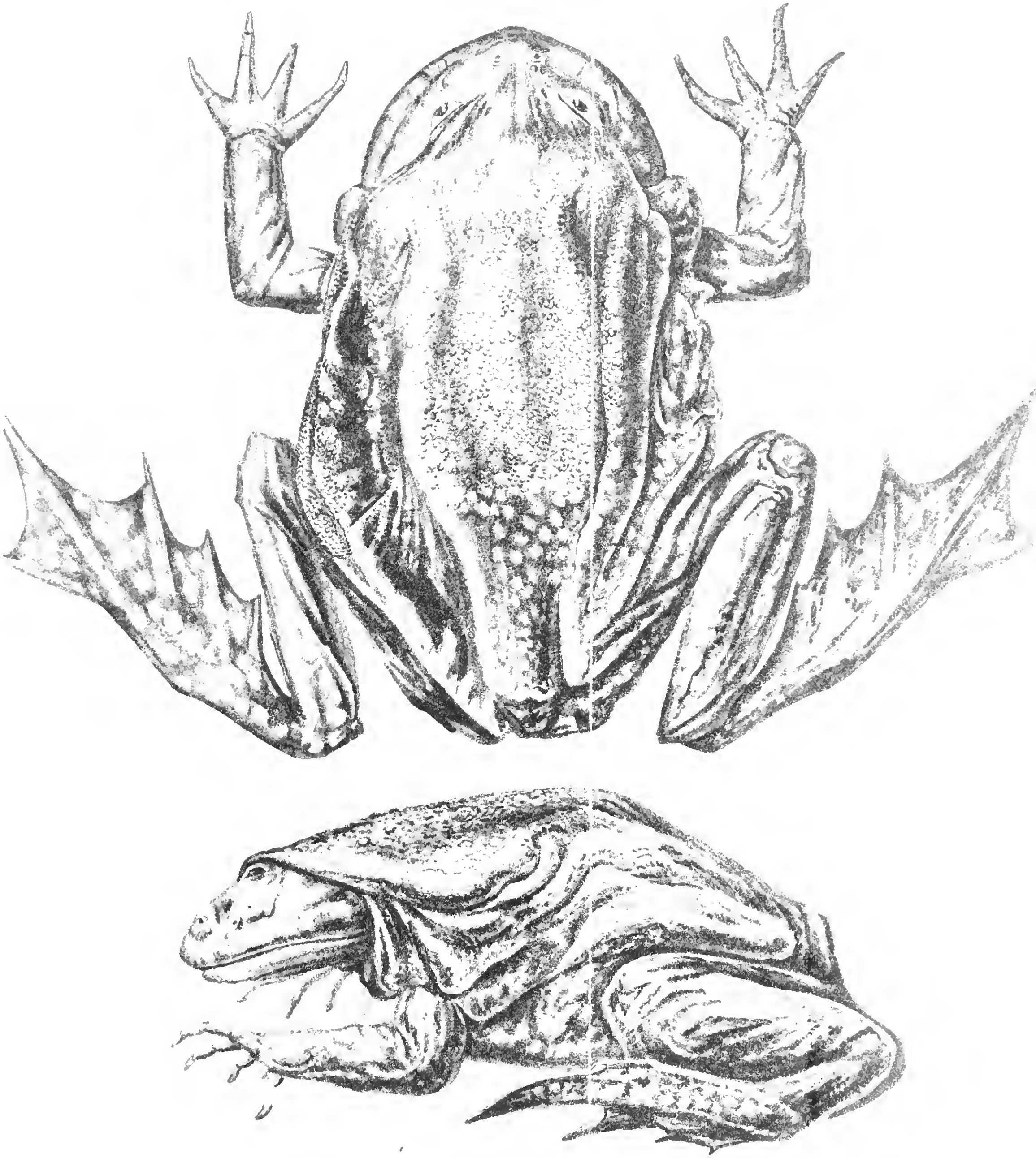
Two examples presented by Col. E. A. Flint, were from the Cuzco Valley.

Ophidians.

Tachymenis peruviana Tschudi.

We are indebted to Col. E. A. Flint for one young and three adults from the Cuzco Valley. This species is quite variable. These examples have eight upper labials, the eye over the fourth and fifth, and in three of them there are two anteorbitals instead of one. The colors are of the usual pattern and very distinct.

Cambridge, November 26, 1875.



No. 12. — *Exploration of Lake Titicaca, by* Alexander Agassiz *and* S. W. Garman.

II. *Notice of the Palæozoic Fossils by* Orville A. Derby, M. S. *With Notes by* Alexander Agassiz.

Sperifera camerata Morton.

This well-known species occurs at Yampopata and the island of Titicaca. The specimens are well preserved, and their identity with the North American and Brazilian forms cannot be doubted. Like some of the latter, they show concentric lamellæ like those represented by d'Orbigny on his *S. condor.** In my paper on the Brazilian Carboniferous Brachiopods I have united with doubt *S. condor* with *S. camerata.* Mr. Agassiz's specimens, which come from near d'Orbigny's locality, and are associated with the same forms, appear to clearly establish their identity. As in North America, this species enjoys a wide range. D'Orbigny and Salter † identified it from various localities in the vicinity of Lake Titicaca. Toula ‡ describes it as a variety of *S. striatus* from Cochabamba on the eastern slope of the Andes, and I found it in a specimen brought by Professor James Orton from the Pichis River, Peru.

Athyris subtilita Hall sp.

This species occurs in the collection from Yampopata, d'Orbigny describes it under the name *Spirifer Roissyi* from Yarbichambi, and Salter and Toula have identified it from the Isthmus of Copacabana and Cochabamba.

Rhynchonella sp.

A species of this genus is represented by fragments on a slab from Yampopata. Though not sufficiently well preserved for positive identification, there are reasons for believing it the same as the form figured by Salter from Santa Cruz, and by Toula from Cochabamba as *R. pleurodon* Phillips. This form is doubtfully identified by Meek and Toula with *R. uta* Marcou (*R. osagensis* Swallow), to which it is certainly much more nearly allied than to Phillips's species. A similar form occurs at the Pichis River locality, in Peru.

* Voyage dans l'Amérique Méridionale, Paléontologie, p. 46, Pl. V. Fig. 11 - 14.

† Quart. Jour. Geol. Soc., Vol. XVII. p. 50.

‡ LIX. Bde. d. Sitzb. d. Kais. Akad. d. Wissensch. I. Abth., 1869.

Streptorhynchus sp.

A single fragment of a dorsal valve represents this genus. Part of the cardinal process is exposed, showing that it belongs to the group characterized by a high ventral area and a long cardinal process, for which *S. Hallianus* Derby may be taken as the type. It is marked by a distinct median depression, which, if constant, will distinguish it from any species known to me.

Chonetes glabra GEINITZ.

Chonetes glabra Geinitz Carb. und Dyas in Nebraska, p. 60, Pl. IV. Fig. 15 – 18.

This characteristic species of the North American and Brazilian Coal Measures is represented by several specimens on a slab from Yampopata. Toula has also identified it from Cochabamba.

Productus costatus? SOWERBY.

This form appears to be the most abundant fossil at Yampopata. It is identical with the common form of the North American Coal Measures, as a careful comparison of numerous well-preserved specimens proves. I follow Hall and Meek in questioning its identity with the European *P. costatus*.

Judging from d'Orbigny's and De Koninck's figures, *P. Inca* d'Orb. is identical with this, differing only in being a little larger than any of Mr. Agassiz's specimens. European palæontologists have referred *P. Inca* to *P. semireticulatus* Martin, but it is certainly much more like *P. costatus?* than the North American and Brazilian forms referred to Martin's species. These last, when well preserved, are covered with very numerous, closely set hair-like spines quite unlike the few scattered coarse spines characteristic of *P. costatus*. *P. Inca* appears to have had a spiny covering of the latter kind, as had also many of the European forms of *P. semireticulatus* figured by Davidson and De Koninck. As specimens usually occur with the spines denuded and the scars more or less obscured by weathering, the two forms of the so-called *P. semireticulatus* are almost indistinguishable, though appearing very different when perfect. To unite them, as is usually done, is to ignore one of the best specific characters among shells of this class.

The collection contains a few casts in red sandstone from the island of Titicaca, that appear identical with the Brazilian forms of *P. semireticulatus*.

Productus Chandlessii DERBY.

Productus Chandlessii Derby, Bull. Cornell Univ., Vol. I. No. 2, p. 51, Pl. IV. Compare *P. boliviensis* d'Orb.

A single specimen from Yampopata is identical with the Brazilian form to which I have given the above name. Since seeing it I am led to suspect that d'Orbigny's *P. boliviensis* is the same species, though his figures represent a very different shell, with some characters probably never seen on a species of this genus. De Koninck's figures are much more like our shell, though, if strictly accurate, the two would appear to be distinct. Aside from some differences in form, the front of the shell in his figures is quite strongly ribbed, while among hundreds of specimens from Brazil it is uniformly smooth. The differences are sufficiently important to warrant the retention of my name till the original types of *P. boliviensis* can be examined.

Productus Cora D'ORBIGNY.

Productus Cora d'Orbigny (op. cit.), p. 55, Pl. V. Fig. 8 – 10.

There are several fragments on a slab from Yampopata which most probably belong to this species, the type of which was from the neighboring locality of Yarbichambi. It is unfortunate that we have no really good specimens from Bolivian localities to show clearly the characters of the species. D'Orbigny's figures of it are useless for purposes of identification, and Toula, who had specimens from Cochabamba, thinks that the European specimens figured under the name by De Koninck, and which are now referred to as the type of the species, are distinct. If it should prove so, a thorough revision of the peculiar group of *Producti* to which this belongs will be necessary.

The Brazilian forms referred with a question to this species are apparently identical with those collected by Mr. Agassiz.

Euomphalus antiquus D'ORBIGNY.

Solarium antiquum d'Orbigny (op. cit.), p. 42, Pl. III. Fig. 1 – 3.

The specimens referred here are in the state of partial casts, occurring both at Yampopata and the island of Titicaca. They agree in the most essential particulars with d'Orbigny's type, though differing somewhat from his figures and from each other in the prominence of the spire, the form of the whorls, and the development of the thin carinas characteristic of the species. It is possible that these differences may prove to be of specific importance when larger collections are examined.

This species is named by Meek as one of the types of his subgenus *Omphalotrochus* proposed in the Geol. Surv. of California, Vol. II. p. 16.

Euomphalus sp.

A cast of a species of *Euomphalus* with more angular whorls than the preceding and apparently with only a median carina occurs in the collection from Yampopata, associated with a fragment of a much larger species with smooth evenly rounded whorls.

Tropidoleptus carinatus Conrad sp.

Strophomena carinatus Conrad. Ann. Geol. Rept. of N. Y., 1839, p. 34.

Several slabs* of coarse gray sandstone from the island of Coati, two miles southeast of the island of Titicaca, are covered by well-preserved casts of this species undistinguishable from the forms so abundant in the Hamilton group of New York and the Devonian sandstone of Ereré, Brazil (Rathburn, Bull. of Buffalo Soc. Nat. Sci., Jan. 1874).

The Coati specimens are of large size, with very heavy dental plates and septum.

The undetermined species of *Orthis* figured by Salter (Quart. Jour. Geol. Soc., Vol. XVII., Pl. IV. Fig. 7) appears to me to belong to this species.

Vitulina pustulosa Hall.

Vitulina pustulosa Hall, 13th Rept. State Cab.; Pal. of N. Y., Vol. IV. p. 410, Pl.

Associated with the preceding are casts differing in no respect from those of this species so abundant at Ereré, Brazil.

This extremely interesting collection adds considerably to our knowledge of the geology of the Andes and the relation of the fossils occurring there to those of other parts of the world. Of the nine Carboniferous species, all but *Euomphalus antiquus* are represented in the Coal Measures of North America and Brazil by identical or closely allied forms. In a discussion of the relations of the South American Carboniferous fossils thus far known, I have shown that all the beds yet examined belong to this division of the Carboniferous age.† These beds are now known at a number of widely separated points in Bolivia and Peru, showing a very extended range of the Carboniferous deposits. Besides the numerous localities in and about Lake Titicaca, they are known in the provinces of Arque and Oruro, south of the lake, at Santa Cruz and Cochabamba, on the eastern slope of the Andes, and on the Pichis River, one of the upper tributaries of the Ucayali, in Southern Peru. More recently I have recognized in Professor Orton's collection specimens of a *Productus* and a *Streptorhynchus* from near Moyabamba, in Northern Peru. It is interesting to note in this connection that

* These slabs were not found in place, and may have been brought to the island for building purposes by the Incas (A. Agassiz).

† Bulletin of the Cornell University, Vol. I. No. 2, p. 60.

Squier reports having seen a specimen of coal said to have come from Lake Titicaca.

It is rather surprising that as yet no Subcarboniferous has been found, though the Devonian was found by Mr. Agassiz close alongside of the Coal Measures, the island of Coati being only two or three miles distant from Titicaca.* Very extensive beds in Bolivia have been referred to the Devonian by d'Orbigny and Forbes, but as yet the palæontological evidence is quite defective. Salter states that of the fossils referred by d'Orbigny to the Devonian, only two are certainly supra-Silurian, and those are as likely to be Carboniferous as Devonian. Of the fossils referred to the Devonian by Salter only one, *Phacops latifrons*, was considered as undoubtedly of that age, and this loses much of its value in being in a rolled pebble from an uncertain locality.

The following notes explain in a general way the structure of the Carboniferous system of the elevated plateau of Peru (A. Agassiz): —

In addition to the fossils described already by Professor Derby a number of Fusilinæ were also found in the Carboniferous beds of Lake Titicaca. They have been sent to Mr. Brady for identification. The Carboniferous beds from which the fossils above noticed are derived form the southern terminus of the Carboniferous system as marked on the map of Bolivia and Peru by David Forbes. But this system is not limited to the comparatively small area assigned to it by Forbes. It consists, for the whole area which I have examined, of a series of rather limited elongated basins, the longitudinal axis extending, as noticed by Forbes, in a general northwestern to southeastern direction. The strata generally form a series of short folds often quite sharp, so that at comparatively small distances the rocks dip in very different directions. In the Straits of Tiquina, as mentioned by Forbes, we have strata thrown up nearly vertically dipping east on the west side, and west on the east side; it is by a series of such faults more or less prominent, that the successive basins of the Carboniferous system of the elevated plateau of Peru have been separated. Near Copacabana the metamorphic rocks underlying the denuded sandstones dipping to the east and west are plainly seen. Another such protruded mass I have observed near Puno. Another forms the hill of dark red trachyte to the west of Juliaca, rising directly

* See Note on page 282 (A. Agassiz).

from the alluvial plain, the former bed of Lake Titicaca. To the westward of Puno we find at Vilque, a distance of about fifteen miles, another basin. Again at Santa Lucia, near Maravilles, a third basin still farther to the westward, resting upon underlying conglomerates and metamorphic rocks, in which the strata dip to the eastward, and finally still a fourth basin at Sumbay Station, on the Puno and Arequipa Railroad, at a distance of about fifty miles east of Arequipa. Between the Santa Lucia and the Sumbay basins there is an extended volcanic deposit forming the elevated plain of Vincocaya, at a height of nearly 15,000 feet. Professor Orton also mentions Compuerta as a Jurassic locality, but as he did not collect the fossils himself, the presence of a Jurassic outlier between the basins may be questioned for the present. Of course I do not wish to be understood as stating that there are only four such parallel basins, — a far greater number will undoubtedly be observed hereafter. At all these points there has been bituminous coal found and a number of beds opened, on which more or less exploring has been done. On the northeast end of the peninsula of Copacabana, at Yampopata, a small coal-mine has been opened, capable, with the limited number of men employed, of producing about thirty tons a day of a fair quality of coal, which has repeatedly been used by the two small steamers plying at intervals on the lake. The coal is a grateful substitute for the use of dry llama-dung, for which you are frequently compelled to wait until a sufficient supply can be collected. The works of the coal-mine at Yampopata consist of a tunnel driven in at right angles to the bed at the water level of the lake, giving a back of some six hundred feet. From the tunnel a gangway has been driven a tolerable distance both ways. But all the appliances for mining are so crude, and the knowledge of coal-mining so defective, that with the present system no great results can be accomplished. Yet this mine is situated on the shore of a lake some one hundred and twenty miles long and forty miles wide, round which is gathered a population of no less than 200,000 Indians living in a region entirely destitute of fuel, unless the few bushes sold at a fabulous price for cooking purposes can be dignified by that name. Even this source of fuel is becoming annually more difficult of access, so that whole villages are compelled to use dry llama-dung and other manure as their only combustible. The bed of coal on which the mine is worked dips to eastward, and is about three feet in thickness. Smaller beds have been traced as outcrops to the westward of the Yampopata mine; the same bed has also been opened on the east coast of the peninsula of Copacabana. Near Vilque quite a number of coal-beds are found, in one of which a small pit has been opened and coal of an excellent quality discovered. The bed dips to the west. At Santa Lucia three small beds have been tested, and considerable prospecting without satisfactory results has been done on some of the beds. The coal appears of a rather purer quality, but is mixed with layers of shale. At Sumbay, though there has not been much mining done, the facilities for mining are good. Several beds have been tested to a considerable depth (90 feet), and a good quality of coal developed. As the mines are only about two miles from the railroad, the position is, from its excellent grade to the road, admirable. The railroad from Sumbay to Puno runs directly across the width of the Carboniferous system of the elevated plateau to the west of Lake Titicaca, and the nature of the successive basins, all running more or less northwest and southeast, can readily be traced. Although my observations show a far greater extent of the Carboniferous series than was supposed to exist, it is evident from information gathered in the country that its northern terminus is by no means ascertained. Colonel Flint informs me that in the Cuzco Valley along the railroad from Juliaca to Cuzco there are beds of coal identical with those I had the opportunity to visit. Mr. J. J. Thomson, on his map of the Department of Puno, marks the district to the west of Pomata as Carboniferous. Mr. Orrego, in a sketch of the minerals occurring in the Departments of Arequipa and Puno, mentions also as Carboniferous the localities which I visited along the line of the Arequipa and Puno Railroad. Mr. Orrego also states that this Carboniferous system extends as far north as Caylloma. He subsequently mentioned to me that they form a series of basins having the same general structure and position relatively to intercalated metamorphic rocks noticed above, which at the points of contact have highly metamorphosed the shales and sandstones in the vicinity. Professor James Orton has also found, in the extension of the same general line as the axis of Lake Titicaca, Carboniferous fossils at the head-waters of the Amazonas (Pichis River), while he states that Professor Raimondi of Lima has traced Carboniferous series at a height of 14,000 feet, on the Apurimac, at a locality intermediate between the Pichis River and the Cuzco Valley. I shall return to the general structure of the shores of Lake Titicaca in a subsequent notice, but would only call attention to the fact that Forbes and d'Orbigny assign the rocks along the east shore of the lake to the Devonian. I have been unable to find fossils at any of the localities where I landed, — Vilquechico, Moho, Conima, Carabuco, — and can only state that the rocks (dipping to eastward or westward) are not, except occasionally, the colored sandstones and shales separated by metamorphic rocks, so characteristic of the Carboniferous series of the west shore of the lake and the territory beyond.

No. 13. — *Recent Corals from Tilibiche, Peru, by* ALEXANDER AGASSIZ *and* L. F. POURTALÈS.

THE corals described here by Mr. Pourtalès were collected in a ravine about two miles east of Tilibiche, in the valley of Berenguela. Tilibiche is on the northern edge of the Nitrate Basin to the rear of Pisagua, Peru. These corals are interesting, coming as they do from a height of 2,900 to 3,000 feet above the level of the sea, at a distance in a straight line from the Pacific Ocean of twenty miles. The ravine where they were found is about 450 feet below the general level of the great Nitrate Basin of Peru, on the eastern side of the ridge, parallel to the coast which divides the so-called Pampa de Tamarugal from the lower narrow pampas extending from the summit of the coast terrace (at a height of about 1,100 feet) to its western base. The height of the base of the second parallel chain ranging from 2,500 to 3,000 feet. The river flowing through the valley of Berenguela has cut a deep cañon not only through the comparatively soft deposits underlying the Nitrate Basin, but also through the Jurassic beds which constitute the greater part of the chain forming the eastern edge of the Nitrate Basin. The corals were found attached to the surface of the rocks in the interstices between adjoining masses, growing much as they would at the present day in similar circumstances.

From the general features of the country along the Pacific coast of Peru it requires but little imagination to reconstruct the former internal sea formed by the Coast Range, which must have, within comparatively recent geological times, covered the whole of the Nitrate Basin, and which has gradually been elevated to its present position. At one time (the older period) this inland sea was connected with the Pacific through the breaks of the Coast Range forming the quebradas of Vitor, Camarones, Pisagua, Loa, etc., and subsequently became an inland salt lake disconnected from the Pacific, to be eventually drained by the breaking through of the barriers at the old points of connection with the Pacific. This inland salt lake was thus gradually changed to a lagoon, and finally entirely drained as soon as the rivers flowing through it, forming the above-mentioned valleys, had cut their way as cañons through the strata underlying it. It seems therefore possible that even if the former extension of the Pacific Ocean over the tract occupied by the nitrate beds cannot account entirely for the deposition of the salt and nitrates; it must at any rate have played an important part in their formation. The rivers, taking their rise higher up in the Andes to the eastward, flowing through the basins, are all fresh. The water near the general surface of the basin is saline, but as we go down we soon reach a stratum of absolutely fresh water, showing that if the saline matter were brought down from the mountains it must have all been washed out at the present day, and that the main cause to which the formation of the nitrates has been assigned is no longer active. Certainly neither the number nor size of the extinct and actual river-beds crossing the Nitrate Basin favors the presumption that they could have been a sufficient cause for the accumulation of the immense deposits of salt extending over the large area covered by the nitrate and other saline beds.

From the careful observations made by Darwin on the elevation of the west coast of South America, the positive proof of the recent elevation of the continent (at certain points) to a height of 800 feet is placed beyond doubt, it can, judging from terraces and other somewhat less positive proofs, be considered as reasonably certain that this elevation extended to a height of 1,300 feet, while the presence of corals at Tilibiche would seem to leave but little doubt that the continent has gradually been raised within a comparatively recent period to a height of at least 2,900 feet. The presence of extensive saline basins on the west slope of the Andes, at a height of over 7,000 feet, flanked on their western edge by low ridges, may be due to a similar cause. But, however this may be, we might almost be tempted to claim that the elevation of the continent can be traced to a still greater height, judging from the presence of eight species of Allorchestes, a genus belonging to a truly marine family of Crustacea (Orchestiadæ) in Lake Titicaca, at a depth of 66 fathoms, and thus attempt to establish the former connection with the sea of the lake now at a height of 12,500 feet above the level of the Pacific. Only eight, and two of these are probably identical species, out of eighty-one known species of this family, as I am informed by Mr.

Faxon, inhabit either fresh water or live inland in moist localities. It is, however, quite remarkable that in none of the other fresh-water lakes in which marine forms have been found, Lakes Superior, Michigan, Lake Wetter, or in Lake Baikal, and other lakes supposed formerly to have had a connection with the sea, has this family as yet been discovered, though a closely allied species of Allorchestes has an extensive geographical distribution in the rivers of the Northern United States. It must also be remembered that we have four species of Orchestias which are land inhabitants, living under damp leaves at a considerable distance from the sea.

There were a few other interesting specimens found in this locality which unfortunately have been lost. One species of Millepora, very closely allied to M. alcicornis, and a species of a Crustacean, closely allied to a large Aega, which was found in a pool near Tilibiche.

In the saline pools there were numerous specimens of fresh-water Gastropods (Hydrobiniæ). Diptera and Neuroptera larvæ were found in abundance.

These corals are fossilized into a compact crystalline limestone, the crystals having generally destroyed the internal structure; they are impregnated with salt, which effloresces after washing.

Isophyllia duplicata n. sp. (Plate, figs. 1, 2, 3.)

Rounded masses about 10 cm. in diameter; the lower surface is not preserved, so that the absence or presence of an epitheca remains undetermined. Calicles coalescing in very sinuous series, containing sometimes six or seven centres which remain, however, always very distinct. The adjacent walls remain always separated by a furrow, across which the costæ are frequently continuous. The latter are thick and appear to have borne blunt spines. The septa are thick, with blunt equal teeth; four cycles, with occasional rudiments of a fifth, the septa of the first, second, and sometimes third, not very different, and reaching to the centre. No paliform lobes, but sometimes a slight thickening of the septa in their place. Columella generally absent; occasionally one or two obscure papillæ represent it. Width of calicinar valleys 5 to 6 mm., of mural furrows 2 to 3 mm.

This genus and its nearest allies (Symphyllia we do not think can be separated from it) is not represented in any lower strata than the Tertiary, and they have their fullest development in recent seas. There are none living now, however, on the Pacific coast of America, but Symphylliæ, Mycetophylliæ, Manicinæ, and other genera of the *Lithophylliacées méandroides* of Milne-Edwards and Haime are very abundant and characteristic of the West Indian Fauna.

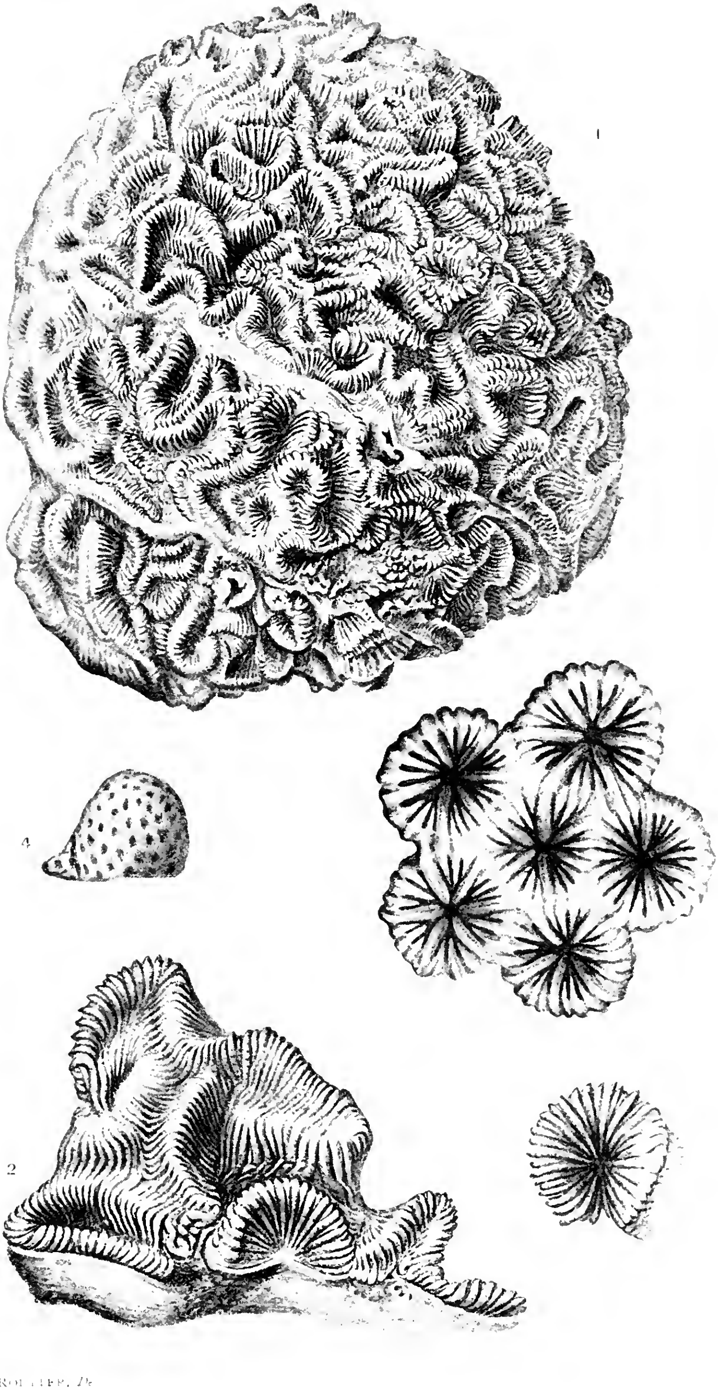
Convexastræa? peruviana n. sp. (Plate, figs. 4 and 5.)

