MEMOIRS

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

AT

HARVARD COLLEGE.

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Memoirs of the Museum of Comparative Zoölogy
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REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM AUGUST, 1899, to JUNE, 1900, COMMANDER JEFFERSON F. MOSER, U. S. N., COMMANDING.

XIV.

THE SOLENOGASTRES.

By HAROLD HEATH.

WITH FORTY PLATES.

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THE SOLENOGASTRES.

INTRODUCTION.

The present paper embraces the results of the study of a collection of over three hundred specimens of Solenogastres, which have been taken in the Pacific during the various expeditions of the U. S. Fish Commission Steamer "Albatross." Based primarily on material from the Museum of Comparative Zoölogy, it includes, through the generosity of the late Mr. Alexander Agassiz, the description of other species collected during recent years. The territory embraced in these explorations is very extensive, including the entire coast of North America from Lower California to Bering Sea, the Kurile Islands, the Japanese Archipelago, and the Hawaiian Islands. The major portion of the material was collected by the following expeditions: Tropical Pacific, 1899-1900; Hawaiian Exploration, 1902; Alaska Investigations, 1890 and 1903; California Coast Exploration, 1889 and 1904; Japanese Expedition, 1906.

Species	Station	Number of Specimens	Depth in Fathoms	Locality
Chaetoderma argentea	4231	1	82–113	Alaska, near Naha Bay.
" attenuata	4244	1	50–201	" vicinity of Pr. Wales Id.
	4250	5		
	4252	2		
" californica	4381	1	618–667	California; S. pt. N. Coronado Id.
" erudita	4258	10	282–313	Alaska, Lynn Canal.
	4264	41		" Chatham Strait.
" hawaiiensis	3992	1	283–528	Hawaiian Ids.; near Kauai Id.
	4130	1		
" japonica	3721	1	207–250	Japan, S. of Honshu Id.
" montereyensis	4485	9	39–356	California, Monterey Bay.
	4508	7		
	4522–4525	139		
" nanula	4369	1	260–284	" off San Diego.
" robusta	3210	4	483	S. of Alaska Peninsula
" scabra	4538	1	795–871	California, Monterey Bay.

Species	Station	Number of Specimens	Depth in Fathoms	Locality
Limifossor talpoideus	4258	4	282–313	Alaska, Lynn Canal.
	4264	6		" Chatham Strait.
" fratula	4369	2	260–284	California, off San Diego.
Drepanomenia vampyrella	3907	1	304–315	Hawaiian Ids., off Oahu Id.
Pachymenia abyssorum	4397	1	2196–2228	Off southern California.
Proneomenia hawaiiensis	3864	2	163–277	Hawaiian Ids.
	4001	1		
" insularis	4157	1	762–1000	" " near Bird Id.
Driomenia pacifica	3716	3	65–125	Japan, Ose Zaki; vicinity of Misaki.
	4935	1		
Dorymenia acuta	4407	2	302–638	Off southern California.
	4415	6		
	4416	3		
Strophomenia farcimen	3748	2	73–200	Japan, S. of Honshu Id.
" ophidiana	3755	1	52–77	" " " " "
" regularis	3717	1	63–100	" " " " "
" scandens	4156	3	286–568	Hawaiian Ids., near Bird Id.
" spinosa	3748	1	73–200	Japan, S. of Honshu Id.
	4935	2		
	4936	2		
" triangularis	3716	2	65–125	" " " " "
	4935	2		
	4936	1		
Lophomenia spiralis	4176	2	537–672	Hawaiian Ids., near Niihau Id.
Alexandromenia agassizi	2992	6	460	Revillagigedo Ids. off Mexico.
" valida	2980	1	603–1350	Off S. California.
	4382	1		
	4389	1		
	4391	1		
Halomenia gravida	4804	2	229	Kurile Ids., near Simushir Id.
Herpomenia platypoda	4781	11	482	Aleutian Ids., near Agattu Id.
Dondersia californica	4303	1	21	California, off San Diego.
Ichthyomenia porosa	4400	20	500–542	" " " "
	4402	2		

Up to the present time none of these molluscs has been described from the North Pacific. A few species are known to occur about Australia and the Philippines, and an extensive collection was made in the East Indian Archipelago by the Siboga Expedition. The present collection embraces thirty-one species of which all are new with the exception of *Limifossor talpoideus* Heath; the species belong to fourteen genera of which eight are new. From this material it becomes increasingly evident that this group of molluscs is cosmopolitan; but there is no evidence of a bipolarity or any indication that the north and south poles were centres of distribution. And furthermore there is no apparent relation between size and geographical distribution.

In concluding this section of the paper it becomes a most pleasant duty to express my obligation to those who have aided in its completion. To Hon.

G. M. Bowers, Dr. D. S. Jordan, and Dr. C. H. Gilbert I am indebted for a portion of the material, to certain data relating to a few of the species and for many courtesies while on board the "Albatross." I am likewise under deep obligation to Drs. E. J. Nolan and H. A. Pilsbry for the use of the magnificent library of the Philadelphia Academy of Sciences, and for several suggestions of a most helpful character. To Dr. W. K. Fisher I am indebted for the identification of the alcyonarian hosts and for a specimen of *Chaetoderma hawaiiensis.* I also wish to express my gratitude to my assistants, Miss R. M. Higley, and Mr. F. W. Weymouth who have greatly lessened the burden necessarily involved in such a study as this. And finally my indebtedness to the late Mr. Alexander Agassiz is very great; in every way possible he helped the work along.

HISTORICAL REVIEW.

The first known reference to any species of Solenogastre occurs in the works of Loven, who in 1844 briefly described as a gephyrean worm *Chaetoderma nitidulum.* During the next thirty years a number of systematists adopted this scheme of classification though there was some difference of opinion concerning the exact position of the species within the group. Diesing ('59), Keferstein ('65), Quatrefages ('65), and Baird ('68) allied it to Sipunculus or Priapulus; Theel ('75) created for it a new family (Chaetodermidae), while M. Sars ('69) placed it among the gephyreans without any comment. Dalyell ('53) in "The Powers of the Creator" gives under the name *Vermiculus crassus* an abbreviated description and one figure of an undoubted Chaetoderma, according to Koren and Daniellssen ('77) *C. dalyelli,* but the description is much too indefinite to make the determination certain.

During this time M. Sars discovered another species of Solenogastre, belonging to a new genus and ultimately to a new family, which he placed ('69) among the Mollusca without any comment whatever, merely giving it the name *Solenopus nitidulus.* Some years later Tullberg ('75) described what is considered to be the same species under the name *Neomenia carinata.* This last named author's investigations mark a distinct advance in our knowledge of these forms, since they are concerned not only with the study of the external characters but with the internal organization as well. In certain respects, especially in the treatment of the urogenital system, the work is seriously at fault, but nevertheless it was thoroughgoing enough to lead Tullberg to conclude that, while the species is vermian in what he considered to be probably the most important characters, it is on the other hand decidedly similar to certain of the Mollusca.

In 1876 von Graff subjected *Chaetoderma nitidulum* to an examination, which considering the amount of material and the methods then in vogue, was more than ordinarily searching; and while he, like Tullberg, fell into error regarding the urogenital organs, his results relating to the other systems, especially the nervous, were of the greatest importance. While not entirely committed to any particular belief regarding the animal's relationships he was inclined to uphold Keferstein, Diesing, and others; and yet he drew attention to the fact that the spicules, gills, mode of egg development, and musculature are so unique that the genus may in reality belong elsewhere, possibly in close proximity to the Turbellaria owing to the close correspondence in the nervous systems.

In 1877 and the following year von Ihering proposed a new classification of the Mollusca based on extensive anatomical researches largely concerned with the nervous system. He drew attention to the very important fact, not previously recognized, that in many fundamental respects the Solenogastres are allied to the Chitons. In his opinion the ancestral neomenian was probably not distantly related to the gephyreans or nemerteans and accordingly lacked a true shell, and Chitonellus, with its small shell and extensive girdle, is thus more closely related to the Solenogastres than other Chitons and must therefore be looked upon as a connecting link. Owing to the presence of lateral nerves the Chitons, Chitonellus, and the Solenogastres are clearly differentiated from the gephyrean worms and annelids, so that in this and other respects they approach the molluscs. On this account a new phylum of Vermes, the Amphineura, was created for their reception. The following year ('78) this same author reviewed the work of Tullberg, Koren and Daniellssen, and von Graff in a suggestive paper, and was more strongly convinced than before that his conclusions were justified. These papers of von Ihering's created much criticism, some of it decidedly hostile, but it is undoubtedly true that, while some of the results have not proved to be correct, the work as a whole had a stimulating effect and has been productive of much good.

During this same period ('77) Koren and Daniellssen described a number of species collected along the Scandinavian peninsula. In most cases the descriptions are so brief that they are not even of generic value, and the animals remain practically unknown down to the present day. *Neomenia carinata* (*Solenopus nitidulus*) is described at some length, but the facts adduced are not strikingly different from those presented by Tullberg. By these authors the Solenogastres were considered to be true molluscs, and were placed among the opisthobranchs in a new order, Telobranchiata.

During this same year Lankester ('77) placed himself on record to the effect that members of the genus Neomenia are among the most generalized molluscs, related to the Chitons and Chitonellus, yet belonging apart in a phylum which he termed Scolecomorpha, the first division of Mollusca eucephala.

Another of the important papers which appeared during this year came from the hand of von Graff, who investigated the anatomy of *Neomenia carinata* and reexamined *Chaetoderma nitidulum.* From the facts disclosed this author was convinced that not only are the two forms constructed upon the same plan, but that the establishment of the Amphineura as a separate phylum by von Ihering was wholly justified. "Wir erkennen in Neomenia und Chaetoderma Modificationen einer sehr alten Urform, vom denen die letztere näher den Würmer, die erstere näher den Mollusken anknüpft." In quite a remarkable way the facts discovered in the study of these two species supported von Ihering's contention that the Solenogastres and the Chitons are allied forms, though they did not force one to the belief that the Amphineura are necessarily to be placed in the phylum Vermes, and von Ihering himself abandoned this position a short time later.

About the same time Hansen ('77) published a most important paper on the anatomy of *Chaetoderma nitidulum*, and in the treatment of all the systems, especially the urogenital, advanced our knowledge to a considerable extent beyond the old position. For the first time the mode of development of the sex products was determined, and their route traced to the exterior; in other words the broader features of the anatomy of Solenogastres now became comprehensible. In the opinion of the author, Chaetoderma does not clearly belong to any definite place in the existing system of classification; that while certain molluscan characters appear, others are strongly suggestive of annelid relationships, so that its exact position is yet in doubt.

The following year Gegenbaur ('78) in the "Grundrisse" made a few very guarded statements regarding the relationships of Neomenia and Chaetoderma which may, provisionally at least, be designated the Solenogastres and may be regarded as a division of the group Vermes. The ventral groove of Neomenia "represents the first stage in the formation of that pedal surface of the body which is seen in the lowest Mollusca." On the other hand the nervous system, while decidedly different from that in the worms, nevertheless presents some fundamental resemblances.

With the exception of two or three short notices no other papers appeared until 1881, which in some respects is the most important year in the history of the group. At this time Spengel described the innervation of the osphradium, and in several species of molluscs discovered deep-seated resemblances in the elements of the nervous system and their arrangement. On the basis of this work, which includes the examination of Neomenia, Chaetoderma, and two unidentified species of Solenogastres, and with the additional help afforded by the work of Tullberg, von Graff, and Hansen he emphatically claimed, in opposition to von Ihering and Gegenbaur, that the Amphineura are true molluscs. Accordingly he established the Amphineura (Chitons and Solenogastres) as a class of the Mollusca.

A very short time afterward the masterly work of Hubrecht appeared, and in some respects it continues to be the most important work that has ever been published on the subject. The study was based chiefly upon a gigantic species, *Proncomenia sluiteri*, which occurs in Barents Sea north of Scandinavia, and embraced a careful examination of its external and internal anatomy. The results, with a few relatively unimportant exceptions, have been confirmed by the study of many other species, and form a most substantial foundation for studies of more recent date. Concerning the relationships of Proneomenia, Neomenia, and Chaetoderma the author has no hesitancy in agreeing with Spengel that they constitute one order (Solenogastres) of the class Amphineura, the Chitons belonging to the other (Polyplacophora). In a number of succeeding publications this position is held without modification, and the few additional facts of importance that are presented still further emphasize the correctness of the theory.

From this time forth scarcely a year has elapsed without one or more papers appearing on the subject of the Solenogastres. Deep-sea researches or work along the shore line beyond the littoral zone have brought to light an ever increasing number of species whose anatomy is now for the most part fairly well known. Without exception all are built upon essentially the same fundamental plan though in detail each species presents, as is to be expected, some new and interesting modifications. To the majority of zoölogists the accumulated results point unmistakably to the true molluscan nature of these animals, but a glance through some of the succeeding paragraphs will show that there is far from being a unanimity of opinion regarding their position in the phylum and their relation to other groups. The great mass of anatomical details which have been published during the past twenty-five years, serving chiefly to distinguish genera and species, new and interesting though they may be, can be but briefly considered in a review of this character.

In 1882 Kowalevsky and Marion called in question the work of all preceding authors, claiming that they in every case had wrongly oriented the animals, that the anterior end is in reality posterior and *vice versa.* Tullberg's lateral glands (portion of the coelomoducts) are accordingly the salivary glands, the penis with its appendages is clearly the radula, the mouth cavity is the rectum, the "egg bag" (pericardium) is the intestinal coecum above the pharynx, the branchia are the buccal cirri and finally the protrusible pharynx is the combined uterus and oviducts.

This paper called forth an immediate rejoinder on the part of Hubrecht, who reviewed the work of the authors in question, and showed that the orientation of the animals in question is correct, and that Kowalevsky and Marion have created confusion worse confounded owing, for one reason at least, to the fact that they had not seen the species under discussion.

During the next four or five years Kowalevsky and Marion published, either separately or conjointly, several papers preliminary to their chief work which appeared in 1887. In this study the authors describe to a certain extent the habits of five new species of these molluscs collected along the shores of France, and accompany it with a very detailed description of the external and internal anatomy. Some of these last named results are referred to elsewhere in the present paper.

In the meantime Selenka ('85) published an account of the gephyrean worms collected by H. M. S. Challenger, and therein briefly described *Chaetoderma militare* from the Malay Archipelago, adding the remark that he was unable to give any data that might settle its systematic position.

In 1888 Hubrecht described a new genus of Solenogastres (Dondersia) taken in the vicinity of Naples. It is a fairly close relative of Proneomenia and Neomenia, and the anatomical characters are accordingly not strikingly different from those presented in the paper on *P. sluiteri.*

In this same year Hansen ('88) made a study of several species of Solenogastres long before described by Koren and Daniellssen ('77). His researches chiefly concern *Neomenia carinata,* which is shown more conclusively than before to be similar to *P. sluiteri.* *Chaetoderma nitidulum* was found to pass the sex products into the pericardium from whence they pass through ducts into the anal cavity (Hubrecht) or branchial cavity (Hansen).

Pruvot ('90) denied the existence of a heart, or pericardium or dorsal aorta in the Solenogastres. The blood moves in lacunae of which a large one passes dorsally along the mid line propelled by contractions of the body. The paired gonad, posteriorly becomes single, and opens into what has been termed the pericardium, in reality an accessory part of the reproductive system; while the dorsal sinus courses in a tube (hanging partially in the so-called pericardium), which is called, by other authors, the heart. In *Dondersia banyulensis* spermatozoa develop on the external walls of what has been termed the heart, while the lateral walls of the pericardium are ciliated and serve to convey the sperms as in many hermaphroditic gastropods. Eggs are temporarily stored in the "poche accessoire" (pericardium), and the kidneys are in reality genital ducts without renal function.

In a later paper ('90) the same author describes a few very interesting stages in the development of *Dondersia banyulensis,* and two years afterward adds some further observations regarding the embryology of *Prōneomenia aglaopheniae.* Ova in the pericardium (of other authors) lack membranes; as these are present in extruded eggs it follows that the supposed kidneys are in reality shell glands. The segmentation stages resemble those of scaphopods and pelecypods, and to some extent this similarity is visible in the later development. A gigantic coat of ciliated cells (a highly developed velum probably) is formed, and within this the embryo forms by a process certainly not primitive or at all events unlike that of other molluscs studied up to the present time. When the velum is thrown off the larva resembles to some extent a young Chiton, possessing seven imbricated calcareous plates along the dorsal surface and laterally situated flattened spines in what appears to be the girdle. The internal organs at this stage are practically undeveloped, and as the later growth is wholly unknown the present results throw but little light upon the important subject of the phylogenetic development of the group.

Pelseneer ('90) considered (*contra* Hubrecht and others) that Chitonellus is not a primitive form intermediate between the Solenogastres and more typical Chitons, but on the other hand is highly specialized. These conclusions were based on data supplied by a study of the branchia, nervous system, and shell. In an introduction to the extensive work of Blumrich ('91) Hatschek seconds Von Ihering in his attempt to place the Chitons and the Solenogastres apart from the gastropods, and agrees also with Pelseneer in regard to the position of Chitonellus.

Owing to the studies noted in the preceding paragraphs the broader features of the anatomy of these animals have been settled beyond dispute, and consequently the papers from this time forward serve in large measure to supply details, and to a limited extent indicate the phylogenetic relationships of this group of animals. The more special features relating intimately to the various systems are noted to some extent in the main body of the present paper, while the general considerations are discussed on p. 164–173. Among the more extensive of these works are those of Pruvot ('91), who has described several species from the shores of France; Wiren ('92) whose study of several species from the Scandinavian coast is among the best that has ever appeared; Simroth ('93) and Pilsbry ('98) whose systematic works are of the highest value; Thiele whose various papers during the past fifteen years have added materially to our knowledge of the anatomy of molluscs, including several species of Solenogastres; Nierstrasz (1902, etc.), who with an abundance of material collected chiefly by the Siboga Expedition, has added extensively to our information of these animals; and finally the present writer who has contributed some data relating especially to the nervous system.

Since the above was written Nierstrasz has published an important report (1908) reviewing the work of various investigators since the appearance of Simroth's paper in 1893. It is a valuable contribution, and the scheme of classification there adopted will be of much service.

Turning now to the broader features of the classification of these animals we find that practically every investigator in this field of research is agreed with Spengel that among the Mollusca their nearest relatives are the Chitons; but regarding their more accurate position within the phylum differences of opinion appear. Von Ihering in 1877 called attention to the fact that the Solenogastres and the Chitons are not distantly related, especially if we consider Chitonellus to be a connecting link and therefore a primitive animal. According to this line of reasoning the Solenogastres, devoid of a radula (none had been discovered at that time) and shell, are the more ancestral and are so closely related to the worms that both they and the Chitons constitute a special phylum (Amphineura) of Vermes as noted in a previous paragraph. Hubrecht, without laying much stress on the ancestry of the Amphineura, though he hints at their derivation from a platyhelminth ancestor, was likewise of the opinion that the Solenogastres are primitive, and that Chitonellus is a link connecting them with the more highly modified Chitons. It may be mentioned also that Haller in '94 modified some of his previous ideas, having become convinced of the correctness of von Ihering's and Hubrecht's position.

The above idea was combated by Pelseneer ('90) who claimed that Chitonellus is nothing more than a highly modified Chiton and in no direct way related to the modified group of the Solenogastres. Hatschek ('91) agreed with this theory though he did claim with von Ihering (a theory abandoned by him in '90) that the Amphineura are Vermes. Grobben ('94) likewise considered this the correct view though he believed the Amphineura to be true molluscs. This notion is implied in the work of Haller ('82), who made the claim that the Chitons and the Solenogastres are distinct groups of animals which have been derived from a common vermian ancestor. In a more vigorous fashion Thiele argues from the same standpoint.

With one or two exceptions those who argue along the line just indicated regard the Solenogastres as primitive animals, and are accordingly opposed to several investigators who hold a diametrically opposite view. Simroth, Wiren, and Heath believe that the Solenogastres early branched off from some primitive polyplacophore and while retaining several primitive features are in other respects degraded organisms. Pelseneer and Garstang take practically the same view. Marion, in a sense, does the same as he compares the adult Solenogastre to the larva of the Chiton. Plate traces the Solenogastres and Chiton lines of descent to some ancestral mollusc which may have given rise also to the present classes.

In regard to the derivation of the molluscs, and the Solenogastres especially, from some premolluscan ancestor there are a number of widely divergent theories. In 1877 von Ihering believed that among the worms the gephyreans are most closely related to the Solenogastres. Haller ('82) on the other hand regarded them as more closely allied with the nemerteans. Hubrecht, Thiele, Plate, and a number of other writers consider that the molluscs, or at all events the Solenogastres, arose from a turbellarian-like ancestor. This idea has been most fully developed by Thiele. According to him the progenitor of the molluscs and the Solenogastres (which are considered to be worms) was in the fundamental characters of its organization similar to the modern cotylean polyclad. The often frilled sensory margin of the body became the mantle, which for purposes of protection, developed a cuticular covering and ultimately a shell, while the ventral sucking disc expanded into the molluscan foot which in its least modified form occurs in Haliotis and similar species.

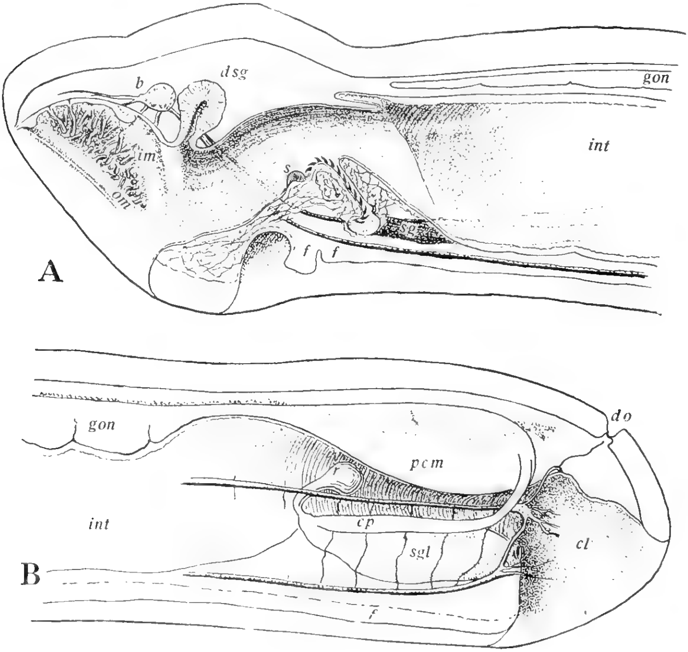
GENERAL FEATURES, METHODS, ETC.

External Characters.— The Solenogastres constitute a group of marine animals, which combine with features more primitive than in any other molluscs numerous others indicating a high degree of modification. All are bilaterally symmetrical, worm-like in form, usually nearly round in cross section, and vary in shape from short thick set to very slender greatly elongated types. While the average length is not far from twenty-five millimeters several species such as *Notomenia clavigera* and *Kruppomenia minima* are from one to four or five millimeters long, and on the other hand *Proneomenia sluiteri* reaches the giant size of one hundred and forty-eight millimeters.

The mouth, or more properly the atrial opening, usually in the form of an elongated slit, holds an antero-ventral position, and is clearly separated from a ventral median furrow, in the Neomeniina extending throughout the entire length of the body. This latter structure is generally considered to be a true pedal groove, the small fold included therein and abundantly provided with glands being the foot. In the Chaetodermatina no external trace of these organs exists, but a gap in the ventral musculature, and a thickening of the muscle bands on each side of the mid line, and in Limifossor a definite pedal sinus, indicate that they were present at a former time. In what must be considered a primitive condition the ventral furrow is posteriorly continuous with what has usually been termed the cloacal cavity, which contains the openings of the urinogenital apparatus, anus, and the respiratory organs. As is more fully shown in a succeeding paragraph, the cloaca is in reality a mantle cavity, and the two branchiae it contains in the Chaetodermatidae are undoubtedly true ctenidia. On the other hand the folds of the cloacal wall, sometimes excessively developed and highly vascular, do not appear to be rudimentary nor degenerate ctenidia.

A cuticular sheath, often of great thickness, envelops the body, and contains from one to seven or eight layers of calcareous spicules. Where more than one layer is present groups of cells constitute papillae or organs of problematical use. In the adult condition all traces of a shell are absent, but in the development of *Myzomenia* (*Dondersia*) *banyulensis,* as determined by Pruvot, a stage occurs in which the embryo bears on its dorsal surface seven slightly imbricating, calcareous plates.

Internal Anatomy. — In regard to the internal organization there are numerous features that indicate a degraded condition, due probably to parasitic habits or an adaptation for a life in the bottom ooze. In Chaetoderma the alimentary tract is a comparatively simple tube passing directly through the body, (as with other Solenogastres), provided with a radula, reduced to a single median tooth, and a voluminous unilobed liver. In other genera (Prochaetoderma, Limifossor) of the family the radula is of large size, and is typically formed and placed. In the Neomeniina this system is more complex. The first division of the digestive tract, which may be termed the atrium, probably corresponds to a highly modified buccal plate, and though usually connected with the mouth (Diagram p. 20, A) may be separated from it. The walls are modified into ridges and cirri, probably sensory structures. A radula is generally present though often greatly reduced in size. In addition to the dorsal salivary glands, probably existing in certain Chaetodermatina as well, a ventral pair is usually



Diagrams illustrating structure of a neomenian. A anterior end. b brain; dsg dorsal salivary gland; f foot; gon gonad; im, om inner and outer atrial ridges enclosing the cirrose area; int stomach-intestine; s subradular organ; sg ventral salivary gland. B posterior end. cl cloacal cavity; cp dorsal limb of gonoduct; do dorso-terminal sense organ; pcm pericardium; r seminal receptacle; sgl ventral limb of gonoduct or shell gland.

attached near the radula. A definite digestive gland is wanting, the mid-gut pouches being lined with hepatic cells.

Owing to the great reduction of the foot and correlated changes, several peculiarities appear in connection with the circulatory system. As in the Chitons the heart is posterior, and the aorta passes along the mid line dorsal to the gonad to connect with the head cavity, which in Limifossor is limited posteriorly by a well-developed septum. In this genus there are indications also of a pedal sinus, but behind the head region it largely disappears, the blood flowing between the gut and body wall to the branchial region. Passing through the ctenidia, or the folds in the cloacal wall, when these are present, the blood makes its way to the posterior end of the heart.

The nervous system bears a striking resemblance to that of the Chitons. There is a greater concentration of the nerve cells to form well-differentiated ganglia, but otherwise there are, in such species as *Proneomenia hawaiiensis*, no especially unique features. The supraoesophageal mass originates three pairs of nerves, which innervate the buccal and neighboring body walls and three pairs of connectives, the labiobuccal, pedal, and lateral. The first named, in a typical condition, is decidedly Chiton-like both as regards its position and elements. The other two, passing backward throughout the entire length of the animal, are united frequently by commissures and connectives, and may fuse completely (Chaetodermatidae) in the cloacal region. In a number of other species the pedal cords, after diminishing in size in the hinder regions of the body, may lack any connection with the lateral ganglia, or they may terminate in ganglionic enlargements (*ganglion posterius inferius* of Wiren) united by connectives with similar swellings (*gang. post. superius*) on the end of the lateral cords. The latter ganglia are invariably united by a heavy commissure passing dorsal to the rectum, and the pedal cords likewise may be connected by a subrectal commissure, thus completing a circumrectal nerve ring.

In the Solenogastres the secondary body cavity comprises that of the gonad, pericardium, and the ducts leading from this latter space to the cloaca. In the Neomeniina the species are hermaphroditic; in the Chaetodermatina dioecious. The sexual elements pass through the pericardial cavity into the coelomoducts, which in an immature condition are relatively simple, and in some species at least are not fused before they open into the cloacal cavity, characters which the Chaetodermatina retain throughout life. In the Neomeniina, on the other hand, various modifications may occur which produce a high degree of complexity. Two or more seminal receptacles are usually present, and the walls of the median undivided section and a portion of the canals leading on to the pericardium become greatly thickened to form the shell gland. Whether these canals ever function as kidneys is an unsettled question. In the Chaetodermatidae there are indications that they do, but at the present time there is no experimental evidence in support of such a view.

Our knowledge of the development of this group of animals is very incomplete. From Pruvot's work on *Myzomenia banyulensis,* and my own on Halomenia, it is evident that the early history resembles that of certain lamellibranchs and the scaphopods. Pruvot's interesting discovery of a stage where the embryo bears seven calcareous shell plates indicates, as a number of authors maintain, that the Aplacophora have descended from polyplacophorous ancestors.

METHODS. — On several occasions I have tried the effects of various killing fluids, and am convinced that for general histological work alcohol is the most satisfactory and is easily controlled. Specimens from deep water are usually in a moribund condition when they come up in the dredge, and undergo practically no contraction when plunged directly into 70% alcohol. Where the animals are more hardy or have been taken in comparatively shallow water it is advisable to add gradually chloretone (aceto-chloroform) dissolved in alcohol until they are completely narcotized. They may then be placed in 70% alcohol for a few hours and preserved permanently in an 80% solution. In warm weather it is sometimes necessary to keep the specimens in a cool place until thoroughly fixed, and in any case it is necessary to use considerable quantities of alcohol. In the study of the nervous system I have found vom Rath's fluid highly satisfactory especially when the material is treated subsequently with a 1% solution of pyroligneous acid. When sufficiently oxidized the nerve fibres remain grayish in color and are usually quite distinct among the yellow muscle and connective-tissue fibres. For staining I have generally used Delafield's haematoxylin, rarely using rubin as a secondary stain.

In connection with certain features of the nervous system the specimens used were of sufficient size to allow of dissection. Under such circumstances paraffine was poured into a small dissecting pan and while it remained soft the mollusc was partially imbedded in it, thus obviating the use of pins. Dissection was done under alcohol by means of a needle mounted on the end of the arm of an instrument for mounting diatoms.

In removing the cuticle from about the spicules *eau de Javelle* is preferable to caustic potash which frequently exerts a decided corrosive action on the more delicate spines.

Occurrence. — Owing to the methods employed the Solenogastres described by the earlier authors, and a small fraction of those subsequently discovered, have been taken in comparatively shallow water, in a very few cases within the littoral zone. However it cannot be said that they are essentially shore forms, for the various deep-sea explorations of recent years have demonstrated that, in certain localities at least, they are a characteristic feature of the deeper regions of the sea and only exceptionally extend into habitats along shore.

With the publication of the present paper the number of species of Solenogastres reaches a total of ninety-two. In most instances these have been described from one or at most a very few specimens, but the scantiness of material appears to be the combined result of habitat and mode of capture. As mentioned in a succeeding paragraph, these animals are either attached to some coelenterate host or they burrow in the bottom ooze. In the first case they may be readily dislodged and lost; in the second they are usually out of reach. On several occasions, while acting as temporary naturalist on the U. S. F. C. Str. "Albatross," I have been able to examine carefully large quantities of mud, which has been scooped from the bottom, and have secured unusually large numbers of individuals of a few species. In Alaska (Sta. 4264), for example, the dredge load contained forty-seven specimens belonging to two different genera (*Limifossor talpoideus* and *Chaetoderma erudita*). Again in Monterey Bay, California, one haul (Sta. 4522) contained fifty-nine *Chaetoderma montereyensis*, while in a neighboring locality (Sta. 4523–4525) eighty were taken. In the National Museum I recently examined a large number of small animals taken by the "Albatross" in the Atlantic, and discovered no less than thirty specimens of these molluscs belonging to two genera. From such data and considering that the amount of territory explored is but a tithe of the entire sea floor, it is reasonable to suppose that in point of numbers and of species these animals will far surpass their nearest allies, the Chitons.

Owing to the fact that up to the present time no Solenogastres have been reported from the North Pacific, and since the species described in the present paper have usually been collected from widely separated stations in a single dredge haul, it follows that there is little to be said definitely regarding their general distribution. It is an interesting fact that of the eight species taken in Japan six belong to the genus Strophomenia. The genus Limifossor is represented by two species off Alaska and California respectively. This last named region is likewise the home of *Alexandromenia agassizi* and *A. valida*. Species of Chaetoderma occur in the ooze in all of the carefully explored territory mentioned in the introduction. However, it cannot be said that in any case we have any very definite information regarding the geographical limits or relative abundance of a single species.

There is little to be said regarding the vertical distribution of the species described in the present paper. Where several individuals have been secured from a number of stations each species appears to be restricted to a fairly definite depth. *Chaetoderma nitidulum* is reported to have a range of from 14–1250 meters. A much greater depth may be possible for *C. hawaiiensis* from Station 4130 where the initial sounding recorded 1362 fms.; but since the closing sounding was 358 fms. it is probable that the latter figure is more nearly correct, as a second specimen was taken at a depth of 528 fathoms (Sta. 3992). In many places the ocean floor is exceedingly rough and characterized by high almost vertical cliffs bounding fissure-like valleys. Under such circumstances a number of soundings are desirable in order to avoid the necessity of accepting great extremes in vertical distribution though these may in reality exist with certain species.

MODE OF LIFE, FOOD. — The species belonging to the Chaetodermatidae are, so far as known, inhabitants of the sea bottom where they excavate burrows which they rarely leave. Wiren ('92) who kept over one hundred specimens of *C. nitidulum* in captivity says they progress through the ooze by means of the alternate contraction and expansion of the prothorax aided by movements of the entire body; and that when at rest they ordinarily direct the body vertically with the cloacal chamber widely expanded, and the branchiae fully exposed at the opening of the burrow at the surface. When disturbed they disappear instantly several inches into the mud. In most respects these observations answer for *C. erudita* which I kept some time in captivity. This animal from time to time advanced through the ooze in the manner described by Wiren but it never appeared at the surface. For hours together it remained quietly in its burrow with the gills fully expanded and when disturbed retreated but slowly, though the gills were at once retracted and the cloacal chamber closed. The individuals acting in this manner were apparently in a normal condition since the alimentary canal of several kept in captivity for nearly one month contained quantities of food.

The members of the suborder Neomeniina, on the other hand, are not known to burrow, but are usually found on some species of hydroid, coral, and exceptionally (*Proneomenia vagans, P. desiderata*), on plants. Now and then specimens have been dredged unattached and it may be that they, like *Neomenia* *carinata* and *Stylomenia salvatori*, crawl about freely over the sea bottom, though it is possible also that they have been loosened from some host.

The relation of mollusc and coelenterate has not been thoroughly worked out, but there are many indications and some definite proof that it is a genuine case of parasitism and not an accidental association or a case of commensalism. In *Drepanomenia vampyrella* from the Hawaiian Islands the proboscis of one individual was inserted into the body wall of some species of Epizoanthus, many of whose reproductive and other cells had been withdrawn so that here there is no doubt that this Solengastre is a parasite. The presence of nematocysts in the alimentary canal of several other species, including most of the species of Strophomenia, indicates that they likewise are in the same category. Hubrecht ('80) states that a bit of alcyonarian coral was found in the mouth of *P. sluiteri*, but he calls attention also to the fact that diatoms and entomostracans occurred in the faeces in the cloacal cavity, and Heuscher ('92) records the presence of Entomostraca in the gut itself. It thus develops that the diet of such species is varied, and it is possible that such forms as *P. vagans* and *P. desiderata* which were found crawling about on plants belong to this same class.

So far as known the food of the Chaetodermatidae consists of microscopic organisms and organic remains which they scoop up while burrowing through the ooze. Wiren ('92) believes that the buccal plate (Mundschild) acts as a digging organ, and this may indeed be the case but the exceedingly small amounts of inorganic material, which make their way into the digestive tract, indicate that in addition to functioning in a purely mechanical fashion it manifests a decided selective action. When selected the food is carried backward by the great conical tooth in the genus Chaetoderma, and in the form of a more or less spherical bolus, mixed with the secretion of the salivary glands, is carried into the mid gut. In Prochaetoderma and especially Limifossor the radula and its supports are of large size and indicate active, predatory habits, but the contents of the gut are essentially the same as in Chaetoderma.

Color, Size. — In a preserved state the skin of the Solenogastres is usually unpigmented, the light yellow or yellowish brown tint of the animal being due to the cuticle investing the body. In many species, especially of the Chaetodermatidae, this may be obscured to a greater or less degree by the multitudes of refringent spicules imbedded in it or by some of the internal organs. The liver for example is often dark brown, and shining through the translucent body wall and the overlying cuticle and spicules, gives a decided frosted gray tint to several species. The red color of the blood plasma may impart a pinkish tinge especially in the head and cloacal regions. An incrustation, rusty red or black, may cover the entire animal though it is usually restricted to the posterior extremity. In a very few species some of the hypodermal cells contain pigment, red, yellowish red, lilac, or yellow in color. *Echinomenia coralliophila*, a species living on *Corallium rubrum*, is provided with movable scales which when depressed give the body a whitish tint resembling the tentacles of the host, and this may possibly be the case with *Strophomenia spinosa*. Upon raising the spines the pigmented hypodermis becomes less obscured and the animal assumes a reddish color similar to the coral stalk.

The smallest sexually mature Solenogastres are not over 5 mm. long, and on the other hand *Proneomenia sluiteri* attains, as previously stated, the great length of 148 mm. The average length is probably not far from 30 mm.

Length Index. — In the discrimination of species the so-called length index, or the ratio of length to breadth of body, has been used to a considerable extent, but from several experiments in the preservation of fresh material, I am convinced that it is of little use, certainly not with closely related forms. For example nearly sixty *Chaetoderma montereyensis*, which had come up in the same dredge haul, were treated with slow alcohol in precisely the same fashion and yet the length indices varied fully twenty per cent. Some specimens must invariably be subjected to a greater pressure than others in the dredge load, and these are more flaccid and less contractile and with them the length index is relatively greater.

COMPARATIVE ANATOMY.

Foot and Glands. — It is now a generally accepted fact that the ventral furrow and its included fold represents a greatly reduced pedal furrow and foot. In the Chaetodermatina all external traces of these structures have disappeared completely, but internally a gap in the ventral musculature and a thickening of the longitudinal muscles on each side of the mid ventral line and in Limifossor a well-developed pedal sinus in the head region indicate their former existence. In what appears to be the least modified species, the foot consists of a single fold, but in several other species this is accompanied on each side by a fold of almost equal height and length, and in the Neomeniidae the creeping surface is often comparatively broad and is developed into several folds. Whether one or more of these plaits exist each is bounded by a single layer of ciliated epithelium which as a rule is continuous with the lining of the cloaca. The last named space is certainly a true mantle cavity and the plume-like branchia it contains in the Chaetodermatidae are ctenidia. On the other hand it is questionable if the folds developed in the cloacal walls, as in Alexandromenia for example, are homologous organs.

As in the Chiton embryo two sets of pedal glands exist, termed by Hubrecht ('80) the anterior and posterior pedal. The first named is a highly developed organ filling the greater part of the space between the body wall and gut in the head region. It is composed of pyriform cells whose ductules lead into the anterior end of the pedal furrow, which is usually developed into a cavity of considerable size, where they make their exit by separate intercellular openings. The posterior pedal gland is situated above and slightly to each side of the foot throughout its entire extent. Its cells are likewise pear shaped and open intercellularly into the pedal furrow.

HYPODERMIS AND PRODUCTS. — What is sometimes termed the skin consists of two main elements, the hypodermal cell layer and the overlying spiculose cuticle. In the majority of species the hypodermis consists of a single layer of cells, and exceptionally (*Paramenia palifera, Ichthyomenia ichthyodes,* for example) forming a more or less irregular many cell layer. Concerning the nature of the elements entering into its formation there are numerous differences judging from the accounts of the various authors, and the functions ascribed to them are equally diverse. The ordinary hypodermal cells, those responsible for the formation of the cuticle, are usually cubical or low columnar in form with round or oval nuclei imbedded in a finely granular cytoplasm pigmented in a few species (*e. g. C. nitidulum*) which blends with the overlying cuticle. In the same general situation gland cells are present in several species together with more slender elements which may perform a sensory function.

The papillae occur in all Neomeniina in which there is more than one layer of spicules imbedded in the cuticle. Generally speaking each consists of a comparatively slender stalk which is attached to the hypodermis, and on the other hand expands into a more or less globular mass in contact with the free surface of the cuticle or may even project above it. The cells composing the swollen portion are apparently filled in life with a highly spongy, possibly vacuolated protoplasm which in preserved material may shrink greatly, producing radiating pseudopodia-like processes. In *Halomenia gravida* outpouchings of the gut occur at fairly regular intervals along the dorsal side of the animal on each side of the mid line. These penetrate the somatic musculature (Plate **32**, fig. 5) and come in contact with the under surface of modified papillae, which appear to be capable of a certain amount of protrusion owing to the agency of a surrounding blood sinus. The significance of this remarkable state of affairs is very obscure; and for that matter the various functions such as excretion, touch, and pressure relations which have been ascribed to these organs as yet rest upon no direct experimental evidence. That they are the homologue of the aesthetes in the Chiton shell is a reasonable assumption, but this carries with it no trustworthy evidence regarding their office.

The spines form from one to several layers in the cuticle, and present a great variety of forms. In the Chaetodermatina spearhead-types prevail, and in the Neomeniina, where there is but one layer, this shape may likewise occur. In those species with more than one layer the usual type is needle-shape, and with it may be associated radially directed spicules usually with truncated bases.

SPICULE DEVELOPMENT. — In a number of species of the present collection, notably *Proneomenia hawaiiensis*, *Strophomenia scandens*, and *Halomenia gravida*, certain of the more important details of the formation of the spiculose investment of the body appear with unusual distinctness, and to avoid needless repetition the results are discussed once for all in the following paragraphs. Speaking first of *Proneomenia hawaiiensis*, in the earliest stages of the spicule formation, where the calcareous product is no larger than the neighboring hypodermal elements, several cells are seen to be taking part. One of somewhat larger size than the others, and with clear finely vacuolated cytoplasm and distinct granular spherical nucleus, rests underneath the base of the spine. Its general appearance is essentially like that of the cell beneath the spicules of *C. nitidulum* as figured by Wiren or the spicule forming cells in the mantle of certain species of Chitons, and is *par excellence* the lime secreting element.

Wiren is of the opinion that the basal cell is a modified wandering cell that has left the blood stream and migrated to the hypodermis. In all of the Solenogastres under discussion the wandering cells are of a granular character with no distinct cell membrane and clearly different from any of the hypodermal cells. Furthermore in the species under discussion I have never seen these plasma cells outside of the somatic muscle layer, and there are never any indications that the spicule forming elements are derived from any other source than the hypodermis.

In very early stages, perhaps from the first, the spicule is surrounded by a delicate cuticular sheath whose reaction to the ordinary stains indicates a composition unlike the material in which the spicules are imbedded. This spicule sheath is probably formed by seven or eight cells, slender in form, indistinct in outline, with dense nuclei and attenuated bases which are imbedded in the hypodermis proper. They entirely surround the basal cell, and distally their membranes become continuous with the spicule sheath, which as Plate **36**, fig. 5, shows, is thus interrupted a short distance above the base of the spine.

At a relatively early stage in the development of the spine a minute cell (Plate **36**, fig. 11) may be detected between the basal cell proper and the spicule sheath. At first it appears to be connected with the deeper portions of the hypodermis by a single stalk that passes to one side of the basal cell; but in later stages such a connection disappears and the cell in question becomes closely applied to the base of the spine. It appears to be responsible for the formation of the spicule sheath immediately above it and in the following way for the cavity of the spicule itself. At first the cuticle above this small basal sheath cell is of uniform thickness and the lime salts, deposited presumably by the basal cell proper completely fill the spicule sheath, but very soon a minute knob-like elevation appears on the basal part of the sheath, and, perhaps owing to this increased thickness of the cuticle, it interferes with the deposition of calcareous material, for from this time on a cavity develops in the spine that in size and position corresponds to the cuticular knob. As the latter increases in size the spicule cavity enlarges, and when in later stages there is a decrease the cavity becomes proportionately narrowed until both finally disappear together.

In the earliest stages of its existence the long axis of the spine is at right angles to the hypodermis, but as development progresses it becomes more and more inclined until it reaches the final horizontal position. This rotation is probably due in large measure to the unequal elongation of the attached cells, while the continual advance of the free tip of the spine through the surrounding cuticle is due to the addition of new material basally. During this whole formative period and after its completion the entire spicule is migrating also toward the free surface of the body. Hubrecht and several other subsequent observers consider that this movement is caused by the continual cuticular current, so to speak, brought about by the perpetual addition of new material in contact with the hypodermis, a belief with which I concur for on any other supposition it would be difficult to account for the perfectly vertical, unbent position of the slender remnant of the matrix cells in late stages.

Until the spine has been carried outward for a distance equal to one fourth or one third the thickness of the cuticle the matrix cells retain their usual connections and generally are fairly distinct though showing more or less shrinkage (see Plate 36). This latter feature becomes strongly marked beyond this stage and as the cells shift to a distinctly subterminal position their boundaries disappear, and in the neighborhood of the spine they become dense and fibrous. Still later they migrate to a point fully one eighth the length of the spicule from a terminal position, their attachment to the spicule sheath becomes reduced to a minute knob-like disc and all but the basal portions of the cells themselves become transformed into a slender fibrous stalk, which elongating as additions are made to the cuticular investment of the body, maintains its attachment with the spine as long as the latter remains in the cuticle. In the region of the hypodermis the outlines of the matrix cells remain distinct and unmodified with the exception of the enclosed basal cell which becomes distinctly fibrous. In certain slightly abnormal cases the stalk is sometimes unusually broad and under such circumstances the basal cell in later stages becomes distinctly fibrillar throughout its entire length, while the surrounding ensheathing cells assume rather a cuticular appearance and never so far as I have seen assume a fibrous character. In a very considerable number of cases the fibres, of unknown nature, that have developed in the original basal cell may be seen to extend beneath the level of the hypodermis, or to unite with others that may be traced for varying distances into the somatic muscles beneath. In the region of the buccal cavity, in *Proneomenia hawaiiensis*, they may be followed through spaces in the muscle layer into close proximity to the ganglionic masses bordering on the cirri. So long as the spicule remains imbedded in the cuticle the stalk is in connection with it, and appearances suggest that after the basal cell ceases to be functional as a spicule forming agent it may transmit impulses to the central nervous system as the spines and scales in the mantle of the Chitons are supposed to do.

In Halomenia, Lophomenia, Dorymenia and all of the species of Strophomenia described in the present paper this type of development prevails. In some species the matrix cells become detached from the fully formed spine, but otherwise no fundamental differences exist. Regarding the species described by other authors, Hubrecht and Heuscher agree that in *Proneomenia sluiteri* a cup of several cells clasps the base of the spicule, and Kowalevsky and Marion and to a certain extent Pruvot, and Wiren have made similar observations on other species. Through the generosity of Professor Hubrecht I have been able to examine a portion of the type of *P. sluiteri* and though the cells are not so clearly defined as in *P. hawaiiensis* there is no doubt that in both the spines follow the same course of development. Nierstrasz writes of *Cyclomenia holo-*

sericea "The spicula remain in connection with the hypodermis by thin threads, met with everywhere in the spicula" (cuticula?) and of *P. discoveryi* he states that "The spicules are formed in small accumulations in the epidermis" though one cell only is said to be active.

Thiele has consistently argued in favor of one matrix cell and it is probable that he has focussed his attention on the type of spine I am about to describe.

As noted in a preceding paragraph, there are in addition to the tangentially placed spicules in some species others that from the beginning to the close of their development are directed radially. This latter type of spine, so far as I have determined, has a mode of development completely different from the one just described. In *Strophomenia triangularis* for example as soon as it becomes clearly recognizable it rests upon what appears to be a single cell, and as long as it remains in the cuticle no additional elements put in an appearance. In the later stages the matrix cell usually becomes more cup-like closely clasping the base or side of the spine (Plate **36**, fig. 18), and it may elongate to form a slender stalk but it is always unicellular. It is to be noted, however, that in this species, and perhaps in others, there are additional, radially directed spines of much larger size which appear to be formed by more than one cell though this is not certain owing to the fact that the base of each spicule is crowded against the somatic musculature.

In the Chaetodermatidae Wiren has shown that but one formative cell exists though in its early stages the spine is surrounded by three hypodermal cells which may exercise a moulding influence. From my studies I doubt this last statement. In both Chaetoderma and Limifossor the formative cell is surrounded by hypodermal elements but there is no evidence that in the development of the spine they take any active part. It thus becomes evident that there are various types of spicule formation among the Solenogastres just as there are among the Chitons, but it is a most interesting and significant fact that the most common type of Chiton-spine development (according to Plate, '01, Theil C, p. 372) is almost the precise counterpart of what exists in *P. hawaiiensis* and several other species.

Wiren is inclined to the belief that after the spicule forming cells have performed their function they become transformed into the hypodermal papillae. There is confessedly no definite evidence to substantiate such a theory, and on the other hand there are one or two facts that tend to discredit it. In the first place there is no definite relation between the number of papillae and spines; in the majority of species the latter considerably outnumber the former, notably in Alexandromenia. And again where the spicule retains its connection with the original formative cells such a fate is out of the question. And finally a few authors, notably Heuscher, have observed the origin of these organs directly from the hypodermis. I have seen many times papillae-like elevations (Plate **36**, fig. 18) such as Heuscher figures, and I am strongly of the opinion that they have no connection with the matrix cells.

DIGESTIVE TRACT. — The anterior division of the alimentary canal consists of a cavity whose walls are provided with two folds (Mundleisten), usually of a horseshoe-shape that define the cirrose area where the wall is modified into numerous finger-shaped filaments. In the greater number of species this and the succeeding portions of the gut are intimately united, but in *Rhop. aglaopheniae*, Dondersia, and a few other species they are distinctly separated by a ridge covered with the spiculose cuticle investing the body generally. Thiele considers that this sensory atrium is an ectodermic invagination of the integument corresponding possibly to the Chiton snout. Accordingly where the separation is complete the true mouth is posterior to the opening of the atrial cavity, and where the latter is fused with the gut the mouth is situated behind the internal buccal ridge. In the Chaetodermatidae this anterior division is absent or is represented, as Thiele assumes, by the buccal sensory plate and possibly the semicircular groove (halbmondformige Grube).

The limits of the pharynx are difficult to define but it is generally assumed that it contains the radula and the outlets of the salivary glands. As a rule its epithelial lining is unmodified though it may be greatly folded and, in some species form papillae, which afford an outlet for the dorsal salivary glands. If an oesophagus exist it is usually not clearly differentiated from the pharynx, and in the following pages I have disregarded it.

In the Neomeniina the digestive gland or "liver" is not differentiated from the stomach or intestine. This last named organ may possibly be represented by the ciliated tract attached to the under surface of the gonad. In the Chaetodermatina the digestive gland, stomach, and intestine are clearly defined and are not essentially different from what exists in other molluscs. The cloacal chamber is probably an ectodermic invagination and a true mantle cavity. There is no evidence that it is an expanded rectum.

MUSCULAR SYSTEM. — This system has been described in a very few species though most authors refer to the more obvious features especially the nature of the body wall. This consists of an outer circular layer, resting in some species upon a layer of diagonal fibres that in turn is in contact with a system of longitudinal bundles. In the anterior and posterior regions these are subject to various modifications, forming mouth and cloacal sphincters and dilators, and affording attachment for the gill retractors or anteriorly for the multitudinous muscles operating the forward section of the digestive tract. These last named muscles have never been fully studied in any species though they are fairly well known in *Chaetoderma nitidulum* and *Limifossor talpoideus.* As the matter rests at present there is a similarity between the various species with respect to the somatic musculature and to certain of the more conspicuous bundles elsewhere in the body, but beyond this our data are too insufficient to permit of close comparisons.

PRIMARY BODY CAVITY AND SEPTA. — The space between the alimentary canal, gonad, and body wall, the primary body cavity, reaches a varying height of development according to the species. In the Chaetodermatina it constitutes a comparatively limited pseudovascular system and in some of the Neomeniina it is likewise much reduced, but in several species it becomes much more extensive. This haemocele is divided by a horizontal septum that extends between the longitudinal fibres on each side of the body beneath the gut and so forms a ventral blood sinus. In the Neomeniina it is small, but is bounded, in every species described in the present paper, by connective-tissue fibres perforated here and there to permit of communication with the overlying blood spaces. In Chaetoderma a vertical septum separates heart, gills, and pallial complex from the remainder of the primary body cavity. It is not present in the Neomeniidae nor in Limifossor. In the last named genus there is an additional partition, essentially the same as in the Chitons, which separates the head cavity from the succeeding portions of the haemocele. It is perforated by the aorta, alimentary canal, and a pedal sinus which passes forward into close proximity to the mouth.

CIRCULATORY AND RESPIRATORY SYSTEMS. — The heart is developed as a fold of the dorsal pericardial wall reinforced by a varying number of muscle fibres, and in some species differentiated into an auricle and ventricle. From its anterior end the aorta arises and passing dorsal to the gonad leads into a more or less definite head cavity. In the Chaetodermatina and a very few Neomeniina this vessel possesses definite walls; in the others it is part of the general lacunar network. In Limifossor a distinct connective-tissue septum bounds the head cavity posteriorly, but in the greater number of other species the blood spaces in the head region communicate directly with those surrounding the mid gut. These last named sinuses are in communication also with a ventral median pedal sinus even though the foot be absent. In the posterior end of the body the blood is collected in a branchial sinus, if gills be present, or is conveyed to the posterior end of the heart by means of clearly defined channels in the neighborhood of the rectum. In the Neomeniina the haemoglobin is contained in the corpuscles, and in the Chaetodermatina by the plasma.

In the Chaetodermatina two plume-like respiratory organs, which spring from the anterior wall of the cloacal chamber, are in all essential respects like those of the Chitons and are doubtless true ctenidia, the space wherein they are contained being the mantle cavity. In the Neomeniina such organs are absent, though the cloacal wall may be developed into folds in some species of large size, penetrated by numerous sinuses and covered with a richly ciliated epithelium. It is believed by some investigators that such lamellae are incipient or degenerate ctenidia but there is little to support such a theory.

Apart from these organs it is probable that respiration takes place over the surface of the body, especially along the ventral furrow if such be present. It has been suggested also that the great buccal folds may possess a combined respiratory and sensory function.

Nervous System.— In the Solenogastres there is a more pronounced concentration of the nerve cells to form definite ganglionic enlargements than in the Chitons, and the nerves supplying the mantle-cavity complex arise from a more restricted section, but in the arrangement of the brain, pedal and lateral ganglia, and the labio-buccal system there is a very distinct fundamental resemblance between the two orders. In every case the brain, usually if not always bilobed, is situated on the dorsal side of the alimentary canal about the intersection of the mouth and pharynx. From its anterior face three pairs of nerves originate in the Neomeniina and innervate the buccal wall and the adjacent regions of the body. About the bases of the atrial cirri these fibres connect with accumulations of nerve cells which may be the homologue of the great ganglionic masses in contact with the brain in the Chaetodermatina. In this last named group these accessory nerve masses, ten in number in Limifossor, are connected with the brain by several nerves, and on the other hand give rise to fibres which innervate the sensory buccal plate (Mundschild). In what appears to be the most primitive condition three pairs of connectives, the pedal, lateral, and labio-buccal, take their separate origin from the brain as in the Chitons. Such a state of affairs is the rule in the Neomeniina. In *Chaetoderma erudita* these cords unite immediately before plunging into the accessory ganglionic masses attached to the brain but retain a delicate connective-tissue sheath, and hence a perfect individuality, until they pass into the brain. In some other species of the genus, as for example *Chaetoderma nitidulum*, they fuse indistinguishably as they enter the brain. Finally in Limifossor the pedal and lateral cords fuse a comparatively long distance from the brain, and at a less remote position are completely united with the labio-buccal connective.

In every case the pedal ganglia are almost as long as the animal and hold a ventral position on each side of the pedal furrow though not always in close proximity to it. In several species commissures at fairly regular intervals have been seen uniting these cords, and equally numerous connectives have been traced to the lateral nerves which hold a more dorsal position along the sides of the body. In the posterior end of the animal the relation of these elements varies considerably in the different species. In *Proneomenia hawaiiensis*, for example, the pedal cords become reduced in calibre, and finally break up into small nerves which have not been shown to have any connection with the lateral cords though they come into the neighborhood of some of the small nerves originating from them. In *Strophomenia scandens* the last two or three latero-pedal connectives are of relatively large size and the union of the lateral and pedal ganglia is clearly established. Furthermore in several species, such as *Lepidomenia hystrix*, and *Neomenia carinata*, the posterior ends of the pedal cords terminate in ganglionic enlargements (*ganglion posterius inferius*, Wiren) united by a commissure of more than usual size situated ventral to the rectum. The posterior ends of the lateral ganglia are also frequently enlarged (*ganglion posterius superius*) and are invariably united above the rectum, thus completing in several species a circumrectal nerve ring. In the Chaetodermatidae the lateral and pedal ganglia are united, at least in the anterior end of the body, by commissures and connectives but more posteriorly these main ganglionic cords terminate in a large nerve mass, the so-called gill ganglion, continuous across the mid line above the rectum.

In what probably represents a typical condition the sublingual or buccal system, in reality the labio-buccal, holds essentially the same relations as in the Chitons. Connectives lead from the brain along the pharyngeal wall and unite with ganglia about opposite the forward end of the radula or in the neighborhood of the openings of the ventral salivary glands. These nerve masses probably represent the labial and buccal ganglia of other molluscs, and in at least one species, *Strophomenia scandens*, are united by three commissures and the subradular system. One of these commissures, the dorsal buccal, crosses the dorsal side of the pharynx, while two pass ventral to it. In *Proneomenia hawaiiensis*, where the subradular system is most highly developed, a connective arises from the inner face of each labio-buccal ganglion and unites with a small subradular ganglion which is in close contact with a subradular organ. These two ganglia are in turn united by a subradular commissure. In the genus Chaetoderma also there is a well-defined subradular system (p. 57).

In several species of Solenogastres various authors have found what corresponds to the labio-buccal connectives and ganglia, and in most of these cases have found one commissure which is either the ventral buccal or labial. In the Neomeniidae the subradular organ is usually wanting together with the customary nerve supply; and in most species it is impossible to find more than one buccal commissure. However these nerves are usually very small and difficult to trace so that negative evidence in this case may not be entirely trustworthy.

SENSE ORGANS.— In the majority of Solenogastres a dorsal sense organ exists in the mid line in the cloacal region. In the Neomeniina it consists of a circular depression, naked or covered with a thin cuticular layer, and surrounded by spicules which in its contracted condition overarch it. When expanded by an underlying blood sinus a disc-like projection is elevated from the bottom of the depression and is raised above the surrounding spines. In the Chaetodermatina a groove, likewise overarched by spicules when contracted, is probably a homologous structure. In both families these organs are innervated by nerves from the dorsal commissure uniting the lateral nerve cords. Various functions have been assigned, but without any experimental evidence.

Thiele believes that the ventral furrow may be tactile but no sense cells have been shown to exist. In the gills on the other hand stiff hairs have been found among the cilia and are considered to be parts of sensory elements. Osphradia are unknown.