Mostly in small spheroidal masses, from 1 to 8 cm. in diameter. Calicles crowded, small (2 mm. in diameter), deep. Septa thick, with apparently smooth edges, in six regular systems and three cycles, the primary septa alone reaching the centre, but leaving a small space between the ends. Septa of adjacent calicles sometimes coalescing. No distinct wall or furrow perceptible between the calicles. No pali or columella visible, although a small space in the centre looks as if it had been occupied by the latter.

This fossil, which at first sight reminds one of a Porites, on account of the size of the calicles and general aspect, comes nearest the genus Convexastræa, and particularly Convexastræa Waltoni Edw. & H. Still I am not quite satisfied with this identification. The species of that genus described thus far belong to the Jurassic and Triassic formations.

Explanation of the Plate.

Fig. 1. Isophyllia duplicata n. sp. Nat. size.
" 2. Magnified portion of the same.
" 3. Single calicle nearly circumscribed, magnified.
" 4. Convexastræa ? peruviana n. sp. Nat. size.
" 5. Calicles of the same magnified.



P. Roetter, Del.

No. 14.—*The Development of Salpa, by* WM. K. BROOKS, Ph. D.

Sketch of Adult Structure.

THE accounts of the general anatomy of Salpa, published by Sars,* Krohn,† Huxley,‡ Vogt,§ Müller,|| and Leuckart,¶ leave little to be done upon this subject; but since these papers cannot be procured easily in this country, and are absolutely inaccessible to the majority of American students, it will not be out of place to give, as briefly as possible, a description of the structure of this aberrant and highly interesting genus. This seems the more important since many parts of the developmental history must be unintelligible to those who are not familiar with the more important peculiarities of the adult structure.

The animals classed together as Tunicata agree very closely, as far as general plan of structure is concerned; and although they vary greatly in form, and in the relative size, position, and degree of development of the various organs, all the important structures found in one may usually be found in the others; and although the genus at present under discussion departs very widely from what may be considered as the typical form, those who are acquainted with the structure of one of the fixed ascidians will find no difficulty in tracing its homology with Salpa.

The chief difficulty in gaining a clear conception of the relations of

* Fauna littoralis Norvegiæ. VII. 63-85.

† Observations sur le génération et le développement des Biphores. Ann. de Sc. Nat., VI. 1846, 110.

‡ Observations upon the Anatomy and Physiology of Salpa and Pyrosoma. Phil. Trans. 1851.

§ Recherches sur les animaux Inférieurs de la Méditerranée. Mém. de l'Institut National Genevois, 1854, II. 1-62.

|| Verhand. der phys. med. Gesellschaft in Wurzburg. Bd. III. p. 57.

¶ Salpa und Verwandte. Zoologische Untersuchungen, II.

The literature of our subject is so extensive that a complete historical sketch would enlarge our account of the adult structure beyond reasonable limits; accordingly authorities will be referred to, in this chapter, only in those special cases which have a peculiar interest. The chapters which treat of the development will contain references to the various writers, giving a history of the progress of our knowledge of this subject; and very complete historical sketches of our knowledge of Salpa in general may be found in the papers by Huxley and Leuckart, above referred to.

the various parts of a tunicate animal lies in the fact that it is composed of a number of nearly concentric tunics or sacs, which are connected with each other in a rather complicated manner; and the names given to these parts by the various authors are not always used in the same way; the names used by one being applied by another to totally different organs, so that it is difficult to understand what part a name is intended to designate unless the terms used are defined carefully. The precise term used is of minor importance, provided its meaning is clearly stated, and since Huxley, in his paper on Pyrosoma,* has defined, with great clearness and exactness, all the terms which he uses, I shall employ his nomenclature as far as possible.

The Test. — The outer wall of a Tunicate is the "cellulose test" (Figs. 1 and 3, *a*). This is a sac with two openings, — the "branchial aperture" *e*, and the "atrial aperture" *g*.

The Outer Tunic. —Within the cavity of the test, and united to the latter at the two openings, is the "outer tunic" (Figs. 1, 2, and 3, *b*). This also is a sac with two openings, and usually conforms to the shape of the inside of the test, to which it may or may not be united; whenever the two are separated over a considerable area, there is, of course, a chamber between them, but as this is not one of the true cavities of the body and is of no homological importance, the test may be regarded as enclosing no especial cavity. The outer tunic is usually more or less muscular, and is often spoken of as the "muscular tunic"; it is the "second tunic," of most writers. Its cavity — that is, the space between its inner surface and the outer surfaces of the tunics within it — is the true "body cavity," and since all the blood-channels of Salpa and the forms allied to it are parts of this "body cavity," more or less shut off by the union of portions of the outer tunic to those within, it is often convenient to speak of it as the "sinus cavity," or "sinus system." Within the outer tunic are the "branchial sac," with its diverticulum, the digestive organs; and the "atrial tunic."

The Branchial Sac. — During the earlier stages of development the branchial sac is an entirely closed chamber surrounded by a tunic, which is in turn entirely surrounded by the body cavity, by which it

* On the Anatomy and Development of Pyrosoma. Trans. Linn. Soc., 1860, XXIII. pp. 193-250.

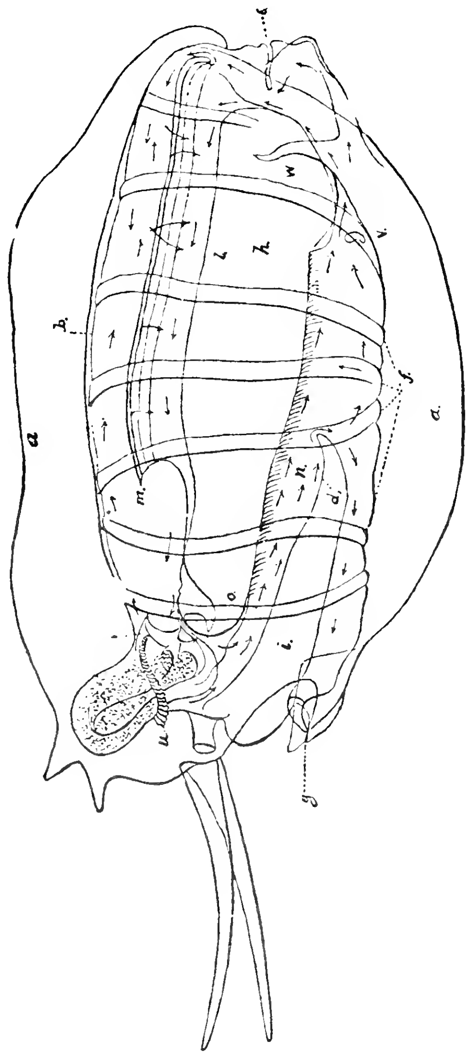
is separated from the outer tunic; at an early stage of development, however, the outer and branchial tunics unite at the anterior extremity, and the central portion of the area thus united disappears by absorption, so that an opening is formed through which the cavity of the branchial sac communicates with the outer water; this opening is the branchial aperture. Since the test, the outer tunic, and the branchial sac are all united around its circumference, the free edges are composed of all three of these. Upon the inner surface of the outer tunic around the aperture there is a set of muscles, by the contraction of which the opening may be entirely closed. The interior of the branchial sac bears several structures which are very constant in form and position throughout the group. Upon the hæmal side there are two long parallel folds which project towards the ventral axis of the cavity, and form the boundaries of a deep longitudinal furrow (Figs. 1, 3, and 24, *m*), which projects as a vertical ridge into that portion of the body cavity which forms the hæmal sinus, but remains in free communication with the branchial cavity by a cleft upon its neural side. In consequence of the thickness and opacity of the epithelium which lines the fundus of this fold, it appears (especially in the transparent Tunicata in a fresh state) like a strong hollow rod, mounted upon a thin ridge-like plate, and has been called the "endostyle."

The bottom of the furrow is richly supplied with very long cilia, and its sides are glandular, and secrete an adhesive slime, which serves to entangle the particles of food which are carried with the respired water into the branchial cavity. Upon each side of the endostyle and parallel to it, there is a prominent line of cilia (Fig. 24, *l*, also 1, 3, 32 and 33, *l*) to which the name "epipharyngeal ridge" has been given; these two ridges are continued backward beyond the posterior termination of the endostyle, where they unite to form the "posterior epipharyngeal ridge," which passes backward along the middle line of the posterior wall of the branchial sac to the mouth (Fig. 1, *o*), before reaching which they again separate in Salpa, and pass, one on each side of the tongue-shaped organ shown in Fig. 1, *o*. In front of the anterior end of the endostyle the two epipharyngeal ridges diverge from each other so as to pass around the branchial sac, near its anterior end, and thus form the "peripharyngeal ridges" (Figs. 2, *k*, and 33, *k*). Upon the neural median line of the branchial sac, and therefore opposite the endostyle, there is a row of tongue-shaped organs projecting into the respiratory cavity; these are the "languettes." The number of these is very variable; in Salpa there is only one (Figs. 1 and 3, *w*), in Pyrosoma there are eight, and in most of the fixed ascidians the number is much greater.

At the posterior end or base of the branchial sac, its wall is directly continued into that of the œsophagus (Fig. 24, o',) which is short and opens into a somewhat dilated stomach (Figs. 24, o'', and 4 o''). The cavities of these organs are continuous with the branchial cavity, and since the branchial sac is shown, by its development, to be nothing more than the anterior end of the digestive tract, Huxley has called it the "pharynx"; but it will be much more convenient, for our purpose, to retain the name which indicates its functional but not its morphological relations. The anterior opening, already described as the "branchial aperture" is undoubtedly the true homological mouth, but it is much more convenient to make use of the name which indicates its function, and to apply the term "mouth" to the aperture of ingestion, at the point where the œsophagus leaves the base of the branchial sac. The intestine bends around the stomach and then runs forward nearly parallel with the œsophagus (Fig. 24), and usually terminates at a point which is anterior to the mouth; the anus opens into the cavity of the "atrium," which is now to be described.

The Atrial Tunic. — Since the form and relations of this structure are very variable in the different Tunicata, a clear conception of it as presented in the typical forms is essential to a correct appreciation of tunicate structure and development in general, and, owing to a lack of such a clear conception, many of the published accounts of these animals are of very little value. In the perfectly transparent genus Perophora, which presents exceptionally favorable conditions for the study of the atrium, the two openings of the external tunic are at the same end of the body; one of these, the branchial aperture, is formed by the union of the branchial sac and outer tunic, as already described, while the other, the atrial aperture, is formed in a similar way by union of the outer and atrial tunics. The latter is a large bag, parallel to the branchial sac, and upon that side of it which bears the languettes; at the bottom of this sac, which Huxley has called the "mid-atrium," are the external openings of the intestine and reproductive organs. On each side of the body the atrium is, as it were, tucked into the space between the branchial and the outer tunic, thus forming two long and broad but very shallow "lateral atria," the cavities of which are continuous with that of the mid-atrium; these lateral atria are extended upon each side of the branchial sac until they almost meet, and thus cover the whole surface of the sac except a narrow line over and parallel with the endostyle. In a transverse section we should have the test and outer tunic as two concentric circles, and, within these, sections of the branchial and mid-atrial chambers side by side and separated from the outer tunic and from each other by the sinus cavity; the cross-sections of the lateral atria would be shown as two long parallel-walled diverticula from the mid-atrium, curving around the branchial sac, and almost meeting upon its opposite side. The outer wall of each lateral atrium is separated from the inner surface of the outer tunic, and the inner wall from the outer surface of the branchial sac by blood sinuses; but the separation from the branchial sac is not complete, for at certain points this is united to the atrial tunic so that the branchial sinus is divided up into a network of longitudinal and transverse vessels or blood-channels, crossing each other at right angles. In each of the parallelograms thus formed the two tunics are absorbed, thus forming a "branchial slit," through which the respired water passes from the branchial chamber into the cavity of the lateral atrium, through which it is driven into the mid-atrium, from whence it escapes through the atrial aperture. It is difficult to give a clear account of the relations of the branchial sac and atrium without the aid of diagrams, but an illustration may help to a conception of this somewhat complicated subject. In the middle of a long glass tube blow a bulb to represent the stomach, and enlarge one end of the tube to represent the branchial sac, and the other to represent the mid-atrium; the small tube uniting the branchial sac to the stomach will represent the œsophagus, and that which connects the stomach to the atrium will represent the intestine. Now bend the intestine around the stomach so that the branchial sac and atrium shall lie side by side, flatten out the latter, and wrap it around the branchial sac, and the whole will form a pretty correct model of these organs in a typical Tunicate. This illustration is open to one objection, inasmuch as it seems to imply that the branchial sac and atrium are serially homologous, while, in fact, the latter is not a part of the digestive tract, but originates independently. Such a model will represent only the condition of the organs in the adult,

Fig. 1.



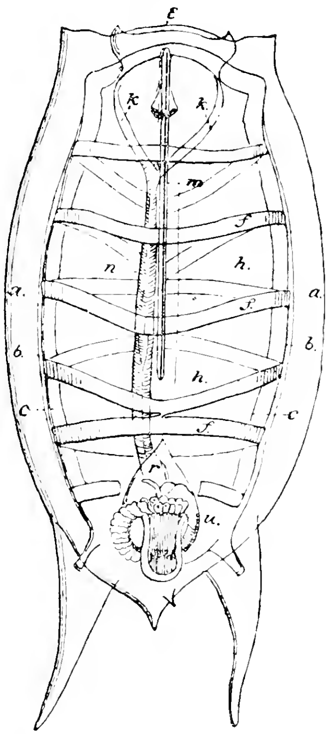
Adult solitary Salpa, viewed from the side: *a*, test; *b*, outer tunic; *d*, wall of atrial chamber; *e*, branchial aperture; *f*, muscular girdles; *g*, atrial aperture; *h*, branchial cavity; *i*, atrial chamber; *l*, epipharyngeal fold; *m*, endostyle; *n*, gill; *o*, mouth; *r*, heart; *u*, chain of males; *v*, ganglion; *w*, languette.

and although the branchial sac may be regarded as a pharynx, the atrium is in no sense a rectum.

The various tunics above described, with their diverticula and appendages include all the organs of a tunicate animal, with the exception of the nervous system, the heart, and the reproductive organs.

Nervous System.—The nervous system is situated within the body cavity, and is attached to the inside of the outer tunic between the two external openings (Figs. 1, 3, 24, and 33, *v*).

Fig. 2.



Adult solitary Salpa: hæmal view: *a*, test; *b*, outer tunic; *c*, wall of branchial sac; *e*, branchial aperture; *f*, muscular girdles; *h*, branchial cavity; *k*, peripharyngeal ridges; *m*, endostyle; *n*, gill; *nu*, nucleus; *r*, heart; *u*, chain of young males.

The Heart.—The position of the heart varies greatly, but it is usually found near the digestive organs (Figs. 1 and 3, *r*), and in all Tunicates its motion is periodically reversed.

The Reproductive Organs.—These are usually placed upon or near the intestine, and their external openings are near the anus.

We are now prepared to consider the special modifications presented in the organization of Salpa.

The *test* (Figs. 1, 2, and 3, *a*) is very thick, and, in our species, so perfectly transparent that its outline can be traced only when the animal is seen strongly illuminated upon a dark background. The branchial aperture is at the anterior end of the body of the solitary form (Figs. 1, 2, *e*), although the test of the chain-Salpa (Fig. 3) projects some distance in front of it, upon the hæmal side; in both the test extends posteriorly beyond the atrial aperture *g*. In the young of both forms the latter opening is much nearer the branchial than in the adults, and in this respect the young Salpa resembles the adult of the ordinary fixed ascidians. The shape of the test varies greatly in the different species, as well as in the two forms of the same species. The solitary form of our species,* when seen from above or from below (Fig. 2), is barrel-shaped in outline, with the posterior extremity obtusely pointed and the anterior truncated. At the sides of the posterior extremity the test is prolonged so as to form two long, slightly curved processes, each of which contains a cœcum of the outer tunic, with a cavity which is continuous with the sinus system. When seen in profile (Fig. 1), it is truncated at both ends, from the neural to the hæmal side; the extremities are slightly convex; the posterior truncating plane is more inclined than the anterior. Besides the two large posterior processes there are six much smaller ones, two on the median line and two pairs, all of which are composed of the test only, with no inner chamber. The anterior opening for the admission of water (Figs. 1, 2, 3, *e*) is by far the larger; it occupies the whole width of the body, while the posterior one (*g*) through which the water is expelled is much narrower, and placed at a short distance from the posterior extremity, at the base of the truncating plane, on the neural side; the anterior opening being nearer the hæmal side. The lips which close these openings are quite prominent, and can be thrown considerably beyond the general outline, either when drawing in water or forcing it out.

Since the Chain-salpæ are normally united into a chain composed

* This species is very abundant along the southern shore of New England, and was described by Desor (Proc. Boston Soc. Nat. Hist., III. 1848, p. 75) as Salpa Caboti; and subsequently figured and described by A. Agassiz (op. cit. XI. p. 17) under the same name. It seems to agree, in all respects, with the Salpa spinosa, Otto, figured and described by Sars (Fauna littoralis Norvegiæ, 1846, p. 85, Tab. 10, Figs. 1, 2, and 9). The Salpa spinosa of Otto is stated to be the same as the S. mucronata-democratica of Forskål, but as I have not been able to see Forskål's figures, I am unable to tell from his description whether the American species is the same.

of two rows of alternating zooids, the tests are flattened at the points where they come into contact with each other, and the surface is therefore composed in part of flat facets and in part of curved sur-

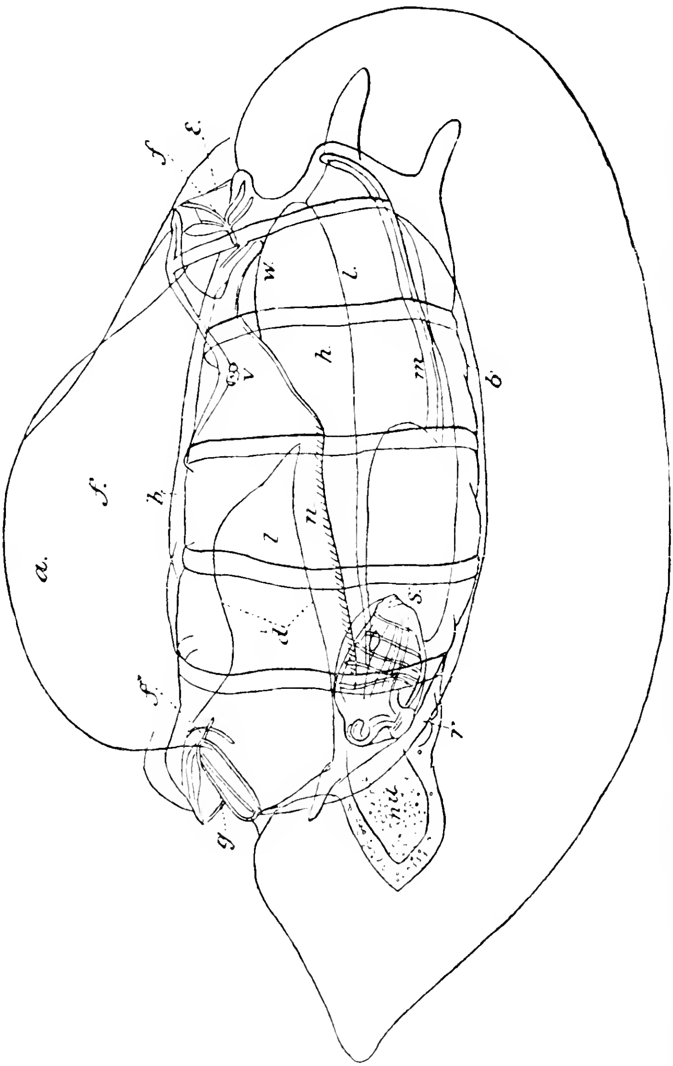


Fig. 3.

Adult Chain-salpa; side view: *a*, test; *b*, outer tunic; *d*, atrial tunic; *e*, branchial aperture; *f'*, muscles of branchial aperture; *f''*, muscles of atrial aperture; *g*, atrial aperture; *h*, branchial cavity; *l*, epipharyngeal fold; *m*, endostyle; *n*, gill; *r*, heart; *s*, embryo; *v*, ganglion; *w*, languette.

faces; and at the point where two zooids are in contact a spur, or diverticulum, from the outer tunic of each projects through the test, and meets and is joined to a corresponding spur from the outer tunic of its neighbor. These diverticula are hollow, and the blood passes into and out of them; but the cavity of each is separated by a partition from that of the one to which it is joined, so that there is no communication between the sinus systems of adjacent zooids. Each is furnished with eight of these spurs, by two of which it is attached to the neighbor in front of it on the same side of the chain; two serve to join it to the one directly behind it; two unite it to the neighbor obliquely in front on the opposite side of the chain; and the remaining two connect it with the one obliquely behind it. When the chain is quite young, the test is thin and the surface curved at all points, and the spurs project some distance beyond it, and thus keep the animals apart, and at the same time bind them together; but as they grow larger the tests thicken, embrace, and gradually cover up the spurs, and at last the tests of the two adjacent zooids meet and become flattened by mutual pressure, and tend to force the animals apart, and the chain now falls apart at the slightest disturbance; so that a full-grown chain can be found only in water which has been unusually still for some days. Although the motion of the separated zooids is not as active as that of a united chain, in which all the components act together to effect locomotion, they live and flourish when separated, and all traces of the spurs disappear, and the body again becomes rounded and presents the form shown in Fig. 3, the outline of which differs in several prominent features from that of the solitary form. The long terminal processes are wanting, and the posterior end of the body is prolonged into a broad, bluntly pointed cone, which contains the digestive and reproductive organs, and is the so-called "nucleus."

We may state here that the solitary form, which is the female, is hatched from an egg which is carried within the body of the Chain-salpa; and the Chain-salpae are the males, and are produced by a process of budding from the body of the female, and a single egg passes into the body of each male before birth.

The *outer tunic* (Figs. 1, 2, and 3, *b*) conforms to the inner surface of the test, and the two are usually in contact, although they are united only around the edges of the apertures, and may easily be separated from each other. Upon the inner surface of the outer tunic, the ganglion (*v*) and the muscular girdles (*f*) are attached.

The *branchial sac* presents all the characteristics already described as peculiar to this structure. It is attached to the outer tunic around the edges of the branchial aperture (*e*), the lips of which are reflected inward and provided with a complicated system of muscles (Figs. 3, 24, and 33, *f′*); the whole forming a valve which usually prevents the water from passing outward, although it may be so arranged, by the contraction of the muscles, that the contents of the branchial sac may be violently expelled through it.

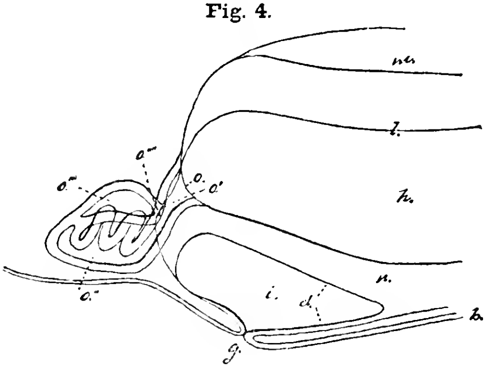
Owing to the transparency of Salpa, the endostyle is very prominent, and has the appearance of a solid rod in the adult, although earlier stages show that it is simply a furrow between two longitudinal folds. There are only two branchial slits, one on each side; but these are very large, and cover almost the whole surface of the branchial sac, except the median dorsal and hæmal lines. On the neural side, the branchial slit opens directly into the atrium, and the line where the two tunics unite is marked by the so-called "gill" (*n*); the posterior border of the slit is seen in Figs. 4, 32, and 33 as a curved line passing by the anus and mouth, and then bending forward to become continuous with the epipharyngeal fold (*l*), which bounds the slit on the hæmal side. Its anterior boundary is the peripharyngeal ridge, and it will be seen that the branchial sac is a complete cylinder only in that short portion which lies anterior to this ridge; while from this backward to the mouth, its sides are entirely wanting, and the branchial cavity opens directly into the atrium.

Although the inside of the branchial sac is supplied with cilia, as in all Tunicates, these do not seem to be of as much functional importance as in the remaining members of the group, since respiration is effected entirely through the action of the muscular girdles, which also assist deglutition and are the organs of locomotion. These contract rythmically, with great regularity, and at each contraction the water is expelled from the branchial sac through the atrial aperture; and when the muscles are relaxed, the elasticity of the test distends the chamber, and a fresh supply is drawn in through the branchial aperture, the lips of which readily admit its passage in this direction, while a similar set of valves allow its passage out of the atrial aperture, but prevent its return. As the result of this rythmical discharge of water, the animal is impelled forward with a motion which is pretty uniform in the case of a perfect chain;

although the solitary individuals, and those which have been set free by the breaking up of a chain, move by jerks. Since the blood circulates in the sinus system which surrounds the branchial sac and atrium, and also penetrates the cavity of the gill, which is simply part of the body cavity shut off by the union of the branchial and atrial tunics, its aeration is amply provided for.

If a little carmine is added to water containing Salpæ, the manner in which the food is conveyed to the mouth can be distinctly seen. The carmine, drawn in with the water, adheres to the inner surface of the branchial sac, anterior to the epipharyngeal ridges, and is then rolled along by the cilia until it reaches these ridges, the cilia of which are so set that they change its direction and convey it to the anterior end of the endostyle, the cilia of which gradually carry it backward toward the mouth. The contraction of the muscles now becomes more vigorous, and at each contraction the body is so compressed that the epipharyngeal ridges come into contact with the hæmal or branchial surface of the gill, and the water is forced along the tube thus formed, driving the food before it to the mouth.