In the Chaetodermatidae the anterior sensory plate is innervated by a heavy set of nerves and probably acts as a tactile organ. Owing to the heavy cuticular covering it may act also as a digging organ, operating in a general way like a hog's snout.

In *Proneomenia hawaiiensis* a low sensory ridge encircles the atrial wall immediately within its outer opening. It is composed of high columnar cells which rest throughout their entire extent upon a rod-like mass of nerve cells. Internal to this are the usual atrial ridges (Mundleisten), of which the more external closely parallels the sensory tract just mentioned, while the inner one passes nearly around the canal at the commencement of what is probably the mouth cavity. Both are usually well-developed ciliated folds, capable, in some species, of great distention owing to the large blood sinuses contained within. Between the ridges the lining of the atrium is developed into simple or branched, finger-like processes termed cirri. Each is composed of glandular and sensory cells frequently pigmented, and is penetrated by a slender canal traversed by a nerve fibre. Regarding the function of these organs and the ridges it is variously considered that they are gustatory, olfactory or tactile, or even respiratory. The cirri may be protruded from the opening, and this fact in connection with their glandular character has suggested that they may serve also to collect food; but judging from *Drepanomenia vampyrella* (page 79) there are times when they are inoperative in this respect.

Regarding the papillae in the hypodermis of the Neomeniina various hypotheses have been suggested. They appear to be connected with nerve fibres, and may reasonably be considered the homologue of the aesthetes in the shell of the Chitons, but up to the present time there is no proof that such is the case, nor that they are tactile, or secretory, or excretory, organs as some authors have maintained.

A subradular organ, normally located and innervated, is known to exist in a few species (page 86). In its finer details it bears a striking resemblance to its homologue in the Chitons and perhaps functions in the same way.

COELOM.— The secondary body cavity comprises the gonad, pericardium, and gonoducts whose relations have been determined in most of the known species of Solenogastres although their physiological significance remains very incomplete. The gonad, usually paired, is situated along the dorsal side of the animal between the body wall and alimentary canal. Posteriorly it is continuous, by means of two ducts, with the pericardium which in turn is in communication with the cloacal cavity by means of two canals, the coelomoducts.

So far as known all the Chaetodermatina are dioecious while the Neomeniina are hermaphroditic, and generally speaking the gonad is of the same length as the liver and therefore nearly as long as the body in members of the first named suborder. In the young the reproductive gland is paired, and in the adults with the exception of the genus Chaetoderma this condition of affairs persists, though sometimes partially obscured by the development of numerous germinal folds. In the Neomeniina the sperms arise along the outer walls of the gland while the ova, in some species surrounded by a follicle, are more inwardly placed. In the mature state the ova and spermatozoa make their way through the short, ciliated canals terminating the gonad posteriorly, and enter the pericardium from whence they pass to the outside through coelomoducts of various degrees of complexity. In the young of some of the Neomeniina these last named canals are simple tubes of about equal calibre throughout, but in later life they become modified into a shell gland and one or more seminal receptacles. In adult Chaetodermatina these canals remain comparatively simple, and there is some evidence that they function as excretory organs as well as genital ducts.

In every case the coelomoducts originate from the hinder wall of the pericardium as comparatively small, ciliated tubes which pass anteriorly to about the level of the forward wall of the pericardium where they make a sharp bend and join the so-called shell gland in the Neomeniina. At the intersection of these two divisions from one to twenty-five vesicular appendages are usually attached, which have usually been considered seminal receptacles though the arrangement of the sperms in a few species indicate that for at least a part of the breeding season they may function as seminal vesicles. As the distal or ventral portions of the coelomoducts usually unite before entering the cloaca the shell gland which they form is a bicornuate, comparatively swollen structure with excessively thick walls and contracted lumen. It is reasonably certain that this organ functions as a nidamental gland, forming possibly an albumenous envelope before the egg passes to the exterior.

In intimate connection with the genital apparatus just described there are a number of problematical organs which in some cases at least appear to have some rôle to play in the reproductive process. These include the genital spicula or penes such as occur in *Neomenia carinata*, *Dorymenia acuminata*, *Pararhopalia pruvoti*, *Stylomenia salvatori*, and several other species. These are either relatively large calcareous paired spines, which ordinarily are concealed in sheaths formed as anteriorly directed diverticula of the cloacal wall, provided with protractor and retractor muscles and in some cases with a gland, or similar diverticula, may conceal numerous spines of much smaller size. While the function of these organs is unknown it is reasonable to believe, with several authors, that they are excitants and possibly in a few species they may serve to attach the animals *in coitu*.

The preanal gland (Hubrecht), which is attached to the anterior face of the cloacal wall in *Proneomenia sluiteri*, and opens at the end of the pedal furrow or right and left under the cloaca, may be associated in some way with the reproductive process.

Physiology.— Several authors, notably Wiren, have called attention to the striking resemblance between the Chiton kidney and the coelomoducts of certain species of Chaetoderma; and again the presence of crystals has been noted in these same organs. It thus becomes very probable that they aid in the removal of waste matters, and as noted on page 169 the fact that the male and female glands are identical in form and structure indicates that they play no especially important part in the egg-laying process, merely conveying the ova from the pericardium to the exterior. In the Neomeniina there are certain indications that the coelomoducts do not serve as kidneys, and the fact that they are non-glandular in immature individuals points also to their non-excretory character.

In other parts of the body of several other species of Solenogastres there are organs of widely different character which are believed by various authors to hold the office of excretory organs. These include a number of structures which are in close proximity to the cloacal wall or are modifications of it. Among them are anal, preanal, or byssus (improbable) glands probably not in all cases homologous and evidently in some species playing a part in the process of reproduction, especially where they are muscular, vesicular invaginations of the cloacal wall. Pruvot described a mass of spongy, glandular cells in *Myzomenia banyulensis*, forming a low elevation on the floor of the cloacal cavity, and containing yellow granules similar to others of larger size in the free cells of the underlying tissue. The supposition is that these last named elements are leucocytes, which, collecting materials from the blood, pass them to the cloacal wall from whence they are voided to the exterior. Thiele states also that in *Proneomenia neapolitana* there is an accumulation of cells irregular in form, forming a preanal gland between the hypodermis and the somatic musculature. Similar elements are attached to the cloacal wall, the rectum, and coelomoducts, and others of somewhat like character are found in the intestinal sinus. Their resemblance to chlorogogue cells is marked, and for this reason chiefly they are believed to exercise the same function. Heath also has noted the presence of certain cells, along the ventral sinus of *Limifossor talpoideus*, whose shape and granular contents suggest the connective-tissue, concrement-bearing elements in the Chitons and other molluscs as noted by Brock. The papillae have been looked upon as glandular bodies by several authors and of these a few consider them to be excretory. On the other hand they may function as organs of special sense (see page 40).

Respiration to a certain extent probably occurs over the general surface of the body, especially in those species with thin cuticle or where the cuticle is provided with blood sinuses. The ventral groove, as several authors have suggested, certainly permits the interchange of gases. The walls of the atrial cavity, especially the cirri and ciliated folds are believed also to take a share in the process, and it has even been suggested that the entire stomach-intestine may be active. In the Chaetodermatina definite ctenidia perform the respiratory function, while in the Neomeniina the thin walls of the cloacal cavity, often thrown into folds, sometimes of enormous size, and in contact with extensive blood sinuses, are undoubted active agents in this respect.

In some species, such as in Alexandromenia the atrial ridges are of large size and their superficial extent is increased by the development of secondary folds and papillae. As these are penetrated by large blood sinuses it is probable that they act to a certain extent as respiratory organs though it is doubtful if this is their chief duty. The cirri on the other hand never, or very rarely, contain blood spaces and are very probably special sense organs.

As the functions ascribed to the various sense organs, real or supposed, have been tested experimentally in a few cases only, it is not surprising that the opinions of authors differ widely. Considering first the sense of touch it is probable that it is located over the general body surface, for living specimens of *Chaetoderma erudita* and *C. montereyensis* respond to mechanical stimuli applied at any point. A number of investigators have noted the presence of nerves in contact with the hypodermis in other species and Wiren has traced some of them into the deeper portions of the cuticle where they are supposed to function in the sense of touch. In those species with thin cuticle and freely projecting spines it is likewise supposed that the latter serve as tactile organs. This same activity is ascribed also by Thiele to sense cells which he has detected in the foot of certain Neomeniidae (*Neomenia grandis, Proneomenia vagans*). Of the various activities which have been connected with the much discussed papillae of the hypodermis is the ability to distinguish vibrations, amount of water pressure, or more generalized stimuli affecting the tactile sense. It is to be noted, however, that on the other hand these organs are said by several authors to be strictly glandular. A remarkable problematical relation of some of the papillae, considerably modified, to the anterior coecum of the stomach-intestine in *Halomenia gravida* (p. 147) is difficult to explain on any hypothesis.

From experiments Wiren finds the gills of Chaetoderma to be very sensitive, and considers that the stiff hairs situated among the cilia are probably tactile. The buccal papillae are said by Heuscher to be organs of touch; they are certainly not universally, if ever, food collecting organs. In close connection with the anterior border of the mouth of a few species in a living condition Pruvot, and Kowalevsky and Marion have detected sensory hairs, that in some species are attached to elevations, apparently the homologue of the sensory ridge, that

I have found paralleling to some extent the outer buccal sensory fold (p. 84). Pruvot has noted that as some of these animals progress they move the anterior end of the body from side to side, and appear to be using the organs in question to detect the character of their surroundings, so that they may be tactile. In Ichthyomenia there are many pits, apparently ciliated, in the anterior end of the body. These are probably sense organs, but of unknown function.

The buccal sensory plate in the Chaetodermatidae with its enormous nerve supply may very probably function also as a tactile organ as Wiren and others have assumed, but it is to be noted that while this structure takes an active part in the excavation of burrows it is probable that it serves to detect the presence of food. At all events the alimentary canal of these animals is singularly free from inorganic materials, and in the absence of any other well-defined organs in or near the buccal cavity it is not improbable that the plate acts as an olfactory or more than usually delicate tactile organ. These same activities or possibly the sense of taste have been assigned to the frontal sense organ noted in the preceding paragraph.

The dorso-terminal groove in the Chaetodermatidae and its homologue in the Neomeniidae is usually considered to be an organ of special sense, Heuscher alone alleging the contrary owing to the fact that the depression in *Proneomenia sluiteri* was filled with detritus. This condition is not infrequently encountered in animals which have been excavated from the material in a dredge, but it is certainly not a normal state of affairs. Concerning its function we have absolutely no positive evidence. It is reported by Pruvot that it may hold the same office as the frontal sense organ though the belief appears to rest upon nothing more tangible than a certain similarity of structure.

CLASSIFICATION.

While the modification, by Nierstrasz, of Simroth's scheme of classification doubtless fails of necessity to indicate accurately the phylogenetic relationships of the Solenogastres it has the virtue of being more convenient than any other now in use and hence has been adopted in large measure. The family name Parameniidae must be discontinued. Cockerell ('03) has shown that Pruvot's genus Paramenia is preoccupied and has proposed the name Pruvotina, hence in the following table I have used a new family name Pruvotiniidae. The family

Lepidomeniidae Nstr. containing Dondersia must retain Simroth's name Dondersiidae.

As has been noted by other authors the genus Proneomenia as created by Hubrecht, has been much enlarged to include a number of species some of which probably belong to other genera. *Proneomenia weberi* appears to be very closely related to *Dorymenia acuta* and may in reality belong to Dorymenia.

In the genus Strophomenia the long pharynx, the papillae and the numerous seminal receptacles are so characteristic and similar in the species of the present collection that I have no hesitancy in placing all in the same genus. Pruvot's material was poorly preserved, as he states, and under such circumstances the peculiar condition of the ventral salivary glands is readily explained as I know from experience. The radula sac is likewise incorrectly placed, being much too far forward. Evidently in Pruvot's species all traces of this organ have disappeared. With this revision the species are quite similar. It is probable that *Rhopalomenia indica* Nierstrasz belongs to this genus.

Order APLACOPHORA v. IHERING.

Suborder. I. Chaetodermatina Simroth.
Spiculose integument continuous all around the body.
Chaetodermatidae, p. 42.

Suborder II. Neomeniina Simroth.
Spiculose integument interrupted beneath by a longitudinal ventral furrow.
Neomeniidae, p. 44.
Proneomeniidae, p. 45.
Pruvotiniidae, p. 47.
Dondersiidae, p. 48.

CHAETODERMATIDAE SIMROTH.

Opening of mouth and anal chamber terminal. Body with more or less sharply marked regions. Ventral furrow and fold lacking. Two highly developed plume-like gills. Radula distichous, polyserial or strongly reduced to a large unpaired cuticular tooth. The mid-gut possesses, in most cases, a well-developed digestive gland. Copulatory apparatus lacking. Coelomoducts remain separate. Cuticle thin, spicules flat, often needle-form, but solid. Inhabit bottom ooze.

Chaetoderma Loven, 1845.

Body vermiform, without ventral groove; mouth and anal chamber terminal. Two gills. Sexes separate. Radula reduced to conical peg. Type of genus *C. nitidulum.*

C. argentea, sp. nov.

Length 24 mm. by 1.6 and 2.6 mm. through the metathorax and preabdomen respectively. Silvery white. Spines, in side view, usually bent. Alaska. (p. 62.)

C. attenuata, sp. nov.

Body long and slender, measuring 61 mm. in length by 1.5 through the metathorax and 2.7 through the preabdomen. Buccal plate relatively small. Alaska. (p. 55.)

C. californica, sp. nov.

Body measuring 24 mm. in length by 1.6 mm. greatest diameter. Larger spines with expanded bases. California. (p. 64.)

C. erudita, sp. nov.

Average length, in preserved state, 27 mm. by 2.5 mm. average thickness of preabdomen. Buccal plate deeply cleft by mouth opening. Brain of large size. Alaska. (p. 59.)

C. hawaiiensis, sp. nov.

Body slender, measuring 12–19 mm. in length by 0.5–0.6 mm. greatest thickness. Buccal plate broadly elliptical, perforated in centre by mouth. Hawaii. (p. 49.)

C. japonica, sp. nov.

Length 17 mm. by 1.5 mm. greatest thickness, buccal plate shield-shape, perforated by mouth opening. Japan. (p. 67.)

C. montereyensis, sp. nov.

Length 45 mm. by 3 mm. greatest diameter. Buccal plate unusually large. Tooth stout. Monterey Bay, California. (p. 61.)

C. nanula, sp. nov.

Body small, comparatively stout, measuring 9 mm. in length by 1.4 mm. greatest diameter. Spines keeled and of heavy appearance. California. (p. 66.)

C. robusta, sp. nov.

Body heavy, measuring 60 mm. long by 3.5 and 4.7 mm. through the metathorax and preabdomen respectively. Buccal plate shield-shape. Largest spines relatively slender without definite keel. Alaska. (p. 68.)

C. scabra, sp. nov.

Small, measuring 12 mm. in length by 2 mm. greatest diameter. Body wall relatively thin. Brownish, becoming olive-green in region of digestive gland. Monterey Bay, California (p. 63.)

Limifossor HEATH, 1904.

Body short. Radula very large, distichous, with twenty-eight transverse rows in *L. talpoideus* (about the same number in *L. fratula*). Dorsal salivary glands present. Stomach and digestive gland well developed, and distinct from intestine. Type of genus, *L. talpoideus.*

L. fratula, sp. nov.

Slaty gray with yellowish cast. Spines from middle of body 0.5 mm. long. Length index 1.3–4.7. California. (p. 72.)

L. talpoideus.

Slaty gray in color. Spines, from all parts of the body, 0.02–0.38 mm. in length. Length index 1–6. Alaska. (p. 69.)

NEOMENIIDAE SIMROTH.

Body compressed, more or less crescent-shaped, without distinct divisions. Index 7 at most. Opening of atrium ventral, of the anal chamber ventral or terminal. Ventral furrow present, usually with several folds. Cuticle sometimes comparatively thick, spines mostly needle-like, flat, grooved, or hollow. A circlet of gills in the anal chamber. Radula and salivary glands usually lacking. Epidermal papillae, of simple structure, usually present. Fore gut protrusible. Coelomoducts separate or united to form shell gland or copulatory organ. Digestive gland lacking. Penial spines usually present. Free, creeping about over bottom.

Drepanomenia, gen. nov.

Body short and thick. Hollow needle-like spines with truncated bases; slender stalked papillae. Ventral salivary glands long and tubular. Coelomoducts simple, without appendages. No copulatory apparatus. Type of genus *D. vampyrella*, sp. nov.

With characters of the genus. Hawaii. (p. 77.)

Pachymenia, gen. nov.

Body stout, measuring 27 by 4.5 mm. One layer of awl-like spines, papillae multicellular with broad bases, posteriorly ill defined. Pharynx very large and muscular with numerous glands some of which open by one pair of ducts at forward border of pharynx. Dorsal and ventral limbs of coelomoducts provided with numerous glands. One pair of small seminal receptacles. Cloacal wall covered with glands except region of branchial folds. No copulatory spines. Type of genus

P. abyssorum, sp. nov.

With characters of the genus. California. (p. 72.)

PRONEOMENIIDAE Simroth.

Worm-like. Radula distichous or polystichous, sometimes lacking. Salivary glands tubular, lobed or lacking. Cuticle thick, spicules mostly needle-like in several layers. Epidermal papillae present. Gills usually lacking. Coelomoducts usually united into shell gland, sometimes separated. Copulatory apparatus may be present. Free living, partly or entirely parasitic.

Proneomenia Hubrecht, 1880.

Body elongated, vermiform, the length 9–50 times the diameter. Cloaca opening ventral. Foot present, the groove passing into the cloaca. Cuticle thick with crowded spicules. No gills. Radula multidentate. Two salivary glands. Copulatory organs present or absent. Type of genus, *P. sluiteri*.

P. hawaiiensis, sp. nov.

Length 36 by 2 mm. Dorsal and ventral salivary glands. Radula with 38–40 teeth in each transverse row. One pair of seminal receptacles. No copulatory organs. Hawaii. (p. 82.)

P. insularis, sp. nov.

Anterior end similar to the foregoing species (posterior end missing). One pair long, tubular salivary glands. Radula polystichous with 28 transverse rows. Hawaii. (p. 90.)

Driomenia, gen. nov.

Measurement 9 by 1 mm. Cuticle thick, papillae present, spines needle-shaped, slightly curved. Atrium separate from mouth opening, no radula, one pair globular ventral salivary glands. Antero-lateral pericardial wall prolonged into a pair of horn-like pouches. One pair seminal receptacles. No copulatory spines. Gills absent. Type of genus

D. pacifica, sp. nov.

With characters of the genus. Japan. (p. 93.)

Dorymenia, gen. nov.

Vermiform, body terminating posteriorly in a finger-shaped elongation. Radula polystichous, with 48–51 longitudinal rows of 22 teeth each. One pair of seminal receptacles. A pair of long copulation spicules closely associated with a pair of globular coeca likewise opening separately into the cloaca. Type of genus

D. acuta, sp. nov.

With the characters of the genus. California. (p. 95.)

Strophomenia Pruvot, 1899.

Body elongated, cylindrical, the thick cuticle penetrated by acicular spicules and closely crowded vesicular papillae; radula and salivary ducts, caudal sense organ sometimes absent (?); two distinct genital openings into the cloaca. Type of genus, *S. lacazei*.

S. farcimen, sp. nov.

Length 18 by 2 mm. Papillae small, closely crowded. Radula with 15 transverse rows of 24–28 teeth. 19 seminal receptacles. Japan. (p. 119.)

S. ophidiana, sp. nov.

Length 43 by 2.5 mm. Papillae fairly numerous. No radula. 23 small seminal receptacles. Japan. (p. 112.)

S. regularis, sp. nov.

Anterior end missing. Papillae small, closely crowded. 12 seminal receptacles. Japan. (p. 116.)

S. scandens, sp. nov.

Length 32–39 by 1.6–2.1 mm. diamter. Papillae crowded. No radula. 15–18 seminal receptacles. Hawaii. (p. 106.)

S. spinosa, sp. nov.

Length 28 by 1 mm. Papillae few. Radula small, monoserial or biserial with 8 transverse rows. 12–31 seminal receptacles. Japan. (p. 122.)

S. triangularis, sp. nov.

Length 12 mm. by 1.6 mm. diameter. Triangular in cross section. Radula distichous, apparently comb-like with 16 cusps in each row. Seminal receptacles 10–12. Japan. (p. 125.)

PRUVOTINIIDAE, nom. nov.

Worm-like. Cuticle, as a rule, thick; spines as in Proneomeniidae or hook-like. Epidermal papillae present or absent. Radula distichous, simple or double comb-form, or lacking. Salivary glands globular, lobed or tubular. Gill folds present. Coelomoducts united to form unpaired shell gland. Copulatory apparatus may be present. Ventral furrow and fold present. Free or living on coral, etc.

Lophomenia gen. nov.

With dorsal keel; length 24 mm., diameter 1.5 mm., 3 ventral folds. Cuticle thick, with numerous needle-like spines in several layers; papillae few, club-shaped. Radula distichous, 20 transverse rows. Dorsal salivary gland large; ventral globular. 2 seminal receptacles, 2 bundles of many copulatory spines. Type of genus

L. spiralis, sp. nov.

With characters of the genus. Hawaii. (p. 128.)

Alexandromenia, gen. nov.

Body relatively short and thick, length 25–32 mm. by 3.5–5 mm. diameter. Spicules small needle-like associated with larger radially directed ones. Papillae very large, multinucleate. Foot, 5–9 folds. Gill folds 20–40. Numerous pharyngeal glands and enormous lobulated glands opening on the sides of the pharynx. Radula monoserial. 1 pair seminal receptacles. Type of genus

A. agassizi, sp. nov.

Posterior end truncated, gills exposed. Monoserial radula with slightly curved rectangular teeth. 40 gill folds. California. (p. 133.)

A. valida, sp. nov.

Posterior end rounded, cloaca opening ventral. Teeth with two horn-like projections. 20 gill folds. California. (p. 142.)

Halomenia, gen nov.

Body short, length index 7:1. Spicules needle-like. Papillae large, in places resting upon diverticula of the mid gut. 2 ventral folds. Gills 26–30. Radula distichous. 1 pair seminal receptacles or vesicles. Type of genus

H. gravida, sp. nov.

With the characters of the genus. Kurile Islands. (p. 146.)

DONDERSIIDAE Simroth.

Body often worm-like. Cuticle thin; spines flat and solid. Papillae lacking. Radula distichous, monoserial or lacking. Salivary glands globular, sac- or tube-like. Gill folds lacking. Coelomoducts united or separate. Copulatory apparatus may be present. Ventral fold and furrow may be absent. Living free, or on corals, etc.

Herpomenia, gen. nov.

Length 11–18 mm. by 0.6–0.9 mm. Foot smoothed out, ciliated. Ventral salivary glands very large, encircling the thick walled very muscular pharynx. Radula lacking. 1 pair seminal receptacles. Shell gland almost globular. Type of genus

H. platypoda, sp. nov.

With the characters of the genus. Aleutian Ids., Alaska. (p. 151.)

Dondersia Hubrecht, 1888.

Body long, length index 10–48. 1 ventral fold. Spicula needle- or spatula-shaped, flat. Cuticle very thin, no papillae. Dorso-terminal sense knots present. 1 pair of short ventral salivary glands, which unite before opening out into the pharynx. Radula small, monoserial or biserial. Mouth cavity and pharynx opening separated from each other. No copulation spicula. Type of genus, *D. festiva.*

D. californica, sp. nov.

Dorsal salivary glands very scant; ventral small. Radula with at least 12 pairs of teeth. Immature. California. (p. 155.)

Ichthyomenia Pilsbry, 1898.

Body cylindric-conic, broader behind, narrowed in front. Cloaca opening a terminal transverse slit, a prominence in front of it. Foot groove and foot present, disappearing posteriorly. Cuticle not papillose, the ventral spicules leaf-shaped, the rest scale-like, imbricating. No gills. Radula well developed or rudimentary, with apparently two rows of teeth. Length 5 to 13 times the breadth. Type of genus, *I. ichthyodes.*

I. porosa, sp. nov.

Body pale yellowish white, 16 mm. long by 1.2 mm. thick. Scales fish-like and club-shaped. Upwards of 50 sensory pits in the anterior end. No radula. California coast. (p. 159.)

DESCRIPTION OF SPECIES.

Chaetoderma hawaiiensis, sp. nov.

Two specimens of this species were dredged in the vicinity of Kauai Island. The first came from the western end (Sta. 4130) at a depth of 283–309 fath.; the second from the northern extremity, Mokuaeae Islet (Sta. 3992), at a depth of 528 fath.

The first specimen was found in a mass of polyps of Epizoanthus (Plate **2**, fig. 3) elevated at least a foot above the bottom, and densely matted together in such a manner as to preclude the possibility of accidental lodgment. The second individual was found by Dr. W. K. Fisher among the spines of a species of starfish (*Odinia pacifica* Fisher) also in such a position that it could scarcely be due to accidental shifting. There is no especial reason for considering this species a parasitic form nor indeed a commensal, for the food in the alimentary canal consisted of small quantities of plant spores, sponge spicules, and organic debris such as is ordinarily found in those species that burrow in the ooze. It seems more probable that it, like *Chaetoderma nitidulum*, as described by Wiren, may leave its burrow to crawl about on the bottom, or as in the present case even on the bodies of other animals.

In its external features this species displays the usual characteristics of other members of the family. The body including the globular and apparently non-retractile prothorax, itself about 2 mm. in length, is 12 mm. long. Immediately behind the swollen part of the prothorax the diameter of the body is 0.65 mm., and this continues with little change through the anterior half of the animal. Beyond this point the calibre gradually increases to $1\frac{1}{3}$ mm. in the neighborhood of the cloaca, beyond which a slight decrease occurs that continues to the end of the body. In the other specimen the size of the prothorax is the same, but the length of the metathorax (19 mm.; diameter 0.5 mm.) and the abdomen (7 mm.; diameter 1 mm.) is considerably greater and bears witness to the futility of using the length index in the discrimination of some species.

The color of both specimens is a slaty gray, though this is usually obscured by an inorganic incrustation covering the body generally. In the region of the metathorax the larger spines are completely hidden in a granular deposit that gives this part of the animal a brick-red shade. The same substance, in one case black in color, is present in several other species of Chaetodermatidae in my possession, and may perhaps be an excretory product thrown out from the coelomoducts.

The cuticular plate covering the frontal sense organ is almost circular in outline and is elevated above the general surface of the prothorax. This is especially the case with the lateral portions which assume the form of pronounced folds decreasing in height as the centre of the organ is approached. The boundary between the cuticle and the underlying epithelial cells is not sharp and the outlines of the cells themselves are not clearly visible. The greater number appear to be sensory elements and are distinguished by their relatively slender appearance (the diameter being to the height as one to four) and by darkly staining elongated nuclei placed in the basal half of the cell. Among these are a few cells of the same height, but of greater diameter, which contain spherical centrally placed nuclei with a small amount of chromatin. Great numbers of ganglion cells are situated in immediate contact with this sensory plate, and some of the more deeply seated clearly connect with nerves passing out from the precerebral ganglia (as I have termed the great accumulations of ganglion cells in contact with the brain in the Chaetodermatidae), and on the other hand originate fibres that pass down to the frontal organ (Plate **28**, fig. 1). A very few small pyriform gland cells, staining almost black in haematoxylin, extend from the midst of the ganglion cells to the sense organ where they probably open to the surface. Large numbers of muscle fibres attach also to the sensory epithelium and at several points there are indications that they pass between the hypodermal cells and connect directly with the overlying cuticle.

The hypodermis is practically the same as in other species and not particularly favorable for the solution of any of the several problems connected with it. Its cells differ considerably in form and appearance. In the swollen part of the prothorax they are slightly higher than broad; in the metathorax the reverse is true; while in the abdominal region the height is about twice the diameter. Everywhere their boundaries are indistinct, and thus unlike the sharply defined central nuclei. Here and there are more slender elements with elongated darkly staining nuclei, and somewhat more numerous are the basal cells in contact with the base of the overlying spicules. These latter cells vary widely in general appearance from very small compact elements to others large, globular, and much vacuolated, owing to different stages of development and probably to some extent to mechanical compression. No pigment cells exist, nor wandering cells nor other elements that are sufficiently different from the usual constituents to be placed in a separate catagory.

The spicules are of the usual spearhead shape, and form a continuous series of increasing size, from those of the prothorax with a length of .0275 mm.

to others on the postabdomen .225 mm. long. Plate **37**, fig. 12, gives an accurate idea of the usual type of spine, these being from the middle of the metathorax.

The mouth opening is situated about the centre of the frontal sense organ and is remarkable for its minuteness. From here to the region of the radula the canal is relatively small, not exceeding one seventh of the greatest diameter of the prothorax. It is invested by a thin layer of muscles and is attached also to a considerable number of scattered fibres that pass outward and are inserted in the body wall. Ganglion cells arranged in groups as in the Neomeniidae are also fastened to the buccal mass. The epithelial lining consists of high columnar cells with basal nuclei imbedded in moderately dense cytoplasm, that more distally becomes filled with a finely granular colorless secretion. In one specimen particles of a golden yellow color occurred in, or between, some of these elements, but whether they were developed *in situ*, or had been produced by cells more externally placed, it is impossible to determine.

While in one specimen the digestive tract continues of about the same calibre throughout, the other expands widely in the region of the radula, and at the anterior end of this enlargement a circular fold is present that is probably homologous with the proboscis of Drepanomenia, for example. In one individual this swollen section is almost completely filled with diatoms, plant spores, sponge spicules, and organic remains some of which appear to have been mixed with some viscous secretion and moulded into globular masses.

From a point corresponding to the hinder border of the globular part of the prothorax to the anterior end of the preabdomen, the wall of the digestive tract is relatively thin due to the scarcity of muscle fibres and the lowness of the epithelial cells. The latter are columnar elements of medium height with spherical basal nuclei and an abundance of a finely granular, light yellow substance filling the entire distal half. At various points throughout the prothorax and metathorax this substance is in the act of escaping in the form of droplets constricted from the cell, and all stages exist between this and the development of a finely granular secretion filling the canal. Cells freed of this secretion are cubical in form and are usually relatively dense. Cleared specimens show that while in this part of the gut true pouches do not exist the canal is by no means entirely straight, wrinkles and folds occurring throughout, though they lack the definiteness and regularity of the dilations in the Neomeniidae.

At the level of the front end of the gonad the development of digestive fluids becomes relegated to a set of cells that form a large diverticulum extending to the hind end of the body. In this digestive gland, judging from the material in hand, two distinct kinds of material are secreted, but in widely differing quantities according to the locality. The cells attached to the gonad are usually more or less pyriform with comparatively small, dense almost homogeneous nuclei placed basally, while the remaining protoplasm is closely packed with innumerable granules. By far the greater number of these are spherical and of yellow or slightly greenish yellow tint. They are liberated, as is the secretion in the more anterior parts of the gut, by the constriction of droplets from the distal end, and may be seen undergoing disintegration and solution in many different places. Among the granules of this character are others in the form of small particles of a distinct pink or violet color after treatment with haematoxylin. They have every appearance of being an end product and not a stage in the development of the more abundant secretion.

Elsewhere in the gland the cells are of looser texture, the basal nuclei are relatively larger and granular and many if not all contain the two species of secretion just described. Generally the yellowish product is scant in amount, while in many cells the violet tinted substance accumulates in spherical or elliptical masses, surrounded by a vacuole in preserved specimens, that almost fills the cell. These secretory products are passed out entire, and in a single section as many as twenty-five may hold positions in the lumen of the gland. Making their way forward many if not all pass into the intestine, and here may be seen in various stages of solution, forming at first a vacuolated product that before dissolving completely transforms into a finely granular material of maroon color after treatment with haematoxylin.

The cells of the intestine are cubical in form and in front of the pericardium show signs of slight glandular activity. Behind this point this phase of activity disappears, and cilia become developed and continue to the opening into the cloacal cavity.

The large size of the ganglia and the abundance of the nerve cells that envelop them and also the sharpness of even the smaller nerves renders it possible without much effort to gain a very clear idea of the nervous system of this species (see Plate 7, fig. 2). As is there shown the brain, located some distance above the digestive tract, is distinctly enveloped in a delicate connective-tissue sheath and is clearly bilobed in form though its outlines are somewhat obscured by great masses of ganglion cells (forming the precerebral ganglia) attached chiefly to its lateral and anterior surface. A considerable number of delicate fibres, passing out from the brain, attach to these ganglionic bodies which in turn are connected with large numbers of nerve fibres that pass chiefly to the walls of the mouth and the frontal sense organ.

This part of the nervous system is thus essentially as we find it in other Solenogastres. In *Proneomenia hawaiiensis*, for example, the supraoesophageal ganglia are connected with several nerves some of which unite with groups of ganglion cells attached to the bases of the cirri, and from these again other nerves pass to the digestive tract and probably to the body wall. In Chaetoderma the chief difference is that the nerves uniting the brain and precerebral ganglia are very short.

In the present species the pedal and lateral connectives unite immediately before plunging through the precerebral ganglia, and as Plate 7, fig. 2 shows the labio-buccal cord unites with them before the brain is reached. This same condition of affairs exists also in two species of this genus taken in Alaska, though much more obscured than in the present species. At the posterior end of the prothorax the pedal and lateral cords that have gradually approached each other actually come in contact and in one specimen even fuse for a short distance and lose the usual sheath of ganglion cells. Anterior to this point two pedal commissures exist, but until the hindmost part of the body is reached no farther trace of such nerves has been found. On the other hand latero-pedal connectives are present throughout the entire length of the animal.

The relations of the labio-buccal ganglia are represented in Plate 7, fig. 2. The non-ganglionic connectives imbedded in the pharyngeal wall unite with the superficially attached ganglia, that are also united by a commissure passing behind the median tooth. In front of the radula there are connectives giving rise to nerves passing dorsally to what is probably the subradular organ and in addition attaching to a ganglionic mass in the mid line. As this part of the nervous system appears with greater distinctness in *C. attenuata* it is more fully described in that connection.

Throughout the entire metathorax the lateral and pedal cords pursue their course almost in contact, here and there giving rise to nerves that soon disappear, and finally join in the extreme posterior end of the body. Shortly after their union they are connected by a heavy ganglionic commissure passing dorsal to the intestine. In the mid line it develops a single nerve that makes its way into the tissue of the rectum, while on the dorsal side four fibres originate, two of which pass at once into the gills while the others attach to the inner side of the cloacal epithelium, and branching repeatedly supply this membrane and the dorsal body wall and a well-marked fold of the hypodermis to be described presently. At the junction of the latero-pedal cord and the commissure a nerve arises that passes backward and appears to supply the ventral body wall of the cloacal region.

Owing to the debris encrusting the posterior end of the body it is impossible to determine the position of the dorsal sensory groove in entire specimens. In sections it is seen to occupy the usual position, that is from the extreme hinder end of the animal forward to a point almost immediately above the level of the anal opening. As is represented Plate 6, fig. 8, it consists of a relatively deep fold of the hypodermis, that anteriorly rapidly disappears but is continuous with a ridge-like elevation in the mid dorsal line extending for a short distance more anteriorly. Some of the spines of the immediate neighborhood are of comparatively small size and overarch the depression, which is also covered by a thin continuation of the cuticle investing the body.

The cells of this organ consist of those common to the hypodermis, and others which are much more slender and compact with spindle-shaped nuclei usually subcentrally placed. The latter elements are probably sensory and connect with small groups of ganglion cells holding positions immediately beneath the circular somatic muscles in the neighborhood of the organ, and on the other hand are undoubtedly related with nerves from the branchial ganglia. That this is a definite sense organ and the homologue of the dorsal organ of the Neomeniidae, as maintained by various authors, there is little doubt, but there is nothing that more definitely establishes its function.

The gonad extends from the front end of the metathorax to the pericardium with which it is united by two short and comparatively wide ducts. Both specimens were sexually mature males and considerable quantities of spermatozoa occupied positions in the pericardial cavity, and at various points in the coelomoducts. These last mentioned organs arise from the postero-lateral borders of the pericardial chamber in the form of clearly defined tubes, whose cells are nearly cubical in form and support an abundance of large cilia. Bending sharply inward each becomes continuous with a canal, of much larger size and different structure, that after extending forward for a short distance pursues an irregular course opening symmetrically on each side of the rectum. The large non-ciliated portion of the ducts is composed of rather low cells with well-defined, basally placed nuclei, in which the chromatin exists in the form of a moderate number of sharply defined granules. In the more distal part of each cell is a sharply defined vacuole, in which are one or two light greenish yellow bodies, having the appearance of concrements such as occur in the kidneys of several molluscs. At various places these are in the act of escaping through the ruptured or dissolved end of the cell or having become free are undergoing a process of solution. Such an appearance in the kidney of other molluscs would not in any way appear unusual.

and leads to the irresistible conclusion that here the coelomoducts are not only morphologically related to the renal organs in the Chitons or other molluscs, but physiologically also as Wiren first clearly stated.

Chaetoderma attenuata, sp. nov.

Eight specimens of this species were dredged near the southern limit of Alaska, buried in glacial mud brought down chiefly by the Stikine River. One from Kasaan Bay (Sta. 4244) occurred in green mud at a depth of 50–54 fathoms; five opposite the mouth of the Stikine River (Sta. 4250) were in the same habitat at a depth of 61–66 faths.; while two in the waters of Stephens Passage (Sta. 4252) were buried in gray mud at a depth of 198–201 faths. Their appearance in life, Plate **4**, fig. 3, answers closely for preserved material. The type specimen measured 45 mm. in length by 1.7 mm. through the metatherax, and 2.6 mm. through the abdomen. The color of alcoholic material, which is the same as the living save for the pinkish tinge due to haemaglobin in the head and gill region, is almost white with a tinge of yellow, becoming grayish where the liver is located.

The body wall, including muscular, hypodermal, and cuticular layers, is of median thickness and is typically located, but in specimens killed in vom Rath's fluid certain elements appear that have not been fully described, though they probably occur in all species of the genus. These are the so-called giant cells (Riesenzellen Wiren) which in ordinary material present the form of empty vesicles with the nucleus imbedded in the wall. In life this cavity is filled with a secretion, that after treatment with fluids containing osmic acid, is granular as Wiren has remarked. In favorable situations it may readily be seen that fibres, muscular at least in part, extend from the somatic musculature and penetrating the hypodermal layer attach to the sides of these cells (Plate **25**, fig. 7). Appearances suggest that the secretion, upon the contraction of the fibres, is forced into the neighboring lacunae, but in no case has this been actually observed though proximally the cell may be produced into a comparatively slender, short stalk. Distally the cells are usually in close contact with the free surface of the cuticle and present a sharply defined rounded appearance. Posteriorly these elements become somewhat less numerous and of smaller size. In alcoholic killed material the fibres may be distinguished, but their attachment to the cell body is very indistinct.

Wiren ('92) states that these giant cells are not sharply differentiated from the basal matrix cells of the spicules, but this refers, so far as I am able to judge, merely to their form as the spicule mother cells do not contain any clearly defined granular secretion. On the other hand the matrix cells shade much more perfectly into the cubical elements that probably form the cuticle.

The mouth, placed in a cleft on the dorsal side of the buccal plate, opens into a tube whose form and general appearance are represented (Plate **25**, fig. 1). The lining epithelium consists of the usual high columnar cells produced into several irregular longitudinal folds, through which the outlets of the buccal glands make their way. These last named organs are comparatively abundant, especially on the ventral side of the pharynx, and extend from the region of the brain to the radula.

A subradular organ certainly exists in this and several other species, if position and innervation be any criterion. In material killed in vom Rath's fluid it appears with the greatest distinctness as a sharply defined median area composed of high columnar cells situated immediately in front of the peg-like tooth (Plate **25**, fig. 10). In alcoholic material the appearance is not so striking, and yet there is very little difficulty in distinguishing the organ. However, with such material it is sometimes a task to determine its innervation. Nerves in the immediate vicinity are usually visible, but to trace these into the ganglia is frequently a perplexing operation. In vom Rath's material on the other hand the entire system is clearly differentiated (see section on nervous system).

The radula and its supports (Plate **25**, fig. 2) are of comparatively large size but are typically arranged and require no especial description. Beyond the radula the gut becomes circular (Plate **25**, fig. 3), the epithelium relatively high and a finely granular secretion fills the distal two thirds of the component cells. Among these are a very few more globular elements with a darkly staining more granular secretion. Beyond the pharynx the gut widens, the cells become lower and slightly glandular with the exception of a very few cells containing a yellow secretion. Beyond this point the relations of stomach, intestine, and liver are typical and require no detailed description.

The brain and anterior portion of the nervous system closely resemble what is found in *C. erudita*, and so require but little additional description. It appears that the labio-buccal connectives have an origin independent of the lateral and pedal, which as in *C. erudita* unite before entering the brain. The commissures of the pedal cords are relatively more slender than those of *C. erudita*, save the anterior one which is of exceptional thickness. In some cases nerves arise from the commissures and are distributed to the body wall.

The labio-buccal system is of unusual interest since it possesses what may be considered to be a subradular system with ganglia and connectives with fibres passing into the above described organ in front of the radula. The labio-buccal connectives pass backward as usual and unite with the well-known ganglia imbedded in the pharyngeal musculature: and these bodies are in turn united by a cord in which two small ganglia are intercalated. A nerve which apparently has escaped observation arises from the posterior surface of each of the larger ganglia (Plate **13**, fig. 3), and imbedded in the pharyngeal wall may be traced to the forward border of the stomach.

A short distance in front of the labio-buccal ganglia a clearly defined fibre arises from each of the connectives (Plate **13**, fig. 3), and, imbedded in the muscle of the pharynx, courses downward and inward and joins a ganglionic mass that gives slight evidence of being paired (Plate **25**, fig. 10). To the outside of the ganglion (or ganglia) a nerve arises from each of these connectives uniting with the labio-buccal connectives, and coursing dorsally attaches to the base of the subradular organ.

There is absolutely no doubt of the existence of this system, the grayish nerves showing with great distinctness against the yellowish muscle fibres in material killed in vom Rath's fluid. In material fixed in alcohol on the other hand it is sometimes difficult to trace. The ganglionic mass may closely resemble a salivary gland and the nerves from it counterfeit muscle fibres; nevertheless with an oil immersion lens I have been able to demonstrate its presence in all the species of the genus described in the present paper, and in a specimen of *C. nitidulum* kindly sent me by Professor Hubrecht. As is more fully noted on page 172 I believe that the ganglion and its connectives constitute a subradular system the homologue of the one I have described in some of the Neomeniidae.

Posteriorly the pedal and lateral ganglia unite in the customary fashion, and at the point of union give rise to two small nerves which become closely applied to the body wall, and after branching are lost to sight among the longitudinal somatic muscle fibres. From the suprarectal ganglionic mass (Plate **12**, fig. 4), several branches arise some of which appear to have escaped observation, or at all events have not been traced to any considerable extent. Of these the larger pair originate from the ventral side of the ganglion and make their way ventrally to the sides of the rectum, where according to Wiren's figures and description they diminish very rapidly in diameter and form a delicate subrectal commissure. In the present species this is certainly not the case, nor is it true of *C. erudita*, for arriving at the rectum each follows it posteriorly to the anal opening, and then passes outward almost at a right angle and becomes imbedded in the ventral gill retractors and in this position may be traced almost to the apex of the gill. Between its point of origin and its attachment to the rectum at least four small nerves arise and extend fan-like into the ventral gill retractors which they probably innervate. I have been unable to find any subrectal commissure.

From the dorsal side of the suprarectal commissure four nerves arise, of which the outermost pair extends dorsally through the superior gill retractors, and imbedded in the dorsal cloacal wall, which it probably innervates, may be followed for a very considerable distance. The inner pair pursues much the same route at first, but upon emerging from the dorsal retractors and while imbedded in the cloacal wall each nerve turns sharply upon itself, and bending slightly toward the mid line and somewhat ventrally it enters the dorsal gill retractor and in this position may be followed close to the tip of the gill. Each of the branchia thus has a double nerve supply as in the ctenidia of the Chitons for example.

The gonad, with the usual characteristics, opens into the pericardium by means of very short dorso-ventrally compressed tubes separated by the aorta. The pericardium is of unusual size, extending behind the heart nearly to the posterior end of the body. As may be seen Plate **36**, fig. 2, it is interrupted by the dorsal gill retractors, but behind these muscles the cavity again becomes continuous across the mid line, extending down the sides of the cloacal cavity (Plate **25**, fig. 5) and posteriorly forming a horn-like extension in the mid line. The heart is the usual tubular organ but posteriorly it unites with an atrium, which may be considered an auricle or an invagination of the ventral pericardial wall continuous posteriorly with the efferent branchial sinus.

The openings of the coelomoducts hold the usual position, at the sides of the suprarectal commissure, but the tubes with which they communicate are in the first part of their course very slender, ciliated, and somewhat convoluted. In this condition they extend ventrally and join the glandular portion (Plate **36**, fig. 2). The cells of this secretory portion are of the usual type, almost cubical vacuolated elements containing a small concrement. The position of the external opening is shown (Plate **25**, fig. 5).

Wiren ('92) has accurately described a patch of glandular epithelium, a modification of the cloacal wall, which on each side of the body surrounds the openings of the gonoducts and extends to a certain extent over the base of the gills. The cells composing it are high and consist of very slender supporting cells and glandular elements filled with an almost homogeneous substance, containing in favorable preparations groups of small prismatic crystals. This description answers for the present species with the exception of the crystals which have not been found. Wiren compares this glandular area with the shell gland of the Neomeniidae, though claiming it acts as an excretory organ. Beyond certain histological resemblances there are no cogent reasons for accepting such a theory.

Chaetoderma erudita, sp. nov.

Ten specimens of this species were taken in Lynn Canal, Alaska (Sta. 4258) at a depth of 300–313 fathoms; and forty-one were dredged in Chatham Strait, Alaska (Sta. 4264) at a depth of 282–293 fathoms. In both cases the bottom consisted of very tenacious green mud. A number of individuals were kept in an aquarium aboard ship and lived apparently in a normal state, burrowing extensively and in some instances feeding on organic debris. Two males gave off considerable quantities of sperms during a period of over an hour. It escaped from the sides of the cloacal cavity, lateral to the gills and soon diffused into the surrounding water. Much care was taken in the preservation of these animals, and yet the shrinkage was considerable, in the case of some of the more active ones, amounting in six individuals to a decrease in the body length of one fourth. It thus becomes apparent that the length index or ratio of length to diameter is not to be depended on in the discrimination of species.

The entire animal is represented (Plate **4**, fig. 9); the buccal plate (Plate **4**, fig. 11), and the spicules (Plate **37**, fig. 15). The hypodermis comprises three fairly distinct types of cells. Of these the most conspicuous, in alcohol killed material, is the basal cell of each spine whose nucleus is placed considerably above the level of the other types. In material killed in vom Rath's fluid the Reizenzellen of Wiren, well-defined globular cells, are very distinct and contain a highly vacuolated material which almost totally disappears in alcohol killed specimens. In some cases fibres, probably muscle, attach to these elements as in *C. attenuata*, but their relations are difficult to determine. The remaining cells are simple low columnar elements of the usual appearance.

The mouth, a relatively wide opening in the deeply cleft buccal plate, opens into a laterally compressed buccal tube that beneath the brain develops longitudinal folds and a more circular outline (Plate **29**, fig. 4). As far as the forward end of the radular supports buccal glands in great abundance are attached to its walls. The subradular organ is not as sharply defined as in *C. attenuata*, yet is clearly distinguishable as a median ventral elevation composed of slender columnar cells of greater height than those of the adjoining epithelium. In one specimen killed in vom Rath's fluid the protoplasm of the component cells is much vacuolated or in a very small number contains a granular secretion. Posterior to the radula, whose general appearance is sufficiently shown (Plate **29**, fig. 8), the pharynx becomes dorso-ventrally compressed, then circular and opens into the stomach. This is a relatively spacious organ with thin unfolded walls that posteriorly become thicker and folded. The relation of intestine and liver are typical and require no description. In the proximal part of the liver, and throughout the major portion of the intestine, there are considerable quantities of organic remains, diatoms, sponge spicules, a few fragments of entomostracans, and several chambered Foraminifera whose protoplasm was only partially digested.

The nervous system of this species is exceptionally clearly defined in one specimen killed in vom Rath's fluid and for this reason has been more thoroughly studied than any other species of the genus described in the present paper with the exception of *C. attenuata*. The brain is very distinctly bilobed, a deep indentation occurring on its anterior surface. From its lateral and forward borders nerves pass into the precerebral ganglia which in turn send tremendous bundles of fibres to the buccal sensory plate. In some species the connectives to the pedal, lateral, and labio-buccal systems have distinct origins in the brain, but in the present case they are united for a considerable distance (Plate **13**, fig. 3). Each of these compound connectives after leaving the brain and passing forward a short distance gives rise to the labio-buccal connective and considerably farther on the pedal and lateral connectives become differentiated. The pedal and lateral ganglia are in the usual positions and are united by frequent connectives and commissures. At the points of origin of these nerves there are no very clearly defined enlargements though anteriorly the pedal and lateral cords are of large size and gradually taper posteriorly, attaining their average size about the hinder border of the prothorax. As these ganglia diminish in size the connectives and commissures become reduced in calibre and are difficult to follow yet they may be traced here and there throughout the entire length of the animal.

As in *C. attenuata* a nerve arises from each labio-buccal connective about the level of the forward border of the radula and passing inward and downward joins a small subradular ganglionic mass. In this species the ganglion shows no indication of being paired. Each of these subradular connectives gives rise to a nerve distributed to the subradular organ and more laterally swells somewhat though ganglion cells are lacking. From each of these enlargements a nerve is developed, and after branching in the pharyngeal musculature becomes lost to view. This subradular system does not appear with the diagrammatic clearness of the one in *C. attenuata*, but there is no especial difficulty in determining its relations which are essentially the same in the two species.

In the posterior regions of the body the nervous system very closely resembles that of *C. attenuata*.

The gonad, with the usual characteristics and relations, opens into the forward end of the pericardium by means of comparatively large tubes in sexually mature animals. In some animals, possibly owing to killing fluids, the pericardial cavity is greatly distended with spermatozoa which have made their way into the proximal half of the coelomoducts. These last named tubes communicate by wide openings with the pericardium and on the other hand extend forward as ciliated tubes for a short distance. Beyond this point their walls become glandular and are thrown into numerous convolutions which render it impossible, without much effort, to determine their exact relations. Posteriorly each duct becomes more simple, though of fairly large calibre, so that it contracts the cavity of the cloacal chamber; and on the ventral border of the fold thus developed the outlet canal is formed (Plate **29**, fig. 5).

Chaetoderma montereyensis, sp. nov.

This species is evidently abundant in the deeper waters of Monterey Bay, California, as 155 were taken distributed through the following stations: nine from 4485, seven from 4508, fifty-nine from 4522, fifteen from 4523, thirty-one from 4524 and thirty-four from 4525. In every case the bottom was mud and the depth varied from 39 to 356 fathoms. Chloretone (aceto-chloroform) was used with good results as a narcotizing agent and 70 % alcohol served as a fixing agent. The length of a medium sized specimen[1] is 45 mm. with an average diameter of 2 mm. through the prothorax and 3 mm. through the preabdomen. The color in life and preserved material is yellowish white.

The hypodermis very closely resembles that of *C. attenuata*. The spines are represented in Plate **37**, figs. 2, 3.

The mouth opens through a slit in the subelliptical buccal plate (Plate **4**, fig. 17) and leads into a laterally compressed tube which becomes circular in

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[1] Generally speaking the larger specimens come from the shallower depths. This is very marked in comparing those from Sta. 4525 with others from Sta. 4508. These size differences, however, do not appear to be correlated with any constant structural peculiarities.

outline slightly in front of the radula (Plate **27**). Throughout its entire course to the hinder borders of the radula its walls, more than commonly muscular, afford lodgment for numerous salivary glands whose secretion stains darkly with haematoxylin. The radula, its supports and musculature are typically situated but are exceptionally heavy and powerful. The remaining divisions of the digestive tract are related as usual and are represented on Plate **27**. Countless thousands of diatoms, together with nondescript organic and inorganic remains, fill the intestine and in some specimens, the stomach.

The pericardium is a comparatively spacious chamber, extending backward some distance over the cloacal cavity (Plate **27**, fig. 9), and is perforated by the superior gill retractors; but otherwise neither it nor the tubular heart and the connecting sinuses are peculiar in any important particular.

The nervous system has been studied in considerable detail, and in all essential respects has been found to resemble that of *C. attenuata* for example.

The gonad, with the usual characters, opens into the pericardium by comparatively wide, dorso-ventrally compressed tubes. The inner openings of the coelomoducts are likewise of large size (Plate **27**, fig. 8) and the adjacent ciliated section also though the latter is unusually short. This ciliated section unites with a division of the glandular part (shown on the left, Plate **27**, figs. 2, 8). The outlet (Plate **27**, fig. 9) occurs in the customary position and is surrounded by the glandular modification of the cloacal epithelium as in *C. attenuata* and a few other species.

Chaetoderma argentea, sp. nov.

One specimen (Plate **4**, fig. 7) of this species was taken in southern Alaska in the green mud of Behm Canal (Sta. 4231) at a depth of 82–113 fathoms. It was in a moribund condition and with the exception of slight movements of the body and gills gave no signs of life. The measurements are, total length 24 mm. diameter of the prothorax 1.6 mm. while the greatest diameter of the preabdomen was 2.6 mm. The color in life and in a preserved state was a silvery white.

The cuticle is scant in amount and the hypodermis is comparatively low and is composed of small cells cubical or low columnar in form. Among these are the giant cells (Reisenzellen) from which the secretion has disappeared but they are attached to faintly staining fibres whose exact relations have not been determined. The spines are represented (Plate **37**, fig. 6).

Although the animal when captured was alive it never relaxed sufficiently to allow the buccal sensory plate to become exposed. In sections this last named organ appears to be typical though the glands that open along its margin are more than usually developed. The preradular section of the gut is of average diameter, fairly muscular and is provided with numerous glands uncommonly compact except on the dorsal side behind the brain. Violent contractions of the prothorax have apparently been responsible for the dislodgment of the epithelial lining of this part of the digestive tract; but there are indications that a subradular organ exists and the nerve supply is distinctly evident. The radula is constructed on the usual plan as may be seen (Plate **26**, fig. 2). Beyond the radula the gut becomes narrow, circular in section and very soon unites with the capacious stomach whose relations to the intestine and liver are of the usual type. The stomach and especially the intestine contain a considerable amount of inorganic and organic material, diatoms being especially abundant.

The single specimen is a male with the gonad distended with sex products in all stages of development. Violent muscular contractions have forced a mass of sex cells, many of them immature, into the pericardium; and at various points along the coelomoducts fully developed sperms are present. The reno-pericardial openings, at the level of the posterior border of the suprarectal commissure, are relatively wide and lead into correspondingly spacious, highly ciliated tubes which pass almost directly ventrally to a point about opposite the mid lateral line where they unite with the glandular portion (Plate **36**, fig. 1). This last named section extends as a slightly convoluted tube to a point about opposite the posterior border of the gonad where it bends sharply upon itself and ventral to the dorsal ciliated section opens into the cloacal chamber at the usual point.

The nervous system shows with distinctness and has been traced in considerable detail, but as the results show it to be essentially the same as in *C. attenuata* and *C. erudita* it demands no especial description. The subradular ganglion with the usual connections is clearly a single mass.

Gland cells in the gills are very definitely distributed, in cross sections being disposed along the transverse axis of the body (Plate **26**, fig. 5).

Chaetoderma scabra, sp. nov.

One individual was dredged in Monterey Bay, California at a depth of 795–871 fath. It measures 12 mm. in length, 1 mm. through the metathorax and 2 mm. through the greatest diameter of the preabdomen. The expanded portion of the prothorax is light brownish yellow; more posteriorly the brown shade is more pronounced, becoming olive-green in the region of the liver which shows through the translucent body wall. An orange-brown substance incrusts the spines about the cloacal opening. The spicules are represented (Plate **37**, fig. 19).

The form of the buccal plate and the position of the mouth opening are shown (Plate **4**, fig. 16). The adjacent section of the digestive tube rapidly assumes a circular form in section, and a few compact groups of gland cells become applied to the dorsal, and to a less extent the lateral walls. Immediately behind the brain these lobules become larger (Plate **30**, fig. 3), but soon disappear more posteriorly. The radula was cut obliquely and it is therefore somewhat difficult to determine its exact relations. The tooth appears to be relatively slender, but its supports and musculature are typical. Behind the radula the pharynx again becomes circular and in this form joins the stomach (Plate **29**, fig. 9). This last named organ is at first thin walled, but the epithelium soon grows higher, becomes folded and soon smooths out at the level of the posterior end of the prothorax (Plate **29**, fig. 11). Again becoming thick walled and of small calibre it unites with the liver and intestine. From this point onward these last mentioned organs are of the usual type.

The pericardial cavity is of more than average size (Plate **29**, fig. 10) and the heart is highly muscular; otherwise neither these organs nor the connecting sinuses are unusual.

The specimen is sexually mature and multitudes of sperms have made their way from the gonad through wide tubes into the pericardium and the proximal portion of the coelomoducts. The openings of these latter organs into the pericardial cavity are comparatively large and the ducts themselves are relatively simple. As in some other small species the glandular portion is a simple canal extending as far forward as the posterior end of the gonad where it bends abruptly and making its way posteriorly opens by an inconspicuous pore into the cloacal chamber.

The nervous system is distinct and sharply defined and has been carefully examined, but it does not differ in any important respect from that of *C. erudita* for example.

Chaetoderma californica, sp. nov.

One specimen was collected in the neighborhood of San Diego, California, (Sta. 4381) at a depth of 618–667 fathoms. It measures 24 mm. in length by 1.6 mm., the average thickness of the metathorax, and 2 mm. the average diameter of the preabdomen. The general appearance of the animal and the relative length of the various divisions of the body are shown (Plate **4**, fig. 6). The color of the protrusible portion of the prothorax is yellowish brown, while the remainder of the body is yellowish green. A rusty red substance, possibly excreta, incrusts the spines in the cloacal region.

The cuticle is of moderate thickness and rests upon a hypodermal layer whose nuclei, placed at various levels in the region of the prothorax, have at first sight the appearance of being more than one cell thick. The most common type of cell is relatively slender and contains an oval granular nucleus. Among these are other elements, probably spicule matrix cells, each of which contains a spherical nucleus larger in size than those of the foregoing class of cells and placed in the neighborhood of the base of a spine above the general level of the hypodermis. As in *C. attenuata* spaces exist at frequent intervals in the hypodermis and from the vicinity of each fibres pass into the underlying muscular layer. As noted on page 55 there are reasons for the belief that these are gland cells, of unknown function, whose secretion is dissolved through the agency of alcohol when used as a fixing agent. The shape of the spines is shown (Plate **37**, fig. 14).