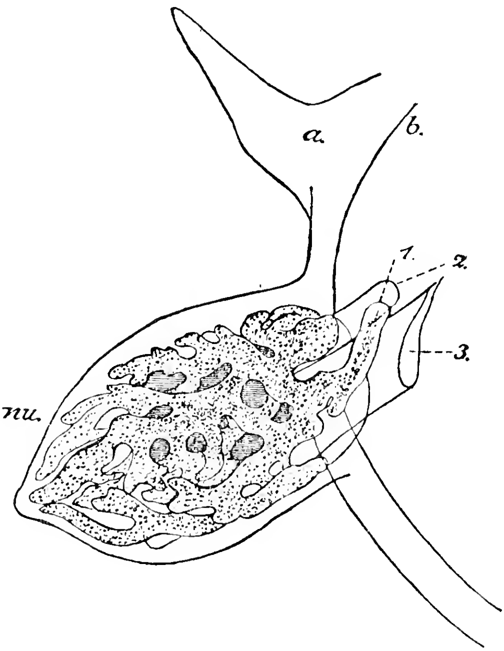
Fig. 4.



Digestive organs of very young solitary Salpa, figured with the neural side below: *b*, outer tunic; *d*, wall of atrium; *a*, atrial aperture; *h*, cavity of branchial sac; *i*, cavity of atrium; *l*, epipharyngeal ridge; *m*, endostyle; *n*, gill; *o*, mouth; *o′*, œsophagus; *o″*, stomach; *o‴*, intestine; *o⁗*, anus.

The Digestive Organs. — In the adult these are so obscured by the organs which overlie them that it is almost impossible to trace their course, which must therefore be studied in the young. Fig. 4 shows the atrial and part of the branchial chamber, and the digestive organs of a very young solitary Salpa, in which the cavity of the intestine is not yet in communication with the stomach, and is still imperforated at the anal end. The mouth (*o*) opens at the base of the branchial sac, on the hæmal side of the posterior end of the gill (*n*), and is joined by a short curved œsophagus (o') to the stomach (o''); the intestine (o''') is parallel to the long axis of the stomach, and the anus (o'''') is close to the mouth, but opens, not into the branchial, but into the atrial chamber, the posterior boundary of which is indicated by the line *l*.

Fig. 5.



Nucleus of adult Chain-salpa, — male; figured with the neural side uppermost: *a*, test; *b*, outer tunic; *1*, external aperture of testis; *2*, anus; *3*, mouth; *nu*, nucleus.

The whole digestive tract is immovable, and without muscles, and the food is driven through the permanently distended cavity by means of the cilia, with which its entire inner surface is lined. The great posterior sinus surrounds the digestive system on all sides, and the nutriment is absorbed directly from its surface by the blood. In the young a layer of large dark-colored cells may be seen, covering the posterior portion of the stomach and intestine (Fig. 33); these seem to be the first traces of the "tubular hepatic system"; a layer of anastimosing tubes which, in the adult, covers the outer surface of the stomach and intestine, and opens into the stomach at its anterior end. The function of this organ is much disputed, but as nothing definite is known upon the subject, a history of the discussion is not necessary here.*

The Testis. — In the adult Chain-salpa, the digestive organs are covered, outside the "hepatic organ," by the glandular organ shown in Fig. 5. This is a layer of arborescent folicles opening into the atrium by two apertures (*1*), one on each side of the anus (*2*); and a microscopic examination shows that it is the testis. It is found only in the Chain-salpa, which is therefore a male; while the ovary is developed within the body of the solitary Salpa, and will be described at length in connection with the development of the chain.

Fig. 6.

Spermatozoa, from the testis of an adult and from the branchial sac of an immature male.

The Ganglion and Sense Organs. — As an adaptation to its locomotive life, the nervous system of Salpa is more highly developed than in most of the adult Tunicata, and is provided with highly specialized sense-organs, which are supposed to be those of sight and hearing. The structure of these organs is described at length in the papers by Vogt, Leuckart, and H. Müller already referred to.

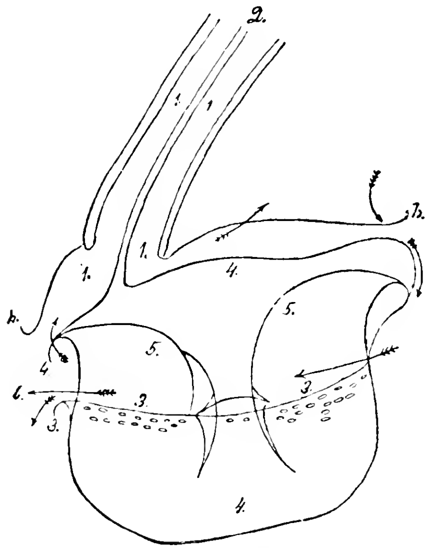
The Heart and the Circulation. — Since the discovery by Van Hasselt in 1824, that the circulation of Salpa is subject to periodical and somewhat regular reversal of its direction, the heart has been made the subject of especial study by numerous observers; but owing to its delicacy and transparency and to its rapid pulsation, its structure and mode of action have never been correctly described, and can be made out only by studying the living animal after it has been treated with ether until the contractions have grown very feeble and slow.

It consists of three concentric saddle-shaped portions, of which the upper (Fig. 7, *4*) and the lower (*3*) are thick and inflexible, while the middle one (*5*) is thin and composed of parallel rows of muscles, which

* Leuckart, pp. 33–38, devotes considerable space to this subject.

extend transversely from one side to the other. The muscular saddle is larger than the upper, and is attached to it around its entire edge, so that there is a closed empty chamber between the two; and the lower edges of all three are united, thus forming a crescent-shaped passage between the lower and muscular saddles. When the muscles of the middle saddle are relaxed, as in death by etherization, this layer is drawn up against the upper one, apparently by atmospheric pressure, and the upper closed chamber is no longer visible, while the

Fig. 7.



Heart and proximal portion of stolon of young solitary Salpa: *h*, outer tunic, continued into the outer wall of the stolon; *1*, sinus chambers of stolon; *2*, prolongation of pericardium; *4*, forming the partition of the stolon; *3*, inner saddle of pericardium; *4*, outer saddle of pericardium; *5*, muscular saddle; *6*, arrow showing the course of the current through the cavity of the heart.

lower crescent-shaped channel is open throughout its entire length; as the heart lies in the sinus system, this channel is of course filled with blood. Now it is plain that if one of the transverse muscular bands which compose the middle layer be contracted, the latter must be drawn down at this point until it comes into contact with the upper surface of the lower saddle, as seen in the figure, in which two such points of contraction are shown. This will of course divide the channel through the heart, so that there will no longer be an unobstructed passage.

The muscles contract successively in order, from one end of the heart to the other, and the middle layer is thus thrown into a wave, which sweeps along the roof of the lower layer and drives the blood before it, and before the first wave has travelled from one end of the heart to the other a second follows it, and so on. After this has gone on for some time the muscles begin to contract in the reverse order, and the waves start from the other end and the direction of the current is reversed. The cause of this change or the meaning of the reversal is as yet by no means clear, although after the pulsations have continued for some time in one direction numbers of blood-globules may be seen crowded together in certain organs, such as the elæoblast; and these block up the sinuses until they are set free by the change in the direction of the current.

In our species the blood-channels are in all cases sinuses, which are parts of the body cavity and have no special walls, although several writers insist that in certain parts of the bodies of other species the blood circulates in true vessels lined with epithelium.

Embryology of the Solitary Salpa, — Female.

We are now prepared to enter upon the history of the development of Salpa. This is rendered somewhat complicated by the fact that the two forms, besides differing considerably in structure, are developed in totally different ways; and before the embryo of the second generation has completed its development within the body of its parent, the formation of the third generation begins within it: accordingly at certain stages we are compelled to study an embryo going through one series of changes, and within this another embryo differing in form, and undergoing an entirely distinct form of development.

On account of the manner in which the two forms of development overlap, it is somewhat difficult to select a point at which to begin our account. The fertilization of the egg seems to be the best point of departure, although some parts of the description cannot be clearly understood until the account of the development of the male has been read.

The Egg: its Fertilization and Segmentation.—At the time when the

Salpa chain is discharged from the body of the solitary form each "zooid" * contains a single egg,† which is situated upon or very near the median plane of the neural side of the animal, within the sinus

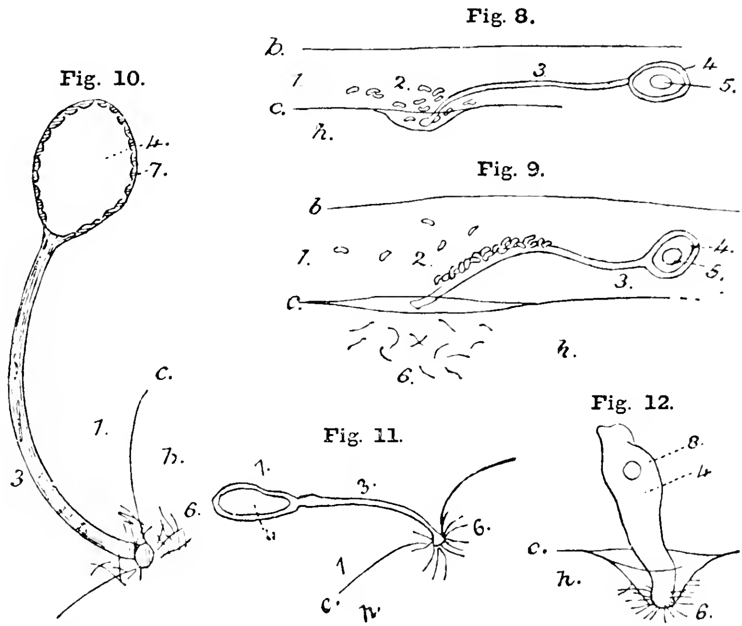


Fig. 8, egg before impregnation. Figs. 9 and 10, egg during impregnation. Figs. 11 and 12, changes following impregnation: *b*, outer tunic of male; *c*, wall of branchial sac of male; *h*, cavity of branchial sac of male; *1*, sinus system of male; *2*, blood corpuscles of male; *3* gubernaculum; *4*, yolk; *5*, germinative vesicle; *6*, spermatic filaments; *7*, capsule of egg; *8*, nucleus.

system, and midway between the atrial orifice and the stomach (see Figs. 31, 32, 33, and 34, *s*). There is no observable trace of a vitelline membrane; the yolk is transparent without granules, and the germinative vesicle does not contain a germinative dot (see Fig. 8). ‡

* The use of the word "zooid" in this connection must not be understood to imply any opinion as to what is or is not a zoölogical individual; it is used merely as a convenient word to designate one of the males which compose a chain.

† Leuckart says (Ueber Salpen, p. 49) that some species contain more than one egg.

‡ Huxley, who studied what appears, from his description, to be the species here described, says (Salpa and Pyrosoma, p. 577) that there is a germinative dot occasionally. Leuckart (p. 51) gives the germinative dot as one of the characteristics of the egg, but I have not been able to find it in any instance.

The egg is inclosed in a capsule of small epithelial cells (see Fig. 10), which are in direct contact with the surface of the yolk, and upon the lower surface of this capsule there is a long stem or gubernaculum, which passes down the side of the body of the zooid in the sinus between the branchial sac and outer tunic, and is attached to the wall of the branchial sac, upon the right side, near the heart. According to the observations of H. Müller (Ueber Salpen. Zeitsch. f. wiss. zoöl. IV. 3), "the stalked capsule which, in all new-born Chain-salpas, encloses the egg, is an evagination from the wall of the branchial sac, and the epithelium of the latter is directly continued up the stem and over the yolk"; but I was unable to trace the epithelium on to the gubernaculum, which seems to be a solid rod of protoplasm, passing through the wall of the branchial sac and projecting into its cavity. At the point where the gubernaculum joins the wall of the branchial sac, the latter is slightly depressed, so as to form a cup with its convex surface turned towards the branchial cavity, so that the cavity of the cup, which is to form the "brood-sac," is a diverticulum from the sinus system; and blood-corpuscles may usually be found within it, as well as upon the sides of the gubernaculum, adhering together so as to form irregular clusters, as shown in Fig. 9.*

Very soon after the chain is discharged into the water, the egg undergoes impregnation, which, however, is not effected by the spermatic fluid of the zooid which contains the egg, nor by that of any other zooids in the same chain. The testis, at this time, is in a very rudimentary state (see Figs. 33 and 34, *t*), and does not become developed until after the solitary embryo into which the egg is developed has been discharged from the body. Wherever Salpa is found at all, it is very abundant, and individuals at all stages of growth occur together, so that some portion of the fluid discharged into the water from the testis of an adult male readily finds its way into the cavity of the branchial sac of the young male which carries the unimpregnated ovum, and numbers of actively moving spermatic filaments may be found within this cavity at this time. These filaments seem to be drawn to the exposed tip of the gubernaculum by some attrac-

* Leuckart (p. 47) describes this cup as a solid organ developed upon the wall of the branchial sac; although he refers to Vogt's correct description of it (Bilder aus dem Thierleben, 82).

tive force, since they swarm about it; and great numbers become attached to it, as well as to the wall of the branchial sac in its vicinity, as shown in Figs. 9, 10, 11, and 12. A few of them penetrate the gubernaculum, and work their way up towards the egg (Fig. 10); and, although none were actually seen which had travelled over much more than half the distance between the tip of the gubernaculum and the egg, there seems to be no obstacle in their way, and they prob-

Fig. 13.

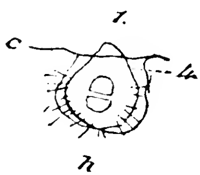


Fig. 14.

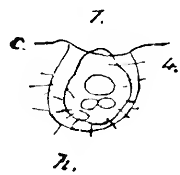


Fig. 15.

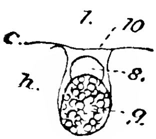


Fig. 16.

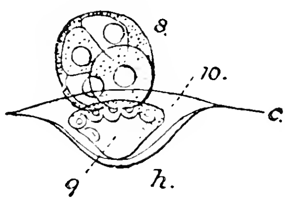


Fig. 17.

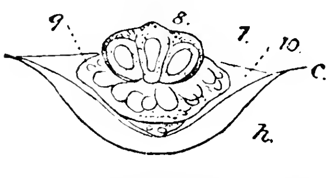
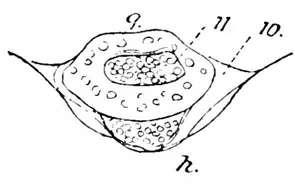


Fig. 18.



Successive stages of segmentation: *c*, branchial tunic of male; *h*, cavity of branchial sac of male; *1*, sinus system of male; *4*, yolk; *8*, food-yolk; *9*, germ-yolk; *10*, orifice of brood-sac; *11*, invagination orifice.

ably reach the yolk; but the subsequent changes follow so rapidly that no egg was found showing them so situated.

Immediately after impregnation the germinative vesicle disappears, but as the actual process was not observed, nothing can be stated as to the manner in which the disappearance takes place. Soon after this is lost sight of, the gubernaculum becomes irregularly swollen and shortened, as shown in Figs. 11 and 12, and the yolk now seems to be prolonged into its cavity, although at an earlier stage the epithelium of the capsule appeared to surround the entire surface of the yolk. The swelling and shortening go on rapidly, and in a short time the egg presents the appearance shown in Fig. 12. A single nucleus can now be seen at the point previously occupied by the germinative vesicle, and the egg, nourished by the blood which bathes it, begins to grow, and is already somewhat larger than before impregnation. The shortening of the gubernaculum continues until the egg is drawn down from the median neural surface of the nurse to the point upon the right side of the lower or hæmal surface of the branchial sac, where the gubernaculum is joined to the latter, as already described. The brood-sac, or cup-like depression of the branchial sac, has meanwhile increased in size, and now forms a nearly hemispherical cup, large enough to contain the egg, which is soon entirely withdrawn into it, as shown in Figs. 13 to 18. Since the cavity of the brood-sac is a diverticulum from the sinus system of the nurse, the blood has free access to it, and bathes the egg on all sides. The latter is perceptibly larger at this time than it was during the stage last described, and this process of growth continues during the whole of the subsequent development; so that the embryo, at the time when the first traces of organs make their appearance, is many times larger than the unimpregnated ovum, and when the solitary embryo escapes from the body of the Chain-salpa it is two or three times as large as the latter itself was at the time when the egg was fertilized. This remarkable growth is mentioned here, in advance, as it will not be referred to in the subsequent description, although it must be understood as going on at all stages.

The egg is now pear-shaped, and is attached by its broad end to the floor of the brood-sac, at the point where the gubernaculum originally joined the latter (see Fig. 13); the nucleus is now divided into two, all traces of the epithelial capsule have disappeared, and nothing more is known about it.

Of the two nuclei now present the lower, with the portion of yolk which surrounds it, is destined to form the "germ-yolk" of the embryo, and soon divides again, as shown in Fig. 14, and at a stage a little later, Fig. 15, it is composed of a mass of minute segments. The upper nucleus of Fig. 13 with its portion of yolk forms the so-called "food-yolk," and segments much more slowly. In Fig. 15 it is not at all divided, and in Fig. 16 it is divided into four large spherules, enclosed in a common membrane. The food-yolk now gradually becomes invaginated into the germ-yolk, as shown in Fig. 17, and is soon entirely surrounded by the latter, forming the symmetrical vase-shaped "gastrula," shown in Fig. 18.* The cavity of the gastrula opens directly into the sinus system of the nurse, and the blood now circulates into and out of the primitive digestive cavity, as well as around the outside of the embryo, which grows rapidly, and soon fills the brood-sac, so that its outer surface comes into contact with the latter, which soon ceases to be visible as a separate covering (Figs. 19 and 20), and of course the blood no longer bathes the outside of the embryo, although it continues to pass into and out of the primitive digestive cavity. The germ-yolk now becomes finely segmented, although the spherules are still somewhat larger than the more transparent ectoderm cells outside them. The invagination cavity or "primitive digestive cavity" becomes separated into two portions; the outer remains in free communication with the sinus system of the nurse and forms the inner chamber (Fig. 19, *10*) of the placenta, and its opening becomes the orifice of the placenta. This persistence and functional importance of the "orifice of Rusconi" are very remarkable, and seem to have no parallel among the other Tunicata, or in any of the various groups of animals with which it has been proposed to associate them. The gastrula of Salpa seems to be a special adaptation to the very anomalous mode of development of the embryo. The lower portion of the primitive digestive cavity now becomes entirely surrounded by the endoderm, and soon becomes obliterated, as shown in Fig. 18. Very soon a cavity reappears in this portion of the embryo, and persists and forms the cavity of the branchial sac (Fig. 20, *13*). A constriction now appears upon the outside of the embryo, separating the placenta from the embryo proper, and soon a body cavity becomes visible, separating the branchial sac from the outer wall, and also extending up around the placenta, to form its outer chamber (Fig. 22, *12*).

The placenta, therefore, consists of an inner chamber communicating with the sinus of the nurse, and having no communication with

* A number of eggs at all stages between the two represented in Figs. 17 and 18 were found, but the two here shown seem to be all that are necessary for clearly representing the process. Huxley (Plate XVI. Fig. 7) gives a figure of a stage in which the invagination is about half completed, but he does not refer to it in the text.

any of the cavities of the embryo; with a cavity which is part of the original "cavity of invagination," and is surrounded by a wall of cells derived from the endoderm: and an outer chamber bounded on the inside by the cells of the endoderm, and on the outside by the ectoderm,

Fig. 19.

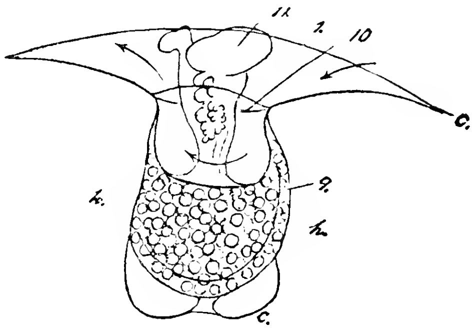


Fig. 20.

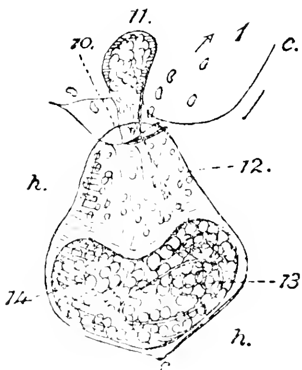
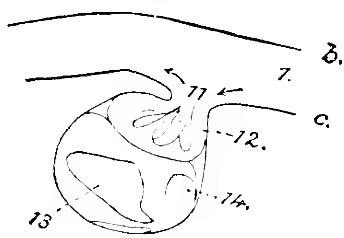


Fig. 21.

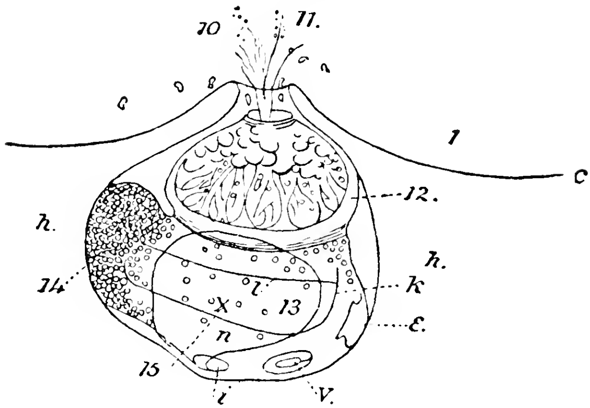


Successive stages in the formation of the embryo: *b*, outer tunic of male; *c*, wall of branchial sac of male; *h*, branchial cavity of male: *1*, sinus system of male; *10*, opening of inner chamber of placenta; *11*, club-shaped organ; *12*, outer chamber of placenta; *13*, branchial cavity of embryo; *14*, nucleus of embryo.

having no communication with the sinus system or other cavities of the nurse, but being directly continued into the body cavity of the embryo.

The Placenta. — For the sake of clearness we will neglect for the present the changes which are now taking place in the body of the

Fig. 22.



Embryo a little more advanced: *15*, lateral atrium; *i*, mid-atrium; *e*, branchial aperture; *k*, peripharyngeal ridge; *l*, epipharyngeal ridge; *v*, ganglion.

embryo, and will describe at once the subsequent development of the placenta. The inner cavity of this is at first one undivided chamber into and out of which the blood of the nurse is constantly passing; but soon a singular club- or stump-shaped structure (Fig. 18, *11*) appears in its opening, dividing this, at first incompletely, into two, and projecting into the sinus system of the nurse as well as into the cavity of the placenta, and serving to more effectually divert the blood into the latter. Appearances seem to indicate that this organ is not derived from any of the parts of the nurse or embryo, but is formed directly from the blood, by the aggregation and fusion of its corpuscles. Observations upon this point were made so frequently and with such uniform results that there seems to be little doubt that it does originate in this way. No traces of a cellular structure were observed in it. It is at first entirely free from all the adjacent parts, but very fine threads are soon visible extending from it, and some of these soon unite to the neck of the placenta and serve to anchor the two together; the terminations of the remaining threads were not traced, but they seemed to float in the blood of the sinus.

The lower end of this organ now extends downward, and joins the bottom of the placenta, and soon becomes divided into a number of root-like portions (Figs. 19, 21, and 22, *11*), which separate the cavity into irregular intercommunicating lacunae, through which the blood now passes, and among the meshes of which the corpuscles are often entangled, so that the circulation is much less rapid than in the sinus outside. Before this stage is reached the blood of the fœtus also begins to circulate, and as the outer chamber of the placenta is part of its sinus system, the small corpuscles contained in its blood can be seen passing around the outside of the inner chamber, and thus coming into very close proximity to that of the nurses. Huxley's account of the placental circulation at this period is so good that it will not be out of place here, although he adds very little to the accounts previously published by Sars and Krohn. He says (p. 575), that the placenta "contains two perfectly distinct cavities or sacs; of these the outer is concave and cup-shaped and envelops the inner, which is subspherical. Now the outer sac is in free communication by a narrow neck, divided into two channels by a partition, with the dorsal sinus of the fœtus; and the inner sac is in equally free communication by a neck similarly divided, with a short sinus arising immediately behind the heart; and as there is no communication between the two sacs, it follows that the current of blood in each is perfectly distinct from and independent of that in the other. A more beautiful sight, indeed, can hardly be afforded to the eye of the microscopic observer than the circulation in this organ. The blood-corpuscles of the parent may be readily traced entering the inner sac on one side of the partition, coursing round it, and finally re-entering the parental circulation on the other side of the partition; while the fœtal blood-corpuscles, of a different size from those of the parent, enter the outer sac, circulate round it at a different rate, and leave it to enter into the general circulation of the dorsal sinus. More obvious still does the independence of the two circulations become when the circulation of either mother or fœtus is reversed."

The following historical sketch of our knowledge of this structure is also taken from Huxley's paper, page 592: "Cuvier* speaks of finding a fœtus attached to the parent by a pedicle; and, referring to a figure, he says: 'Ce corps rond [evidently the placenta] seroit-il un organe servant uniquement pendant le temps de la gestation pour établir l'union entre la mère et son petit et qui s'effaceroit ensuite?'

Chamisso † calls the pedicle of attachment 'pediculus umbilicalis'; the placenta, 'globulus opacus.'

* Ann. Mus. d'hist. nat. 1804, IV.

† Nova Acta, 1832, XVI. pp. 362 – 422.

"Meyen was the first to give this structure the name of placenta, and his account of it is so very clear and precise that it is wonderful it should have been subsequently forgotten or overlooked. He says: 'Wir haben bei ganz jungen Individuen den Verlauf der Blut-bewegung selbst by 200-maliger Vergrösserung beobachten können. Der Muttertheil der Placenta hat nur wenig Gefässe, um so mehr aber der Fötus-theil, in dem sich ein ausserordentliches Convolut von Gefässen befindet, das sich in einem Stamme endigt, der sich in das grosse Bauchgefässe ganz in der Nähe des Herzens ergiesst. Ein unmittelbares Uebergehen der Blutgefässe aus dem Muttertheil in den Fötus-theil haben wir nicht sehen können. Hat der Fötus die hinlängliche Ausbildung im Leibe der Mutter erreicht, so verwächst das grosse Blut-gefäss und die Placenta fällt ab.' — Page 440."