The alimentary canal opens through the dorsal half of the buccal plate; its first section (Plate **27**) is a narrow canal that rapidly widens in the neighborhood of the brain. To its lining epithelium the usual muscles attach and afford lodgment for numerous buccal glands. These last named organs extend from the mouth to the level of the brain and are similar to those of *C. nitidulum* save that the cells are less compact and of larger size. In the neighborhood of the radula the walls of the pharynx become more folded than in *C. nitidulum* and are unique in possessing a pouch (Plate **31**, fig. 8) of considerable extent, into which the glands of the dorsal side open. Behind the radula the canal gradually narrows, its folds become smoothed out whereupon it unites with the stomach.

The salivary glands consist of several globular cells surrounding a small lumen that in some instances is in direct communication with the digestive tract. However each cell communicates with a small ductule which gives evidence, not of passing the secretion into the lumen of the gland, but directly into the digestive tract through intercellular channels of the lining epithelium.

The radula presents no especially noteworthy features. Its conical tooth is slightly more slender than is usual (Plate **31**, fig. 1), but the cuticular winglike supports and musculature are entirely typical.

As usual the pharynx opens by a comparatively narrow pore (Plate **31**, fig. 2) into the stomach whose relations to the liver and intestine are normal. Large quantities of organic remains occur in the gut, Radiolaria, diatoms, and sponge spicules being distinguishable. Associated with these are numerous rounded cells (Plate **35**, fig. 11) that occur also in the digestive gland. In most cases these are free but occasionally one may be seen that is encysted in the cells of the organs mentioned. Rarely they are associated in pairs as though in the process of conjugation.

The gonad holds the usual position and like the sperms, in all stages of development, presents no noteworthy characters. Posteriorly the halves of the organ diverge, become rather indistinct though their route may be traced with certainty, owing to the presence of spermatozoa, passing lateral to the heart or the expanded base of the aorta and opening into the pericardium. This last named space lacks the almost diagrammatic outline as in *C. nitidulum* and is much more limited in extent, but its relations to the gonoducts are very similar.

Chaetoderma nanula, sp. nov.

One specimen of this species was dredged off the coast of southern California (Sta. 4369) at a depth of 260–284 faths. It is 9 mm. in length by 0.9 and 1.2 the average diameter of the metathorax and preabdomen respectively (Plate **4**, fig. 1). The color of the globular, protrusible portion of the prothorax is light brownish yellow (though this may have been produced by tannin from the cork), while the metathorax and preabdomen are considerably darker, the latter region becoming olive-green. A dark brownish substance incrusts the spines about the cloacal opening. The hypodermal layer is comparatively thin, the cells small and somewhat indistinct, yet are typical so far as may be determined. The spines are represented (Plate **37**, fig. 18).

The mouth opening represented (Plate **4**, fig. 12), leads into a relatively spacious tube lined with slender columnar cells except along the dorsal side where they are almost cubical. A median fold, located immediately in front of the radula, probably represents a subradular organ since it is typically innervated. Salivary glands are almost wholly lacking, a small group attached to the pharyngeal wall adjacent to the radula being all that is visible in the present specimen. The radula is small but typical. Beyond it the tube narrows considerably, the lining becomes folded and in this form it unites with the stomach. At the outset this last named organ is plain walled but near its union with the liver becomes considerably sacculated. The intestine is distended with fragments of Radiolaria, sponge spicules, and organic debris. Parasitic Protozoa, resembling those from *Chaetoderma californica*, are abundant and are imbedded in the epithelial lining of the stomach, intestine, and liver throughout their entire extent.

The animal is a female, not perfectly mature, and the ducts leading into the pericardium are accordingly small. The openings into the coelomoducts are likewise minute, and the ciliated tube with which each connects is relatively long and slender. The glandular division with which it unites is a comparatively simple tube, at first directed forward until it reaches the level of the front end of the heart whereupon it bends abruptly and makes its way to the opening into the cloacal chamber (Plate **28**, fig. 10).

The nervous system is in an excellent state of preservation and is clearly defined, but a careful study has failed to disclose any noteworthy feature. It may be mentioned that a subradular system exists similar in all respects to that of *C. attenuata*.

Chaetoderma japonica, sp. nov.

One specimen (Plate **3**, fig. 7) was dredged off Honshu Island, Japan (Oi Gawa, Sta. 3721) at a depth of 207–250 fathoms. The body is comparatively slender, measuring 17 mm. in length by 1.3 mm. through the metathorax and 1.5 mm. through the preabdomen. The color is almost white with a slight tinge of yellow. A slight incrustation, brick-red in color covers the spines in the cloacal region. The spines are of the usual type.

The mouth opens through a distinct pore in the buccal plate (Plate **3**, fig. 8) which, like the neighboring section of the digestive tube, is abundantly supplied with glands, small celled and more than commonly compact. These continue, for a considerable distance behind the radula, apparently unchanged in character though in many cases closely applied against the bases of the buccal and pharyngeal epithelium. This first named organ with its supports and musculature is typical, as may be seen in Plates **30**, **31**. As the major portion of the body was not sectioned the union of liver and stomach has not been seen; otherwise these organs conform to the usual plan. The prerectal portion of the intestine is lined with an exceptionally high epithelium so that the lumen is very small where it is not distended with pellets of faecal matter consisting principally of diatoms and sponge spicules.

The nervous system is not especially favorable for study and accordingly only its more general features have been examined. In this respect it is typical.

The specimen is a female and the fully formed ova present the customary appearance and are developed in a gland holding the usual position. The ducts leading into the pericardium, are large and as in the case of the last named space, and the gonoducts, are filled with eggs mostly disintegrated, due perhaps to violent movements of the somatic musculature. The gonoducts open by relatively large pores into the pericardium and as moderately spacious tubes without any marked convolutions, extend to their openings into the cloaca (Plate **30**, fig. 7). Surrounding these pores the cloacal epithelium is modified to form the glandular area similar to that of *C. attenuata.*

Chaetoderma robusta, sp. nov.

Four specimens of this species were taken south of the Alaskan peninsula (Sta. 3210) in green mud at a depth of 483 fathoms. The largest specimen (Plate **4**, fig. 5) is 60 mm. long with an average diameter through the metathorax and preabdomen of 3.5 and 4.7 mm. respectively. The smallest is 35 mm. long with an average metathorax diameter of 2 mm. and 3 through the preabdomen. Where the spines have not been dislodged the general color of the body is slaty gray shading to buff at the anterior end of the body. A yellowish brown substance incrusts the spines about the cloaca.

The hypodermis consists of numerous small cells rather closely crowded so that the cells lack distinctness. However giant cells are visible and faint fibres, connective tissue or muscle, springing from the underlying body wall appear to attach to them. Spicule-matrix cells in all stages of development are visible, and in each case the spines are attached to only one cell so far as it is possible to judge. The remaining elements are comparatively slender, compact and lack any noteworthy features. The spines are represented in Plate **37**, fig. 4.

The buccal plate is shield-shaped in outline (Plate **4**, fig. 19), and is pierced by the mouth opening. The buccal and pharyngeal cavities are slender, and the walls of more than average thickness (Plate **30**). The lining cells are accordingly very slender, ciliated and are thrown into a few prominent folds. The ductules of a very large number of salivary glands make their way between the cells and in some cases are in the act of pouring their secretion into the canal. A subradular system is present, and as usual two nerves are distributed to a median fold of pharyngeal epithelium that probably functions as a subradular organ. However with the exception of affording scarcely any outlet for the salivary glands its cells are not clearly distinguishable from the general epithelium. The radula consists of the usual conical tooth, rather heavier than usual, but with supports and musculature of the customary type. Beyond the radula the tract becomes circular in cross section before uniting with the stomach whose relations to the liver and intestine are typical.

The circulatory system presents no noteworthy features beyond the fact that the heart is suspended by a fold of the pericardial wall reinforced by a few connective-tissue fibres, and is surrounded by a pericardial cavity that posteriorly extends as a slit-like space between the cloacal and body walls far along toward the posterior end of the body.

In its general features the nervous system closely resembles that of *C. erudita* and *C. attenuata*. The labio-buccal system has been worked out in detail, but it is no exception to the statement just made.

The gonad is of large size and is distended with spermatozoa that have made their way through wide canals into the pericardium. As usual the pericardial openings are situated close to the suprarectal commissure, and lead into clearly defined ciliated ducts which very soon unite with the glandular portion. In this species the glandular portion is at first relatively slender, and but little convoluted yet it soon enlarges greatly, becomes much folded and extends as may be seen in Plate **30**, figs. 5, 7, from the posterior limit of the gonad to its opening into the cloacal cavity.

Limifossor talpoideus Heath.

Zool. Anz., 1904, **5**, p. 28. Zool. Jahrb. Abth. Anat. Ontog., 1905, **5**, p. 21.

Several specimens of this species were taken in Alaska in the Lynn Canal (Sta. 4258) and in Chatham Strait (Sta. 4264) at depths ranging from 282–313 fathoms. The general appearance of these animals is shown (Plate **10**, fig. 1). The length ranges from 6–12 mm. and the diameter from 1–2 mm., the ratio 1:6 being constant.

The mouth, almost terminal in position, is bounded by the sensory plates (Mundschild) and more dorsally by the type of spine covering the prothorax generally. The plates in life undergo rapid changes in form, but histologically and in their innervation they resemble their homologue in Chaetoderma. The deep semicircular groove (halbmondförmige Grube) situated beneath the mouth and sensory plates, is lined throughout with the spiculose integument of the body. The spines are triangular or leaf-like and range in length from 0.02 mm. in the region of the mouth to those about the cloacal chamber 0.38 mm. long.

The hypodermis is relatively very thin, the boundaries of the cells indistinct and similar in general to that of other species of Chaetoderma. The somatic musculature likewise is very similar in the two genera.

The mouth leads into a comparatively narrow canal with longitudinal folds covered with a well-defined cuticle. In the region of the radula the canal enlarges, develops a subradular pocket (Plate **10**, fig. 4) and dorsally continues as a circular tube to its junction with the stomach. Attached to a dorsal diverticulum numerous cells pour their secretion into the pharynx. A clearly defined subradular organ does not exist and yet the fact that in the mid line the cells are more than usually high and slender and are in close proximity to nerves from the labio-buccal ganglia indicates that the area exercises a sensory function. The radula and its supports and attendant musculature are enormously developed and indicate active predatory habits, but in every case the alimentary canal contains little besides a few diatoms, sponge spicules, and a small quantity of inorganic detritus. The radula with twenty-eight transverse rows is of the distichous type (Plate **34**, figs. 3, 6), the long claw-like teeth being united while in the radula sheath by a clearly defined basement membrane. When freely exposed this membrane splits along the mid line and the teeth become located on each side of a deep cleft in the forward end of the radular supports (Plate **10**, fig. 10). Odontoblasts, in typical fashion, form the teeth which are subsequently enveloped by numerous enamel cells.

The radular supports comprise two great masses of muscle and connective tissue which together form an ovoid mass grooved dorsally to hold the radula tube. To these numerous muscles attach that are in part responsible for the movements of the teeth. A detailed description of these and other muscle bands has been given in another place (Heath '05) and an attempt has been made to determine their functions.

The stomach is sharply differentiated from the remainder of the digestive tract (Plate **10**, fig. 4) and occupies practically all of the space between the end of the radular supports and the forward border of the gonad and digestive gland. Its epithelial lining is produced into a number of heavy folds that gradually blend with those of the oesophagus. In most cases the intestine leaves the posterior end of the stomach in the mid line, and immediately ventral to this union the liver opens by a single pore. This last named organ is relatively voluminous, filling much of the space beneath the gonad between the stomach and forward cloacal wall where it ends blindly. The intestine, of practically the same calibre throughout, makes its way by a fairly direct route to the front end of the pericardium. Here it bends abruptly downward and passing under the cloacal wall opens to the exterior in the mid line.

A clearly defined connective-tissue septum bounds the head cavity posteriorly as in the Chitons. It passes immediately behind the radular supports and is penetrated by the alimentary canal, dorsal aorta, and pedal sinus.

The pericardial cavity is of trihedral form and encloses a tubular and more than usually muscular heart without any distinct subdivisions. The aorta passes out from its forward border, and as a distinct tube with definite walls makes its way between the halves of the gonad to an opening in the septum bounding the head cavity. This latter space communicates with a well-defined pedal sinus, which perforates the septum and pursues its course posteriorly, communicating here and there with the general visceral cavity, to the neighborhood of the cloacal cavity. Here both sinuses unite on their way to the gills from which the blood passes above the dorsal gill retractor to enter the heart.

The brain, clearly bilobed, develops fibres which unite with five pairs of precerebral ganglia that in turn give rise to nerves passing to the sensory plate. The lateral, pedal, and labio-buccal connectives unite before entering the brain. The last named are first to be differentiated and holding the usual position at the sides of the pharynx, they unite with the ganglia lateral to the dorsal salivary glands. These nerve masses are united by the usual commissure and by another passing dorsal to the pharynx in the neighborhood of the salivary glands. What appears to be a complete one passes ventrally into the neighborhood of the subradular organ. A nerve from each ganglion passes backward and probably innervates a portion of the digestive tract. The lateral and pedal ganglia, with the usual relations, extend to the region of the cloaca where they unite to form on each side a well-defined enlargement connected by a suprarectal commissure. From each swelling several nerves arise that are distributed to the cloacal and body walls; while from the commissure branches are developed, dorsally and ventrally, that innervate the ctenidia.

The gonad extends from the stomach to the pericardial cavity into which it opens by relatively long and slender ducts. The coelomoducts have the form of simple tubes extending from the pericardium to separate exits in the cloacal chamber. Their inner openings are situated in the infero-lateral angles of the pericardial cavity and are guarded by high pyriform cells devoid of cilia. On the other hand the succeeding portion of the canal, of very small calibre, is composed of cubical elements covered with a heavy ciliated coat. This division makes its way forward to the outside of the dorsal gill retractor and unites abruptly with the glandular portion, which although a single tube is so convoluted that it becomes a relatively voluminous structure. Its walls are composed of more or less cubical cells of which the cytoplasm is scant in amount owing to the presence of one or two great vacuoles. The general structure bears a fairly close resemblance to certain kidney tissue yet there is no positive proof that it possesses an excretory function. The outer openings are on each side of the anus a short distance anterior to it, and though very minute in preserved material they are nevertheless clearly defined.

Limifossor fratula, sp. nov.

This species is represented by two individuals taken off the coast of southern California (Sta. 4369) at a depth of 260–284 fathoms. In general it so closely resembles the foregoing species that a very brief description will suffice. The body, slaty gray in color with a slight yellowish cast, is shorter and thicker than in *L. talpoideus*, and owing to a heavier body wall is much firmer. The spines of the two species are very similar in form, but in the present species they are of considerably larger size. Spicules from the middle of the body are 0.5 mm. in length while in *L. talpoideus* the largest of the body do not exceed 0.38 mm. The hypodermis is also proportionately thick and what are probably matrix cells are frequent and sharply differentiated from the other elements of the hypodermis, and hence different from *L. talpoideus* in this respect.

The digestive tract in the two species is, neglecting minor differences, built upon the same plan. Heavy as is the radula and its supports in *L. talpoideus* it is even heavier in the present case, and the teeth are of larger size, making it so difficult to section them that at present there are no clear indications of their exact shape though it appears certain that the smaller cusp of each tooth is larger than in the preceding species. The muscles that operate the radula are typical but are unusually heavy.

The nervous, circulatory, and reproductive systems are very similar in the two species.

This species is readily distinguished from the foregoing by the size of the spines, the structure of the hypodermis, and the heavier musculature and consequent firmness of the body.

Pachymenia abyssorum, sp. nov.

One specimen of this species was dredged off the southern coast of California (Sta. 4397) in 2196–2228 fathoms, the greatest depth recorded for any Solenogastre. In bringing the animal to the surface the consequent decrease in pressure upon the body resulted in the active release of gases from the blood, causing the displacement of the cuticle to a considerable extent, the shrinkage of the hypodermal cells and the partial destruction of the foot at various points; otherwise the tissues are in a good state of preservation. The body is thick set, externally resembling *Alexandromenia valida*, and measures 27 mm. in length by 4.5 mm. average thickness. The color is a light yellowish white. As is indicated (Plate 39, fig. 4), the foot is exposed for a considerable distance, and is unusually broad and doubtless in life is capable of forming a relatively large surface possibly enabling the animal to crawl about on the bottom ooze. As in the case of Alexandromenia this individual is unattached and may be accordingly a roving form.

The cuticle is approximately three times the thickness of the hypodermis, but is scant in amount owing to the vast numbers of needle-like spicules, of varying sizes, imbedded in it. As noted above the hypodermal layer is not in a good state of preservation, but it may readily be discovered that the cells are unusually slender, and laterally and ventrally form papillae in the head region. There are low elevations at other points over the body but it is not certain that they are definite papillae.

The external opening of the anterior pedal gland is a cavity of large size whose walls are provided with folds of unusual height. On the posterior wall these are approximately seven in number, the outermost on each side being very large. Behind the cavity the five included folds disappear while the large lateral ones unite in the formation of a foot with a creeping surface of greater width than in any other known species of Solenogastre. In the posterior end of the body the foot decreases in size and becomes continuous with small folds of the cloacal wall.

The anterior pedal gland is a voluminous organ lying at the sides of the body opposite the external outlet. The cells composing it are exceptionally small but otherwise present no noteworthy characters. Behind it shades into the posterior pedal gland without any appreciable change in the character of the cells. Throughout the entire extent of the foot the gland is unusually large and the ductules appear to open over the entire creeping surface.

The external atrial opening is subterminal and large, and leads into the customary cavity provided with ridges and cirri typically situated. As may be seen in Plate **39**, fig. 1, the external ridge is continuous across the mid line in front of the external opening of the atrium and though relatively small at this point it rapidly increases in height, finally becoming of such a size that it may be seen in external view. The inner ridge is likewise small anteriorly but behind becomes as extensive as the external fold. Behind these two folds are continuous with each other and are connected with several long plaits in the hypodermis which extend to the external opening of the pedal gland. The cirri are simple unbranched processes, slightly pigmented and contain a muscle or nerve fibre extending, in some cases at least, throughout their entire extent.

The atrium communicates dorsally with the succeeding section of the digestive tract whose general relations may be determined from an examination of Plate **39**, figs. 1, 6. The walls of this division are provided with numerous muscle bundles of irregular distribution between which are multitudes of glands staining actively when treated with Delafield's haematoxylin. The cells composing these glands are without distinct cell boundaries, are made up of vacuolated protoplasm containing droplets of various sizes and are grouped into lobules of various bulk. In many places they extend into the folds of the epithelial lining of the pharynx and give evidence of opening through intercellular channels.

Some distance toward the dorsal side of the animal a fold of large size appears in the wall of the digestive tract which narrows the pharyngeal cavity to a relatively small tube. At this point the epithelial lining becomes thicker, a character which it retains to the stomach-intestine, and the walls become surrounded by a heavy sheath of circular muscles to which vast number of gland cells attach. These gland cells are grouped into slender lobules, and owing to the fact that they are much vacuolated their tint is fainter than in the case of those of the preceding division of the tract. The nuclei also are of larger size and more distinct, but the secretion presents the same general appearance. A slender duct on each side of the pharynx (Plate **40**, fig. 6) extends from the region of the ventral labio-buccal commissure (Plate **39**, fig. 8), to its outlet (Plate **39**, fig. 6). Posteriorly each ends blindly and anteriorly is provided, as in the case of Alexandromenia, with a papilla which is doubtless capable of being protruded into the pharyngeal cavity. Throughout its entire extent the ductules from these glands attach to the canal, but behind it they connect with intercellular channels and so pour their secretion directly into the pharyngeal cavity. The glands with this last named outlet present the same appearance as those communicating with the ducts except in the neighborhood of the stomach-intestine where they become more compact.

No trace of a radula or radula sac exists.

The pharynx or oesophagus projects for a great distance into the stomach-intestine which is provided with several longitudinal ridges instead of the customary sacculations. The middle portion of the body was not sectioned but as these ridges are present in the posterior end of the animal it is probable that they extend throughout the entire length of the gut. Many of these folds contain blood sinuses which often produce a marked distention. The lining epithelium is composed of more than usually slender cells many of which contain more or less spherical, granular masses. Posteriorly the intestine narrows, passes between the coelomoducts and opens into the cloacal chamber. No traces of food were found in the tract and accordingly we are without any knowledge of the animal's feeding habits.

The walls of the cloacal chamber are provided with a number of slender outpouchings and to these are attached multitudes of gland cells grouped into lobules of different sizes. Each cell is pyriform and contains a somewhat granular slightly vacuolated secretion that makes its way by a delicate ductule through an intercellular opening into a diverticulum of the cloacal wall. The general arrangement of these structures is shown in Plate **39**, fig. 2.

The pericardial cavity is comparatively spacious and the contained heart, consisting of two divisions, is moderately muscular. The aorta in the present specimen is of small size but in its relations to the gonad and the anterior end of the body it is typical. Owing probably to the size of the foot the ventral sinus is large and connects in the usual fashion with the head sinuses and here and there throughout the body with the visceral sinus. In the posterior part of the body it divides, passes dorsally on each side of the intestine and after passing posteriorly for a short distance breaks up into a small number of lacunae which connect with the gills. From these organs the blood passes through rather ill-defined channels in the somatic musculature to the posterior end of the heart.

Five or six pairs of relatively large folds appear in the cloacal wall running more or less parallel to the outer opening near which they are situated (Plate **39**, fig. 2). Here and there these develop numerous minor wrinkles (Plate **40**, fig. 7) which pass from one main fold to another or extend some distance over the cloacal wall. As usual they all contain blood sinuses but otherwise are not especially modified.

The brain, imbedded in the numerous glands attached to the forward wall of the pharynx, is an unusually elongated structure and without distinct signs of being bilobed. From its anterior face the usual nerves, heavy in appearance, are distributed to the body wall and the ganglionic masses about the bases of the cirri. The lateral, pedal, and labio-buccal connectives arise from the extreme lateral boundaries of the brain and follow the usual course. A very slight enlargement marks the point of union of the lateral ganglion with the corresponding connective, while one of twice the diameter occurs in the case of the pedal cords. The last named structures are united at fairly definite intervals by clearly defined commissures and about the same number of connectives attach to the lateral ganglia. A nerve from the anterior pedal enlargement passes to the wall of the outlet of the anterior pedal gland, and two branches originate from a corresponding point on the lateral ganglia and applied to the somatic musculature extend far forward into the anterior end of the body. The labio-buccal connectives, imbedded in the pharyngeal glands, pass backward about half the length of the pharynx where they join the ventrally placed ganglia (Plate **39**, fig. 8). These masses are in turn united by a strong commissure provided in its mid section with several ganglion cells from which a nerve arises and extends backward for a considerable distance attached to the pharyngeal glands. What appears to be a dorsal commissure springs from the upper side of the ganglia, passes dorsally and may be traced here and there amid the glands over the dorsal surface of the pharynx. It has not been followed throughout its entire extent yet I have but little doubt that it is a definite commissure. From the posterior borders of each labio-buccal ganglion a nerve arises and imbedded also in the glands of the pharynx extends for a considerable distance posteriorly before it becomes lost to view. Finally it may be said that the arrangement of the brain and anterior portion of the nervous system is more regular than in the case of Alexandromenia for example, but otherwise there is no fundamental difference.

In the posterior end of the body the pedal ganglia continue to be united by commissures of large size and practically the same number of connectives unite them with the lateral ganglia placed high up on the sides of the body. In front of the anterior cloacal wall the pedal cords bend dorsally and provided throughout with ganglion cells attach to the lateral nerve masses at the sides of the pericardial cavity (Plate **40**, fig. 4). From the posterior end of the lateral and pedal ganglia nerves arise and extend backward along the body wall and in some places pass into the cloacal folds.

A well-defined dorsal sense organ is present whose location is represented (Plate **39**, fig. 2). Owing to the fact that it is of small size, that the cells like those of the hypodermis are not well preserved and because of the oblique direction of the sections its structure has not been accurately determined yet so far as the examination has gone it appears to conform to the usual type.

The ovo-testis occupies the usual position on the dorsal side of the animal and extends forward to the posterior end of the pharynx. The ova are unusually large and are surrounded by a chorion, but with these exceptions neither they nor the spermatozoa present any especially noteworthy features. The ducts leading from the gonad into the pericardium are of comparatively large calibre.

In several respects the coelomoducts are remarkable structures and unlike those of any other known Solenogastre. In the vicinity of their inner openings the pericardial wall becomes thickened and numerous small folds appear which converge and in some cases at least become continuous with the adjacent section of the duct. A short distance beyond the pericardial cavity and as far distally as the seminal receptacle each duct affords attachment for a vast number of glands of unknown function. These are slender diverticula (Plate **40**, fig. 2), composed of very small cells with indistinct boundaries filled with a finely granular faintly staining secretion. In the present specimen large quantities of spermatozoa are present in the coelomoducts and frequently these have made their way into some of the diverticula where they form masses without definite arrangement. Whether this is a normal occurrence or a *post mortem* effect cannot be definitely decided with the material in hand. Beyond these glands the dorsal section of the coelomoduct becomes thin walled, without folds and soon joins the ventral division which as Plate **39**, fig. 2, indicates is of large size, thin walled, with few folds and is crowded with sperms. Immediately ventral to the union of the dorsal and ventral limb of each duct there is a small globular outpouching to whose internal wall large numbers of spermatozoa are attached so that in position and function it is to be considered as a seminal receptacle. Sperms with the same mode of attachment are found in considerable numbers adjacent to the seminal receptacles and rarely at much greater distances, even as far as the undivided section or shell gland. The cavity of this last named organ is not much larger than that of the dorsal section and its epithelial lining is relatively thin but a multitude of glands, attached throughout its entire extent, give it a heavy appearance. These glands are composed of compact, pear-shaped cells arranged in lobules that open by intercellular channels in the epithelial lining of the shell gland. As may be seen in Plate **39**, fig. 2, the shell gland pushes inward the anterior wall of the cloacal chamber so that its outlet is far within this last named cavity.

Drepanomenia vampyrella, sp. nov.

This species is represented by a single specimen dredged off the southern coast of Oahu Island (Sta. 3907) at a depth of 304–315 fath., where the temperature was 43.7 F. It was coiled tightly about a solitary polyp of Epizoanthus, and further examination showed that the proboscis of the mollusc was protruded through the body wall of the coelenterate, whose reproductive and other tissues had been drawn into the alimentary canal of its captor. There is therefore no doubt that this species is carnivorous and that its association with the actinian is not an accidental one or a case of commensalism.

The body (Plate **2**, fig. 2) measured 9 mm. in length, was slightly compressed laterally, particularly its anterior half, and in form was somewhat spindle shaped, being largest about the middle section of the body and gradually tapering off toward each end, especially posteriorly where the body becomes quite slender before terminating in a truncated extremity. A well-defined keel extends along the entire animal in the mid dorsal line. The color was faint yellowish white.

The cuticle surrounding the body is of medium thickness, measuring 0.35 mm. in the keel and 0.28 mm. elsewhere in the dorsal region, but gradually decreasing to half this amount on the ventral surface. It includes a single layer of radially directed spicules (Plate **32**, fig. 6), ranging in size from those in the first stages of formation to others of the keel 0.129 mm. long. All are of the same general form represented in Plate **37**, fig. 7. It is to be noted that many of the spicules are not in contact with the hypodermis, even the matrix cells having disappeared, but are situated far out toward the surface of the body. Beneath each developing spine are several cells apparently instrumental in its formation.

The cells of the hypodermis are very small and indistinct and accordingly have been examined only superficially. The prevailing cells are slender with subcentral nuclei, and are developed into numerous small elevations, some of which connect by strands with the overlying papillae (Plate **32**, fig. 6). These last named organs contain upwards of eight cells in the enlarged portion; none appear to exist in the exceedingly slender stalk.

As in other species of the family the ventral furrow commences close to the hinder border of the lip, and extending the entire length of the animal becomes continuous with the cloacal opening. Anteriorly it contains a relatively deep excavation into which the anterior pedal gland opens by the usual numerous intercellular ducts. This last named gland occupies practically all of the visceral cavity between the region of the brain and the anterior end of the gonad. The cells composing it are generally pyriform, with an average diameter of .021 mm. and are filled, save for the small compact nuclei, with a finely granular substance that stains intensely with logwood dyes. In some cases this secretion appears to be undergoing solution, and presents a vacuolated appearance, a character that is very pronounced among the cells of the posterior pedal gland. These latter elements are related also to the foregoing in general form, size, and appearance, and extending to the cloaca and opening on each side of the foot, are thus seen to hold the usual position.

At the hinder border of the crypt into which the anterior pedal gland opens, the foot arises as a single, small prominence and rapidly assumes its fully developed condition. Posteriorly it gradually decreases in size, disappearing, so far as may be judged from longitudinal sections, at a point immediately in front of the gonoduct openings.

The general relations of the anterior section of the digestive tract are fully represented in Plate 7, fig. 4. As will be seen the atrial opening is subterminal in position and of medium size. The relations of the succeeding parts, while much the same as in Proneomenia, for example, are somewhat obscured by the protrusion of the pharynx. An outer ridge, composed of the usual type of columnar cell though apparently lacking cilia (Mundleist), is present. The inner ridge, probably related as in other species, has in the present specimen been carried out on the tip of the pharynx, an interesting fact as it indicates that these cells may be sensory, and of service in determining the character of the animal's food or surroundings. Between these two prominences the usual cirrose area is present, the cirri being of relatively large size and unbranched. It has been suggested that the cirri, secreting a viscous material, may serve in the capture and retention of food. Here, however, is an animal killed in the act of feeding with its proboscis penetrating its host. The material drawn into the pharynx does not come into contact with the cirri, which in this case must certainly have some other function, though it is difficult to say what this may be.

In its present extended condition the pharynx is relatively slender, almost wholly devoid of longitudinal folds and is relatively muscular. Heavy retractor muscles attach to the buccal wall and serve to withdraw the pharynx, that appears to lack special retractors of its own. In some species of Neomenia the ventral salivary glands are described as being more or less coiled; in the present species this would probably be the case, but with the protrusion of the pharynx their openings into the canal have been carried forward until they are very close to the end of the proboscis. Each gland is unbranched, composed of excessively spongy cells and is possessed of a relatively large lumen, and a length of fully one fourth that of the body. In view of the fact that Drepanomenia has no radula it appears probable that the salivary secretion exercises a solvent action on the tissues of its victim, and the liquified material is then sucked in. The digestive tract in the present case is well filled with a finely granular substance in which one may recognize here and there the remains of cells, chiefly reproductive, belonging to its host.

As may be seen (Plate 7, fig. 4), the stomach-intestine extends forward a considerable distance in front of its union with the pharynx, thus forming an extensive anterior coecum. On this sack a number of short outgrowths are developed chiefly on the dorsal side. A short distance behind the front end of the gonad gut pouches appear arranged with great regularity, and from this point on digestive cells attain their fully developed condition. In the region of the pericardium the sacculations vanish, the canal narrows rapidly and the liver cells are replaced by low columnar cells thrown up into longitudinal ridges extending to the opening into the cloacal chamber.

In this specimen the pericardial cavity is relatively large (Plate **6**, fig. 3), and the heart it contains is considerably distended with blood, rendering it possible to some extent to determine the course of the circulation. The blood returning from the gills, and another smaller portion that appears to come directly from the hinder portions of the body, pours into a well-defined auricle situated at the hinder end of the pericardial cavity beneath the ventricle. Its walls are only slightly less muscular than those of the ventricle, and owing possibly to muscular contractions, are developed into several pouches that do not have the appearance of blood glands. From the auricle the blood passes into the ventricle through a comparatively large opening guarded by a well-developed muscular flap probably functioning as a valve.

From the front end of the ventricle a clearly defined vessel arises, and passing forward unites with the dorsal aorta. This latter vessel holds its usual position between the body wall and gonad, but it extends backward over the dorsal side of the pericardium as far as the posterior end of the ventricle. Anteriorly the relations of the vessels in the gonad and of the aorta to the head cavity are essentially as they are in *P. hawaiiensis.* This appears to be the case also with the sinuses in other parts of the body, though using longitudinal sections through the somewhat twisted body, it is not possible without much labor, to determine their connections accurately.

With the protrusion of the pharynx the brain has been carried some distance ventrally, but under ordinary circumstances its position and the relations of the nerves which it develops are probably not unusual. As Plate **7**, fig. 4, shows three pairs of nerves pass to the atrial wall as in other of the Neomeniina, and are probably destined, here as there, to supply the cirri, anterior musculature, and hypodermal sense organs. So far as may be judged from sections, the labio-buccal connectives originate some distance from the pedal and pallial, and may be clearly seen to pass down to ganglia situated on the sides of the pharynx where it unites with the buccal wall. From the hinder border of each ganglion a fibre originates that may be the inferior or ventral commissure, but owing to innumerable muscles it was not possible to determine this conclusively. Neither was it possible on this account to determine if any subradular system exists.

The relations of the pedal and lateral ganglia call for few special remarks. In some places it was possible to demonstrate pedal commissures, and to trace connectives between the pedal and lateral cords, especially in the hinder regions of the animal where the cords are closer together. The most posterior connective is especially heavy (Plate 11, fig. 1), and develops two or three fibres whose branches may be traced to the musculature of the body wall. On the inside a very few exceedingly delicate nerves pass to the terminal section of the coelomoducts. From the posterior swollen section of the lateral cords (*ganglion superior posticus*) several nerves arise chiefly distributed to the body wall. The dorsal commissure is relatively heavy and closely applied to the dorsal wall of the rectum. In the median line it gives rise to a nerve that may be traced to a point near the dorso-terminal portion of the body. In position it corresponds to the nerve supplying the dorsal sense organ in other Solenogastres described in this paper, but no such well-defined sensory area appears to be present in this species.

In this species the paired gonad, without any special peculiarities, terminates rather abruptly at a point about as far forward as the hinder border of the atrial opening, and on the other hand passes by two relatively large ducts into the spacious pericardial chamber (Plate 11, fig. 1). From the lateral portions of a small recess at the posterior end of this cavity each coelomoduct arises, and after passing downward for a short distance then passes forward, gradually increasing in size until it reaches a position about level with the hinder tip of the gonad. Here it bends abruptly and coursing backward unites with the one of the opposite side, and as a short common duct makes its way to the cloaca.

Each canal commences its course with an epithelial lining essentially like that of the pericardial wall, being composed of low flat cells entirely devoid of cilia and lateral cell boundaries. These deficiencies are soon overcome, however, and there are evidences in some of the cells a short distance from the pericardium of a slight glandular activity. In proportion to the increasing diameter of the duct the cells show a greater width and height and the cilia become a strongly marked feature. This holds true for only a portion of the canal however for at a point slightly below the level of the lateral nerve the character of the lining changes abruptly. At this point the cells become high and columnar along the dorsal side of the tube and form a ridge, extending forward to the most anterior turn in the duct. The cilia with which this part of the tube is provided are probably operative in driving the sex products toward the exterior. There are no evidences that they ever form a groove such as has been described in a few other species, and it must rather be supposed that both sex products travel much the same path. At the anterior sharp turn of the coelomoduct the ciliated ridge passes, so far as may be judged from sections, into a ciliated patch that occupies the anterior wall of the canal, and extends a short distance down the posteriorly directed section, corresponding to the shell gland in other Solenogastres. This patch, roughly circular in outline, is composed of low columnar cells provided with very long, powerful cilia. Posteriorly the cells of this region blend with others of the same general appearance, but without cilia, and filled with an abundant secretion in several cases in the act of being discharged. This glandular area is limited to a narrow girdle encircling the duct, and is sharply defined from the succeeding portions of the canal, whose walls are developed into numerous folds obscure at first but in the neighborhood of the cloaca of considerable height. The cells in all of this corrugated section, the shell gland of other Neomeniina, vary in height according to the size of the fold of which they form a part, but all agree in being relatively slender with central dense nuclei external to which the cytoplasm is filled with some glandular product of yellow tint. In the terminal section of the cloacal passage this substance is present in considerable quantities and at various points has made its escape in an unchanged condition into the neighboring duct.

Proneomenia hawaiiensis, sp. nov.

This species is represented by three individuals, one perfect and two mutilated. The first was dredged in the neighborhood of Kapuai Point off the western extremity of Kauai Island (Sta. 4001) at a depth of 230–277 fath. where the bottom consisted of coarse sand and the temperature was 44.3° F. The imperfect specimens were taken in the vicinity of Mokuhooniki Islet (Mokuo Niki), a small island close to the eastern border of Molokai Island (Sta. 3864) at a depth of 163–198 fath. where the temperature was 57.5° F. and the bottom consisted of shells and fine volcanic sand. All the specimens came in unattached and without any food in the digestive tract so that nothing is known of their mode of life.

The perfect individual measured 36 mm. in length and 2 in average diameter, and this proportion of 1 : 18 appeared to be the same in the imperfect specimens. The body (Plate 3, fig. 10) is elongated, tapering gently from the forward to the hinder end, and is slightly elliptical in cross section. A rusty red incrustation covered the entire animal save the anterior tip and the lips, where the color was light lemon-yellow.

As in other members of the genus the atrial opening is subterminal and presents the appearance of an elongated slit encircled by rounded lips. Immediately behind it the ventral furrow takes its rise and extends to the posterior end of the body where it becomes continuous with the subterminal cloacal opening. Sections show a well-defined dorsal sense organ with small surrounding spines (Plate **32**, fig. 10) but owing to the debris encrusting the body this was not externally visible.

With the exception of the ventral furrow the body is covered by a relatively thick cuticle that must be an efficient means of protection and at the same time render the animal relatively sluggish. As usual innumerable calcareous spicules are imbedded in the cuticle, forming five or six irregular layers. These spines are of two distinct types; one, the larger and more abundant form with rounded extremities (Plate **37**, fig. 5a) is placed more or less parallel with the hypodermis while the second (b) extends at right angles to it and projects slightly above the external body surface. Spines of somewhat this same general form are located along the ventral furrow and about the atrial and cloacal openings; but in their mode of development and owing to numerous intermediate stages it may be seen that they belong to the first class. A more detailed description of the position and development of the spines of this species is given on page 28.

The cuticle is penetrated also by many papillae whose arrangement and general appearance are shown (Plate **33**, fig. 3). As Hansen has noted they appear like so many baloons situated inmediately below the external surface of the cuticle and connected with the hypodermis by a slender fibre. This distal expanded part appears to consist of several cells each with basally placed nucleus and an outer vacuolated section which usually fuses with the corresponding part of the other cells. These elements pass without any sharp line of demarcation into the stalk that contains from four to six elongated nuclei and in turn unites without definite cell boundaries with a small number of cells of the hypodermis. In many cases delicate fibres may be traced from these hypodermal cells into the deeper tissues of the body, and at the anterior end of the animal they may occasionally be followed into close proximity to the ganglionic layer surrounding the atrial wall; nevertheless while appearances seem to favor the belief that these are nerve fibres and the papillae are sense organs the evidence is not complete.

The pedal gland is coextensive with the foot and consists of two long slender bands of cells situated a short distance within the body on each side of the ventral furrow into which their secretion is poured. In the body proper the position, size, and number of the component cells in cross section is shown (Plate **14**, fig. 3). This condition of affairs exists to the front end of the gonad where the gland cells become more abundant and of larger size, occupying approximately one fourth of the visceral cavity at the level of the posterior end of the radula. Their outlets still continue in the ventral furrow and in addition occur throughout the region of the anterior division of the foot, which contains extensive blood lacunae and may probably be protruded at times beyond the ventral furrow.

The anterior pedal gland abuts against the front end of the pedal gland proper and, occupying more than half of the space between the buccal mass and the body wall, extends as far forward as the brain. The main body of each of its cells consists of spongy cytoplasm containing an abundant secretion that stains faintly in Delafield's haematoxylin. The included nucleus is relatively very small, granular and very irregular in form. Several cells are usually grouped together and surrounded by a few connective-tissue fibres. Each cell is attached by a duct with the ventral furrow chiefly in front of the foot. All of the ductules of both pedal glands open between the cells of the ventral furrow.

The atrial opening leads into a cavity of relatively generous proportions (Plate **5**, fig. 2) with walls abundantly supplied with sense organs of several different types. The most external of these, which I have termed the outer atrial ridge (Plate **14**, fig. 1), presents the appearance of a low prominence situated just within the lips and encircling the atrium except in the mid line behind. Its cells are comparatively slender and in addition to the darkly staining and usually basally situated nuclei, they contain numbers of greenish yellow pigment granules. Lying in contact with the inner ends of these cells is an accumulation of ganglion cells forming an elongated mass coextensive with the ridge itself. From it nerve fibres may readily be traced to the sensory cells adjoining, and in an opposite direction large nerves occasionally pass inward, and soon become confused with the ganglionic elements attached to the bases of the cirri above. That this is a highly sensory structure there is no reasonable doubt, but to define its function more accurately is at present impossible.

Of almost identically the same length as the sensory ridge just described and directly in contact with its inner border is another inwardly projecting fold of much greater height and widely different character. It likewise encircles the atrium save on the posterior side where its free extremities unite with another ridge of corresponding height and appearance that farther within the body also encircles the atrial cavity. The epithelial cells bounding these ridges (Mundleisten) are columnar, richly ciliated and besides the centrally placed spherical nucleus contain a small quantity of greenish yellow pigment. Within the ridges are a few connective and muscle elements and an occasional nerve fibre, all loosely arranged and permitting the entrance of multitudes of blood corpuscles that probably cause the distension of these organs.

The area bounded by these two sensory prominences is the cirrose region characterized by the presence of numbers of hollow finger-shaped projections each attached by its base and extending into the atrial cavity. The cells composing these organs differ to some extent in different specimens but agree in being low, non-ciliated, and charged with a considerable quantity of the usual greenish yellow pigment and a varying amount of some hyaline secretion that often covers their external surface. More slender elements, scant in numbers, occur among these ordinary cells; they may be sensory but some at least appear to be cells from which the secretion has recently been discharged. The cavity within each cirrus is usually very slender and is traversed by a muscle and nerve fibre. In very exceptional cases there are one or two blood corpuscles; but neither in this nor in other species of Solenogastres have I found any indication that these play an important part in the process of respiration. Beneath the cirri is a felt-work of muscle, connective and nerve fibres together with blood corpuscles and leucocytes beyond which is a mass of ganglion cells connected with the central nervous system and on the other hand with sense organs of the atrium and probably of the hypodermis.

A very short distance within the inner ridge the digestive tract narrows rather abruptly, the character of the epithelial lining changes radically, and since it marks the point of entrance of the dorsal salivary gland it may be considered the line separating the mouth and pharynx. According to such an interpretation the pharyngeal wall, lined with a relatively heavy cuticle, is thrown into a series of ridges that course more or less longitudinally throughout its entire extent. In the majority of cases the cells are high, with central oval nucleus and a slight secretion that had escaped at various points through some of the exceedingly minute pores passing through the lining cuticle.

The so-called dorsal, or accessory, salivary gland is attached to the dorsal wall of the pharynx immediately behind the brain (Plate 5, fig. 2). The cells composing it are one layer thick, and as the duct itself is short and unbranched the gland is necessarily compact and globular in form. The epithelial lining of the pharynx is continued inward to form the lining of the duct between whose cells the secretion is discharged. The cells of the gland are comparatively large, with small nuclei and an abundance of a lightly staining secretion, and are grouped into several clusters separated from each other by a small amount of connective tissue.

The paired ventral salivary glands are long tubular unbranched structures opening into the pharynx on each side of the front end of the radula. Their position and general appearance are represented (Plate **14**, figs. 7, 9). Each constituent cell is high and columnar in form, composed of vacuolated cytoplasm and possessed with nuclei ranging from spherical to slender spindle-shaped forms correlated with different stages of glandular activity. The secretion within the main duct is finely granular and has only a slight affinity for logwood dyes.

In this species the radula is relatively well developed and is located as in other members of the genus. The teeth are formed by odontoblasts of the usual high columnar type characteristic of the Chitons and prosobranchs and are of the form represented (Plate **34**, fig. 13). All the teeth are of essentially the same form and number not less than from thirty-eight to forty-five in each transverse row. There is no indication of a median tooth so far as the sections show but each tooth adjacent to the mid line is somewhat smaller than its fellows (Plate **34**, fig. 13). In some species of Solenogastres the teeth are reported to be merely thickenings of a continuous cuticular plate, but in this species they are clearly distinct, a well-defined suture not only separating each tooth from the others but from the basal plate as well.

Immediately in front of the radula and somewhat covered by its forward border are two areas of high columnar cells (Plate **34**, fig. 2) that are more or less sunken in a well-defined sheath. In another place (Heath '04) it has been shown that these organs probably correspond to the subradular organ in the Chitons and some of the prosobranchs. Their innervation is discussed in the section on the nervous system.

The usual relation of pharynx and stomach-intestine are shown (Plate **5**, fig. 2). In another specimen the anterior dorsal coecum is considerably more developed and there is also a small ventral one that extends forward between the salivary glands. A short distance behind the pharynx the cells of the digestive tract shade gradually into the relatively high pyriform hepatic cells of the stomach-intestine. There are strong evidences that the distal part of these cells loaded with secretory products separates from the remaining nucleated portions and dissolves in the alimentary tract and that the process is repeated indefinitely, the basal nucleated parts developing anew the glandular distal portions.

Upon reaching the front end of the cloacal passage (slime gland) (Plate **14**, figs. 5, 6) the alimentary canal becomes crescent-shaped in cross section, the concave surface being in contact with the gonad. Before reaching the cloaca it becomes elliptical and the epithelial lining is developed into longitudinal folds that persist to the anal opening.

The heart is irregularly cylindrical in form, lacks any clear subdivisions and is attached to the dorsal wall of the pericardium. From its anterior end the dorsal aorta takes its origin and coursing forward between the gonad and the body wall finally makes its way into the roughly defined head cavity. At irregular intervals it gives rise to small ventral branches that pass between the halves of the reproductive gland and enter a sinus lying along the under side of the organ. From this vessel lateral branches extend around the sides of the gonad and open into the visceral cavity dorsally. This relation of aorta and gonad continues as long as any trace of the latter exists, and anterior to this point the aorta gradually enlarges and finally in the neighborhood of the brain passes into the "head cavity." This last named space is not bounded posteriorly by a septum, but is well defined by the front end of the pedal gland through and around which the blood passes backward by small channels into the visceral cavity proper. This large sinus surrounding the digestive tract is subdivided into two roughly defined spaces, a relatively large sinus lying beneath the intestine and a very much smaller one located between it and the foot. At irregular intervals these two communicate and small lateral canals also connect the pedal sinus with the main section of the visceral cavity. The latter also communicates with the ventral intestinal sinus by fairly well-defined lateral canals that occupy positions between the gut pouches. In the neighborhood of the cloacal passage these minor sinuses unite with the larger and the blood, that has travelled backward in all of them, makes its way dorsally to open into the hinder end of the heart.

In a foregoing account (Heath '04) the nervous system of this species has been described and in this connection it is only necessary to mention the more prominent features. As is represented (Plate **5**, fig. 2), the brain is situated in a depression immediately in front of the dorsal salivary glands. Anteriorly it develops six nerves whose branches supply in large measure the sense organs of the buccal wall and probably the hypodermis and the musculature of adjoining regions. Posteriorly it gives rise to three pairs of nerves, the lateral, pedal, and labio-buccal connectives. The lateral cord almost immediately takes up its permanent position at the sides of the body; the pedal passes downward and backward to unite with the pedal ganglia that occupy the usual ventral position; while the labio-buccal connectives pass backward along the sides of the pharynx and unite with the labio-buccal ganglia that are placed at the sides of the radula. About mid way between the brain and ganglia the labio-buccal connectives are united by a commissure (dorsal buccal) that passes across the dorsal side of the pharyngeal wall, while a second (ventral buccal) passing over the radula unites the buccal ganglia. Each of these last named nerve masses, connected by the well-known commissure dorsal to the radular sac, gives rise to a prominent nerve that passes inward and unites with a ganglion situated near the base each of the subradular organs mentioned in connection with the radula. Each subradular ganglion is in turn connected with a commissure imbedded in the tissue beneath the pharynx. The relations of these ganglia and the attendant sense organs is essentially the same as in the Polyplacophora. They are much more concentrated in the latter group but the various elements may be readily homologized.

Through the body proper the pedal and lateral cords are united by connectives corresponding roughly to the number of gut pouches. About the same number of commissures also unite the pedal cords. These connectives and commissures disappear about the middle of the slime gland and a short distance beyond this point the pedal cords disappear apparently without forming a posterior connective (Plate **13**, fig. 4). The lateral cords on the other hand pass into the posterior ganglia that give rise to many nerves supplying the surrounding tissues and are united by a strong commissure dorsal to the intestine. In the mid line this commissure develops a nerve that supplies the dorsal sense organ.

The dorsal sense organ is located on the mid dorsal line a short distance from the hind end of the animal. Sections show that the cuticle in this region is almost wholly lacking and that the neighboring spines bend over and protect the otherwise naked sensory area. In each specimen the spines were much worn and the upper part of the sensory hollow was filled with debris so that no outward sign of this organ was visible. In one individual, probably abnormal in this regard, there were two dorsal sense organs, one a short distance in front of the other in the mid line. The posterior one corresponds most closely to the single one of the other individuals and will be first described.

The cuticle over the sensory region is almost wholly absent and the hypodermal cells, that ordinarily are small and distinct, become clearly defined, columnar, and depressed below the general level of the hypodermis. To the bottom of this hollow are attached a group of ganglion cells that connect in turn with a nerve from the postpallial commissure. Several muscle fibres are also united to the base of this organ. Judging from appearances the pressure of the blood beneath causes an eversion of the cells of the sensory pit bringing them to the level of the general body surface while the contraction of the muscle fibres produces their withdrawal and, if of sufficient strength, the overarching of the surrounding spicules.

The anomalous sense organ mentioned previously as occurring slightly in front of the dorsal organ proper consists of two sensory pits in all essential respects like the one just described. They are separated by a ridge (Plate **32**, fig. 10) on which the spines are relatively small and the hypodermal epithelium only slightly different from that found over the body elsewhere. Nerves from the post lateral (pallial) commissure pass to the depressed area that thus appears to be the sense organ proper.

As in other Solenogastres the hermaphrodite gland is in the form of two greatly elongated sacs closely appressed along the mid line and extending nearly as far forward as the brain. As usual the ova are developed along the inner wall while the spermatozoa are produced more externally. In the region of the heart each half of the gonad becomes narrowed to a small duct that communicates with the front end of the pericardium, which in one of the specimens was of large size and filled with sex products.

From the postero-lateral borders of the pericardium the coelomoducts arise (Plate **13**, fig. 4) as relatively slender tubes, and coursing forward and downward make their way by a fairly direct course to a point near the front end of the shell gland into which they open. Each canal is in the form of a greatly elongated spindle lined throughout the first part of its course with low flat cells, having indistinct boundaries like those of the pericardial cavity. In the middle enlarged section they attain a greater height becoming nearly cubical, a shape they retain throughout the remainder of this section of the genital canal.

The shell gland or slime gland is a comparatively voluminous organ roughly U-shaped in form (Plate **11**, fig. 5). Anteriorly each limb communicates with the spiral seminal receptacle and the section of the gonoduct just described while posteriorly both unite and enter the cloaca by a comparatively narrow opening. In striking contrast to the low epithelium of the dorsal limb of the genital canal the lining cells of this section possess clearly defined walls, are high and slender, and are glandular in character. Those in the neighborhood of the seminal receptacle differ considerably in the nature of their secretion from those of the succeeding portions. With the exception of a small mass of protoplasm containing the spherical granular nucleus the cytoplasm is charged with a product apparently muciform, staining intensely with logwood dyes. In many cases the material has been discharged leaving a relatively spongy protoplasmic matrix. When relieved of their load the cells show no sign of degeneration but continue to elaborate the secretion which forms as minute granules uniformly distributed throughout the protoplasm. As these increase in amount they unite, finally becoming one confluent mass that almost completely fills the cells. In the only other specimen which was sectioned this portion of the gonoduct is composed of cellular elements of the same appearance, but the secretion is hyaline and unaffected by Delafield's haematoxylin, a condition of affairs due in all probability to a different phase of glandular activity.

In both specimens these cells of the anterior third of the shell gland blend rather gradually with those of the succeeding section of the duct. As Hubrecht notes in *Proneomenia sluiteri* the cells are very slender elongated elements with basal nucleus and a secretion, developing at first in the form of minute granules which subsequently fuse and form particles of larger size until one great droplet occupies almost the entire cell often crushing the nucleus into an almost indistinguishable mass. It is worthy of note that all the cells in a fairly well-defined area are usually in the same stage of activity, perhaps discharging their burden while those of neighboring regions may be entering into the first stages of the process. In many cases where the secretion has recently been discharged it acts as a highly viscous fluid that only gradually undergoes liquifaction and fills the lumen of the cloacal passage.

Proneomenia insularis, sp. nov.

This species is represented by a small portion of the anterior end of one individual including the radula and the comparatively long ventral salivary glands.

The specimen was found in the bottom of a jar containing some alcyonarian corals that were dredged near Bird Island (Sta. 4157) at a depth of 762–1,000 fath. where the bottom consisted of white mud and foraminiferous sand with a temperature of 38°. In external appearance and especially in the relations and structure of the cirri, atrial ridges, the radula, salivary glands, and other of the more important organs this species shows a very close resemblance to the species of Proneomenia just described; accordingly I have very little hesitancy in placing it in this genus. The present fragment, cylindrical in cross section save for a slight flattening of the ventral surface, measured about 1.5 mm. in diameter and terminated anteriorly by a rounded extremity (Plate 8, fig. 4). There is no crest. Its enveloping cuticle, of the usual yellow color, is comparatively thick and contains large numbers of tapering spicules with rounded ends (Plate 37, fig. 16). Another type of spine occurs in the deeper layers of the cuticle in the form of relatively short basally truncated bodies which are in contact with a stalked cell of the hypodermis. In the case of the larger spicules of this character the sharp distal point may protrude freely above the cuticle.

The anterior pedal gland is relatively voluminous, extending forward as far as the cirrose area, posteriorly to the front end of the oesophagus and filling nearly all of the visceral space between these two boundaries. As has been noted in other species of the genus this gland opens separately into a comparatively large space situated behind the mouth opening and continuous with the front end of the pedal furrow. Posteriorly this organ passes without a sharp line of demarcation into the pedal gland proper that holds the same relation to the animal as in the preceding species, but in bulk and in size of its cells it is probably twice as large. Behind the opening into which the anterior pedal gland pours its secretion the foot commences as a low median ridge that gradually assumes its full size though this is considerably short of that of the foregoing species.

The opening of the atrium holds the same position and is of the same relative size as in *P. hawaiiensis* (Plate 8, fig. 4). The ridges and the cirrose area are likewise very similar in the two forms. The ciliated ridges are not so high in this species owing possibly to the amount of contained blood and the cirri, somewhat more slender than in the foregoing species, are united by their bases into groups of two or three.

The junction of the atrial cavity and the pharynx is characterized by a ridge similar to that of the preceding species, but is not farther marked by the presence of a dorsal salivary gland. A very few relatively large cells are situated among the nerve fibres passing out from the brain, but while they are in the correct position for the unpaired gland no ducts have been discovered.

The paired salivary glands present the same general appearance as in *P. hawaiiensis*. In the present specimen each organ extends from its opening at the sides of the forward end of the radula backward twice the distance from the front end of the animal to the opening of the salivary duct. Beyond this point the remaining portions of the body are missing. The cells are of the usual high columnar type and are more vacuolated than in any specimens of the preceding species.

After extending backward for about half its length the pharynx bends abruptly upwards and unites with the stomach-intestine. In the angle thus formed is placed the radula that is considerably shorter than in the foregoing species. The teeth also are much smaller though of somewhat similar shape and judging entirely from longitudinal sections there are probably not less than twenty-eight transverse rows with at least twenty-four teeth in each row and possibly more. On the other hand the radular supports, in the form of several transverse rods of compact connective tissue, are more highly developed. The relation of the pharynx and the stomach-intestine are sufficiently shown (Plate 8, fig. 4). The anterior coecum, the gut pouches, and the digestive cells are also essentially like those of *P. hawaiiensis* and require no comment.

In connection with the circulatory system there are no unique characters. Every blood space was crowded with corpuscles, spherical in form, with dense nuclei and cytoplasm, colorless after treatment with Delafield's haematoxylin, and containing several refringent granules.

In this species the brain is of medium size, its greatest diameter equaling one eighth the average diameter of the body, and is situated some distance behind the union of the pharynx and mouth. As usual three pairs of nerves pass from its forward and lateral regions to the front part of the body, becoming lost to view in the region of the cirri or more laterally among the body muscles. The connectives passing backward are completely ensheathed in the anterior pedal gland whose granular substance renders it very difficult to follow them to their destination. It has been possible to trace the relatively large pedal fibres to the pedal ganglia, and the lateral connectives to their position along the sides of the body, but the labio-buccal connectives are exceedingly difficult to differentiate. However with the aid of high magnification their course has been traced beyond question to the ganglia situated on each side of the pharynx about the level of the radular supports. Each is characterized by a much elongated spindle shape, the connective uniting with its anterior end and the ventral commissure attaching posteriorly. This latter nerve arches over the dorsal side of the radula and otherwise presents the usual appearance. A dorsal buccal commissure, subradular system, and labial commissure were not found.

Immediately in front of the radula is a ridge of columnar cells that may correspond to the subradular organ. In several sections it is also possible to distinguish fibres that have the peculiar refraction of other undoubted nerves; yet in spite of persistent effort it has not been possible to determine their relations.

Three pedal commissures have been proven to exist and eight palliopedal connectives, all with the usual relations.

The paired gonad extends forward to a point slightly behind the level of the hinder end of the radula supports. Anteriorly its cells are entirely male, minute ova appearing only in the most posterior part of the fragment.

Driomenia pacifica, sp. nov.

Three individuals of this species were taken off the southern end of Japan, two from Ose Zaki (Sta. 3716) at a depth of 65–125 fms. and one from Kagoshima Gulf (Sta. 4935) at a depth of 103 fathoms. All were imbedded in a mass of hydroids belonging to the genus Sertularella. The body is of uniform diameter, measuring 1 mm. by 9 mm. in length. The color in alcohol was a yellowish white.

No dorso-terminal sense organ has been discovered.

The cuticle is thick and contains an innumerable number of hollow spicules of varying sizes but with the general form represented in Plate **39**, fig. 5. The usual hypodermal cells are not especially favorable for study, but on the other hand those of the papillae (Plate **38**, fig. 10) are exceptionally clear. In the distal portion of each papilla the cells are spindle shaped, usually compact and finely granular, and appear in many cases at least to be continuous with a slender fibre which traverses the stalk and may be followed readily into the tissue beneath the hypodermal layer. Beyond this point their course cannot be determined with certainty and accordingly there is no clear evidence as to whether they are muscle or nerve.