Krohn, Huxley, Leuckart, and Vogt subsequently investigated the structure of this organ, and have correctly described its more important features as they exist when fully formed, but its origin and the nature and structure of the club-shaped core are here described for the first time.*

The embryo, at the stage last described (Fig. 20), consists of the outer tunic derived from the outer layer of the gastrula, the body cavity, and the branchial sac, the wall of which is formed from a portion of the cells of the inner layer, while the remainder form a large mass (*14*), at what is to be the posterior end of the body. The subsequent development of these parts, as well as the formation of those which subsequently make their appearance, will now be described.

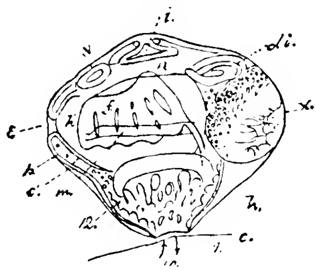
The Outer Tunic. — Little need be said of this; it is not at first covered by the test, which makes its appearance later, apparently by excretion from the surface of the outer tunic; the latter now covers all of the embryo except the part in contact with the placenta, and is reflected on this to form the outer wall of the outer or fœtal chamber, as already described. It is entirely separated, at first, from the branchial sac by the body cavity, but at a later stage an invagination appears at the anterior end (Fig. 22, *e*), which unites with the anterior end of the branchial sac, and a perforation appears which forms the incurrent opening (*e*, Figs. 1, 3, 23, 24, 25, 33, 34). The

* Leuckart says (p. 53), that the residual yolk becomes the placenta, but we have seen that this becomes invaginated to form the digestive layer of the germ, and that the placenta is not formed until the close of the gastrule stage.

atrial opening (*g*) in the same figures is formed in a similar manner, but somewhat later, by coalescence with the walls of the atrial chamber. The muscular bands which adhere to the inside of the outer tunic of the adult are derived from the atrial tunic, and will be described in connection with that organ.

The Body Cavity. — During the early stages the whole surface of the branchial sac, except the region next the placenta, is surrounded by the body cavity, the connection of which with the outer chamber we have already described. As development progresses, the outer tunic and the wall of the branchial sac unite at various points, and the atrial tunic is formed between them and has regions of attachment

Fig. 23.



Embryo more advanced than the one shown in Fig. 22, but less highly magnified: the muscular girdles are partially separated: *1*, sinus system of nurse; *10*, opening of placenta: *12*, outer or fœtal chamber of placenta; *c*, branchial sac of nurse; *h*, branchial cavity of nurse; *b*, outer tunic; *c'*, wall of branchial sac; *e*, branchial aperture; *h'*, branchial cavity; *i*, mid-atrium; *w*, gill; *m*, endostyle; *f*, muscles; *v*, ganglion; *x*, elæoblast; *d i*, digestive organs.

to both, so that we no longer have a single body cavity, but instead of it a sinus system.

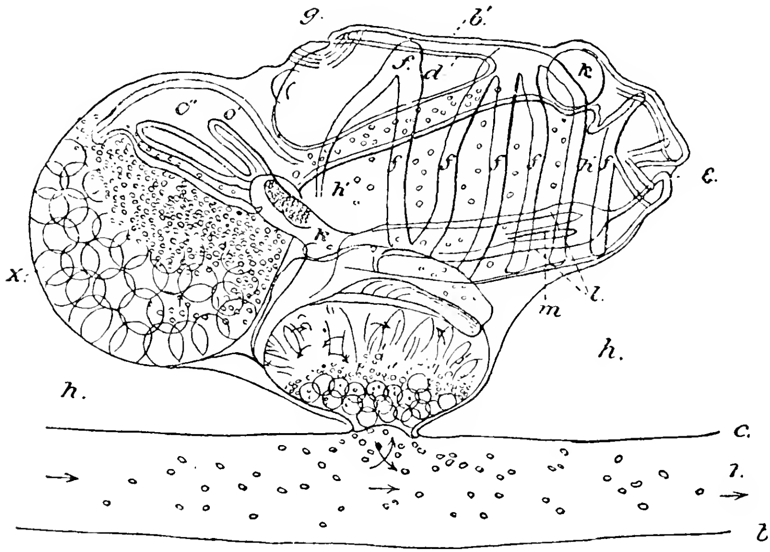
Branchial Sac and Digestive Organs.— The branchial sac is at first a single, nearly oval cavity (*13*, Fig. 20), occupying a little more than the anterior half of the embryo, while the posterior half is filled with a mass of cells (*14*, Fig. 20), which are to give rise to the various organs of the nucleus. The cavity of the branchial sac soon becomes lengthened backward, so as to occupy two thirds or three fourths of the body of the embryo (Figs. 22, *13*; 23 and 24, *h*), and the nucleus is divided, unequally, into two portions, of which the smaller (Fig. 23, *d i*), which is upon the neural side, gives rise to the wall of the digestive organs, while the larger or hæmal portion (Fig. 23, *x*) becomes the elæoblast. The cavity of the œsophagus soon becomes visible as a diverticulum from the posterior end of the cavity of the branchial sac, and is in direct communication with the latter at the earliest stage observed. Two diverticula are now formed upon the lower or hæmal surface of the œsophagus, side by side and parallel with each other (Fig. 4, o''); as these grow they gradually unite and form a single large diverticulum, which is bent forward towards the mouth so that it lies nearly parallel with the œsophagus, as shown in Fig. 24, o''. Since the cavity of the stomach is derived from that of the branchial sac, it must, like the latter, be regarded as a portion of the primitive digestive cavity of the gastrula. The cavity of the intestine, however, first appears as a closed chamber, parallel with and on the hæmal side of the stomach, and having no communication with the cavity of the latter (Fig. 4, o'').

The partition which separates the two soon disappears, and they become continuous, although the anal end of the intestine, which is close to the mouth, is still closed. After the chamber of the mid-atrium or cloaca has been formed the anus unites with this, the partition disappears, and the digestive organs now form an U-shaped tube, connecting the branchial with the atrial cavity. As nothing was learned of the development of the so-called "hepatic organ" of the solitary Salpa, I will now give what little was learned about it in the chain-salpa, in order that this description of the mode of formation of the various organs may be as complete as possible. In the young chain-salpa, at the time it is discharged into the water, the posterior end of the stomach and the side of the intestine are covered with a single layer of large, nucleated, dark-colored cells (Figs. 33 and 34), which present the characteristics of liver cells, and agree in appearance, and approximately in position also, with the liver cells upon the wall of the upper portion of the stomach of a Polyzoön.

At the time that the observations upon Salpa were made a species of Appendicularia was very abundant. The wall of the stomach of this bore, upon the *inside*, two large clusters of cells which were arranged in a single layer, and agreed, in appearance, color, &c., with those found upon the *outside* of the stomach of Salpa, which are undoubtedly liver cells, and the rudimentary "tubular hepatic organ."

The study of this organ was extremely difficult, as the elæoblast of the solitary Salpa obscures this portion of the digestive organs at all stages, while, during all stages but the earliest, it is hidden in the chain-salpa by the testis. The second portion of the nucleus, which is much larger than the portion which forms the digestive organs, is

Fig. 24.



Embryo at the time the first traces of the stolon appear: *1*, sinus system of nurse; *b*, outer tunic of nurse; *c*, branchial tunic of nurse; *h*, branchial cavity of nurse; *b'*, outer tunic; *d*, atrial tunic; *e*, branchial aperture; *f*, muscles; *g*, atrial aperture; *h'*, branchial cavity; *k*, heart; *l*, epipharyngeal ridges; *m*, endostyle; *o*, mouth; *o'*, œsophagus; *o''*, stomach; *x*, elæoblast. Through an error the ganglion, as well as the heart, is marked *k*.

situated upon the hæmal side of the body, as already stated (see Fig. 23, *x*), and soon becomes divided up into large transparent cells, filled with oil globules, or with a body of oil-like appearance and refractive power, but not divided into globules. These cells soon become polygonal by mutual pressure, and form a large spherical mass which increases much more rapidly than the remaining organs of the body (Fig. 24, *x*), and at the time the Salpa chain begins to be formed within the body, the mass of cells is nearly as large as all the other portions of the embryo. The blood circulates freely among the cells and over the outside of the mass, which is not separated from the sinus system by any membrane, and the blood globules, and the oil which escapes from the older cells, often accumulate in large masses near the digestive organs and heart.

This organ, for which Krohn has proposed the name "elæoblast," attains its greatest development in the embryo, and begins to disappear as soon as the chain begins to form within the body, and is therefore provisional, as pointed out by Krohn, and has no permanent place or function in the adult. Meyen regarded it as a yolk (p. 401), and there seems to be little doubt that it is, if not strictly yolk, at least something having a very similar use, and supplying the material which is to be employed in the formation of the zooids of the chain. Leuckart states (p. 57), that it is found in both forms of Salpa, but this is not the case. It is always present in the solitary Salpa during the embryonic development, and the nucleus of the young chain-salpa divides, like that of the solitary form, into an upper smaller portion, which gives rise to the digestive organs, and a lower, larger portion, which thus agrees with the elæoblast in its mode of origin, and, during the earliest stages, in appearance also (Fig. 32, *t*). It never attains a great size, as compared with the other organs, and soon forms a compact globular mass of cells (Fig. 34, *t*), which in the adult chain-salpa forms the testis (Fig. 5). Since the testis of the chain-salpa agrees so closely with the elæoblast of the solitary one, it seems very probable that this is also a reproductive organ, and that Meyen was right in calling it a yolk-deposit. It is not a true ovary, for this originates in a different way, as will be shown further on.*

The Atrium. — The adult Salpa is composed of three principal tunics, each enclosing a special cavity. The formation of the outer one of these, the outer tunic, has already been described, and we have seen that it is derived from the outer layer of the gastrula; its cavity has

* Few organs have had their functions more disputed than this elæoblast. Many of the earlier observers considered it a liver, and Sars repeats this error, although Meyen had previously determined its connection, in some way, with development. Krohn discovered that it was transitory and provisional, but does not commit himself in regard to its function. Huxley described the true liver, and, although acquainted with all that had been written upon the elæoblast, says (p. 571), "There would seem to be no clew either to the homology or to the function of the elæoblast. Without hazarding a conjecture, it may be remarked, as a curious fact, that these animals, so remarkable for possessing in the fœtal state a true though rudimentary placental circulation, possess an organ which in structure and duration somewhat calls to mind the thymus gland." Leuckart (p. 57) concludes that it is a depot of nutriment stored up for future use, but he does not state whether it is to be used in the formation of the embryo or in the development of the chain. We will return to the subject of its homology with the testicle further on.

also been described as the body cavity or sinus system. The inner tunic, or branchial sac, has been shown to be part of the inner or digestive layer of the gastrula. The third tunic, now to be described, is the atrial tunic, and its cavity the atrial chamber or cloaca. The earliest stages in the formation of this tunic were not traced in either form of Salpa, but as it presented, when first observed, an appearance very similar to that described by Kowalevsky,* as presented during the early stages in the development of Pyrosoma, it is possible that it originates in the same way; although in the absence of any observations upon its origin, the fact that Kowalevsky's observations upon Pyrosoma are here referred to must not be regarded as implying anything more than a belief that the similarity which is known to subsist between the two genera, in many other respects, may extend to the way in which the atrium is formed. In the egg-embryo of Pyrosoma two circular depressions appear upon the neural side of the outer tunic, near the anterior end, and these deepen so as to form tubes derived from the outer layer, with cavities which open externally; these tubes lengthen and penetrate the body cavity upon each side of the branchial sac; their external openings close, and they become separated from the outer tunic, and form the "lateral atria" of Huxley.† According to Huxley (pp. 215, 216), — and Kowalevsky's account corroborates that of Huxley in every particular, — these at first "are very small and thick-walled; they soon become larger and the walls proportionally thinner, and the sacs themselves are both absolutely and relatively larger.

"In Fig. 29 they are very much larger and thinner, and their relations to other organs are especially worthy of attention. The outer layer of each is applied to the outer tunic of its side, leaving a small interspace, which communicates freely with the great posterior sinus, in which the intestine and genatilia are disposed, and with the anterior sinus which lies between the pharyngeal wall [branchial sac], and the external tunic. This interspace is, in fact, the parietal sinus. The internal layer, continuous with the outer anteriorly and posteriorly, but separated from it by a wide chamber for the rest of its length, is applied against the wall of the pharynx [branchial sac], for

* Ueber die Entwickelungsgeschichte der Pyrosoma. Von A. Kowalevsky. Archiv. für Mikr. Anat., XII., 1875, p. 597.

† Huxley, Anatomy and Development of Pyrosoma, p. 205. Trans. Linn. Soc., XXIII., 1860, p. 193.

four fifths of the extent of the latter, and then coats the lateral portions of the gastro-intestinal tract, forming the antero-lateral boundary of the great posterior sinus. The space between the wall of the pharynx and the inner layer of the sac communicates anteriorly with the anterior sinus, posteriorly with the posterior sinus, and it is interrupted at several points by the union of the pharynx and inner layer with one another. It represents the system of branchial sinus." In Salpa this union of the inner wall of the lateral atrium with the branchial sac does not take place. "In side views it is not easy to make out the boundaries of the lateral sacs; but it is most important to observe that, as has been already mentioned, in the middle of the lateral face of the pharynx, and therefore also in the middle of the lateral face of the inner wall of the sac, a series of opake rings with clear centres, the rudiments of the branchial stigmata, make their appearance." In this respect also Salpa differs from Pyrosoma; no branchial clefts are ever formed in connection with the lateral atria. "These correspond with the points of union of the pharynx and the inner wall of the sac. They are at first small, round, and very indistinct, but by degrees they elongate in a direction perpendicular to the long axis of the pharynx, and their real nature becomes apparent. Hence it is clear that these stigmata must eventually open into the lateral sacs, as indeed they may be seen to do in such buds as that represented in Fig. 30; and hence also it follows that the lateral sacs are the rudiments of the lateral atria.

"At first the lateral atria appear to be perfectly distinct from one another, and no atrial aperture is discernible. In buds, such as that represented in Fig. 29, again, they do not extend, posteriorly, further than the sides of the alimentary canal; but in more advanced buds they are produced backward on each side until they pass beyond the level of the posterior margin of the stomach, so that they now constitute the entire lateral boundaries of the great posterior sinus. The longitudinal section of a somewhat smaller bud shows that in this condition the atria are no longer distinct, but are united together below [on the neural side of] the stomach, by a comparatively narrow and short canal, which is the mid-atrium.

"I have not traced out all the details of the process of coalescence of the lateral atria; but I suppose that each branchio-parietal portion of the atrium, at first a distinct sac, is prolonged downwards and inwards, under the stomach, and that the opposed walls of the prolongation become applied to one another, coalesce, and then become perforated.* At any rate, the mid-atrium is now surrounded by a membranous wall, continuous on all sides with the lining of the lateral atria, and applied superiorly and anteriorly against the stomach and œsophagus, posteriorly and inferiorly against the external tunic, but not touching either of these parts, except for a small space on the floor of its chamber, where it becomes united with the external tunic to allow of the formation of the atrial aperture. This aperture is situated on the neural side of the body, in front of the posterior end, which is chiefly occupied by the genitalia; but as development goes on the mid-atrium increases, disproportionately, and encroaches upon the other organs, upwards and forwards, in such a manner that its anterior wall invests the whole posterior and lateral faces of the gastro-intestinal division of the alimentary canal. . . . . The facts which I have detailed are exceedingly important for the comprehension of ascidian structure in general." This account of the form and connections of the atrial chamber applies to those zooids of Pyrosoma which are produced by budding, as well as to the egg-embryo, but according to the observations of Kowalevsky the diverticula which give rise to the lateral atria of the bud-zooid are derived, not as in the egg-embryo, from the outer tunic, but from the branchial sac, or inner tunic, and the cavities are therefore diverticula from the cavity of the latter.†

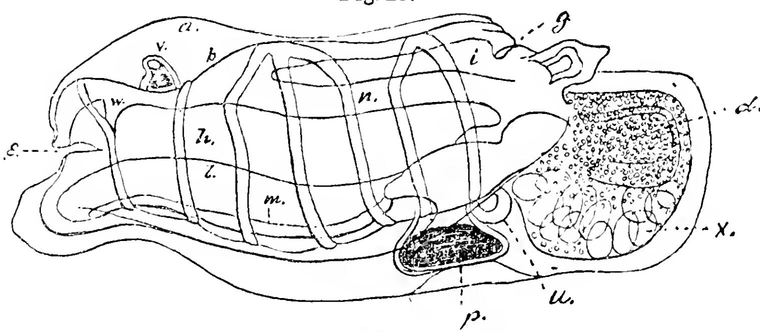
The atrium of Salpa, when first observed (Fig. 22, *15*), was composed of two broad lateral atria within the body cavity, one on each side of the branchial sac, and a very small mid-atrium (*i*); so that we have all the essential parts of this structure, occupying similar positions to those of Pyrosoma, and bearing almost identical relations to the surrounding parts. The lateral atria do not, however, as in most Tunicata, remain connected with the mid-atrium, and unite with the wall of the branchial sac to form the branchial slits, but soon become entirely separated (Fig. 23, *f*), and the two walls of each unite so as to form a broad solid sheet of tissue, which soon splits up to form the muscular bands of the branchial sac, of which there are six in the solitary form, and five in the chain-salpa.

* This conjecture is fully proved by the observations of Kowalevsky.

† Compare also the manner in which the atrium is formed in the bud-zooids of Amauricium and Dideminum. Ueber die Knospung der Ascidien. von A. Kowalevsky. Archiv. fur Mik Anat. X, 1874, p. 441.

The Muscles. — The bands of the two sides of the body are at first entirely distinct from each other, as noticed by Krohn, and all of those upon one side are, at first, united above and below, as in Fig. 23; the hæmal ends of the first, second, third, and sixth, in the solitary Salpa, soon become free, as shown in Fig. 24, and the neural ends separate into two bundles, composed of the first, second, third, fourth, fifth, and sixth, respectively (Fig. 24). The first now separates at both ends (Fig. 25), and after a time the hæmal ends of the fourth and fifth also become free, but the amount of separation is not uniform in specimens of the same age, and the union between the fourth and fifth may persist until the animal is nearly full grown (Figs. 1, 2, and 23); and to this the discrepancy in the various descriptions of the species is due. The neural ends of all the corresponding bands upon the two sides of both forms of Salpa soon unite, as well as the hæmal ends of the first, second, third, fourth, and fifth of the solitary Salpa, which thus form closed muscular belts or girdles encircling the body; while the hæmal ends of the sixth pair of the solitary Salpa, and of all in the chain-salpa, are permanently free. Soon after the muscular layer begins this process of division, it ad-

Fig. 25.



Solitary Salpa, — female, at the time when it escapes from the body of the male, viewed from the side, with the neural surface uppermost: *a*, test; *b*, outer tunic; *d*, digestive organs; *e*, branchial aperture; *g*, atrial aperture; *h*, branchial cavity; *i*, atrial cavity; *l*, epipharyngeal fold; *m*, endostyle; *n*, gill; *p*, placenta; *u*, stolon; *v*, ganglion; *w*, languette; *x*, elæoblast.

heres to the inside of the outer tunic, in which situation the muscles of the adult are always found; and this tunic has accordingly been called the muscular tunic, although, as we have seen, the muscles really belong to the atrial portion of the body. The muscles of the branchial and cloacal apertures do not appear to be derived from the atrial tunic, as they make their appearance in the positions which they subsequently occupy. See Figs. 24 and 33.

The Branchial Slits. — During the changes which have been described as taking place in the lateral atria, the mid-atrium has increased in size (Figs. 23, 24, and 25, *i*), and at last extends almost from the stomach to the ganglion (*v*). When seen in section (Figs. 24 and 33, *i*), it presents an irregularly triangular outline, with its base

Fig. 26.

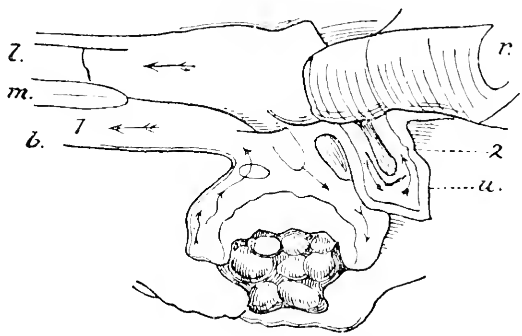


Fig. 26, from Huxley: *b*, outer tunic; *l*, epipharyngeal ridge; *m*, endostyle; *r*, heart; *u*, stolon; 2, central tube of stolon, which in Huxley's figure stops short, and does not reach the outer wall of the heart; but as its connection with the latter is unmistakable, the figure has been altered accordingly.

parallel to the posterior neural surface of the branchial sac, which surface, like the corresponding one of the atrium, is flattened so that they would be shown as parallel by a section at right angles to the one represented in Fig. 33. The branchial and atrial tunics now unite upon each side, so that the sinus (*u*, Fig 4) is converted into a tube which communicates, at its posterior end, with the heart and perivisceral sinus (Fig. 24), and at the anterior end with the neural sinus. This tube is the gill or "hypopharyngeal band," and it is evident that its cavity is part of the primitive body cavity, and its walls are derived from or rather are parts of the branchial and atrial tunics. The centres of the two regions upon the sides of the gill, where these two tunics have become united, are now absorbed, so that a single long and narrow branchial slit is produced upon each side of the gill. The branchial cavity is thus thrown into communication with that of the atrium, and the upper surface of the latter now unites with the outer tunic, and the external atrial opening is formed by absorption. See Figs 1, 24, 25; 3, 33, and 34, *g*.*

The Heart. — I was prevented, by lack of time, from making a series of observations upon the manner in which the heart originates, and accordingly quote what Leuckart (p. 55) gives upon this subject: "The heart presents, at the earliest stages, an oval form, and lies in the space between the nucleus and the ventral surface above the placenta." See Fig. 24, *k*, of the present paper. "One end is directed obliquely upward and backward, and the other forward and downward. At first, as already stated, it is a solid mass of cells, within which a cavity gradually appears [according to Vogt, p. 84, the heart is hollow from the first] and thus becomes transformed into a pouch, whose walls quickly become thin, and also, very early exhibits a pericardium. The first faint pulsations are separated from each other by long intervals, but are to be seen at a period when the ends of the heart seem to be closed. A circulation becomes visible only after most of the other organs are formed; but as the blood contains no globules during the earliest stages, the absence of a circulation cannot be absolutely affirmed."

The Nervous System. — The ganglion, when first observed (Fig. 22, *v*), was a hollow oval chamber, with indications of an opening at the anterior end. As it was impossible to devote much time to the

* Most of the writers upon Salpa have entirely mistaken the nature of the branchial sac, and its relation to the typical form among the Tunicata, and Leuckart seems to be the only one who has recognized the fact that the so-called "gill" is simply the sinus between two large branchial slits. His statement is clear, and, as far as it goes, correct. He says (p. 56): "Kurz nach der Aushöhlung der Ganglionkapsel beobachtet man in der Rückenwand des Embryos eine neue Bildung. (Tab. 11, Fig. 6.) Es entsteht hier in der Mitte, zwichen der Ganglionkapsel und der Wurzel des Nucleus wie früher im Innern des Embryonalkorpers, eine lichte Stelle, die sich allmählig in einen länglichen Hohlraum verwandelt, und jederseits durch die Wand der Athemhohle hindurchbricht. Die Innenlage der Rückenwand, die Anfangs beide Höhlen von einander trennte, wird durch diesen Durchbruch in einen cylindrischen Strang verwandelt, der von der Wurzel des Nucleus nach dem spätern Nervenknoten hinzieht, und naturlicher Weise nichts Anderes, als die erste Anlage der Kieme sein kann. Die Hohle durch welche die Kieme von der Korperwand abgetrennt wird, ist die Kloakhohle, die also auch bei den Salpen, als ein eigner, von der Athemhohle (im engeren Sinne) verschiedener Hohlraum ihren Ursprung nimmt."

As far as this goes it is correct, but he makes no mention of a special tunic around the cloacal chamber, and says nothing of the lateral atria, or of the origin of the muscular bands.

study of this organ, Leuckart's account is again referred to, in order to furnish as complete an account as possible of all that is known of the evolution of all the organs of the fœtus.

According to Leuckart (page 56), "The mass of cells, which is the first indication of the ganglion, and which lies upon the anterior end of the branchial sac, diagonally opposite the heart, to which it is not inferior in size, soon shows traces of a cavity, surrounded by very thick walls, and it continues in this condition for some time. After the remaining organs have gradually been developed, and histological differentiation begins, the cavity of this organ becomes filled up, thus transforming it into a solid mass of cells, which is easily recognized by its great size, and is surrounded by a capsule. The ganglion proper does not seem to exist before this stage is reached, for the primitive mass of cells with the cavity which appears within it are to be regarded, not as the ganglion, but as the capsule within which the ganglion is to be formed."

I have now described the way in which all the organs of the solitary Salpa are formed, with the exception of the ovary, and the stolon which gives rise to the chain; and these can be best treated in connection with the history of the development of the chain-salpa.

Development of the Salpa-Chain.

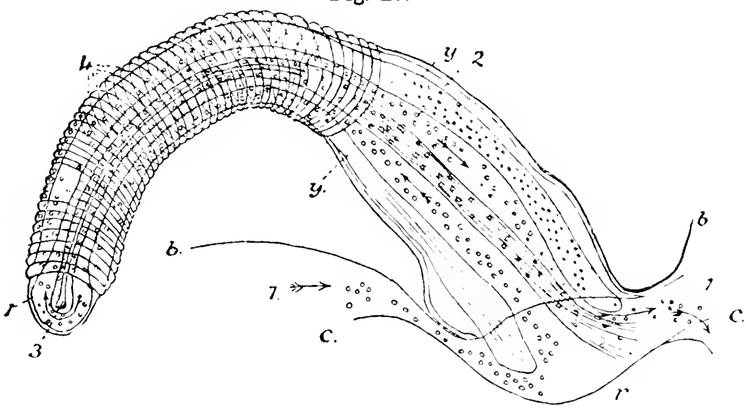
When the solitary embryo has reached the stage of development shown in Figs. 24, 25, 33, *s*, at which time it is about one thirtieth of an inch long, the tube which is to give rise to the chain appears within its body, and is at first simply a cup-like protrusion of the outer tunic into the cellulose test which now surrounds the embryo. This cup (Fig. 25, *u*) is situated midway between the nucleus and the placenta, upon the hæmal side of the body and directly opposite the heart, and its cavity is a diverticulum from the sinus system, into and out of which the blood passes. Since the wall of the cup is derived from the outer wall of the body cavity, while the heart is upon the inner or branchial tunic, it is plain that the cavity of the cup is separated from the pericardium by the width of the sinus system. A small bud-like protrusion now appears upon the surface of the pericardium, and lengthens so as to form a long rod, which extends across the sinus and projects into the cavity of the cup, as shown in Huxley's Fig. 4, Plate XVI., which is copied as Fig.