The anterior pedal gland, occupying the customary position, is composed of the usual pyriform cells of average size. Posteriorly it passes without any change, except a decrease in the number of cells, into the posterior pedal gland which accompanies the foot throughout its entire extent. The outlet of the anterior pedal gland (Plate **38**, fig. 1) is a plain walled, globular cavity heavily ciliated. Posteriorly two lateral and one median fold arise on its walls and soon unite to form the foot which continues to the cloacal opening though the two lateral folds become of small size.

The atrial chamber, distinctly separated from the remainder of the digestive tract by a spiculose ridge, is a cavity with walls fashioned into the usual sensory organs. The inner and outer ridges are moderately low, horseshoe-shaped ciliated folds nearly encircling the chamber and bounding the cirrose area. Each cirrus is very slender, without a distinct cavity and is usually united at its base with one or two others.

The true mouth opening is borne on the summit of a low yet broad proboscis which is separated by a very narrow spiculose ridge from the outlet of the anterior pedal gland. From external view this proboscis is not visible, the ventral furrow appearing to extend to the atrial chamber. The mouth leads into a slender tube, with irregular longitudinal folds, and becoming gradually larger as it courses dorsally it opens into the stomach-intestine. About midway it connects with two short ducts from the salivary glands wedged between the stomach-intestine and the anterior pedal gland in the general position represented (Plate **38**, fig. 1). Each salivary gland cell is pyriform, slightly vacuolated with distinct compact nucleus and unites with the main outlet by means of a very slender ductule.

The anterior coecum and the adjoining section of the gut, is a plain walled tube lined with the usual vacuolated, granular digestive cells. More posteriorly lateral pouches of irregular form appear (Plate **38**, fig. 1) and may be found at fairly regular intervals as far as the anterior end of the pericardium. Here the canal rapidly narrows, becomes circular in outline (Plate **38**, figs. 7, 9) the epithelial lining is reduced in height and by a slender pore it opens into the cloacal chamber whose form and relations are represented (Plate **38**, fig. 2). It may be added in this connection that the walls of the cloaca are devoid of folds, glandular appendages, or modifications of any definite character.

The pericardial cavity is of moderate size but in one respect differs from that of any other Solenogastre. Immediately behind the opening into the gonad the pericardial wall forms two latero-ventral outpouchings of considerable length (Plate **38**, figs. 2, 7). The component cells are low columnar in form, without definite signs of glandular activity and contain relatively large dense nuclei. It is impossible to determine their function though they may be seminal vesicles since cells of the same general appearance compose the lateral pericardial wall and connect these diverticula with the inner openings of the coelomoducts.

The heart is of average size and consists of two distinct divisions. The anterior one, without any sharp boundary line is continuous with the aorta which, throughout its entire length, is a tube of more than usually great size. Its connections with the gonad and the anterior end of the body are normal as are those of the visceral sinus. Large blood spaces occur about the cloacal cavity and as the walls of the latter are thin the exchange of gases may readily take place at this point. The blood corpuscles vary considerably in shape, in some cases being similar to the elongated type found in Strophomenia and at other times appearing almost globular. This may be a *post mortem* effect but the cells are very well preserved.

The nervous system is difficult to trace and accordingly has been examined in its broader features only which show it to be of the usual type.

The single specimen examined is sexually mature and the reproductive gland extends as far forward as the level of the salivary glands. While the eggs are attached as usual to the median wall of the gonad the sperms develop in lateral pouches. In the posterior end of the body these crypts are of large size, extending in some cases far down the sides of the intestine, and they are connected with the gonad by small pores (Plate **38**, fig. 2).

The coelomoducts arise as relatively small tubes from the posterior border of the pericardium and extend forward to the region of the seminal receptacle where as usual they unite with the shell gland. The lining epithelium is low, the cells cubical and ciliated and without indications of being glandular. Each seminal receptacle is a comparatively large club-shaped sac provided with several small outpouchings especially on its distal extremity. In these small pouches multitudes of spermatozoa are attached to the lining epithelium which is composed of slender columnar cells.

The shell gland is in the form of a thick set **Y** and as may be seen, Plate **38**, it contains a cavity of moderate size. The greater number of gland cells are of one type, high columnar elements containing, large numbers of spherical granules. In the neighborhood of the opening into the seminal receptacle these are associated with a small number of cells containing, after treatment with Delafield's haematoxylin, a homogeneous violet colored substance. In close proximity to the opening into the cloacal chamber the dorsal wall of the gland contains a considerable number of cells, which secrete a coal black substance when treated with the above mentioned stain. All of these glandular elements are in contact with slender supporting cells containing mesially placed spindle-shaped nuclei.

Dorymenia acuta, sp. nov.

Eleven specimens of this species were dredged in the vicinity of the Santa Barbara Islands, off southern California, at depths ranging from 302–638 fathoms. The three largest specimens measure 35 mm. in length by 1.25 average diameter, with one exception having a thickness of 2.25 mm. The two smallest individuals are 14 mm. in length by 1 mm. average diameter, and with one exception, a slightly spindle-shaped individual, all of the specimens are slender and of about uniform diameter throughout (Plate **3**, fig. 11). Their color varies from a grayish white, where the brick-red color of the liver shines through the cuticle, to light lemon-yellow. The head is rather sharply pointed, and but slightly differentiated from the body proper, which posteriorly terminates in a very pointed extremity as in *Proneomenia weberi* Nierstr. The atrial opening is relatively small, subterminal and surrounded by tumid lips which separate it from the ventral furrow. As noted in a succeeding paragraph, the anterior pedal gland is highly developed, but its outlet is not especially modified externally. Posteriorly the pedal groove is continuous with the cloacal cavity. The cloacal opening is relatively large, ventral and is overarched by the posterior pointed end of the body, whose lateral margins are involuted, but may perhaps be flared occasionally to expose the genital spicula, the appearance of the hinder end of the animal resembling at such a time *Ichthyomenia ichthyodes* Pruvot.

A well-developed dorsal sense organ (Plate **15**, fig. 11), visible in sections only, is present a short distance from the posterior end of the body, and is supplied with special nerves and blood sinuses as in *P. hawaiiensis*.

The cuticle investing the body is relatively thick (Plate **33**, fig. 4), and is developed by a hypodermal layer in which the component cells are of small size. Those not instrumental in the formation of the spicules or papillae are more or less cubical in form and consist of vacuolated cytoplasm in which the nucleus, usually spherical, holds a central position. At various points the nuclei are dense and elongated and may possibly belong to sensory cells.

The spicules are hollow needle-like structures (Plate **37**, fig. 10), those of the alternate layers crossing the others almost at right angles. In their formation no points of especial interest appear. As usual several cells take part in the process as in *P. hawaiiensis*.

The papillae are of average number and present the appearance represented (Plate **33**, fig. 4). Three or four spindle-shaped nuclei occur in the slender fibrous stalk while from five to seven are present in the swollen distal portion. In this last named situation the nuclei are frequently of two sizes, small dense bodies, and one or two of twice their size with a more vesicular appearance. Judging from many sections both the number and character of these elements are due to different stages in the development of the papillae. In advanced stages these latter organs may open to the exterior and become so filled with debris that the cellular elements save those of the stalk, become obliterated. This, however, is undoubtedly an abnormal condition and marks the close of an active functional existence on the part of the papilla.

The anterior pedal gland, as in various other species of Neomeniina, is a voluminous organ extending anteriorly as far as the brain, posteriorly as far as the forward border of the radula and filling practically all of the space between the gut and the body wall. The cells, where not compressed, are pear shaped with a diameter ranging from .0185–.0351 mm. In the early stages of their existence the cytoplasm is vacuolated and not affected with haematoxylin but with the assumption of glandular activity the secretion, in the form of fine darkly staining granules, appears in the peripheral portions of the cell gradually filling the more central portions with the exception of the small, and at this stage, much shrunken nucleus. Delicate ducts, as usual, lead from the cell body to their intercellular opening into the anterior end of the pedal furrow.

From external view the opening of the anterior pedal gland is not marked by any noteworthy peculiarity, but from sections it may be seen that the pedal groove soon expands inwardly into two extensive lateral diverticula (Plate 15, fig. 1), whose anterior walls, in some specimens, are thrown into low folds and more posteriorly are supplied with very heavy cilia, ranging from one to three times the length of the supporting cell. Along the median dorsal line a large fold exists which more posteriorly is continuous with the foot. Everywhere throughout this fold and over the anterior folds of each crypt the secretion makes its exit in the form of a very finely granular almost homogeneous substance and after treatment with haematoxylin of a slightly pinkish tint.

The posterior pedal gland is also well developed and consists of a rod of cells on each side of the mid ventral line continuous in front with those of the anterior pedal gland with which they are identical save for their slightly smaller size. Posteriorly they gradually diminish in bulk and number, and in the region of the cloaca finally disappear.

The foot consists of very little more than a V–shaped epithelial fold, the included muscle and connective tissue being very scanty, and entirely devoid of blood sinuses or at all events those of sufficient size to include blood corpuscles in preserved material. Throughout its entire extent it is accompanied by two small epithelial ridges which are to be considered special modifications of the hypodermis. The inter-cellular openings of the pedal gland occur in the angle formed by these ridges and the foot.

The atrial opening, holding the usual subterminal position, leads into a cavity possessing essentially the same relations as in various species of Neomenidae. Like *Proneomenia hawaiiensis*, for example, there are two conspicuous ridges surrounding the cirrose area, and external to the outer buccal ridge a low elevation encircles the cavity save in the mid line posteriorly. From this elevation numerous delicate fibrils may be traced to a rod-like accumulation of ganglion cells coextensive with the ridge itself. On the other hand these nerve cells connect by relatively large nerve bundles with the ganglia located near the bases of the cirri.

Of the ciliated ridges (Mundleisten) the more external are in the form of two elevations which approach each other very closely in front and behind, at which points they become low and inconspicuous though in their mid section they are comparatively high. The inner ridge has the form of a horseshoe, the free extremities connecting posteriorly with the ends of the outer ridge.

This inner prominence is relatively short yet high, and like the outer contains a loose meshwork of muscle and connective-tissue fibres among which are numerous blood corpuscles. The cells composing them present much the same appearance as those of the outer low elevation described in the preceding paragraph. Practically all are slender and contain small amounts of pigment and elongated nuclei. Nerve fibres may be followed into the ridges which thus seem to be sensory. In *P. hawaiiensis* these cells are richly ciliated, but in this species all traces of cilia are absent and, it may be added, the material is excellently preserved.

Within the cirrose area and lying behind the innermost ridge the atrial wall in the mid line is developed into a fold, of large size, which is closely packed with multitudes of blood corpuscles. If the buccal ridges serve as respiratory organs, as some authors would have us believe, this structure is certainly more efficient since it is not only voluminous but its epithelial covering is not more than one third as thick as that of the general atrial cavity.

The cirri are prominent structures in this species, being not only numerous but of considerable length and calibre. Each is composed of cubical or low columnar cells filled to a considerable extent with the usual yellowish pigment which more or less conceals the small centrally placed spherical nucleus. At various points these organs may arise singly from the buccal wall, but usually the bases of from four to six are fused, and into this stalk muscle and occasionally nerve fibres may be traced. The cavity of the single cirrus is usually so small that the relation of these fibres remains unknown and, it may be noted, effectually blocks the entrance of blood cells, so that these organs are rather to be considered retractile sensory organs with little respiratory function.

A short distance behind the cirrose area the pharynx originates as a tube with somewhat smaller diameter than the atrial cavity. However, immediately behind the region of the brain the canal from external view expands considerably, but sections of this region show that a great fold develops in the pharyngeal wall which it entirely encircles reducing the cavity to a crescentic slit (Plate **15**, figs. 1, 7). Numerous muscles inserted in the tissue of the fold and on the other hand to the body wall doubtless serve to dilate the canal when the animal is in the act of feeding. Immediately behind this fold, and therefore in the region of the radula, the canal becomes much wider but more posteriorly again narrows and by a comparatively small opening communicates with the stomach-intestine. Throughout the entire extent of the pharynx its epithelial lining is thrown into numerous longitudinal folds, especially in the neighborhood of the radula where they become wavy and in sections present a most complicated appearance. In general the cells of the pharyngeal epithelium are low columnar elements devoid of cilia and overlaid with a clearly defined cuticular layer.

Two sets of salivary glands are present, a ventral pair and a group of cells imbedded in the large fold just mentioned. The cells of the last named gland, which is probably the homologue of the dorsal salivary gland of several other species of Solenogastres, are not grouped compactly as in *P. hawaiiensis,* for example, but are scattered throughout the tissue of the fold and open by separate pores over its entire extent. All the cells are pyriform and in early stages are composed of a finely vacuolated cytoplasm in which the secretion ultimately makes its appearance in the form of distinct granules of comparatively large size. These rarely accumulate to a sufficient extent to hide the nucleus but make their way by well-defined ducts to open by intercellular channels into the pharyngeal cavity.

The ventral salivary glands open into the pharynx at the sides of the extreme tip of the radula, and in the form of tubular outgrowths extend backward for a distance of 3.5 mm. As may be seen (Plate **15**, fig. 2), the ducts are of large size and are bounded by slender cells densely filled with a secretion having much the same appearance as that developed in the dorsal set.

The radula is of the polystichous type, and judging wholly from sections consists of 48–51 rows with twenty-two teeth in each row. All the teeth are of essentially the same shape (Plate **34**, figs. 7, 11) and size with the exception of those on each side of the mid line which appear to be slightly smaller. A very thin yet clearly defined basement membrane is present.

The radula sac rests upon a support consisting of a series of globular cells of which two are of relatively large size and are located symmetrically on each side of the mid line. All of these contain nuclei and a finely granular cytoplasm, which in the larger cells is usually greatly shrunken. To these supports numerous muscles attach, but from sections it is most difficult to describe their relations and define their function.

The matrix cells of the radula are comparatively small and the teeth numerous so that an accurate determination of the development of the teeth and basement membrane is difficult. Odontoblasts, holding the ordinary position and with the usual appearance are present and numerous enamel cells arise from the bottom of the radular sac. These latter elements may be traced forward a short distance among the newly developed teeth where they disappear. The cells responsible for the formation of the basement membrane are not unlike the odontoblasts all of which blend with the epithelial cells of the ventral side of the radular sac. In all essential respects therefore the development of the radula in this species is not unlike what exists in *Limifossor talpoideus*.

Immediately behind the opening of the pharynx into the intestine the walls of the latter develop a circular fold (Plate **15**, fig. 7) which in life may be less contracted and serve as a valve. Anterior to it the intestinal coecum extends as far forward as the brain. It is almost wholly devoid of diverticula, though its low epithelial lining is thrown into numerous small folds on its ventral surface. Slightly behind the valve-like fold just mentioned the intestine proper arises, characterized by diverticula of almost mathematical regularity lined by the usual high club-shaped digestive cells, except underneath the gonad where the intestinal epithelium loses its glandular character and its low columnar cells support a coat of cilia. This state of affairs continues to the front end of the coelomoducts where the canal rapidly decreases in diameter and becomes ciliated throughout. Making its way to the dorsal side of the animal it passes between the pericardium and gonoduct to open into the cloacal chamber.

The pericardial cavity is a comparatively large space whose general shape and relations may be determined from Plate **6**, fig. 4. The cells composing its epithelial lining are indistinct in outline, yet, judging from the nuclei, are more numerous than in any other species of Solenogastre described in the present paper. The heart also is of large size (Plate **15**, figs. 4, 6) in both specimens which were sectioned, and very clearly consists of an auricle and ventricle. The first named division is much distended and the walls are thin and delicate, consisting externally of an epithelial sheet resembling that lining the pericardium, internally supported by a few muscle fibres. These form a loose meshwork from which occasional fibres pass across the auricular cavity to be inserted elsewhere in the wall. The long, sharply defined median dorsal sinus, extending from the posterior end of the body, enlarges as it passes forward and enters the auricle on its posterior border. As usual the ventricular walls are of greater thickness and the spaces formed by the interlacing fibres relatively small and filled with groups of corpuscles. Anteriorly it passes into the aorta which, passing between the two widely separated ducts from the gonad, becomes a vessel of large diameter.

The vessels to the gonad, and the exit of these into the visceral cavity and the communication of the dorsal sinus with the numerous channels in the head region are of the usual type. The sinuses of the head are relatively small yet may readily be followed through the anterior pedal gland and about the buccal wall to a small median ventral sinus situated above the outlet of the anterior pedal gland. Above the forward end of the foot this median sinus widens greatly, and during its journey to the posterior end of the body communicates here and there with the visceral sinus and at various points is divided horizontally by a muscular septum, thus forming two fairly complete sinuses one above the other. In the region of the coelomoducts these channels become sharply defined, though as they approach the cloaca, the ventral one, in frequent communication with the dorsal, gradually diminishes and at the termination of the foot vanishes completely. The remaining ventral sinus has likewise greatly decreased in size in this same region, and communicating frequently with the outlying visceral cavity disappears immediately in front of the cloaca. At the sides of the cloacal cavity and posterior to it the blood probably passes backward in the ventral half of the body, and by means of numerous channels passes into the dorsal half where it is transferred to the heart by several lacunae, the median dorsal one being most clearly defined. The corpuscles are about two thirds the size of those of Proneomenia which otherwise they closely resemble (Plate **35**, fig. 13).

It will be seen (Plate **6**, fig. 4 and Plate **9**, fig. 2), that the coelomoducts arise from the postero-lateral borders of the pericardium by relatively large openings, and extending forward as far as the anterior extremity of the heart communicate by a narrow canal with the conical seminal receptacle, and by a larger opening with the last section, of larger calibre, which unites with a corresponding tube of the opposite side and by a single median opening communicates with the cloacal cavity. Immediately beyond its inner opening the epithelial lining of each duct is thrown into prominent ridges composed of slender ciliated cells in which there are faint traces of glandular activity, which may possibly become more pronounced during the breeding period. Half way to the seminal receptacle the ridges disappear and the cells become lower, more cubical, and apparently are possessed of cilia. Furthermore throughout this same section of the canal some of the cells of its outer half become much elongated and form strands which bridge the cavity. In the neighborhood of the seminal receptacle these are numerous but what their office may be it is difficult to conjecture.

The seminal receptacle is a thin-walled subconical sac provided with very slight internal folds and composed of low cubical cells which bear no trace of cilia nor secretory products. During the time it is filled with sperms, however, the cells become more or less liquified, the nuclei relatively large and pale after treatment with haematoxylin and great numbers of spermatozoa become imbedded in their substance. It unites by means of a short narrow canal with the coelomoduct at the point where the first and second sections meet.

The second section of the coelomoduct, or shell gland, is a tube of comparatively large size (Plate **15**, figs. 4, 6). In the anterior third its walls are thin, almost devoid of folds and the cells composing it vary from cubical elements to others of low columnar form, if the animal be immature or out of the breeding season. As this last mentioned time approaches the cells become greatly thickened and the meagre secretion becomes abundant, filling the cell as a dark, almost black, substance like that of the muciparous gland in many molluscs. This condition of affairs continues along the mid ventral line of the duct for a considerable distance posteriorly. The same modifications occur in the succeeding portions of the coelomoduct, but as the time of sexual activity approaches the cells become greatly elongated, are thrown into large transverse folds and are filled with a faintly yellowish secretion which at other times is scarcely visible.

In this species, as in *P. weberi*, two genital spicula are present and of large size (Plate **6**, fig. 4). Each is inserted in a deep sheath, a diverticulum of the wall of the cloacal cavity, which extends forward and slightly upward to a point about level with the base of the seminal receptacle. The cells of the distal extremity, which are probably the spicule-matrix cells, are very slender elements (Plate **15**, fig. 10), with dense spindle-shaped nuclei imbedded in an almost homogeneous cytoplasm having somewhat the appearance of the odontoblasts of various molluscs. Throughout the remainder of the sheath, especially on its inner half, the cells are considerably smaller and their distal portion appears to be more or less cuticularized (Plate **15**, fig. 5).

Two powerful sets of muscles, the retractors and protractors, attach to the sheath (Plate **9**, fig. 2). The first named consists of a large number of minor bands inserted in the distal end, and on the other hand to the body wall, after having spread out fan-like, a short distance anterior to the seminal receptacle. The protractors are more numerous and attach at various points within a narrow zone immediately behind the retractors. On the other hand, after passing backward, the various groups of fibres become attached to the body wall or to the cloacal wall in the neighborhood of the opening of the spicule sheath. Numerous other strands occur in this region whose function it is to widen the cloaca, enabling the spicule to be exposed while others bring about a counter movement. Those active in the first operation consist of many bands passing radially from the wall of the cloaca to become inserted in the body wall, and others which pass from the cloacal wall anteriorly to blend with the somatic muscles. The remainder, responsible for the reduction of the cloacal cavity, comprise many fibres which attach to the walls of the cloacal cavity, and passing backward unite with the body wall on each side of the forward border of the cloacal opening.

A pair of curious vesicles, irregular in form but of comparatively large size, occur one on each side of the body wedged in between the cloacal wall, spicule sheath, and coelomoduct and, as sections show (Plate **15**, fig. 4), they are separated from each other by a thin vertical wall. On the posterior face of each a short slender tube communicates with the cloaca (Plate **9**, fig. 2). In immature individuals or those not sexually active the walls are comparatively thin, and are composed of cells cubical or low columnar in form without any distinct signs of glandular activity; but as the breeding season approaches the walls become much thickened and each cell develops some substance which gives it a longitudinally striated appearance. This material remains unstained in haematoxylin and as it forms crowds the nucleus to the distal end. There is some evidence, though scanty, that this secretion is poured into the diverticulum and there becomes transformed into a darkly staining mucus-like substance which everywhere lines the walls. Here and there are blood sinuses filled with corpuscles especially in the region of the opening into the cloaca where the cells are lower, without secretory products and covered with an abundance of cilia.

The fact that these modifications occur simultaneously with those of the gonoducts strongly suggests that these organs in some way play a part in the reproductive process. They may function as uteri but obviously such conjectures are of very little value at the present time.

There is some reason to believe that the type of coelomoduct found in Chaetoderma is more like that of Chiton, and accordingly of a more primitive type than in the Neomeniina where they are provided with seminal receptacles, glands often of enormous development and spicula, in some cases, provided also with glandular appendages. It is interesting to note that in an immature condition some of these more modified types present a simpler condition than at a later stage. In small specimens of the present species, about 14 mm. in length the various organs, connected with the reproductive system, hold the relations described above but they are far from being functional. The gonad, for example, is clearly paired throughout its entire length and the epithelium shows the merest traces of reproductive activity. The folds of germinal epithelium, that form a most characteristic feature of the adult organ, are commencing to appear on the latero-ventral surface of the gland, and there are slight evidences of a proliferation of cells on the inner wall of each gland. The dorsal aorta or sinus is of unusual size and in some places separates the two halves of the gonad completely, especially in front of the heart, where they are distant from each other by an interval equal to one third the diameter of the body. Thus widely separated they open into the pericardium, which, as in the adult, is of large size (Plate **15**, fig. 9). The heart likewise is typical. The ducts leading to the exterior are of essentially the same calibre throughout; the seminal receptacle terminates anteriorly in a relatively long flagellum-like process; the spicule sheaths have developed though there are no traces of the organic basis of the spicules themselves as in decalcified specimens of larger size; and the vesicles opening into the cloaca are both present though their outlets are relatively large. Above all there are no signs of glandular activity. As noted on page 169 if these ducts are in part excretory this phase of activity should appear long before sexual maturity and its absence indicates that these tubes are merely for carrying off sex products.

In this species the sheath surrounding the nerve bundles is of unusual density or at all events stains with uncommon intensity in haematoxylin, so that branches not over 0.002 mm. have been followed. Owing to this fact more than usual care has been taken to determine the distribution of the more important trunks.

The brain, holding the customary position, dorsal to the pharynx, is of medium size and very clearly bilobed. From its anterior half the usual three pairs of nerves arise and at their origin each is connected with two ganglia, one very minute in size. These fibres extend laterally and anteriorly and after branching several times connect with ganglionic masses about the bases of the cirri.

A pair of very small nerves spring from the middle section of the brain close to the junction of its lateral and ventral surfaces. Each of these proceeds laterally and ventrally, and coming in contact with the sides of the pharynx branches and becomes lost among the numerous muscle fibres.

From the posterior half of the brain the lateral, pedal and labio-buccal connectives take their rise from independent, distinct roots (Plate **13**, fig. 1). In side view the first two appear to be relatively short but in reality they extend laterally for a considerable distance at the same time bending ventrally to join the corresponding ganglia. All are practically devoid of ganglion cells. At the junction of each lateral connective with the ganglion there is a well-defined enlargement which anteriorly gives rise to a strong fibre passing forward closely applied to the somatic musculature. In the neighborhood of the atrium it branches repeatedly and the resulting fibres connect in some cases, at least, with the ganglia in the neighborhood of the cirri. At the union of this cord and the lateral ganglion another nerve appears which likewise rests against the body wall, and after passing forward and downward becomes lost to sight after branching a few times. This same anterior enlargement develops one or two very small laterally directed nerves which soon become indistinguishable among the somatic muscle fibres.

The lateral and pedal cords traverse the body holding the usual positions. Throughout their entire extent pedal commissures exist and approximately the same number of connectives unite the pedal and lateral ganglia. In the front end of the body, where the connectives are unusually distinct, they are often found to be united by commissures and accordingly lack the regular arrangement sometimes seen in figures of other species. As seen (Plate **13**, fig. 1) the anterior connective gives off a branch that passes forward and seemingly unites with the ganglionic rod of cells attached to the base of the outer atrial ridge. This appears also to be the destination of another nerve originating from the front end of each pedal ganglion.

The labio-buccal ganglia are ellipsoidal bodies resting on the dorsal surface of the ventral salivary glands a short distance behind their outlet into the pharynx. From the anterior surface of each a strong nerve arises and in the usually contracted state of preserved material is considerably twisted before it expands and breaks up into three strong branches. Of these the more dorsal one is the buccal connective attached to the brain. The one immediately ventral to it extends anteriorly, slightly imbedded in the pharyngeal musculature until it arrives at the great dorsal fold. Here it bends sharply inward and deeply imbedded in the muscle bands crosses the pharynx to unite with its fellow giving off one or two delicate fibres on the way. A second dorsal commissure is formed by two relatively small nerves each of which springs from the anterior face of the labio-buccal ganglion. These, in closer proximity to the mid line than the others for most of their course, become united above the pharynx slightly behind the dorsal pharyngeal fold.

At the junction of the labio-buccal connective and anterior dorsal commissure a third nerve arises probably to be considered the subradular connective. A short distance distal to its origin it originates two, sometimes three, small nerves which may be traced deep into the pharyngeal musculature in the neighborhood of the radula. Still farther outward a small ganglion is attached to it by a small stalk and between these two bodies the main fibre continues to complete the commissure.

In the posterior part of the body the pedal ganglia decrease rapidly in size, and become lost to view without being directly connected with the lateral cords. In this region the last four or five commissures are more than usually crowded together. The last three connectives on each side become united before entering the posterior end of the lateral ganglia, which here break up into four strong branches that pass backward, and after dividing repeatedly become lost in the walls of the cloaca and body including the posterior elongation. At the point where these nerves arise the lateral cords are joined by means of the customary suprarectal commissure.

Strophomenia scandens, sp nov.

Three specimens of this species were taken attached to a colony of *Acanthogorgia armata* dredged in the vicinity of Bird Island (Sta. 4156) at a depth of 286–568 fath. where the bottom was white mud and foraminiferous rock and the temperature was 45.8 F. The bodies of these animals were wrapped about the stems of the corals as shown (Plate **2**, fig. 1), but none of the polyps in their immediate vicinity exhibited a shrunken appearance as though these molluscs had been indulging their appetites as in the case of Drepanomenia. The contents of the alimentary canal consisted only of a small amount of a finely granular substance.

The largest specimen measured 39 mm. in length and 2.1 mm. in diameter; the smallest was 32 mm. long with a thickness of 1.6 mm. The two ends of the body are similar in appearance, the posterior being slightly more slender and pointed (Plate **2**, fig. 1). In cross section the body is in general nearly circular, but in both of the specimens at hand the ventral surface is slightly flattened. The atrial opening is an elongated slit surrounded by rounded lips, behind which the ventral furrow commences and posteriorly is continuous with the cloacal opening also subterminal in position.

The anterior portion of the ventral furrow forms a relatively deep depression (Plate **12**, fig. 1) with corrugated walls, the opening of the anterior pedal gland. The gland itself occupies most of the visceral cavity in front of the forward end of the foot (Plate **16**, figs. 1, 4). Its cells are of large size relatively, and are charged with a darkly staining secretion that makes its way by slender ducts to the ventral furrow, where each terminates in an intercellular opening. The secretion appears to be viscous, and in one of the specimens carefully dislodged it extended backward for a distance of 22 mm. as a narrow band.

The cuticle enclosing the body is about 0.2 mm. in thickness and as Plate **16**, shows this measurement is very uniform save in the immediate neighborhood of the ventral furrow. Imbedded in its substance are, roughly speaking, six to eight layers of spicules, those from the back and sides of the animal being represented (Plate **37**, fig. 17). Among these is a much smaller number of radially directed spines that become more minute and more abundant in the neighborhood of the foot.

The hypodermal layer is remarkably sharply defined, and not including the spicule forming elements and those connected with the papillae, consists of cells about twice as high as broad with greatly vacuolated protoplasm and well-defined nuclei occupying a more or less central position. Occasionally more slender cells are encountered but these may in reality belong to the papillae.