26 of the present paper. This rod, crossing the blood current at right angles, more effectually diverts this into the cup, so that a steady stream now passes into and out of the latter, which rapidly lengthens so as to form a tube projecting from the outer tunic into the cellulose test (Fig. 27).

The prolongation from the pericardium (Fig. 27, *2*, and Fig. 7, *2*) also lengthens, and reaches almost to the tip or blind end of the tube, and soon shows traces of a central longitudinal cavity (Fig. 27, *3*), which appears to be entirely closed at both ends. In a cross-section at this stage we should have: first, the outer tube, thin-walled and derived from the outer tunic; within this a chamber continuous with the sinus system, and within this a second tube, derived from the pericardium, with very thick walls and a cavity without connection with any of the pre-existing cavities of the embryo. This inner tube now becomes flattened until its edges unite with the inner wall of the outer tube, the cavity of which thus becomes "divided by a partition into two canals, which are distinct for the whole length of the tube, except at its very extremity, where they communicate just as the two scalæ of the cochlea do; and it thence happens that, in the living animal, a constant current passes up on one side of the partition and down on the other, the direction of the two currents being generally, but not always, reversed with the reversal of the general circulation" (Huxley, p. 573).*

* Huxley's figures of the early stages in the formation of the chain are very correct, and exhibit the relations of the various parts correctly; but the passage above quoted includes nearly all of his description, which is correct as far as it goes, but very brief. Vogt also (Sur les Tuniciers nageants de la Mer de Nice, p. 36) gives a correct account of the tube, but Leuckart, although he was acquainted with and refers to Huxley's description, disputes its correctness. It is so easy to make observations at this period, and their result is so satisfactory, that it is hard to understand how such a difference of opinion could arise; but as Leuckart's statement is made with the greatest confidence, it cannot be passed without notice, and is accordingly quoted here: "Man hat behauptet, dass der röhrenförmige Keimstock der Salpen aus mehreren übereinander gelegenen Häuten bestehe. Ich habe indessen — abgesehen natürlich von der äussern Cellulosescheide, die sich bei der Entwickelung der Knospen in keinerlei Weise betheiligt — vergeblich versucht, diese beiden Häute darzustellen. Das Keimrohr der Salpen zeigt nur eine einzige Substanzlage, und hat eine einfach-zellige Beschaffenheit. . . . . Der Hohlraum, den die Keimrohre einschliest, communicirt, wie wir schon früher beschrieben haben, mit dem Lacunen-system des mütterlichen Leibes. Man sieht auf das Deutlichste, wie die Blutkörperchen an der einen Seitenwand der Keimröhre emporsteigen und später an der entgegengesetzten Wand wiederum in den Kreislauf des mütterlichen Körpers zurückkehren" (page 69).

Fig. 27.

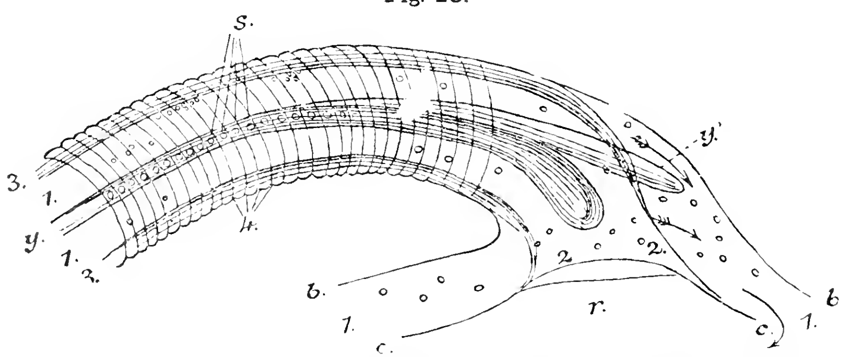


Very young stolon : *b*, outer tunic ; *c*, wall of pericardium ; *r*, heart ; *1*, sinus cavity ; *2*, central tube of stolon ; *3*, cavity of central tube ; *4*, constrictions in outer wall of stolon ; *y*, *y*, ovaries.

At about this period a long club-shaped mass of protoplasm (Figs. 27 and 28, *y*) appears within each of the sinus chambers of the tube; and soon after the constrictions (*4*) make their appearance upon the outer wall. We now have all the parts which are to take part in the development of the chain, and it will be best to state here the future history of each, and to give an outline of the development, before entering into the details.

The wall of the outer tube, which, as we have seen, is part of the outer tunic of the solitary form, is destined to form the outer tunics

Fig. 28.



Proximal portion of stolon a little more advanced, and rotated 90° from the position represented in Fig. 27 : *b*, *c*, *r*, *y*, *1*, *2*, and *4* as in Fig. 27 ; *3*, thickened edges of inner tube ; *s*, germinative vesicles.

of the zooids, and the constrictions upon it indicate the bodies of the latter. By the deepening of these constrictions, each of the sinus chambers, which are diverticula from the body cavity of the solitary form, becomes divided up to form the body cavities of the zooids upon one side of the chain.

The central partition gives rise, near one edge, to a row of bud-like protrusions upon each side, which become the branchial and digestive organs of the zooids of each side of the chain; while a similar double row, upon the other edge, give rise to the ganglia. It is probable that the cavities of the branchial sacs and ganglia originate as lateral diverticula from the tubular chamber of the partition into these buds; but this, for reasons which will be stated presently, could not be determined with certainty. The club-shaped organs within the sinus chambers become divided up into single rows of eggs, one of which passes into the body cavity of each zooid at a very early period of development.

It will be seen from this account that, in Salpa, as well as in Pyrosoma, "gemmation takes place, not, as in so many of the lower animals [e. g. the Hydrozoa and Polyzoa], by the outgrowth of a process of the body wall whose primarily wholly indifferent parietes become differentiated into the organs of the bud; but, from the first, several components, derived from as many distinct parts of the parental organism, are distinguishable in it, and each component is the source of certain parts of the new being, and of these only." * While these changes are in progress the tube lengthens, so that it at length encircles the nucleus, as shown in Figs. 1 and 2, *n*. The constrictions upon its surface deepen, and the wall protrudes between them, and each is soon seen to mark off, on each side of the stolon, the body of a young Salpa, and these soon become large enough to be visible to the unaided eye.

They do not increase in size gradually, from one end of the tube to the other, but develop in sets of from thirty to fifty each, and the development of all which are embraced within a set progresses uniformly. There are usually three of these sets upon the tube of an adult solitary Salpa, but sometimes there are four, two, or only one.

* Huxley, on the Anatomy and Development of Pyrosoma (p. 211).

I have taken the liberty of slightly changing this quotation, since the portion in brackets reads, in the original, "the Hydrozoa and Polyzoa, or *Salpa* and Clavelina among the Ascidians."

The zooids which compose the set nearest the proximal end of the tube are very much smaller than those of the second, which again are sharply distinguished from those of the third, and so on; and at a time when the first are very rudimentary indeed the last present all the organs of the adult, with the exception of the testis, and are ready to be discharged into the water. The carefully drawn, but somewhat rudely engraved figure of the fully developed chain, given by Eschricht,* gives an excellent idea of the position and relations of the various parts at this stage, and is, by far, the best figure which has ever been published. The position of the zooids is uniform throughout all parts of the stolon. The incurrent openings of all are upon the convex, and the excurrent upon the concave or inner side of the tube. The zooids of the opposite sides alternate with each other, and their hæmal surfaces face inwards. They are not perfectly parallel, for the visceral ends of their bodies are nearer each other than the neural ends, which incline outward. Fig. 34 shows a few zooids from a set which is nearly large enough to be discharged. The young chain, when first set free, is about half an inch long, and the single zooids, of which there are from twenty to thirty on each side, measure about one tenth of an inch in length. They grow very rapidly and soon reach their full size, when the chains "are often a foot or even a foot and a half long, and contain two rows of individuals, which are united together in such a way that they stand obliquely to the axis of the chain; the branchial openings are all on the upper side of the chain as it floats in the water, while the posterior openings are all on the lower side of the chain, close to the edge. Each individual is connected both with its mate on the right or left side, and to those immediately in front and behind on the same side. The succeeding individuals in the chain overlap considerably. The chains do not appear to break up spontaneously, but when broken apart by accident, the individuals are capable of living separately for several days. . . . . The individuals composing the chain, when full grown, are about three quarters of an inch long."† I do not think that the separation of the zooids makes the least difference in the length of their life, and the full-grown chains fall apart at the slightest touch, and, unless the water has been perfectly still for several days, chains more than four

* Undersögelser over Salperne, Tab. IV.

† Verrill, Invertebrate Animals of Vineyard Sound (p. 447).

or five inches long are not met with, and those a foot or more in length are very rare indeed, even when the water has been still for some time, and are only found in sheltered places, although full-grown chain-zooids are very abundant.

Huxley states of the species studied by him, which seems to be the same as that found on our coast, that it "but rarely happened that even two or three adhered together, and they never formed the remarkable free-swimming chain of other species. Generally they were found solitary, presenting only on their lateral faces traces of their former adhesion" (p. 574).

The chain-salpa, like the solitary form, moves by means of the stream of water which is continually discharged from the atrial aperture, and since the apertures of all the zooids of a chain are turned the same way, the current produced is quite powerful, and a chain, two inches long, placed in a glass bowl, with a pint of water, will soon set the whole of it in rotation. As we should expect, the motion of a chain is much more uniform and rapid than that of a single Salpa, and they usually move in nearly straight lines, although Mr. Agassiz states (Proc. Boston Soc. Nat. Hist.) that they sometimes change their course to escape capture.

Having now given a sketch of the formation of the chain, we will go back and follow the development of the various parts more minutely.

The Outer Tunic. — Little need be said of the formation of this portion, — the body wall of the zooid. It is derived directly from the outer wall of the tube, and its growth keeps pace with that of the contained organs, which are entirely separated from it, at all the earlier stages, by a distinctly visible body cavity (Fig. 30). The branchial

Fig. 29.

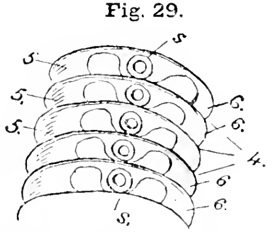
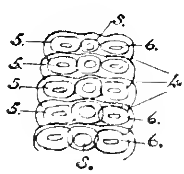


Fig. 30.



Two stages in the development of the zooids upon the stolon: *4*, constrictions which extend into the sinus chambers, and mark off the separate zooids; *5*, the ganglia of the zooids; *6*, primitive digestive organs; *s*, a single ovum within the body cavity of each zooid.

and atrial apertures are formed after the embryo is considerably advanced (Figs. 31 and 32), precisely as in the solitary form. According to Vogt,* this tunic splits into two layers, the outer becoming the cellulose test, and the inner the outer tunic ; nothing of this kind was observed, and appearances seemed to indicate that the test is an excretion from the surface of the body, as stated by Huxley (p. 585), and Leuckart ; but this must still be regarded as one of the unsettled points in the history of the genus.

The Body Cavity. — The constrictions (Figs. 27, 28, 29, and 30, *4*) which mark out the zooids upon the surface of the tube gradually extend inward, and enclose part of the sinus cavity, which thus becomes converted into a body cavity, into and out of which it is quite easy to watch the blood corpuscles of the solitary form make their way. This direct connection of the sinus systems of the young zooids with that of the solitary Salpa persists long after all the principal organs of the former have attained their essential characteristics ; and Huxley states (p. 574) that he has seen "one of the large blood corpuscles of the parent entangled in the heart (which was then not more than one five-hundreth of an inch long) of a very young fœtus." This connection of the two circulations may be seen with such perfect distinctness in our species that the only way in which we can reconcile Vogt's observations upon the circulation of the chain-zooid of S. pinnata with those here detailed is by assuming that there is a very decided and remarkable difference between the species in this respect.†

Digestive and Nervous Organs, and the Egg. — In Fig. 28 part of the proximal portion of a stolon a little more advanced than the one

* Sur les Tuniciers nageants de la Mer de Nice (p. 42).

† According to Vogt (p. 47), the chain-salpa of S. pinnata is provided with an organ, the "stoloblast," homologous in structure and function with the placenta of the solitary embryo. He says that this is situated near the nucleus and heart, and is composed of two chambers, into one of which the blood of the embryo makes its way, and thus comes into close contact with the blood circulating in the sinus system of the parent, which has access to the second chamber. He says that there is no communication between the two, and that none of the blood of the parent gains access to the body cavity of the zooid. Unfortunately his figures, and the letters of reference especially, are so indefinite that very little can be made out by the study of them ; but the explanation has suggested itself that the "stoloblast" may be nothing more than the rudimentary testicle, as Vogt says that it begins to disappear at the same time that the development of the latter begins, and disappears entirely after this is formed.

represented in Fig. 27 is shown, and, in order to exhibit the relations of the various parts more clearly, it is figured in the position which the latter would occupy if it were rotated 90° upon its axis. The side, instead of the edge, of the inner partition is therefore seen, and one of the sinus tubes (*1*), with its enclosed ovary (*y*), is above, and the other below it. The edges of the partition soon begin to thicken and spread out, so that a section would present nearly the shape of a letter H, with a cavity in the cross-bar. The four flaring edges now divide up into four rows of bud-like prominences, and two of these extend into the space between the constrictions which mark out the body cavity of each zooid, and lengthen until they meet upon the median line and surround the egg, which is now found in this position, as shown in Fig. 29. In this figure the prominences as well as the egg seem to be in contact with the outer tunic; but as it was necessary to use pressure in order to obtain a side view, this appearance is to be explained as caused in this way, for at a stage only a little later, but sufficiently advanced to be studied without pressure (Fig. 30), a very distinct body cavity is seen separating them from the body wall. In this figure the portion which surrounds the egg (*s*) has now separated from the portions upon each side of, or more strictly before and behind it, and forms the egg capsule. The two remaining portions (*5* and *6*) have also separated from the partition, and form oval masses, which are free within the body cavity of the zooid. One of these (*5*) is destined to form the ganglion, and the other (*6*) the branchial sac and digestive organs. They are very similar in shape and size, and each contains a cavity entirely surrounded by a thick wall. These cavities are, without doubt, at first diverticula from the cavity of the inner tube or partition, and are invisible in Fig. 29, on account of the pressure to which the specimen there figured was subjected; but the early changes in these parts take place so rapidly that no specimen was found at a stage which admitted of the determination of this point, although hundreds were examined with this end in view. The portion which is to form the digestive organs increases in size much more rapidly than the ganglionic portion, and extends forward under the egg and ganglion, to the anterior end of the body, and thus gives rise to the branchial sac. The subsequent development of these parts does not differ essentially from that of the same parts in the solitary embryo.

The Heart. — This, when first seen, was a granular body beneath and close to the stomach; and its position seems to confirm Vogt's conjecture (p. 45) that it is derived from the digestive tract.

The Testis. — This is at first (Figs. 33 and 34, *t*) a mass of cells, under the digestive organs and behind the heart, and therefore, as has been already pointed out, in the position occupied in the solitary embryo by the elæoblast, with which it agrees in appearance at first, but it does not become excessively developed, as this does; and in Fig. 34, *t*, it is shown as a compact globular mass of cells. As development advances, it spreads out over the surface of the digestive organs, and in the adult it presents the irregularly branched glandular appearance shown in Fig. 5.

The Ovary and Eggs. — Soon after the partition grows out from the pericardium and divides the tube into two chambers, and before the constrictions make their appearance upon the outer wall of the tube, a long club-shaped organ (Figs. 27 and 28, *y*) is seen within each chamber. These seem to lie free within the sinus cavity, and they could not be seen to be derived from any of the pre-existing parts of the embryo or of the tube; and the way in which they make their appearance seems to indicate that they are formed directly from the blood. The elæoblast begins to disappear at about the same time, and as the blood which passes through the latter goes directly to the tube, it is possible that some of its nuclei or smaller cells are thus transported to the tube, and form the basis of the new organs. This, however, is purely conjectural, as nothing was seen which indicated that the club-shaped masses were thus formed.

Fig. 31.

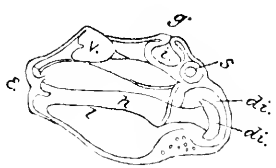


Fig. 32.

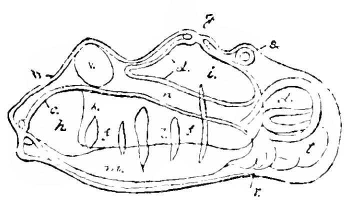
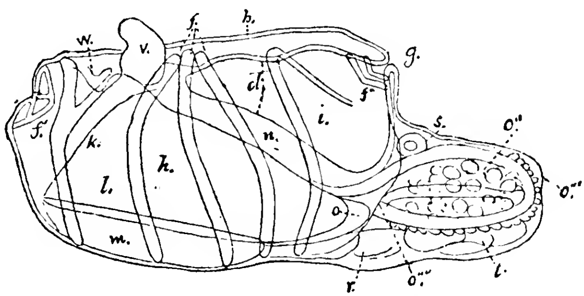


Fig. 31, chain-salpa, before the formation of the intestine. Fig. 32, chain-salpa, somewhat older, showing the manner in which the muscular bands are formed: *b*, outer tunic; *c*, wall of branchial sac; *d*, atrial tunic; *e*, branchial aperture; *f*, muscular girdles; *g*, atrial aperture; *h*, branchial cavity; *i*, atrial cavity; *d i*, digestive cavity; *d i'*, wall of digestive cavity; *k*, peripharyngeal ridges; *l*, epipharyngeal folds; *m*, endostyle; *n*, gill; *r*, heart; *s*, egg; *t*, testicle; *v*, ganglion.

As the tube grows, these organs lengthen also, and soon a single row of germinative vesicles is seen extending along each of them (Fig. 28); they are therefore the ovaries. At the time that the constrictions, which are the first indications of the zooids, appear in the outer wall of the tube, each ovary is seen to be made up of a row of eggs, equal in number to the constrictions; and as the zooids are developed, and their body cavities are separated from the sinus chambers of the tube, the chain of ova also divides, so that a single egg passes into the body cavity of each zooid (Figs. 29 to 34, *s*) and becomes suspended there by a gubernaculum, by means of which it is attached to the wall of the branchial sac, as already described.

Since the chain-salpa, at birth, always contains a single unimpregnated egg, organically connected with its body, and since this egg and the resulting embryo are nourished by the blood of the chain-salpa, by means of a true placenta, and since no reproductive organs have hitherto been described in the solitary Salpa,* it seems most natural

Fig. 33.



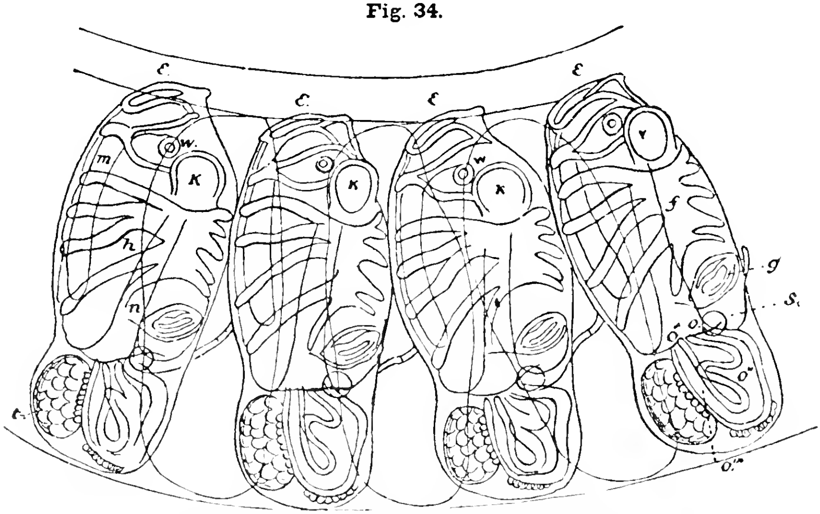
Side view of a single zooid from a chain at the stage shown in Fig. 34; the neural side is uppermost: *b*, outer tunic; *d*, wall of atrial chamber; *f*, respiratory muscles; *f'*, muscles of branchial aperture; *f''*, muscles of atrial aperture; *g*, atrial aperture; *h*, cavity of branchial sac; *i*, cavity of atrium; *k*, peripharyngeal ridge; *l*, epipharyngeal folds; *m*, endostyle; *n*, gill; *o*, mouth; *o''*, stomach; *o'''*, intestine; *o''''*, anus; *r*, heart; *s*, egg; *t*, testis; *v*, ganglion; *w*, languette.

* Although I made my observations without any knowledge that the origin of the eggs within the solitary Salpa had ever been traced, I cannot claim originality for the observation; since Kowalevsky states incidentally, in his paper upon the "Development of Pyrosoma," that this is the case in Salpa. He gives no description or figures, and confines himself to a bare statement of the fact, which occupies not quite one line. The passage containing the reference will be quoted farther on.

My observations were made in August and September, 1875, and Kowalevsky's paper on Pyrosoma was printed in August, 1875, and reached the library of the Boston Society, where I first saw it, on October 11.

to accept the view which has been generally held since the time of Chamisso's famous paper; that is, that Salpa presents an instance of "alternation of generations." This view, in its most modern form, may be stated as follows: "It is now a settled fact that the reproductive organs are found only in the aggregated individuals of Salpa, while the solitary individuals, which are produced from the fertilized eggs have, in place of sexual organs, a bud-stolon, and reproduce in the asexual manner exclusively, by the formation of buds. Male and female organs are, so far as we yet know, united in the Salpæ in one individual. *The Salpæ are hermaphrodite.*" (Leuckart. Salpa und Verwandten, pp. 46 and 47.) When, however, we trace backward the history of one of the individuals which compose a chain, and find that the egg is present at all stages of growth, and has exactly the same size and appearance as at the time when it is impregnated; when we find one organ after another disappearing until at last we have nothing but a faint constriction in the wall of the tube, indicating what is to become the animal, the conclusion seems irresistible, that the animal, which as yet has no existence, cannot be the parent of the egg which is already fully formed.*

Fig. 34.



Seven zooids from a fully developed chain, immediately before its discharge from the body of the female; the references are the same as in Fig. 33.

* The development of the eggs in the body of one zooid, and their passage into the body of another produced by budding from the first is not unusual among the

Summary and General Conclusions.

The life history of Salpa may be stated briefly, as follows :

The solitary Salpa — female — produces a chain of males by budding, and discharges an egg into the body of each of these before birth.

These eggs are impregnated while the zooids of the chain are very small, and sexually immature, and develop into females, which give rise to other males in the same way.

Since both forms are the offspring of the female, the one by budding, and the other by true sexual reproduction, we have not an instance of "alternation of generations," but a very remarkable difference in the form and mode of origin of the two sexes.

After the fœtus has been discharged from the body of the male the latter grows up, becomes sexually mature, and discharges its spermatic fluid into the water, to fertilize the eggs carried by other immature chains.

The fact that impregnation takes place, not, as we should expect, within the body of the solitary, but within that of the chain-salpa is no valid objection to the view that the latter is simply a male, for the number of animals whose eggs undergo impregnation within the body of the female is quite small, and in at least one genus, "Hippocampus," the unfertilized ova are received into a specialized brood-sac upon the body of the male, and there impregnated.

We can also find an analogy for the singular fact that the eggs of Salpa always develop females, while the males originate by budding. The fertilized eggs of the bee always develop female embryos, while the virgin bee, or one from the body of which the spermathecæ have been removed, produces only males, and Professor McCrady has pointed out that the production of the male bees in this manner can be best interpreted as a process of ovarian gemmation. The reproductive process of the bee accordingly presents a very striking parallel to that of Salpa. We cannot fail to associate the fact that in these two ani-

Tunicata. Huxley pointed out, in 1860 (Anatomy and Development of Pyrosoma, p. 212), that each bud carries away part of the ovary of its parent, and one fully developed ovum; and he says : "It is not a little remarkable that the first recognizable part of the new organism should be the foundation of that structure which will eventually develop into a creature distinct from it." Other observers have described a precisely similar occurrence in other Tunicata.

mals the males are developed through a process which falls short of perfect sexual reproduction, and are therefore lower than the female, as far as their origin is concerned, with the well-known fact that throughout the animal kingdom cases occur in which the male is to a greater or less degree supplemental to, and more or less degraded in accordance with the degree to which it is subsidiary to the female.

The supplemental males of certain cirrhipeds, the male Argonaut, with its parasitic hectocotylus arm, and the small males carried upon the backs of certain female spiders are well-known instances of the existence of such a relationship between the sexes. I am not prepared at present to connect these two sets of facts in any way, but we can hardly avoid the conclusion that there is a real connection between them, and that one may furnish the means for explaining the other.

The fertilization of the eggs within the bodies of zooids, produced by budding from the body of that whose ovary gave rise to the eggs, is not unusual among the Tunicata.

As already mentioned, this was first observed in Pyrosoma by Huxley, and has since been seen in Didemnium, Perophora, Amauricium, Botryllus, and Salpa, and there is good reason for believing that it will be found to occur in most tunicates. The zooids of these tunicates are hermaphrodite, and develop eggs of their own, which, however, must pass into the bodies of the zooids of the next generation before they can be impregnated, and the ova which are formed in the ovaries of this generation must pass into the bodies of the third, and so on.

The essential difference between this process and that in Salpa, a difference which is here pointed out for the first time, is, that since the sexes are here distinct, the chain-salpa contains no ovary, and the process therefore comes to an end, while the zooids of the other tunicates are hermaphrodite, and the process may therefore go on indefinitely.

The way in which close interbreeding is prevented in these Tunicata is worthy of notice, and shows that in cases where this would seem likely to occur special arrangements may exist to render it impossible. In most hermaphrodite animals self-fertilization is prevented by the existence of a difference in the periods at which the two reproductive elements ripen. In the hermaphrodite Tunicata just mentioned, self-impregnation is impossible, since the egg must pass into the bud before it can reach a position to which the spermatic fluid can gain access; but the zooid which contains the egg, and the embryo into which the latter is to develop are the children of the same parent, and very close interbreeding would be apt to occur if the testis became mature before the egg had been impregnated. In Salpa, which is not hermaphrodite, the same provision against incest exists, and seems to have been inherited from a hermaphrodite ancestral form, which in turn may have inherited it from a still more remote ancestor before the peculiar method of throwing off the eggs had been acquired, in which its object was, as in most invertebrates, simply the prevention of self-impregnation.

As the remainder of this paper will be mainly theoretical and speculative, I must state here that while I fully realize the difference between observations as to the way in which a phenomenon has been, and speculations as to the way in which it may have been brought about, it does not seem best to omit all theoretical discussion, although the views here advanced may be very much modified or entirely replaced by subsequent discoveries.

Exact observations are permanent additions to our stock of knowledge, and although they may be supplemented they cannot be superseded; while any theoretical views which are reached in the present imperfect state of our knowledge of zoölogy are liable to be entirely set aside by the discovery of new facts, the history of our knowledge of Salpa shows that a theoretical interpretation may be of the greatest utility, and yet be entirely false. Chamisso's theory of the "alternation of generations" in Salpa has resulted in the discovery of the numerous and instructive instances of true "alternation," which now form so large a chapter of zoölogical science, although the facts detailed in this paper show that, as applied to Salpa, this theory is absolutely without basis. I am encouraged by this to give my views of the relationship of Salpa, and of the origin of the separation of the sexes, although I have kept this discussion as distinct as possible from my record of observations.

The free-swimming Tunicata have generally been regarded as the lowest representatives of the group, and Huxley (Salpa and Pyrosoma), gives a series of diagrammatic sections, to show a gradual transition from Appendicularia through Salpa and Doliolum to Pyrosoma and the ordinary Ascidians. Bronn (Klassen und Ordnungen) gives a somewhat similar series, arranged in the same order, but beginning with a Polyzoon and ending with a Lamellibranch and a Brachiopod. It is, of course, unnecessary to enlarge, in this place, upon the fact that the features which have been supposed to unite the Tunicata with the Polyzoa, Brachiopods, and Lamellibranchs are superficial and absolutely without scientific value, as this is now recognized by all who are familiar with what is known of the embryology of these various animals.

That the position assigned to Salpa, in the series above referred to, rests upon a false conception of the nature of the "gill" and its relations to the branchial sac in the ordinary Tunicates, has never been pointed out, but the history of the formation of this structure, as it has been described in this paper, shows that it is not a rudimentary but a specialized form of the branchial sac; and this, as well as all the other peculiarities of Salpa, seem to be special adaptations to its mode of life, and seem to show that it occupies a very high position among the Tunicata.

So little is known of the life history of Appendicularia and Doliolum that their relation to the remaining members of the group cannot be stated with any certainty; but as far as we now know, Appendicularia seems to be an adult representative of the "tadpole larva" stage, and must be regarded, for the present at least, as a very low and embryonic form, while Doliolum appears to stand between Salpa and the ordinary Tunicata as a transitional form.*

Salpa lacks the "tadpole larva" stage, and this is what we should expect in a Tunicate which had become adapted to a locomotive life. The power of locomotion during the earlier stages is very necessary to those animals which subsequently become fixed, and we should expect, according to the theory of evolution, that, wherever these fixed animals are descended from a free ancestor, they should retain, during the early stages, the free locomotive form of their remote predecessors.

* During my work on Salpa specimens of Appendicularia were frequently met with, but no thorough study of them was made, owing to lack of time. Although a constant search for Doliolum was kept up, only two dead specimens were met with during the summer, so that no opportunity for filling the gaps in our knowledge of this form was afforded.

The Cirrhipeds, for instance, pass through a "nauplius" stage, which has been retained because it is necessary, but if a Cirrhiped should now become adapted to a locomotive life, the nauplius stage would lose its importance, and might, in time, disappear by the process of acceleration of development. This seems to have taken place in Salpa. The "tadpole larva" appears to represent a form similar to Appendicularia, from which the Tunicata are descended; and this tailed stage has been retained by most of the fixed Ascidians, but in Pyrosoma, where the embryo does not need special locomotive power, the tail is not formed, although the embryo in its development passes through this stage, which is represented by the so-called Cyathozooid.

In Salpa, not only the tail but all traces of the larval stage have disappeared, and the egg shapes itself at once and directly into the perfect animal. As Herbert Spencer would state it, the indirect method of development has given place to the direct,* as is so often the case in the higher forms of a group; the Cephalopods, among the Mollusca, for instance.

The relations of the branchial sac and atrium may be explained in a similar way. Leuckart has pointed out (loc. cit.) that the "gill" of Salpa is simply a sinus between two large branchial slits, and we have seen that the atrium of the embryo has the two lateral chambers upon the sides of the branchial sac, which in ordinary tunicates communicate with the branchial chamber by the formation of the branchial slits. In Salpa it has been shown that no branchial slits are ever formed upon the sides of the sac, and that the lateral atria become converted into the respiratory muscular girdles. If we attempt to follow out in imagination, the manner in which a tunicate might become adapted to a free locomotive life, we can see that if an ordinary ascidian were to be loosened from its attachment the branchial current would give it more or less motion in the water, and if this free life were advantageous natural selection might in time lead to the separation of the branchial and atrial openings until they reached opposite poles of the body, in which position the current of water would be most efficient as a motive force. (Sars calls attention to the fact that the two openings are nearer each other in the embryonic

* According to Krohn (Wiegem. Arch. 1852, XVIII., I., 53, Taf. 2), Doliolum passes through a larval stage, and at this time is provided with a tail.

than in the adult Salpa, and shows that in this respect the embryo resembles the adults of other tunicates.) As soon as this locomotive life had been established it would be of advantage to have as much water as possible pass through those branchial slits which lie in the straight line connecting the two external apertures, and accordingly those at the base of the branchial sac would become excessively developed at the expense of those upon the sides, and these latter, being no longer of functional importance, would tend to disappear, and if the walls of the lateral atria were at all muscular, as they undoubtedly are in all Tunicata, we can easily understand how they might be so modified as to violently expel the water from the body, and thus still further assist in locomotion. If Salpa is descended from a form having the ordinary branchial sac the presence of the lateral atria in the embryo can be understood, but if we deny all evolution or consider Salpa a low form, they are as meaningless as the aortic arches of an embryonic mammal would be if we did not refer them to a gill-bearing ancestor.

In one respect Salpa is more embryonic than the fixed Ascidians. The structure of its ganglion and sense organs is much more specialized than in them, and resembles that of their larvæ in this respect; but we can see that while a fixed animal, having little need of a specialized nervous system would be likely to possess one much more rudimentary than that of its locomotive larva, a form which remained free throughout life would be likely to retain it in its highly developed form.

We come now to the question: Will the theory that Salpa has been adapted to a locomotive life throw any light upon the separation of the sexes?

"It must have struck most naturalists as a strange anomaly, that both with animals and plants, some species of the same family and even of the same genus, though agreeing closely with each other in their whole organization are hermaphrodites, and some unisexual." In Salpa we have such a case, which a comparison with the other Tunicata shows to have been originally composed of two hermaphrodites; the male organ of the solitary form having been converted into the elæoblast, which becomes excessively developed, and supplies the material for the formation of the chain, while in the chain-salpa the ovary has entirely disappeared.

The life-history of a typical tunicate seems to be about as follows: The tailed larva becomes converted into an animal, which may become sexually mature, as in Ascidia, or may remain rudimentary, as in Pyrosoma, but which, in all cases, develop zooids by budding, and, in most cases at least, discharges eggs into the bodies of these zooids, which are hermaphrodite, and discharge their eggs into other buds in the same way. The process of vegetative reproduction by budding is well known to be antagonistic to true sexual reproduction, and although it is very common among the lower representatives of most of the larger groups of animals, it is not usually found to occur among the higher forms, and is replaced by sexual reproduction, unless there is some special necessity for its retention, as there is in those forms which are fixed, as the Cirrhipeds and Ascidians. Wherever these fixed animals are united into a colony, the power to multiply by budding is of course essential, and however disadvantageous it may be in other respects, it must be preserved, and we see that in the Tunicata it has been so modified that instead of being antagonistic to, it has become to a certain degree accessory to reproduction by eggs. Wherever a colony is arranged in a definite form, as in Pyrosoma, there must be a point at which any further increase in size would be of no advantage; budding will therefore continue until this point is reached, but we should expect that the last series of zooids in each colony would gradually lose the tendency to multiply in this way. After this change had taken place, no more eggs could be discharged from the body, and the ovary, being now of no functional importance, would also tend to disappear. We should therefore have, first, the tailed larval stage, then a variable but limited number of hermaphrodite zooids, and finally, a zooid with the male organs only developed, but containing an egg derived from the ovary of the one next before it in the series.

Suppose, now, that this series of zooids should become adapted to a free locomotive life. The larval stage would disappear, as already shown, and we should now have a series of hermaphrodite zooids, ending with an egg-bearing male. The necessity for budding would cease to exist as soon as the solitary locomotive life was entered upon, and as this process is known to be antagonistic to high evolution and great specialization, it would gradually disappear until the series had been reduced to two, an hermaphrodite zooid hatched from the egg, and an egg-bearing male produced by budding. The series could not be still further reduced to one, for at the period when it had been useful it had been made subservient to reproduction by eggs, and this necessity for throwing off the eggs into the bodies off new zooids still existing, one generation of buds must be formed to contain them.

This "syncopation of development" leads to a diminution in the number of egg-producing zooids, and however advantageous it might be in other respects, it would lead to the diminution and final extinction of the species, unless the number of eggs discharged from each ovary could be in some way increased. If the solitary salpa produced but one bud at a time, only one egg at a time could be placed under the conditions necessary for development, and of course, the number of new embryos hatched during a given period would be only a little more than one tenth as great as at that time when there were ten egg-producing zooids in the series; and in order to allow the syncopation to take place, the number of egg-bearing buds produced by each egg-producing zooid must increase inversely as the number of the latter in the series is diminished. Although most Tunicata produce only a single bud at a time, some, as Amauricium, form a long tube which divides up into a series of five or six buds, which develop simultaneously;* and in Pyrosoma, the Cyathozooid forms a stolon almost exactly like that of Salpa, and this becomes constricted so as to form a chain of four Ascidiozooids.† If, as there seems to be so much reason to suppose, Salpa has been derived through a form like Doliolum, from one similar to Pyrosoma, it must have begun its solitary life with a tendency to produce several buds and thus set free several eggs at a time; and we can readily understand that, as the series was shortened, and it became necessary for the eggs to be discharged more rapidly, this stolon might lengthen, and thus give rise to a greater number of eggs at once. This would demand that, in some way, a supply of nutriment should be provided to supply the material used in their formation, and since the number of males would now greatly exceed that of the hermaphrodites the fertilization of the eggs would now be amply provided for, and the development of the testis of the egg-producing form would no longer be necessary. As this does not develop until late in life, it would exist, during the

* Kowalevsky. Knospung der Ascidian.

† Kowalevsky. Entwickelung der Pyrosoma.

formation of the chain, only as a rudimentary mass of formative cells, which might easily be turned to another use, and some portion of it would accordingly be devoted to the formation of the chain; as no injurious effect would follow, and as more buds could now be produced, the process would go until the testis had been converted into the elæoblast, and we should now have a solitary female hatched from an egg, and giving rise by budding to a chain of egg-bearing males.*

The number of theoretical questions which the development of Salpa suggests is very great, and only a few of those which are the most easily discussed have been noticed here. There are many others upon which the development of Doliolum, when it is better known, may be expected to shed light, and for this reason they are omitted here.

The vertebrate affinity of the Tunicate is now a subject of great interest, but if Salpa is a highly specialized form, departing widely from

* Kowalevsky appears to entertain a somewhat similar opinion of the relation of Salpa to Pyrosoma, as he concludes his paper upon the development of the latter as follows: "Wir finden hier, in geschlechtlicher Beziehung, die beiden Salpen vereinigt.

"Bei den Salpen giebt es bekanntlich zwei Generationen, in der einen entwickelt sich der aus vielen Eikeimen bestehende Eierstock, welcher in den Stolo hineingeht, und sich hier zu je einem einzigen Eie vertheilt, sodann die einzelnen Knospen-resp. Kettensalpen, in welchen weiter aus diesem Eie ein Embryo entsteht, wieder mit einem aus mehreren Eikeimen bestehenden Eierstock.

"Bei Pyrosoma, enthält jede Knospe auch wie die Kettensalpa das einzige grosse Ei zur unmittelbaren geschlechtlichen Vermehrung, und wie die Salpen-Amme, den Eierstock mit vielen Eikeimen zur Bildung der Geschlechtsorgane der künftigen Knospen. . . . . Möchten wir diese Bildung der vier Ascidiozooide mit ähnlichen Vorgängen bei anderen Tunicaten vergleichen, so fällt uns besonders in die Augen die Aehnlichkeit mit den Salpen, bei denen die aus dem Eie sich entwickelnde Salpe noch während der embryonalen Stadien schon den Stolo bildet auf dem auch die einznenlen Knospen angedeutet sind. Bei den Salpen geht aber die Bildung des Stolo langsamer vor sich als die der Amme selbst, und deshalb entwickelt sich die erste früher, wird zu einen freilebenden Thier und um während der letzten Periode ihres Lebens entfaltet sich die Kette.

"Bei der Pyrosoma ist der ganze Vorgang ganz entgegengesetzt und namentlich die Ketteninlividuen resp. die Ascidiozooiden entwickeln sich schneller, dagegen wird der Cyathozooid (resp. Amme) nie zu einem freilebenden Geschöpfe, sondern bildet sich nur so weit aus, um in Stande zu sein, den schon angehauften Nahrungsdotter aufzulösen und die ernährende Flussigkeit den wachsenden Ascidiozooid zuzuführen. Ist diese Aufgabe erfüllt, so geht der Cyathozooid almählig zu Grunde und bei dem Freiwerden der aus vier individuen bestehenden jungen Colonie der Pyrosoma ist er ganz verschwunden."— Pp. 604 and 621. It will be noticed that Kowalevsky fails to see that the formation of the eggs within the body of the solitary Salpa proves this to be the female, and the chain-salpa a male.

the normal course of development and omitting the larval stage entirely, we cannot expect it to throw any additional light upon this question.

The presence of a placenta is of course only an analogy with the Mammalia, since the resemblance is simply functional and not in any sense morphological.*

* A memoir by Todarro (Sopra lo Soiluppo, e l' Anatomia delle Salpe, del Dott. Francesco Todarro, Roma, 1875), on the development of Salpa, reached me after I had finished writing my own account. In this he refers to an abstract published by Kowalevsky in 1868 (Nachrichten von der K. Gesellschaft der Wissenschaften. Göttingen, 1868, p. 407-415); as this is not referred to by Kowalevsky in any of his later papers on the development of the Tunicata, and is omitted from the index of the Nachrichten for that year, it had escaped my notice until my attention was called to it by the reference in Todarro's paper. It is simply a very brief and condensed preliminary abstract, without figures, and although it agrees in general with my own observations, it seems to conflict with them in several important particulars. The developmental history of Salpa is so very complicated that it is hardly possible to decide, in the absence of figures, exactly how much weight to attach to this apparent lack of agreement; and although anything upon the embryology of the Tunicata by this distinguished embryologist, to whom we owe so large a part of our knowledge of this subject, must be regarded as having the highest authority, it does not seem advisable to rewrite my paper in order to refer to views which, from the condensed way in which they are stated, and from the lack of illustrations, it is very possible that I may have misunderstood. In a few cases, however, the want of agreement is too evident to be explained in this way. He says (pp. 109, 110) "that no direct communication, such as has been stated by some to exist, is to be found between the cavity of the placenta and the body cavity of the mother."

The animal which contains and gives birth to the embryo is, according to our view, not the mother, but the male nurse. Regarding the existence of a communication between the body cavity of the nurse and the inner chamber of the placenta, I can only reiterate my statement that, at all stages, from the first appearance of the cavity of the gastrula until the embryo is fully formed, the blood of the nurse can be seen passing into and out of the cavity of the placenta. It is possible that there is a difference between the various species in this respect, for Vogt and Todarro agree with Kowalevsky in stating that at one period at least there is no such communication, while most of the other writers are equally confident that the facts are as I have stated them.

His account of the formation of the stolon also differs somewhat from mine. He says (pp. 412, 413) that this is made up of the following parts: (1) the outer wall, derived from the outer tunic of the parent; (2) the digestive tube, derived from the intestine of the parent; (3) two cloacal tubes, continuations of the posterior ends of the cloaca of the parent; (4) a bunch of cells, which gradually lengthens, becomes tubular, and gives rise to the ovaries of the chain-salpæ; (5) a tube which becomes converted into the nervous systems of the chain-salpæ. According to my observations, the digestive tube is not derived directly from the digestive organs of the parent, but from the pericardium. The two cloacal tubes mentioned are without doubt the same as those which I have called the sinus-chambers of the stolon; and the fact that the blood circulates within, not around them, proves that their cavities are continuations, not of the cloacal, or, as I have termed it after Huxley, the atrial cavity, but of the sinus system or body cavity of the parent. Instead of one ovarian rod, I found two, and failed to discover that they are hollow. In this paper Kowalevsky says that this tube gives rise to the ovaries of the chain-salpæ, although in his paper on Pyrosoma, published in 1875, and already quoted, he seems to agree with me in holding that they develop eggs before the chain-salpæ are formed, and discharge a single egg into each one of these. He fails to see, however, that this proves the solitary salpa to be the true female. His fifth or nerve tube I did not find.

I was unable to homologize the placenta of Salpa with any organ of any other Ascidian. Leuckart compares the foot of a Lamellibranch, the tail of Appendicularia, and the placenta; but this comparison seems to be rather fanciful. Kowalevsky suggests that the placenta may be the homologue of the cyathozooid of Pyrosoma, and the first generation of Doliolum. He says (p. 414): "At the close of this communication I may be permitted to call attention to the general analogy which is to be remarked between the development of Salpa, Pyrosoma, and Doliolum. In Salpa the egg forms an embryo which divides into two parts; one forms the placenta, and the other the embryo proper, which bears a dorsal [hæmal] stolon from which the sexual individuals bud. The egg of Pyrosoma forms a very rudimentary embryo, which produces, through budding, four embryos, which now, in turn, develop four sexual individuals from a dorsal stolon. The egg of Doliolum forms a perfect but sexless individual, which puts forth a ventral stolon, from which are formed individuals with a dorsal stolon, out of which the sexual individuals bud. From this comparison it is manifest that, between the placenta of Salpa, the rudimentary embryo of Pyrosoma, and the free-swimming stolon-bearing Doliolum an analogy exists; that, in a word, we here have before our eyes the different steps in the same developmental process."

I think there can be no doubt that Salpa has originated in a manner somewhat similar to that here pointed out; although the fact that the solitary form or egg-embryo is not sexless, but a female, would seem to indicate that the relation between the three genera cannot be exactly as it is here described. In my account of the manner in which the evolution of Salpa may be supposed to have taken place, I purposely refrained from referring to Doliolum, as we know so little of its development. A complete history, by one observer, of all the stages of one species of this genus, from the egg through all the alternations around to the egg, would be of the greatest interest. At present our knowledge is made up of fragments by various observers of isolated stages in the development of various species.

The Memoir by Todarro now remains to be noticed. This is an elaborately illustrated quarto of 150 pages; and the observations recorded, as well as the conclusions reached, are so utterly at variance with all that has been done by previous observers that it seems impossible to reconcile them. According to this writer, Salpa is the synthetic type of all the Vertebrata, and presents, during its development, peculiarities which are characteristic of each of the classes of this group, including the Mammalia. It is an allantoïdian vertebrate, developed in a true uterus, which is composed of a muscular, a vascular, and a mucous layer; and after impregnation the neck of the uterus becomes closed by a plug of mucus, and the embryo forms an allantois, exactly as in the higher Vertebrata. The sections which are represented in the figures are so strikingly like those of the earlier stages of the higher vertebrates that I am unable to make any comparison between them and my own observations The work seems to have been done almost entirely upon sections of specimens hardened and treated with reagents, and every embryologist is well aware how untrustworthy results reached in this way often are, unless they are carefully compared with those reached by a thorough study of the living embryo, and also verified in every possible way. As I made no sections, but confined my attention to the living animal, I am unable to offer any suggestion as to the way in which what I believe to be the errors of interpretation in this paper are to be explained, and am therefore compelled to confine myself to this very short and unsatisfactory notice.

No. 15.—*Exploration of Lake Titicaca, by* ALEXANDER AGASSIZ *and* S. W. GARMAN.

III. *List of Mammals and Birds. By* J. A. ALLEN, *with Field-Notes by* MR. GARMAN.

THE mammals and birds enumerated in the present paper were collected incidentally by Mr. S. W. Garman, between January 1 and March 5, 1875, while engaged in a general exploration of Lake Titicaca, Peru, under the direction of Mr. Alexander Agassiz. The collection of birds, numbering sixty-nine species, represented by about two hundred and thirty specimens, possesses especial interest as being the first considerable collection ever made at this locality. Although but few new forms were obtained, the collection embraces a number of the species recently described by Messrs. Sclater and Salvin, Cabanis and others, from the collections of Messrs. Bartlett, Whitely, Hauxwell, and Jelski, who during the last six or eight years have made very large collections in Peru.* The resemblance of the bird-fauna of Lake Titicaca to that of neighboring portions of the highlands not far to the eastward, visited by Mr. Whitely, is shown by the fact that of Mr. Whitely's small collection of forty-seven species, made at and near Tinta, on the Vilcamayo, southeast of Cuzco† (11,000 feet above sea-level), twenty-seven, or more than one half, are contained in Mr. Garman's collection.

Mr. Garman collected almost exclusively about the immediate borders of the lake and on the lake itself, so that a large proportion of the species are aquatic.‡ Several of the incessorial birds were met

* For a list of the papers referring to these collections published prior to 1873, see Proc. Zoöl. Soc. Lond., 1873, pp. 252, 253. M. L. Taczanowski has since described twenty new species, and published a list of 495 species collected in Central and Western Peru by M. Jelski (Proc. Zoöl. Soc. Lond., 1874, pp. 501–565). Cabanis has also described several new species from M. Jelski's collection (Journ. f. Orn., 1874, pp. 97-99), and Messrs. Sclater and Salvin have published additional papers on collections made by Messrs. Whitely and Bartlett (Proc. Zoöl. Soc. Lond., 1873, 1874).

† See Proc. Zoöl. Soc., Lond., 1869, p. 151.

‡ Six species are included in the list which were collected by Mr. Walter Davis at Coroico, Bolivia, a few miles to the southwestward of Lake Titicaca, in a forest region.

with mainly in the "tortora" fields which occupy the more shallow parts of the lake. The lake is flanked on the eastern and western sides by high hills that rise quite abruptly from its shores, which are scantily covered with short grasses, cacti, and other coarse spiny plants. There are quite extensive plains at both the northern and southern ends of the lake. Shrubs and low trees occur in some of the ravines and on the island of Titicaca, but they are confined mostly to the southern end of the lake.

Mr. Garman has been able to add interesting field-notes respecting most of the species, which are given in quotation-marks, and are taken mainly from his note-books. Several of the species are left undetermined, some of which may prove to be new; but the only ones I have ventured to describe as such are a Gallinule — a large and strongly marked species — and an Ibis.

MAMMALS.

1. **Conepatus nasutus** (BENNETT) GRAY. Three specimens were obtained, — a female, and two young ones about half grown.

2. **Auchenia Glama** (Linn.) Desm. "The Llama is in this region the beast of burden, but is never ridden. A hundred pounds is considered a sufficient load. Should the animal be overloaded he refuses to go, and is to be induced to move on only by lessening the amount of his load. A load that he is willing to start with is generally one that he can carry the entire day. When travelling where there is a trail the herd march in single file, the driver or drivers walking in front or behind, and urging them along by an oft-repeated hissing, or '*sh — sh — sh*.' They are never beaten and seldom shouted at. The males are commonly used as the carriers, or "cargadores." To improve the wool of the Llama, which is inferior to that of the Alpaca, the natives are in the habit of crossing the two races."

The collection embraces one skeleton and a skin.

3. **Auchenia Pacos** (Linn.) Tsch. "The Alpacas are raised for their wool, and are not used as beasts of burden. As the coat is not shed each year, if not sheared for several seasons the wool grows to be a foot to eighteen inches in length. A year after shearing it is less than six inches. The entire fleece is never taken off, great ragged-looking bunches being left on the thorax and about the shoulders, 'to protect the animals.'

"The Alpacas and Llamas form the chief wealth of the Indian. Knowing his herd to be a source of continual profit, he is loath to part with any of it for money, which 'must be buried in the ground.' Hence it was difficult to secure specimens. Owing to this, and to the idea that they may sell their luck, it took considerable bargaining to induce owners to supply us. After a bargain is made the wife must agree to it, and, of course, she objects until the price is raised. 'It is my brother!' 'It is my sister!' 'It is one of my family!' 'I cannot sell it!' 'Any other than that!' and dozens of similar expressions, that are repeated over any other selected, are urged against selling, until, thoroughly disgusted, one either throws down the price, kills the animal, and takes it, or goes to repeat the scene at some other hut."

Seven specimens were obtained, including a skeleton and six skins suitable for mounting, representing both sexes, and both the black and the brown or coffee-colored races.

4. **Auchenia Vicugnia** (Mol.) Desm. "The Vicuñas, like the Guanacos, are wild, but the young are often captured and reared as pets. The Vicuña is smaller than the Guanaco, and lacks the long hairs that in the latter extend beyond the wool. It prefers the open pampa. When a herd is alarmed they will run for a short distance, and then halt and turn about to gaze at the object that alarmed them. If it approach they scamper on again, to again repeat the manœuvre. Their cry of warning or alarm is a peculiar, rapidly repeated bleating bark, somewhat resembling that of a large squirrel, the last note being prolonged like the bleat of a young lamb, and may be heard for more than half a mile. In March the young are born, at which time the females are found among the foot-hills along the edge of the pampa. We saw many females with young, but in no instance was there more than one."

Five specimens were collected, including a skeleton and several skins suitable for mounting, the latter embracing both sexes and the young.

5. **Auchenia Guanaco.** "The Guanacos did not, like the Vicuña, trust to their swiftness for safety, but took to the hills, where, running from summit to summit, it was very difficult to follow them. Their cry is much like that of the Vicuña. These animals exhibit a great deal of curiosity. Hunters on the plains often throw themselves on their backs, put up their feet and hands, raise a blanket or poncho, or roll over and over to make the game curious; it then approaches gradually until within gunshot. Several are thus often secured before the herd takes to flight. By concealing themselves in pits the Indians are able to draw them within reach of the bolus, — a lariat, to the end of which are attached several shorter lines, each with a weight, usually a rounded stone, at its end. The bolus is thrown in such a manner as to twine around the necks and legs. One of the weights bought at Juli was a fac-simile of the so-called 'sinker stones' from Northern Europe. It was about two and a half inches in length by one and a half in diameter, oval, with a groove cut around its middle for the cord. Though small, it was very heavy, being formed from ironstone, or meteorite, full of pyrites."

Four specimens are contained in the collection, including a skeleton and several skins suitable for mounting, of both the adult and young.

"Some of the habits of the Vicuñas, Guanacos, Llamas, and Alpacas deserve especial mention, particularly so since they do not seem to be generally known. One is that of lying down during the act of copulation, — a habit common to but few if any other of the Ruminants, and one of rare occurrence among other mammals. Another habit worthy of note is that of their depositing their excrement in heaps, for which purpose they are said to return to the same place day after day. In consequence, when travelling through their haunts, one finds at short distances rounded mounds, where for months, and perhaps for years, daily additions of excrement have been made. Economically considered, this habit is of great importance to the inhabitants of a region so scantily supplied with woody vegetation, the dung of these animals being used by them for fuel. The greater part of the cooking, such as it is, is done by its use, and even the government steamers on Lake Titicaca are supplied with fuel from this source. If the pellets of excrement were scattered about as by sheep, it would not be available, but being deposited in mounds it is easily gathered. It is collected to such an extent that it furnishes a profitable source of income, being sold for the use of the steamers.

"The flesh of these animals is inferior to mutton; the natives eat it, but strangers use it under protest. That of the Vicuñas and Guanacos is considered to be better than that of the Llamas and Alpacas."

6. **Habrothrix** sp. incog. One specimen (skin).

7. ? **Reithrodon** sp. incog. One specimen (skin).

8. **Cavia boliviensis** WATERHOUSE. Three specimens.

"'Conejos.' Found in numbers near Puno, under walls and rocks. They were to be taken only late in the evening when they had left their burrows, or early in the morning before they had retired to them."

9. **Dasyprocta Azaræ** LICHT. Two specimens.

10. **Lagidium Cuvieri** BENNETT. Six specimens are embraced in the collection, which vary considerably in respect to the amount of fulvous suffusion, and the distinctness of the dorsal stripe.

"'Vizcacha.' Very common in the rocky districts, but not met with on the pampas. Invariably selects rocky places for its burrows, and builds no mounds at their entrances, which are usually under or between large rocks. Runs about and feeds during the day as well as at night. Is not very tenacious of life, being as easily killed as a rabbit. I sometimes found them a mile away from their homes, and though closely pursued they would pass burrow after burrow till they reached their own. The trails used by these animals in passing to and fro are so well smoothed and worn as to be easily traceable for long distances. Their long tails, which drag on the ground, effectually remove small obstructions as they swing from side to side in running. Their favorite haunts are among the precipitous and broken rocks on the shores of the lake, the hillsides, and the banks of the streams. As is the case with the beaver, new colonies are formed by the young males that are driven from the paternal burrow by the old ones. After a young one has established himself in a burrow of his own construction, usually a few rods distant from the one from which he has been driven, he induces a female to share it with him, and a new vizcacheria is founded. We found many vizcacherias amongst the guacas or tombs. The Indians affect to believe that they are the people ('los viejos') who hundreds of years ago were buried in these sepulchres and have been transformed."

BIRDS.

1. **Turdus chiguanco** Lafr. & d'Orb., Conima and Moho. Five specimens. "'Chihuanco.' Common on the Southern shores. Notes, nests, and eggs very much like those of *T. migratorius*."

2. **Procnias occidentalis** Sclat. One specimen, Coroico, Bolivia. Collected by Mr. Walter Davis.

3. **Tanagra palmarum** Max. Two specimens, Coroico, Bolivia. Collected by Mr. Walter Davis.

4. **Ramphocœlus atrosericeus** Lafr. & d'Orb. One specimen, Coroico, Bolivia. Collected by Mr. Walter Davis.

5. **Basileuterus bivitatus** (Lafr. & d'Orb.). One specimen, Coroico, Bolivia. Collected by Mr. Walter Davis.

6. **Hirundo andicola** (Lafr. & d'Orb.). Two specimens; Moho.

7. **Atticora cinerea** (Gm.). One specimen; Moho.

8. **Phrygilus fruticeti** (Kittl.). "Abundant among the shrubbery at the south end of the lake." Two ♂, one ♀.

9. **Phrygilus Gayi** (Eyd. & Gerv.). "Common towards the southern end of the lake." Mohô and Tiquina. Two specimens.

10. **Zonotrichia pileata** (Bodd.). "Abundant about nearly all parts of the lake." Coroico (Davis), Moho and Conima (Garman); seven specimens.

11. **Chrysomitris atrata** (Lafr. & d'Orb.). Moho; four specimens. "'Silgarito.' Very common in the towns, inhabiting the thatch of the eaves and gables of the houses. A very lively little fellow and a fine singer. His song is quite as jolly as that of the Bobolink. A friend had one in a cage that would throw himself back on his perch, partly spread his wings, and sing as if in a perfect ecstasy whenever a handkerchief was shaken over his head."

12. **Poospiza** sp. incog. One specimen (♀); Moho.

13. **Sycalis luteola** (SPARM.). "Common on the eastern side of the lake." Four specimens; Moho.

14. **Sycalis lutea** (LAFR. & D'ORB.). "Frequent on the eastern side of the lake, occurring with *S. luteola*." One specimen; Moho.

15. **Sycalis uropygialis** (LAFR. &. D'ORB.). "Eastern side of the lake, associated with *S. luteola*." One specimen; Moho.

16. **Icterus cayanensis** (LINN.). "Frequents the grassy marshes near the shores, nesting in the reeds. Habits much like those of the Red-winged Blackbird of the United States (*Agelæus phœniceus*)." Five ♂, four ♀; Moho.

17. **Cyanocorax violaceus** DU BUS. One specimen, Coroico, Bolivia; collected by Mr. Walter Davis.

18. **Agriornis maritima** (LAFR. & D'ORB.). "Rare. The only specimen seen was taken on Titicaca Island."

19. **Muscisaxicola rubricapilla** PH. & LANDB. "Common." Two specimens; Moho and Vincocaya.

20. **Centrites oreas** SCL. & SALV. "Quite common near the shores." Moho and Conima; six specimens.

21. **Cyanotis Azaræ** (NAUM.). Moho, two specimens. "'El Sieta Color.' Though not uncommon, they are quite hard to secure, owing to their habit of quickly and constantly darting about among the reeds."

22. **Tyrannus melancholicus** VIEILL. One specimen, Coroico, Bolivia. Collected by Mr. Walter Davis.

23. **Cinclodes fuscus** (VIEILL.). "Common among the cacti and spiny vegetation of the hillsides." Moho; one specimen.

24. **Cynclodes bifasciata** SCLAT. "Common among the coarse vegetation of the hillsides." Two specimens; Moho.

25. **Upucerthia Jelskii** (CAB.) TACZ. One specimen; Conima.

26. **Upucerthia** sp. incog. One specimen; Moho.

27. **Phleocryptes melanops** (VIEILL.). "Rather common, living in the reeds." Moho; five specimens.

28. **Synallaxis** sp. incog. (Probably *S. stictothorax*, or a closely allied species.) One specimen; Moho.

29. **Patagona gigas** GOULD. "Apparently not common. One only seen." Moho; one specimen.

30. **Oreotrochilus estellæ** (LAFR. & D'ORB.). Moho; five specimens. "Common. The nests were frequently found in the caves on the shore. The young were ready to fly about February 10."

31. ? **Ciccabis** sp. incog. A specimen of an owl (probably *C. melanonota*) was shot by Mr. Garman, but was accidentally lost.

32. ? **Pholeoptynx cunicularia** (MOL.). A specimen of a small owl

was obtained by Mr. Garman, and subsequently accidentally destroyed, which, from his description of it and of its habits, must have been this species.

33. **Buteo erythronotus** (KING). "'Aigle.' Only a few were seen." Two specimens; Moho.

34. **Milvago megalopterus** (MEYEN) = *Ibycter megalopterus* Sharp. "'Alcamarre.' Frequently seen on the plains, walking about in search of food; also visiting the shores of the lake to pick up dead fishes, it being not particular whether its food be fresh or not. It has a strong buzzard-like odor." One adult male and two birds of the year; Moho.

35. **Circus cinereus** VIEILL. One specimen, an adult ♂; Moho.

36. **Sarcorhamphus gryphus** (LINN.). "One specimen, taken near Pampa de Arreiros; altitude about 10,000 feet. One seen at Lake Titicaca."

37. **Colaptes rupicola** (LAFR. & D'ORB.). "'Carpintero.' Common. Nests in holes in the rocks. Said by the natives to be able to bore its way through the hardest rocks, by the aid, as they believe, of a certain much-sought plant, which it holds in its bill." Four specimens, Tiquina and Moho.

38. **Bolborrhynchus aurifrons** (LESS.). "Very common about all parts of the lake, and up to a height of 14,500 feet. Large flocks were frequently met with in the fields. Pairs were often noticed around the gables of the huts in the towns, but whether they built their nests in the thatch was not ascertained." Five specimens; Moho.

39. **Zenaida maculata** (VIEILL.). "A few seen at the south end of the lake; apparently not common." One specimen; Carapata.

40. **Metriopelia aymara** (KNIP. & PREV.). "Rather common about some parts of the lake." Two specimens; Vilquechico.

41. **Metriopelia melanoptera** (MOL.). "Rather common at the north-eastern end of the lake." Four specimens; Vilquechico.

42. **Gymnopelia erythrothorax** (MEYEN). "Abundant towards the north end of the lake, occurring in large flocks." Four specimens; Moho.

43. **Leptoptila rufaxilla** (RICH. & BERN.). One specimen; Coroico, collected by Mr. Walter Davis.

44. **Nothoprocta Branickii** TACZ. "'Perdiz.' Common. Habits similar to those of the partridges of the United States (*Ortyx virginianus*)."

45. **Falcinellus Ridgwayi** sp. nov. *Adult.*—Upper surface and sides of the head, malar region, chin, and throat reddish-cinnamon, becoming lighter anteriorly and darkening posteriorly into reddish-chestnut; neck all round dark purplish-chestnut; whole dorsal surface dark resplendent green, with strong purple reflections, in some specimens the purple predominating in all lights; wings bright shining lighter green, with bronzy and purple

reflections; below wholly dark purple; thighs reddish; no chestnut on the wings or body, nor white about the base of the bill, as in *F. guarauna*, nor has it any dusky markings at the base of the bill, as in *F. igneus;* bill dark red; feet (in the dry skin) black, probably purplish-black in life; bare tibial space dark red.

Young. — Wings, tail, interscapulars, and rump uniform dark glossy green, with faint purple reflections, which in some specimens, however, are quite strong; head and neck dull dusky brown, the feathers of the top and sides of the head with very narrow whitish edgings; lower surface of the body dusky, with a slight reflection of green; bill and feet black.

Bill, 3.85 to 5.15; wing, 10.50 to 11.50; tail, 4.25 to 5.00; tarsus, 2.80 to 3.75; middle toe, 1.40 to 2.80.

In size this species agrees closely with *F. guarauna.* The young differ but little from the young of *F. thalassina.*

Mr. Ridgway, in a recent revision of this group,* based on a large number of specimens, has recognized three American species, under the names *Ibis falcinellus, I. guarauna,* and *I. thalassina.* On showing him specimens of the present species he at once recognized it as a fourth species, and one not before described. It differs from *I. thalassina* Ridgway in being much larger, and in color; in *I. thalassina* the reflections being "vivid bronzed green" instead of mainly purple, as in the present species. In coloration it also differs almost totally from both *I. falcinellus* and *I. guarauna.*

Mr. Garman's collection embraces thirteen specimens of this species, seven of which are adult and six immature. The series presents a considerable range of variation in color, size, and other features.

"'Chihuanquira.' Not rare. Frequents the flats along the shores or streams, wading in the shallow water, and searching in the mud with its long bill for the worms, etc., upon which it feeds. Its flesh is very tender and of excellent flavor."

Thirteen specimens; Moho, Conima, and Vilquechico.

46. **Theristicus melanopis** (Gm.) Wagl. "'Banduria.' Rare. Only two were seen during the voyage. The flesh is very hard and tough. Our cook, disgusted with his experience, declared that cooking only made it worse. The specimen secured flew about two miles after receiving its death-wound, finally dropping dead from mid-air."

One specimen; Conima.

47. **Vanellus resplendens** (Tsch.). "'Centinella,' Spanish; 'Leke-leke,' Indian. Common on the flats and pampas. Considerably annoys the hunter by warning the game of his approach. Keeping at a safe distance, it continually utters the peculiar cry from which it derives its Indian name." Six specimens; Moho.

* American Naturalist, Vol. VIII, p. 110, Feb., 1874.

48. **Thinocorus Orbignyanus** Geoff. & Less. Five specimens. "'Pocoo-pocoo' (Indian name, from its call). Common up to the height of 17,000 feet. When flushed they fly swiftly for a short distance. The female skulks and runs, but the male boldly mounts a rock or other prominence to keep watch. When started a second time he either runs or flies a short distance to another high point near by."

49. **Himantopus brasiliensis** Brehm. "'Kaitche-kaitche.' Named from its cry, by the Indians. Only two were seen."

One specimen; Juli.

50. **Tringa Bairdii** Coues. "Quite common at some localities." Five specimens; Moho.

51. **Gambetta melanoleuca** (Gm.). "Not uncommon." Five specimens; Moho and Conima.

52. **Gambetta flavipes** (Gm.). "Very few seen." One specimen; Moho.

53. **Nycticorax obscurus** Bon. "'Bobo.' Numerous small flocks of six or eight were seen." Five specimens; Moho.

54. **Fulica gigantea** Eyd. & Soul. "'Ajoia.' The only locality in which this bird was found is a mile or two north of Juli. It is said they are much more rare than formerly, in consequence of the destruction of their eggs by the natives. The pair in the collection had frequented the locality in which they were secured for several years, but had been unable to increase their number. Found in company with the 'Choca' (*F. ardesiaca*), and has similar habits." Two specimens (♂ and ♀); Juli.

55. **Fulica ardesiaca** Tsch. "'Choca' is the common name given it by the Indians, in imitation of its cry. One of the most common birds about the lake. Wherever we found 'totora' (reedy shallows), there we found 'Chocas.' Many were so fat and heavy as to be unable to fly. While skirting the totora in our boat, it frequently happened that, when nearing a nest, the male bird would leave the cover and swim boldly out into the open lake. If followed he would lead on until far from the nest, when he would rise and fly into the reeds at some point quite distant from the nest. The eggs and young are taken by the Indians, and the birds are easily domesticated. Those seen among the fowls about their huts seemed quite tame, though not presenting so fine an appearance as the wild birds. Their flesh is quite palatable when well cooked." Ten specimens; Moho, Carapata, and Achecache.

56. **Gallinula Garmani** sp. nov. Similar to *G. galeata*, but much larger and darker. Above very dark bluish-cinereous, darkest on the head and rump. White markings on the wings, sides of the body, and lower tail-coverts, the same as in *G. galeata*, but there is rather less white on the abdomen. The brownish-olive on the back, rump, and secondaries, which is

so marked a feature in *G. galeata*, is so much darker in the present species as to be often clearly distinguishable only in favorable lights. It is most marked on the interscapulars and secondaries. Rostral shield much larger and of a darker red than in *G. galeata*, and extends further up on the head. Bill, 1.07; head, 2.30; wing, 8.50; tail, 3.75; tarsus, 3.50; middle toe, 3.30.

This species is readily distinguished from *G. galeata*, its nearest ally, by its much darker colors and very much larger size. The difference in general size between the two is indicated by a comparison of the length of the wing and tarsus. While the folded wing in *G. galeata* averages about 6.50 to 6.90, the same measurement in the present species ranges from 8.00 to 9.10; while the tarsus averages but about 2.00 in *G. galeata*, in the present species the same measurement is 3.00 to 3.75.

The collection embraces seven specimens, among which there is considerable variation, both in size and color; but the smallest specimens greatly exceed in size the largest specimens of *G. galeata*. Some specimens present a decided olive-brown tint over the middle portion of the dorsal surface, while in others it is scarcely perceptible.

57. **Bernicla melanoptera** Eyton. "'Uyato.' Not common. Difficult to approach, and very tenacious of life." Two specimens (♂); Moho.

58. **Querquedula cyanoptera** (Vieill.). "'Pato Colorado.' Rather rare." Four specimens (two ♂, two ♀); Achecache.

59. **Querquedula flavirostris** (Vieill.). "Common about all parts of the lake. Young obtained in February." Seven specimens; Conima, Vilquechico, and Guicha.

60. **Querquedula puna** (Tsch.). "Rather common. Young ones met with in January." Four specimens (one young); Moho.

61. **Dafila spinicauda** (Vieill.). "One of several birds called by the Spaniards 'Pato de las Cordillieras.' Rather rare, two or three pairs being all we saw in two months." One specimen (♂); Carapata.

62. **Erismatura ferruginea** Eyton. "'Pana.' Very common. Its food consists of seeds of plants, mollusks, worms, etc. The young were less than half grown at the first of February. They dive very quickly, and are able to remain under water for a considerable length of time. Never try to escape by flying. Though exceedingly fat, they are quite tolerable for the table." Fifteen specimens, including ♂, ♀, and young, and also several skeletons; Moho, Achecache, and Vilquechico.

63. **Merganetta armata** Gould. "Rare." One specimen; Moho.

64. **Phalacrocarax brasilianus** (Gm.). "'Miji.' Abundant. They sit much of the time on the rocks at particular localities, where the rocks have become whitened with their excrement, whence they fly at quite regular intervals to their feeding-grounds." Four specimens; Carapata.

65. **Larus serranus** TSCH. "'Gaviota.' Common. Nest about the first of February, on little knobs of earth that project above the water. Though their nests are frequently robbed, they continue to frequent the same locality." Four specimens; Moho.

66. **Rhynchops nigra** LINN. "'Aradora.' Rare; perhaps accidental. The single specimen taken was seen by many people, but none had seen it on the lake before, and regarded it as a stranger. The sailors, who had seen it before along the sea-coast, were sure it did not belong here."

67. **Centropelma micropterum** (GOULD). "'Sondeador.' 'Samboullidor.' Very common about all parts of the lake, where the water is at all shallow. Feeds on fishes, batrachians, etc. In February young were taken about two-thirds grown. They are unable to rise from the water, but by flapping their rudimentary wings and striking the water with their feet they manage to progress quite rapidly for a considerable distance. They dive quickly at the discharge of a gun, — so quickly that unless taken unawares will dodge the shot, — and escape, often swimming a long distance under water before reappearing." Thirteen specimens were obtained of this rare species, which seems mainly confined to this lake.

68. **Podiceps caliparæus** LESS. Two specimens; Moho.

69. **Podiceps Rollandi** QUOY & GAIM. "'Sondeador.' Common. Found in company with *Centropelma micropterum*. Like that species it never attempted to fly, but is very quick in diving, and hence is difficult to shoot." Five specimens; Carapata.

CAMBRIDGE, April, 1875.

No. 16. — *Exploration of Lake Titicaca by* ALEXANDER AGASSIZ *and* S. W. GARMAN.

IV. *Crustacea.* *By* WALTER FAXON.

THE crustacean fauna of Lake Titicaca, as indicated by the dredgings of Mr. Agassiz, carried on with the assistance of Mr. S. W. Garman, in January and February, 1875, is very meagre. Excepting a species of *Cypris*, all the specimens collected belong to one amphipodous genus, *Allorchestes*, which had hitherto afforded but one or two authentic fresh-water species, ranging from Maine to Oregon and the Straits of Magellan. Seven new species are described in this paper from Lake Titicaca. Several of them are remarkable among the *Orchestidæ* for their abnormally developed epimeral and tergal spines. Some are also noteworthy as comparatively deep-water forms of a family commonly regarded as pre-eminently littoral. I believe that no *Orchestidæ* have heretofore been found at a depth so great as sixty-six fathoms,* unless it be *Orchestia* (*Talitrus*) *Brasiliensis* Dana and *Nicea media* (Dana), dredged in the harbor of Rio Janeiro (at what depth is not specified) by the Wilkes Exploring Expedition. The marine species usually inhabit the shore above low-water mark, and the previously described fresh-water species are found in the shallow water of brooks, pools, or edges of lakes. No strictly fresh-water *Orchestidæ* have been reported from the Eastern continent, although a few terrestrial *Orchestiæ* are described as inhabiting moist soil away from the sea.

* The greatest depth of the lake is 154 fathoms.

Order AMPHIPODA.

Family ORCHESTIDÆ.

Genus ALLORCHESTES.

Syn. 1849. *Allorchestes* (in part) Dana, Amer. Jour. Sci. [2], VIII. 136.
1852. *Allorchestes* (in part) Dana, Proc. Amer. Acad. Sci. Boston, II. 205.
1852. *Allorchestes* (in part) Dana, U. S. Explor. Exped. XIII. Crust. Pt. II. 883.
1856. *Allorchestes* Bate, Rep. Brit. Assoc. 1855, p. 57 (no descrip.).
1857. *Allorchestes* Bate, Ann. Mag. Nat. Hist. [2], XIX. 136.
1861. *Allorchestes* Bate and Westwood, Brit. Sessile-eyed Crust. I. 38.
1862. *Allorchestes* Bate, Cat. Amphip. Crust. Brit. Mus. p. 34.
1866. *Allorchestes* Heller, Beitr. z. näh. Kennt. d. Amphip. d. adriat. Meeres, p. 4. Denkschr. d. Math.-Natur. Classe d. Akad. d. Wissensch.
1874. *Hyalella* Smith, Rep. U. S. Fish Comm. for 1872 and 1873, p. 645.
1874. *Hyalella* Smith, Rep. U. S. Geolog. Geograph. Survey of Colorado for 1873, p. 608.

First maxillæ with small uniarticulate palpi. Palpus of the maxillipeds composed of four segments, the distal segment usually bearing a movable spine at its apex. First antennæ shorter than the second antennæ, longer than the peduncle of the second antennæ. First and second thoracic legs subcheliform. Propodite of second pair larger than propodite of first pair, and much larger in the male than in the female. Telson short and entire.

Differs from *Nicea* Nicolet (as limited by Bate and Heller) in having the telson single instead of double or cleft. The fourth segment of the palpus of the maxillipeds is well developed, as in *Nicea* and *Gammarus*, and, as in these genera, is commonly unguiculiferous. Neither Dana, in describing *Allorchestes*, nor Nicolet, in his description of *Nicea* * (published in the same year), mentioned the form of the telson. The two names were therefore synonymes. Bate, in a list of British *Amphipoda*, published in 1856 in the Report of the British Association for the Advancement of Science, indicates, without describing, two genera, *Allorchestes* Dana and *Galanthis*, *gen. nov.*, which, as appears from his subsequent descriptions, were based upon the trivial character of a different relative length of the first and second antennæ, and a *differently formed telson:* Dana's name, *Allorchestes*, being restricted to those species in which the first antennæ are (at least) as long

* Gay's Historia de Chile. Zool., III. 237, 1849.

as the peduncle of the second antennæ and the telson entire, and his own name *Galanthis* including the species with the two pairs of antennæ subequal and short and the telson cleft or double. In 1861 he suppressed the name *Galanthis* in favor of Nicolet's *Nicea*. The proportion of the antennæ and the form of the telson brought together by Bate in his generic diagnoses are not in reality always concomitant, and Heller for the first time properly distinguished the two genera by the character of the telson alone. Grube * adopts the relative length of the two pairs of antennæ (at most a specific character) as the generic distinction. All his species of *Allorchestes* have a double telson, and should be transferred to *Nicea*.

Boeck,† apparently misled by the fact that Bate carelessly describes *Nicea Nilssonii* with an entire telson, and places it under *Allorchestes*,‡ would unite the two genera, giving as a generic character "*appendix caudalis brevis, crassa et fissa*." He furthermore considers both *Allorchestes* and *Nicea* synonymous with Rathke's older *Hyale*,§ the type of which, *H. Pontica*, was carefully described and figured with the posterior caudal stylets two-branched. Boeck has not had access to Rathke's type, as far as I can learn; but in a specimen from the Mediterranean, "which is doubtless Rathke's species," he finds the last pair of saltatory appendages one-branched. This assumption of identity, it seems to me, cannot outweigh the careful description and illustration of the founder of the genus, unless confirmed by examination of the type of *Hyale Pontica*.

In 1874 Professor S. I. Smith described a new amphipodous genus, *Hyalella*, from the fresh waters of the United States, differing from "*Hyale*" in having a styliform fifth segment to the palpus of the maxillipeds and an entire telson. The so-called fifth segment may perhaps be more correctly regarded as a movable spine, like those seen both lateral and terminal on the caudal stylets, or like the *unguis* which tips the dactylopodite of the thoracic legs. However this may be, it is quite as well developed in several species of "*Hyale*" (*Nicea*), and is not therefore a generic character. *Hyalella* is then a synonyme of *Allorchestes*.

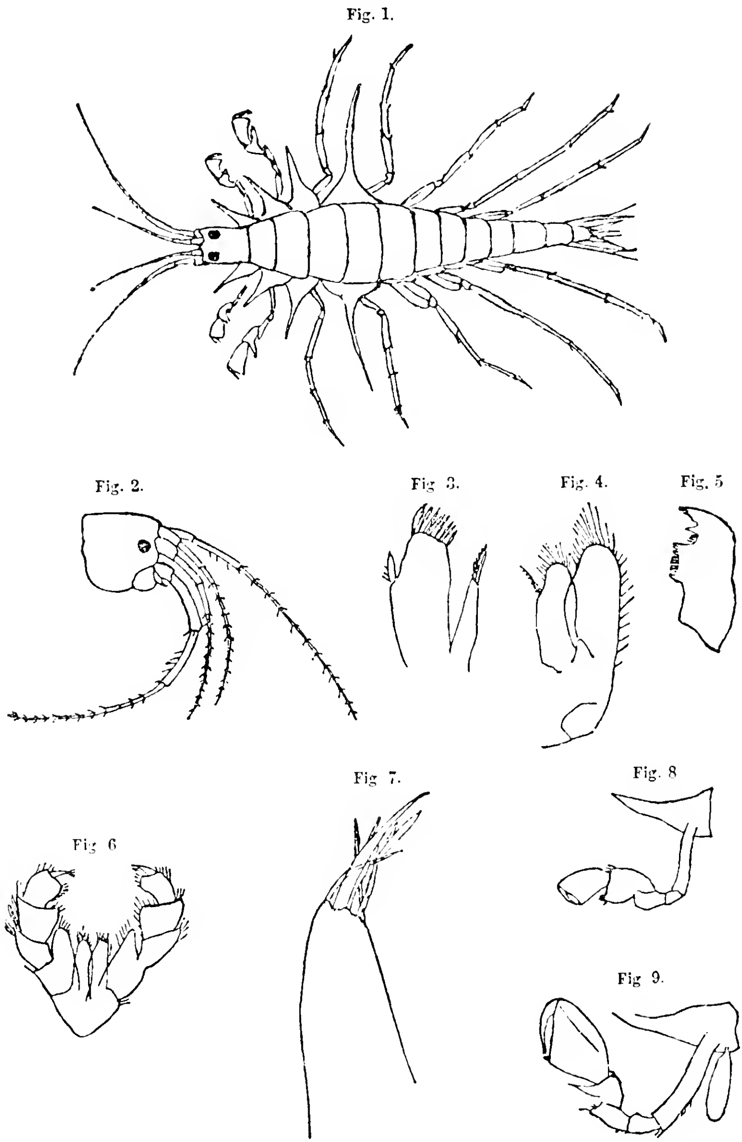
* Beitr. z. Kennt. d. istrischen Amphipodenfauna, Arch. f. Natur. 1866. pp. 382, 387.

† De Skandinaviske og Arktiske Amphipoder, beskrevne af Axel Boeck. Förste Hefte. 1872. I am indebted to Dr. Hagen for a translation of Boeck's Norwegian.

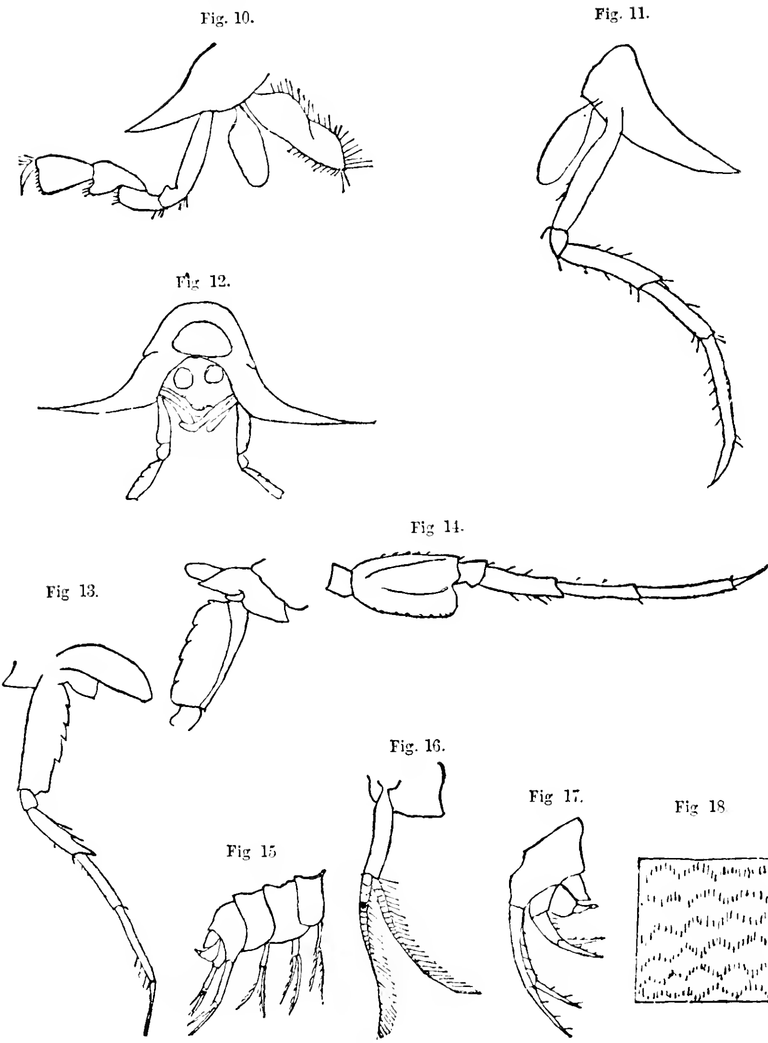
‡ Doubtless a large number of the species placed under *Allorchestes* by Bate in his Catalogue of the *Amphipoda* in the British Museum have in reality a divided telson. In fact, it would seem that the telson is cleft in *most* of the marine forms, and such probably formed the bulk of Dana's original genus *Allorchestes*. The only types of Dana's species that I can discover are two specimens of *A. media* in the Museum of Comparative Zoölogy. In these the telson is cleft to the base. This, however, will not affect the synonymy as given above.

§ Zur Fauna der Krym, p. 87, Pl. V. Figs. 20 – 28, 1836.

Allorchestes armatus, *sp. nov.*



Figs. 1-9. *Allorchestes armatus:* 1. Female, dorsal view (nat. s. 9mm.). — 2. Head. — 3. 1st maxilla. 4. 2d maxilla. — 5. Mandible. — 6. Maxilliped. — 7. Distal end of 4th segment of maxilliped bearing a movable spine. — 8. 1st thoracic leg. — 9. 2d thoracic leg of male.



Figs. 10-18. *Allorchestes armatus:* 10. 2d thoracic leg of female, with epimeron, gill and incubatory plate. — 11. 3d thoracic leg. — 12. Section of body of female (4th thoracic segment) showing the incubatory pouch with two eggs. — 13. 5th thoracic leg. — 14. 7th thoracic leg. — 15. Abdomen, side view. — 16. 2d abdominal leg. — 17. Caudal stylets. — 18. Hairs on the integument under 625 diameters.

Body stout. Hind margin of the segments raised so as to form conspicuous transverse ridges. Fore margin of the head produced into a point between the first antennæ, and on each side in front of the eyes. Eyes round. Epimera of the first four thoracic segments produced into prominent spines. The spines of the first and second pair are of about the same length; the third somewhat longer; the fourth longest, being about twice as long as the third, and exceeding the breadth of the broadest segment of the body. The first three pairs are directed downward and forward, while the fourth project at nearly right angles to both the longitudinal and vertical axes of the body. Telson broad, entire.

Peduncle of first antenna reaching the middle of the last segment of the peduncle of second antennæ; flagellum composed of twelve segments. Second antenna much longer than first antenna; basal segment clearly separated from the head; olfactory denticle prominent; flagellum composed of thirteen segments. Carpopodite of first pair of legs triangular, as broad as the propodite, furnished with setæ on its distal margin; palm of propodite slightly concave, tránsverse; dactylopodite curved. Second pair of legs in the male very large; meropodite armed with prominent setæ at the antero-inferior angle; carpopodite with a long process, setiferous at its extremity, projecting downward and forward between the propodite and the meropodite; propodite large, convex above and below, palm oblique, straight, with small setæ; dactylopodite slender, curved. In the female, the second pair of legs are smaller, the propodite similar to the corresponding segment of the first pair, and not broader than the meropodite; the palm nearly perpendicular to the straight lower margin; lower angle of the meropodite projecting under the propodite as a blunt process, much shorter than the same process in the male. Fifth pair of legs about as long as the fourth. Sixth and seventh of about equal length, much longer than the fifth; when extended backward reaching considerably beyond the end of the longest caudal stylets. Hind margin of the basipodites of the fifth, sixth, and seventh pair of legs slightly serrate. Third pair of caudal stylets very small, curved upward, so as to project but little beyond the telson.

The shell viewed under the microscope is furnished with rows of very minute hairs, arranged as in Fig. 18.

Length from front of head to end of telson, $8^{mm.}$ to $10^{mm.}$ Breadth from tip to tip of fourth pair of epimeral spines, $6^{mm.}$ to $10^{mm.}$

Collected at the following places in the lake: —

Achacache, 11 fathoms,	countless specimens.
Gulf of Puno,	88 specimens.
Gulf of Desaguadero,	1 specimen.
Chuquito, 40 fathoms,	4 specimens.
Juli, 60 fathoms,	25 specimens.
Between Taquili and Amantane, 66 fathoms,	2 specimens.

This seems to be the commonest crustacean of Lake Titicaca. The length of the lateral spines is variable. In specimens from the deeper soundings they are much longer than in those from shallower depths. The specimens from 66 fathoms measure 10$^{\text{mm.}}$ between the tips of the fourth pair of spines; length of a single spine, 4$^{\text{mm.}}$; from front of head to end of telson, 8$^{\text{mm.}}$ Average specimens from Achacache, 11 fathoms, measure 7$^{\text{mm.}}$ from tip to tip of fourth pair of spines; 9$^{\text{mm.}}$ from front of head to end of telson. The former are also lighter colored and more transparent than the latter. Many of the females are with eggs under the thorax.

Allorchestes echinus, *sp. nov.*

Fig. 20.

Fig. 19

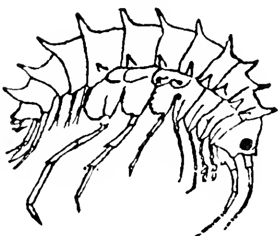
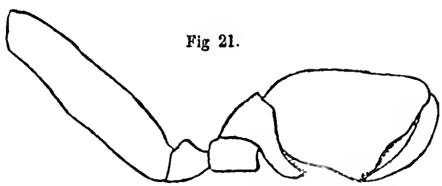


Fig 21.



Figs. 19 - 21. *Allorchestes echinus:* 19 Female (nat. s. 6mm.). — 20. Vertical section of body (4th thoracic segment). — 21. 2d thoracic leg of male.

Body short and very stout, with four longitudinal rows of spines. One row on each side of the median line of the back; each spine of this row arises from the hind margin of the terga of the first thoracic to the fourth abdominal segment inclusive. Another row of eight smaller spines lower down on each side of the body; these arise from the terga of the first thoracic to the first abdominal segments inclusive, near their line of junction with the epimera. Slight projection downward and forward from front margin of the head between the first antennæ; a tubercle on each side below the eyes. Eyes round, large, somewhat protuberant. Epimera of first four thoracic segments large, triangular, their apices directed downward; a ridge extends from the base down through the centre of each of these epimera to the apex. The fourth epimeron has beside the ridge a small tubercle on the hind margin. Fifth epimeron bilobed, with a tubercle on each lobe. Telson entire.

Flagellum of first antenna composed of six to eight segments. Basal joint of second antenna swollen and distinct from the head; olfactory denticle prominent; flagellum composed of nine segments. Second pair of legs large in the male; inferior angle of carpopodite produced; palm of propodite concave, notched just above the lower angle and beset with setæ. In the female the carpopodite and propodite of the second pair of legs are of nearly equal size; lower angle of carpopodite produced as in the male. Sixth and seventh pair of legs very long, — one third longer than the fifth. Basipodites of fifth, sixth, and seventh legs serrate on their hind margin. Length from front of head to end of telson, 5mm. to 7mm.

Llampopata,	10 - 20 fathoms, 2 ♂ 1 ♀
Juli,	60 fathoms, 1 ♂

Allorchestes longipes, *sp. nov.*

Fig. 22.

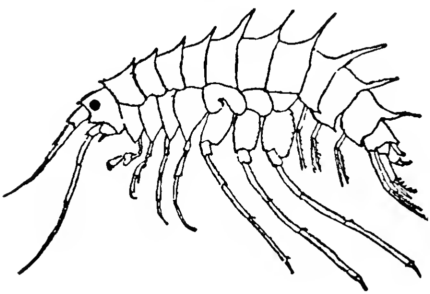


Fig. 23.

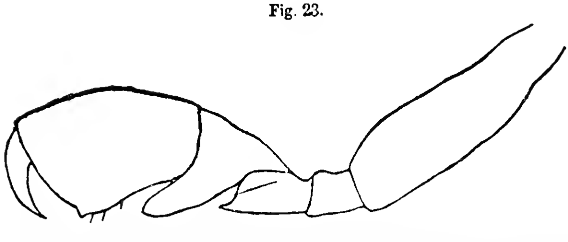


Fig 25.

Fig. 24.

Figs. 22 - 25. *Allorchestes longipes:* 22. Female (nat. s. 10mm.). — 23. 2d thoracic leg of male — 24. End of abdomen, from above. — 25. Posterior dorsal margin of 4th abdominal segment of another individual.

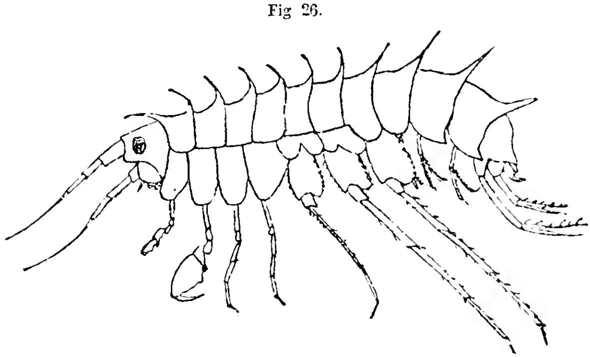
A longitudinal row of eleven spines along the middle of the back. The first spine arises from the fore margin of the first thoracic segment; the rest from the hind margin of the first thoracic to the third abdominal segments. The first five are short, the others long, — the eighth and ninth being the longest. Eye round, protuberant. First to fourth pair of epimera long, produced into a point at their lower extremities. Infero-posterior angles of the first three abdominal segments slightly produced. Hind margin of fourth abdominal segment in some examples has a median projection over the telson, but in others this is reduced to the bold convexity of the whole border (Figs. 24, 25). Telson entire. First antenna equal in length to the distance from the eye to the fifth dorsal spine; flagellum composed of thirteen segments. Second antenna equal to distance from the eye to the sixth dorsal spine; basal segment distinct; olfactory denticle prominent; flagellum composed of fourteen segments. Carpopodite of second pair of legs in the male produced at the lower angle; propodite not very large (but larger in the male than in the female) with a slight projection at the lower angle; a few setæ on the lower margin. Sixth and seventh pair of legs very long, about equal to the distance between the first and ninth dorsal spines. Third pair of caudal stylets very short; a few setæ on the hind margin of penultimate segment, and one very slender seta at the tip of the terminal segment. Length from front of head to end of telson, about 10mm.

Achacache, 11 fathoms,	12 specimens.
Gulf of Puno,	10 specimens.
Gulf of Desaguadero,	1 specimen.
Chuquito, 40 fathoms,	1 specimen.

The specimen from Chuquito is a female with eggs. It is more transparent than the others, the first two dorsal spines longer and curved forward as in *A. lucifugax*. The epimera of the first four thoracic segments are also longer in this specimen than those obtained from other localities.

Allorchestes lucifugax, *sp. nov.*

Fig 26.



Allorchestes lucifugax, male (nat. s. 11mm.)

A longitudinal row of eleven spines along the median line of the back. The first spine arises from the fore margin of the first thoracic segment; the others from the hind margin of the first thoracic to the third abdominal segments. The first spine of the series projects, almost parallel with the longitudinal line of the body, as far as the front of the head. The six following are curved forward. The last three are somewhat longer than the others. Eye oval. First four pairs of epimera long, rounded at their lower ends. Infero-posterior angles of the first three abdominal segments slightly produced.

First and second antennæ of nearly equal length. Propodite of second pair of legs of male with a slight projection at the lower end of the palmary edge; carpopodite produced below. Sixth and seventh pairs of abdominal legs very long, extending far beyond the telson. Telson entire. Length from front of head to end of telson, 11mm.

Juli, 60 fathoms,	1 specimen.
Chuquito, 40 fathoms,	1 specimen.

The two specimens of this species which were taken are males. The integument is delicate and transparent, as in all the specimens dredged in deep water.

This species resembles the last, but differs from it in the longer and procurved anterior spines, and the shape of the four anterior pairs of epimera.

Allorchestes latimanus, *sp. nov.*

Fig 27.

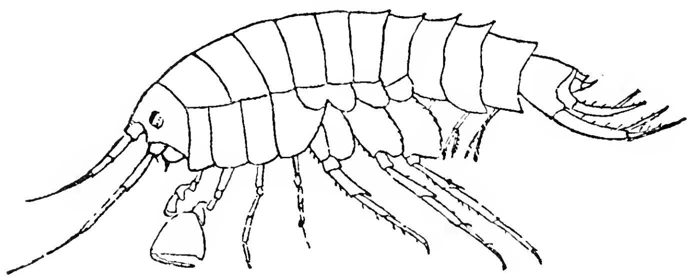


Fig. 28.

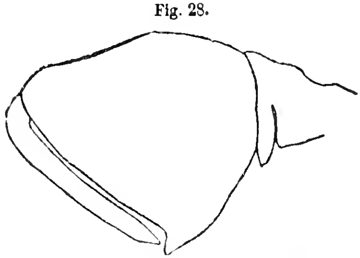


Fig. 27. *Allorchestes latimanus*, male (nat. s. 12mm.). — 28. Hand of second thoracic legs more enlarged.

Body thick. Hind margin of the sixth thoracic to the third abdominal segments inclusive produced into a spiniform tooth on the median dorsal line. Eye nearly round. Epimera of first four thoracic segments quadrilateral, their lower angles rounded. Infero-posterior angles of the first, second, and third abdominal segments prolonged backward. Peduncle of first antenna reaching the middle of the last segment of the peduncle of the second antenna; length of entire first antenna two thirds the length of second antenna. Second antenna equal to distance from front of the head to fifth thoracic segment; basal segment and olfactory denticle conspicuous. Carpopodite of second pair of legs in the male produced below; propodite broader than long, palm nearly straight, with a projection at its lower end. (In the female the propodite is small, as usual in this sex.) Seventh pair of thoracic legs of moderate length, not extending much beyond the telson when stretched backward. The last pair of caudal stylets reach a little way beyond the telson, which is broad and entire. Length, exclusive of antennæ and caudal appendages, 7^{mm} to 12^{mm}.

Llampopata, 10 – 20 fathoms, 11 specimens.

Allorchestes longipalmus, *sp. nov.*

Fig. 29.

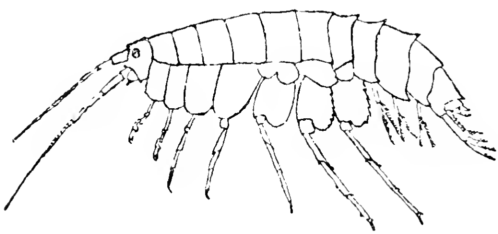


Fig. 30.

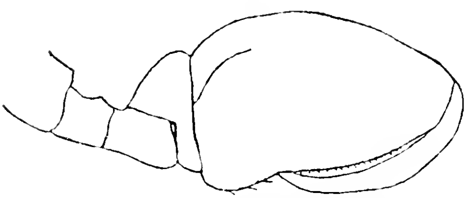
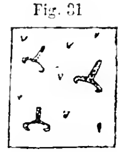


Fig. 31



Figs. 29 – 31. *Allorchestes longipalmus:* 29. Female (nat. s. 11^{mm}.) — 30. Part of 2d thoracic leg of male. — 31. Shell seen under a high magnifying power.

Hind margin of fifth thoracic to third abdominal segments produced into spine-shaped teeth on the median line of the back. Eye round. Epimera of the first four thoracic segments quadrilateral, their lower angles rounded. Infero-posterior angles of the first three abdominal segments produced behind. Telson entire, with a seta on each side of the hind margin. Peduncle of first antenna about as long as the head and first two thoracic segments together; flagellum composed of fifteen segments. Basal joint of second antenna distinct; olfactory denticle prominent; distal segment of peduncle much longer than the antecedent segment; flagellum longer than the flagellum of first antenna, composed of fifteen segments. Propodite of second pair of legs in the male large and swollen; palmary edge sinuous and very long, encroaching upon the lower margin, armed with setæ; lower margin of propodite short; inferior angle of carpopodite produced between the meropodite and propodite. In the female, as usual in the genus, the second pair of legs are weak, the propodite not larger than the meropodite, the palm making nearly a right angle with the lower margin. Seventh abdominal legs, when extended backward, reach the end of the caudal stylets. The shell, seen under a high magnifying power, is furnished with small scattered hairs, with here and there one of those cross-shaped figures seen in the integument of so many of the *Orchestidæ*. Length of body 9mm to 13mm. About two dozen individuals of this species were taken in the lake; the exact locality is not preserved, nor the depth of water. It is closely related to the preceding species, but may be easily distinguished from it by the hand of the second pair of legs.

Allorchestes cupreus, *sp. nov.*

Fig. 32

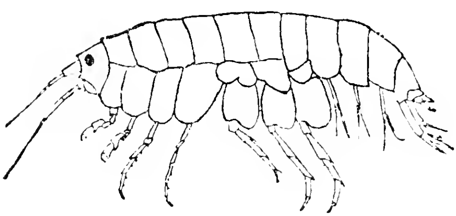


Fig. 34.

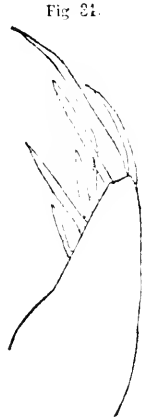
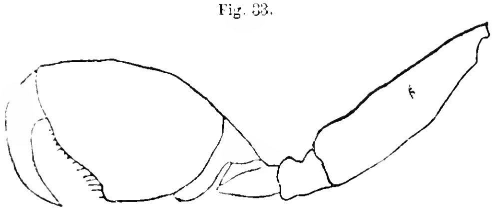


Fig. 33.



Figs. 32–34. *Allorchestes cupreus:* 32. Female (nat. s 10mm.) — 33. 2d thoracic leg of male — 34. Terminal segment of palpus of maxilliped.

Body smooth, without dorsal spines or teeth. Eyes nearly round. Epimera of first four thoracic segments quadrilateral, lower angles rounded. Infero-posterior angles of first three abdominal segments hardly produced backward. Telson entire.

About ten segments in flagellum of first antennæ. Second antenna considerably longer than first antenna, equal to about a third the distance from forehead to the end of the abdominal stylets. Carpopodite of second pair of legs produced downward between the meropodite and propodite; propodite swollen; palm convex, setiferous, with a prominence at its base, against which the tip of the dactylopodite closes; dactylopodite curved, closing against the palm throughout its whole length. Fifth, sixth, and seventh thoracic legs short, with large basipodites lightly serrate on their hind border. Fifth pair much shorter than the sixth and seventh, which are of about equal length. The seventh pair, when stretched backward, reach to the end of the telson. Many parts of the body display a coppery lustre.

In the female, the propodite of the second pair is long and narrow, not broader than the carpopodite; the carpopodite has but a short blunt process at its lower angle in place of the long projection in the male. Length of body, $9^{mm.}$ to $11^{mm.}$ About twenty-four specimens, particular locality not preserved.

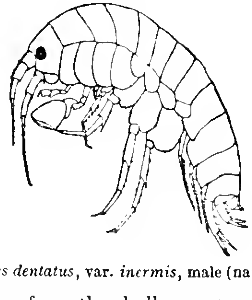
This is a stout species, resembling the last described, but differing in the shape of the propodite of second thoracic legs, want of dorsal teeth, etc.

Allorchestes dentatus, var. inermis.

Hyalella dentata, Smith, Rep. U. S. Fish Comm. for 1872 and 1873, p. 647, 1874.

Hyalella inermis, Smith, Rep. U. S. Geogr. Geolog. Survey of Colorado for 1873, p. 609, 1874.

Fig. 35.



Allorchestes dentatus, var. *inermis*, male (nat. s. $5^{mm.}$).

Six specimens were taken from the shallow water of the "Marjal," a marshy tract on the western side of the lake, overflowed during a part of the year.

They differ from specimens from the United States in having a firmer and less transparent shell, and a little differently shaped propodite to the second pair of thoracic legs in the male; hardly enough to warrant the establishment of a new species when one considers the variability of the species within the limits of the United States.

After an examination of a large number of *Hyalella dentata* and *H. inermis* from Utah, I am satisfied that they are but varieties of one species. The form with dorsal teeth on the first and second abdominal segments is very probably synonymous with *Amphitoe aztecus* Saussure * and *Allorchestes Knickerbockeri* Bate,† as pointed out by Professor Smith himself.

This species (var. *inermis*) was also collected by Mr. Agassiz at San Antonio, Peru, in saline water, 3,300 feet above the sea; nitrate district of Pisagua. The specimens differ slightly from the type described from the United States in having the fifth pair of thoracic legs a little shorter in proportion to the sixth pair.

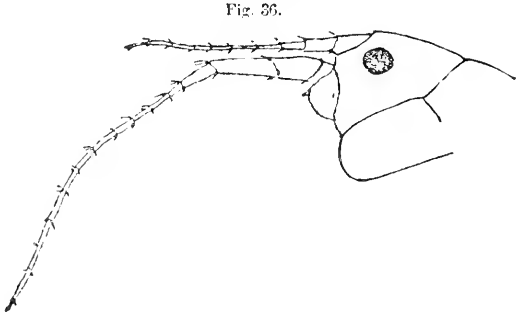
It may be well to announce here the discovery of this species during the voyage of the "Hassler" at Puerto Bueno, Smyth Channel, Straits of Magellan. The specimens do not differ from var. *inermis* from the United States. The ticket accompanying the specimens does not indicate their fresh-water origin; but Count Pourtalès tells me that some animals were collected at Puerto Bueno by Dr. Steindachner and himself in a fresh-water pond and an outlet stream. The *Allorchestes* were probably among them.‡

* Mémoire sur divers Crustacés nouveaux du Mexique et des Antilles, p. 58, Pl. V. Fig. 33, 1858.

† Catalogue of the Specimens of Amphipodous Crustacea in the Collection of the British Museum, p. 36, Pl. VI. Fig. 1, 1862.

‡ Among the Crustacea collected by the Thayer Expedition in Brazil are two species of *Allorchestes*. One is represented by a unique female specimen taken from a canal at Campos by C. F. Hartt. It differs from *A. dentatus*, var. *inermis*, only in the second pair of antennæ, which are half as long as the body and twice as long as the first pair;

Fig. 36.



Allorchestes dentatus, var. *gracilicornis*, head.

Order OSTRACODA.

Family CYPRIDIDÆ.

Genus **CYPRIS**.

Cypris Donnetii?

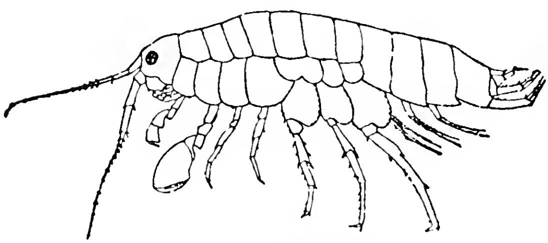
? *Cypris Donnetii*, Baird, Proc. Zoölog. Soc. London, Pt. XVIII. p. 254, 1850.

A great many specimens of *Cypris* were collected by Mr. Garman among the plants growing in the shallow water of the "Marjal." They answer to Baird's description of *C. Donnetii* from fresh-water ponds, Coquimbo.

flagellum composed of thirteen segments. Length of body, 4mm. In the absence of more specimens, I would consider this a variety (*gracilicornis*) of *Allorchestes dentatus*.

The second species is represented by several specimens. It may be called *Allorchestes longistilus*, *sp. nov.* Body smooth, long, and slender. Eyes nearly round. Epimera of

Fig. 37.



Allorchestes longistilus, male (nat. s. 6mm.).

first four thoracic segments quadrilateral. Infero-posterior angles of first three abdominal segments produced. Telson entire, with two long setæ on the hind margin. First antenna nearly as long as the second; flagellum composed of thirteen segments. Carpopodite of second thoracic legs produced below; propodite large, broadest at distal end; palm oblique, with large setæ and a projection at the lower angle. Fifth, sixth, and seventh thoracic legs subequal, the seventh, when extended backward, reaching a short distance beyond the end of the telson. Last pair of caudal stylets very long, extending far beyond the tip of the telson, almost to the end of the second pair of stylets. The female has shorter antennæ and small, long, and narrow propodite to second pair of legs. Length of body, 3mm. to 6mm. Swamp three miles south of Campos. Hartt. Differs from *A. dentatus*, var. *inermis*, in its slenderer body, longer antennæ, and especially in the length of the third pair of caudal stylets.

June, 1876.

Date Due