The development of the spicule is essentially the same as in *P. hawaiiensis* (page 28) both as regards the number and arrangement of the operating cells which also retain their connection with the spine as long as it remains in the cuticle.

As is shown (Plate **32**, fig. 3) the papillae are numerous and closely crowded together at the surface. The expanded portion contains not far from twenty nuclei and the stalk from 2–5; otherwise there are no especial features of importance.

The foot arises in the extreme anterior end of the pedal furrow as a well-defined median ridge whose bounding cells are apparently covered with small cilia; but these are usually obscured by the huge cilia of the cells situated laterally. In the anterior portions of the ventral furrow the secretion from the anterior gland passes through intercellular openings at all points; more posteriorly it passes through the foot and the epithelium in immediate contact with it. The secretion of the anterior pedal gland when treated with Delafield's haematoxylin contains one substance which stains almost black and another of light blue tint. These appear to be two distinct secretions, for the dark substance escapes high up on the sides of the ventral furrow while the light blue product passes out more ventrally.

Behind the opening of the anterior pedal gland each side of the foot is accompanied by a longitudinal fold, which persists to near the hinder end of the animal when the lateral ridges, decreasing in size, pass into the general hypodermal covering of the body and are covered in large measure by the cuticle in which small spicules may be formed.

The atrial opening leads into a well-defined cavity (Plate **12**, fig. 1) whose walls are provided with organs not unlike those in *P. hawaiiensis* for example. The outer sensory prominence and the outer and inner ciliated ridges are not so elevated, but the last two are composed of the same type of ciliated cells. At certain points the outer sensory ridge surmounts groups of ganglion cells from which fibres may occasionally be traced into close proximity to nerves that innervate the cirri. Along the median dorsal line another well-defined elevation is present between the two limbs of the inner ridge, but its cells are like those of the ordinary buccal epithelium and are probably not highly sensory.

In cross section the pharynx is roughly semilunar in shape, appearing relatively narrow when viewed from the side, but with a diameter of one fourth that of the body when seen from the dorsal or ventral surface. In front of the opening of the anterior pedal gland its cells are relatively high and slender, finely granular and contain more or less spindle-shaped nuclei placed at different levels. Behind this point the lining retains the same general character, but is developed into numerous and relatively low transverse folds supported by a small amount of connective tissue. Slightly in front of the labio-buccal ganglia the ridges become higher, the underlying connective tissue more abundant and among the cells of the usual type are a few others of more slender appearance with darkly staining elongated nuclei. It is possible that these elements are sensory in function, but owing to the large quantity of muscle and connective tissue in the neighborhood no special nerve supply has been distinguished.

Beyond these supposed sensory ridges the digestive tract bends abruptly upon itself and coursing upward and forward unites with the stomach-intestine (Plate **12**, fig. 1). There is reason to suppose that this section between the labio-buccal ganglia and the gut represents the oesophagus, but with the exception that its epithelial lining consists of more spongy cells not produced into folds there is little to distinguish it as such.

The relations of the paired ventral salivary glands (Plate **6**, fig. 6) are somewhat peculiar and except in very well-preserved material are difficult to determine, a fact that may be responsible for some of the remarkable relations of these glands as described in some other members of the genus and in Rhopalomenia. In the present species these organs are placed side by side beneath the intestine and extend backward from their outlet for a distance equal to at least four times the diameter of the body. Anteriorly they diverge and enter the pharyngeal wall almost directly above the labio-buccal ganglia. Imbedded in muscle and connective-tissue fibres and some of the outlying pharyngeal glands, each canal now bends sharply upon itself (in two individuals) and becoming much more slender courses downward and somewhat backward to enter the pharynx on its ventral side. From the bend to a point close to their outlet these ducts are not only relatively slender but their lumen is of very small size and save in excellently preserved material, as in one of the specimens, is scarcely to be distinguished from the surrounding tissue. They are also composed of remarkably delicate material for in one specimen in which the organs are in a fairly good state of preservation this section of the gland has macerated and disappeared completely, leaving only the short and firmer outlets into the pharynx and the free main part of the gland.

On the ventral side of the pharynx the glandular portion of each of these organs ceases abruptly and becomes continuous with a canal of somewhat larger calibre composed of small cubical cells, that proceeds almost directly inward and opens ventrally into the pharynx close to the mid line. This terminal section of the salivary glands is a conspicuous object in sections, but its connection with the adjoining glandular part may be readily overlooked in which case the terminal section appears to be a short diverticulum of the ventral wall of the pharynx while the gland proper seems to unite with the pharynx near the dorsal side.

In the present species there is in addition to the various divisions of the salivary glands a median diverticulum whose relation to the digestive tract and buccal commissure support the belief that it is a rudimentary radula. The ventral wall of the pharynx forms a shallow pocket and the salivary ducts open into the bottom of this at each side. Exactly in the mid line and immediately above this pouch there is a small posteriorly directed diverticulum of the ventral wall of the pharynx and in two examples the buccal commissure passes dorsal to it (Plate 6, fig. 6), the relations being the same as in the radula of *P. hawaiiensis* for example. Its epithelial lining consists of low cells composed of highly vacuolated cytoplasm in which the nuclei hold a basal position, but there is no sign whatever of teeth.

Correlated with the posterior attachment of the pharynx is the excessive development of the anterior coecum (Plate **12**, fig. 1), that extends forward to the hinder limits of the atrial cavity. In one specimen its walls are lined throughout with pyriform digestive cells, whose clear basal portion holds a small compact nucleus while the vacuolated distal part contains numerous granules characteristic of this type of cell. In another individual treated in precisely the same way the granular portion of the cells was absent as was the case in other parts of the digestive tract. As was noted in the case of *P. hawaiiensis* this appears to be the normal method of ridding the cells of their secretion. In the hinder portions of the coecum gut pouches appear and becoming more fully developed a short distance more posteriorly they continue with much regularity to the region of the heart where they abruptly disappear. Beneath the anterior end of the pericardium the intestine continues as a tube of relatively large calibre, but at the posterior end it rapidly narrows down to open into the cloaca (see Plate **12**).

As is represented (Plate **13**, fig. 2, and Plate **16**), the pericardium of this species is of considerable size and contains in addition to the heart a number of mature ova. Histologically the differentiation of auricle and ventricle is not clearly marked and save for a constriction there is nothing to distinguish these two divisions. The blood occupying the interstices between all the organs in the posterior part of the body passes into the auricle by a wide opening and thence pours into the ventricle through an aperture not guarded by clearly defined valves. From the forward end of the heart the aorta takes its rise and with the usual position makes its way to the head after having supplied the gonad. The blood spaces at the anterior end of the body are very limited, more so in fact than is indicated in the figures which have omitted the intrinsic muscles of the digestive tract as well as retractors and protractors that attach to the body wall. However, the course that the blood takes in passing through the body proper differs in no essential particular from that of *P. hawaiiensis.*

The corpuscles are spindle shaped (Plate **36**, fig. 12) and the small densely staining nucleus is superficially placed, in some cases being elevated above the surface of the slightly yellowish homogeneous cytoplasm.

In a preceding paper (Heath '04) attention has been called to the fact that in its more important details, especially in the relations of the labio-buccal system, the nervous system of this species shows a striking similarity to the Chitons and certain prosobranchs. The brain is relatively small and holds the usual position on the dorsal side of the pharynx behind the mouth cavity. As usual three pairs of nerves arise from its anterior borders and are distributed to the various structures of the atrial and body walls. From its lateral margins the lateral, pedal, and labio-buccal connectives arise side by side. The lateral present the usual appearance as is also true of the pedal whose union with the pedal ganglia is marked by a well-developed enlargement. In nearly all cases if not invariably the labio-buccal ganglia of the Solenogastres are located near the openings of the paired ventral salivary glands when these exist, and since in the present species these are situated far back the connectives imbedded in the muscular pharyngeal wall are characterized by a relatively great length. The ganglia imbedded in the wall of the pharynx give rise to three commissures and to the subradular connectives. The dorsal and ventral buccal commissures are sufficiently indicated (Plate **6**, fig. 6) to require no farther comment. In one specimen, possibly both, a well-developed ganglionic enlargement occurs on the ventral commissure and may correspond to the buccal ganglion, the other larger ganglion with which it is in close proximity and from which the subradular system is connected representing the labial. From this last named nerve mass another commissure passes ventral to the alimentary canal and in its course gives rise to two nerves which pass backward for a short distance and then become lost in the tissues of the pharynx.

As has been noted a typical subradular system is present in *P. hawaiiensis*. In *Limifossor talpoideus* it holds the customary position, but ganglia are apparently entirely absent. In one specimen of *Strophomenia scandens* very small masses of ganglion cells seemingly represent the subradular ganglia of which no sign exists in the other specimen. In this species no well-defined subradular organ occurs hence the ganglia are perhaps in a state of degeneration.

Owing to the comparatively small size of the latero-pedal and pedal commissures they are not readily followed yet in certain places they have been traced in dissections and sections, so that so far as may be judged they exhibit no unusual features.

In the posterior part of the body the relations shown (Plate **13**, fig. 2) exist. As there indicated the lateral and pedal ganglia are united by two strong connectives, and posteriorly give rise to several branches that pass backward and become lost in the somatic musculature. From the middle of the suprarectal commissure a nerve arises that has been traced to the base of the dorso-terminal sense organ. This last named structure (Plate **32**, fig. 9) is protruded above the general level of the cuticle. As indicated the cells are slender, naked, and rest upon a small accumulation of what are probably ganglion cells. Muscle fibres attaching to the base, are probably retractors, the pressure of the blood in the underlying sinus being responsible for the protrusion of the organ.

The hermaphrodite gland holds the usual position and anteriorly extends to a short distance behind the level of the union of the oesophagus and gut. In all the specimens the sex elements are fully formed, some of the large ova having been dehisced and carried into the pericardial cavity. Posteriorly the gland gradually decreases in size finally passing into two long slender canals that unite with the front end of the pericardium (Plate **13**, fig. 2). This last named cavity communicates posteriorly with the coelomoducts that extend backward a short distance before proceeding forward. At first the epithelial lining of these canals consists of low cells similar to those bounding the pericardium, but these are soon replaced by others almost cubical in form supporting an abundance of long cilia that continue to the seminal receptacles. These latter organs consist of from fifteen to eighteen sacs attached by short ciliated stalks to the gonoduct. In every case they were completely filled with spermatozoa.

The section of the coelomoduct, extending backward from the seminal receptacles, is lined throughout with relatively high columnar cells filled with a darkly staining granular secretion. Immediately back of the seminal receptacles these are developed into several longitudinal folds that quickly disappear more posteriorly. Still farther backward the two ducts unite a short distance in front of their outlet and in this single canal the internal folds reappear and persist to the cloacal cavity.

Immediately ventral to the outer opening of the reproductive system is a short diverticulum of the anterior wall of the cloaca (Plate **13**, fig. 2, dt). Its cells are cubical in form and essentially like those of the cloaca at this point, but there is no sign of spicules or any secretion that indicates its possible use.

Strophomenia ophidiana, sp. nov.

One specimen of this species (Plate **1**, fig. 2), attached to an alcyonarian coral, *Acanthogorgia angustiflora*, was taken off the southern end of Honshu Island, Japan (Sta. 3755) in water 52–77 fath. in depth. It measured 43 mm. in length and 2.5 mm. through the thickest part of the body. The color is creamy white shading to very light brown in the neighborhood of the head. A well-defined dorsal sense organ is present of the usual type.

The cuticle is relatively thick, measuring on an average 0.19 mm., and rests upon a thin hypodermal layer whose constituents present no especially noteworthy features. The papillae are fairly numerous, especially ventrally where they project somewhat above the external surface of the body. Their shape and general character are represented in Plate **33**, fig. 9. Small yellowish granules are scattered throughout the cuticle, but of their origin or function it is impossible to make any definite statements. The spines are shown (Plate **36**, fig. 17).

The sensory atrium is exceptionally small (Plate **8**, fig. 5) and the two outer ridges appear to be lacking altogether. The inner ridge, on the other hand, is clearly developed and typically placed but is of limited extent. The cirri in this genus are united as usual in groups of 2–5 and are composed of the customary cubical pigmented cells. Posteriorly the atrium opens into the buccal-pharyngeal tube, a long slender structure of about the same calibre throughout. Its lining is composed of slender epithelial cells produced into longitudinal folds especially in the anterior half. External to the epithelium is a well-developed layer of circular muscles and in contact with this a sheet of longitudinal fibres which become more abundant in the neighborhood of the stomach-intestine. In its anterior fourth this section of the digestive tract is attached to a considerable number of fibres which extend more or less radially to the body wall. Posterior to this region gland cells, arranged in small pear-shaped groups, are imbedded in the longitudinal muscle fibres and by intercellular canals open into the gut. The beautifully regular arrangement of these organs is shown (Plate **17**, fig. 13).

Ordinarily the stomach-intestine connects with the posterior end of the pharynx or oesophagus, but in the present species such is not the case, for this junction is considerably in front of the ventral salivary glands which are appendages of the pharynx. However the ventral wall of the gut from the dorsal intestinal coecum to the openings of the salivary ducts and for an equal distance posteriorly is clearly pharyngeal in character, lacking the hepatic cells but possessing the characteristic muscle layers.

The ventral salivary glands are relatively long tubular structures penetrated eccentrically by a thin epithelial tube through which the outlying glandular cells open. Close to the outlet into the pharynx this glandular portion disappears, and the delicate duct makes its way through the ventral side of the pharynx to open into a small *cul de sac.*

No radula is present.

The extent and relations of the anterior intestinal coecum are well represented (Plate **8**, fig. 5) and the intestine conforms so closely to the usual type that it demands no description. Posteriorly the gut narrows rapidly, becomes somewhat rectangular in cross section as it passes between the limbs of the shell gland, and shortly before its outlet in the cloaca develops moderately high folds.

The pericardial cavity is of very large size (Plate 18, figs. 2, 3), and the contained heart is of the usual greatly elongated type. There are no distinct signs of a division into auricle and ventricle though a valve-like flap near its anterior end may indicate such or possibly the commencement of the aorta, which for a considerable distance is of as great diameter as the heart itself and even in the head region continues of large calibre (Plate 18, fig. 1). Its relations to the gonad and visceral cavity are similar to what occurs in *S. triangularis.* In the posterior part of the body the channels are more than usually ill defined, but the course of the blood is essentially the same as in the other species of the genus. The corpuscles possess the characteristic elliptical or pointed ovate form, and are accompanied by a relatively large number of leucocytes.

The gonad is fully developed, of relatively large size and the sex products are arranged in the customary fashion. Throughout its entire extent, but especially in the posterior half of the animal, the normal reproductive elements are associated with large masses of eggs in all stages of degeneration. This may be due to *post mortem* changes, but the sharply defined character of the various stages of the spermatozoa, ova, blood corpuscles, and other cellular elements in various parts of the body argues against such a view. In some species of Chitons (*e. g. Ischnochiton magdalenensis*) a considerable number of ova do not pass to the exterior during the egg-laying process, but undergo disintegration and are absorbed. Appearances indicate that this is the state of affairs in the present species, and the almost empty condition of the seminal receptacles further indicates that the breeding season has passed.

The ducts leading from the pericardial cavity are relatively slender though they enlarge somewhat before entering the shell gland, and as the cells change from a cubical to a columnar form they become increasingly glandular. An unusually large number of seminal vesicles are present, twenty-three occurring on the side of the body represented (Plate 9, fig. 1). In these the distal, usually vesicular portion is exceptionally small (Plate 18, fig. 4) but the diameter may be somewhat increased when the organs are filled with sperms. These bodies are attached not only to the forward end of the shell gland but several of them open into the dorsal section of the gonoduct. The component cells are columnar and show at various points faint signs of glandular activity. The shell gland on the other hand is highly glandular, more than usually irregular in outline and as usual in the genus unites with its fellow of the opposite side so close to the cloaca that two openings appear to be present. The cells are all of columnar form and are of one type judging from the darkly staining granular secretion. As in other species of the genus a diverticulum of the cloacal wall is present ventral to the outlet of the shell gland, but there are no indications that it is of any especial significance.

In the other species of the genus Strophomenia described in the present paper there are from few to many diverticula extending outwardly from the cloacal wall, but they never reach the excessive development existing in this species. These are shown, somewhat diagrammatically (Plate **9**, fig. 1). The cells are usually columnar and are filled with a finely granular substance which in various places is in the act of escaping into the cloacal cavity.

The brain, clearly bilobed, is located against the under side of the intestinal coecum at the level of the posterior border of the atrium (Plate **8**, fig. 5). From it the usual three pairs of nerves originate, that after branching unite with ganglionic masses attached to the bases of the cirri or without such union pass to the body wall. The connectives to the lateral, pedal, and labio-buccal systems arise in the customary situations and the relations of the ganglia themselves, so far as they have been determined, are typical. Pedal commissures and latero-pedal connectives occur at frequent, though not perfectly regular, intervals and a corresponding number of unusually heavy nerves arise from the dorsal surface of the lateral ganglia. These have in several cases been followed close to the mid dorsal line but that they form commissures is not assured. They probably innervate the neighboring somatic musculature and hypodermis.

Posteriorly the pedal cords, united by commissures to the anterior cloacal wall, branch repeatedly in this last named locality and innervate the body and cloacal walls and some of the fibres become imbedded in the shell gland. The lateral cords at this same level likewise branch repeatedly and supply the same structures as the pedal, though more dorsally, and in addition give off a few small nerves that attach themselves to the pericardial wall. A very few branches from these last named nerves have been traced a short distance into the heart. The pedal and lateral cords are posteriorly united by one delicate branch; others may exist, but the nerves are not sufficiently differentiated from the surrounding tissue to permit of their being followed for any considerable distance. It is a peculiar fact that no trace of a dorsal posterior commissure uniting the lateral cords has been found to exist.

The labio-buccal connectives arise to the inside of the connectives leading to the pedal ganglia, and at first resting upon the digestive tract and more posteriorly imbedded between the pharyngeal glands may be distinctly followed to well-defined ganglia in the neighborhood of the outlets of the ventral salivary glands. Owing to the fact that these ganglia are united by a large commissure dorsal to the ventral salivary glands, though ventral to the gut, they probably correspond to the labial ganglia. This commissure leads from the posterior ends of the nerve masses which more anteriorly are united by two more nerves ventral to the pharynx. One of these is a simple commissure like the more posterior one and like it is imbedded in muscles. The remaining one, imbedded in the same manner, is of much smaller size and soon unites with two small ganglia resting against the pharyngeal musculature somewhat ventral to the labial ganglia. These smaller ganglia are united also by a slender commissure. Comparing this system with what occurs in *P. hawaiiensis* it is probable that they form a subradular system which as in *Strophomenia scandens* has persisted, though the sense organ itself has almost if not completely disappeared. The labial ganglia are united also by a dorsal commissure leading out from their anterior surfaces. An unusual abnormality exists in this species in the form of two labio-buccal connectives on one side. One of these is incomplete since it is formed by a branching of the usual connective opposite the middle of the anterior pedal gland outlet. The more ventral branch, larger than the dorsal, makes its way to the underside of the pharynx and close to the mid line pursues a course to the neighborhood of the labial ganglia whereupon it bends outward at a sharp angle and unites with its fellow at the anterior end of the ganglion.

Strophomenia regularis, sp. nov.

This species is represented by the posterior end of one animal that, however, is so characteristic as to leave no doubt regarding its relationships. It was found in the bottom of the jar containing specimens of Dendronepthya (Spongodes) sp. and may therefore be considered to have come from the southern end of Honshu Island, Japan (Sta. 3717) at a depth of 75–100 fathoms. The length of the fragment is 9 mm. and the average diameter 1 mm. Its general outline is represented (Plate **26**, fig. 8).

The coelenterate, with which this species was associated in the jar, was originally preserved in formalin that in decomposing had completely decalcified the fragment. It may be clearly seen (Plate **24**, fig. 7), however, that for the most part the spicules are of the usual needle form and are accompanied by a relatively small number with truncated bases, all being imbedded in a cuticular sheath 0.157 mm. in thickness on the side of the body. The hypodermis is very well preserved but presents no unusual features. Here and there, especially at the bases of some of the papillae, it contains cells, sometimes arranged in groups of three, staining darkly and apparently glandular though no trace of any outlet is evident. The spicules retain their connection with the matrix cells as long as they are imbedded in the cuticle (Plate **24**, fig. 7). The enlarged portions of the papillae are relatively small, closely crowded together at the surface and are attached to the hypodermis by clearly defined stalks containing a few spindle-shaped nuclei.

A well-defined dorsal sense organ is present, apparently of the usual type though the oblique direction of the sections makes it somewhat difficult to determine its exact relations.

The foot is comparatively small, moderately ciliated, without any cavity, and extends to the cloaca. It is accompained by the usual glands whose appearance and relations are shown (Plate **24**, figs. 9, 10).

The stomach-intestine presents the customary pouched appearance, and is lined with the ordinary glandular epithelium, changing to almost cubical ciliated elements beneath the gonad. Nettle cells of some coelenterate host are distinguishable in the small amount of material in the digestive tract. In the neighborhood of the front end of the pericardium the intestine narrows, becomes ciliated throughout, more or less rectangular in cross section then passes into a more tubular division which in its terminal section again expands and opens together with the gonoducts into the cloacal cavity.

As may be seen (Plate **24**, figs. 9, 10) the pericardium in this species is of considerable size, and the presence of numerous muscle fibres passing from its walls to those of the body indicates that it probably undergoes considerable variation in this respect, probably while driving the sex products into the gonoducts. The heart, distended with blood, is a well-developed organ and comprises two divisions, an auricle and ventricle presumably. The walls of the auricle are somewhat more dense than those of the ventricle but otherwise their relations to the incurrent and excurrent blood streams are of the well-known type. The blood corpuscles are represented (Plate **24**, fig. 14).

In its general relations the posterior portion of the nervous system resembles that of other species of the genus (Plate **26**, fig. 8). The pedal cords, connected by numerous commissures, continue of about the same calibre until they reach the region of the cloaca. Here they enlarge very slightly, give rise to two or three strong connectives and as many smaller commissures, and then gradually become smaller, disappearing after breaking up into a small number of branches that become lost among the somatic muscles. The lateral cords, on the other hand, enlarge as they approach the posterior end of the pericardium where they form a well-defined ganglion. From it connectives, of at least twice the diameter of those more anterior, pass to the pedal cords. The usual commissure passes dorsal to the gut; while posteriorly two or three nerves make their way into the somatic musculature, and one unites with a sharply defined ganglion from which branches arise whose subdivisions are distributed over the cloaca and the body wall of the same region. In this species the nerves destined to the dorsal sense organ are two in number. They arise, widely separated from each other, from the dorsal commissure, and passing along the dorsal side of the animal reach the base of the sense organ. In the present specimen one of the nerves for a considerable distance traverses the sinus entering the posterior end of the heart.

As is generally the case with the genus the halves of the gonad are relatively wide apart in the posterior part of the body, being separated by a correspondingly wide blood sinus, and more posteriorly they shade gradually into the pericardium. From this latter cavity the gonoducts arise as relatively wide tubes of fairly even calibre lined with cubical ciliated cells without any marked signs of glandular activity. At the union of the dorsal section of the gonoduct with the ventral part or shell gland a number of seminal receptacles are attached, twelve being present on the side of the body represented (Plate **26**, fig. 8).

As may be seen these are of varying size and are attached by short stalks (Plate **24**, fig. 10). In the present specimen developing ova are present in considerable numbers, and a few are free in the cavity of the gonad; on the other hand spermatozoa are of rare occurrence. However, in the dorsal section of the gonoduct adjacent to the receptacles, and in the receptacles themselves sperms are abundant without any definite arrangement or in some of the receptacles attached by their heads to the walls (Plate **24**, fig. 13). Muscle fibres, attached at various points to the outer walls of these reservoirs and on the other hand to the body wall, pericardium or shell gland, probably cause the dilation of these organs, while a delicate cuticular sheath to which the lining epithelium is attached may be responsible in part for their contraction. The shell gland, from side view, is somewhat irregular in outline but in cross section is very symmetrical (Plate **24**, fig. 9). Its walls are of only moderate thickness and at most levels the lumen is a narrow slit. Throughout five sixths of its extent the cells, high and columnar in form, are moderately filled with a finely granular secretion that stains intensely and in this form makes its escape. In the posterior sixth the cells are of essentially the same form, but their contents stain a faint pink. As noted above the rectum opens with the halves of the shell gland into a shallow depression on the forward wall of the cloaca.

Strophomenia farcimen, sp. nov.

Two specimens of this species were collected off the southern end of Honshu Island, Japan (Sta. 3748), at a depth of 73–200 fathoms. One was attached to a colony of the alcyonarian, *Acanthogorgia angustiflora*; the other was likewise clinging to a mass of a species of Dendronepthya (Spongodes). The length of the type specimen (Plate **1**, fig. 1) is 18 mm., width 2 mm. The color in formaldehyde is creamy white. A well-defined dorsal sense organ is present. From external view the outlet of the anterior pedal gland is no wider than the ventral furrow generally which is continuous with the cloaca.

The cuticle, approximately one tenth the thickness of the total body width, rests upon a hypodermal layer of unusual thinness (Plate **33**, fig. 2), and is composed of minute elements most unfavorable for study. The papillae are of moderate size, and are attached to long fibrous stalks containing 3–5 nuclei and at the surface of the cuticle are closely crowded together. At the junction of the stalk and dilated portion as many as 5–9 nuclei may occur in a given section; the remainder of the dilation is filled with numerous small greenish yellow granules. The ordinary type of spicule, needle-like (Plate **17**, fig. 17), forms 5–7 layers, while the second type, usually with more truncated base and more curved acute tip, is located more at right angles to the hypodermal layer. It is worthy of note that the somatic musculature is exceptionally thin, the plump rounded appearance of the specimens in hand being due to the firm consistency of the cuticle.

The anterior pedal gland, holding a position from the atrium to the hinder border of the crypt-like outlet, is composed of lobules of small cells filled with a faintly or darkly staining secretion according to the stage of its development. The ductules make their way through intercellular spaces into the forward end of the pedal furrow, which is comparatively small and in cross section usually presents the appearance represented (Plate **17**, fig. 11). Near its anterior border the foot originates as a high slender fold and extends to the cloaca. Unlike most species the cells of the posterior pedal gland open not only into the bottom of the pedal furrow but also between the cells of the foot, which is provided also with considerable numbers of gland cells.

In several important particulars the digestive canal of the present species resembles that of other members of Strophomenia. The atrial ridges are, as usual, two in number and enclose the cirrose area; the more external is horseshoe-shaped and is composed of slender columnar, ciliated cells which contain spindle-shaped nuclei and a very small amount of pigment. External to the outer one is a low ridge of somewhat similar cells which, as in *P. hawaiiensis*, rests upon a rod-like mass of ganglion cells. The cirrose area is rather small in extent (Plate **7**, fig. 1), and the finger-like processes, arising separately from the bounding wall, are composed of the usual pigmented cells, internally limiting an exceedingly slender cavity penetrated basally at least by delicate strands of connective tissue and probably nerve fibres. The opening from this sensory atrium into the succeeding portion of the gut is bounded by a ring-like fold, which is probably capable of protrusion to the exterior as it is supplied with numerous muscle fibres. Beyond this proboscis the pharynx pursues its way for a distance almost as great as in *Strophomenia scandens*. In the early part of its course its lumen is small, owing to the heavy folds developed in its walls (Plate **17**, fig. 11), but more posteriorly, and especially in the neighborhood of the radula, it becomes a canal of greater size. As far posteriorly as the forward end of the radula its walls are supplied with numerous glands, consisting of many small, pyriform cells, united into bundles by means of connective-tissue fibres, opening probably by separate intercellular crevices into the pharyngeal cavity. In the neighborhood of the opening of the radula sac the canal, probably to be considered as the oesophagus, again narrows, and its walls, composed of high columnar cells, become developed into high ridges extending nearly to the centre of the lumen.

The radula is well developed and typically located, but the teeth composing it are thin and delicate, since the sections display few traces of displacement owing to the sectioning process. In cross sections it is very difficult to determine the exact number of teeth, but there appear to be fifteen rows of from 24–28 in each row each having the form represented in (Plate **34**, fig. 15). The basement membrane is continuous across the mid line, but the bases of the teeth are so fused that at first sight the radula appears to be of the distichous type.

The dorsal intestinal coecum is of great length, as in *Strophomenia scandens*, and is filled, as is the gut, by vast numbers of what appear to be partially digested nematocysts. In a few places ova, probably rasped from the tissues of the host, occur within the food mass. The cells lining the intestinal tract are highly vacuolated and difficult to clearly define. The gut pouches likewise lack the usual regularity of other Neomeniina and frequently present a more than usually complicated appearance in cross section. In the posterior end of the body the gut narrows, and becoming triangular (Plate **17**, figs. 14, 15), passes between the cloacal passage and finally becoming reduced to a small, apparently ciliated canal it opens together with the coelomoducts into a depression in the anterior cloacal wall.

The ventral salivary glands are long tubular bodies opening into the pharyngeal cavity on each side of the radula (Plate **17**, fig. 16). In their proximal portions they are delicate thin walled canals lacking any signs of glandular activity; more distally these tubes continue in an unchanged condition, but each becomes enveloped excentrically in a mass of gland cells. These elements are pyriform, filled with a finely granular, lavender colored secretion, which makes its way into the duct by means of ductules opening through intercellular canals.

The heart is of relatively great length, and, with the exception of a few irregular outpouchings near its posterior extremity, is tubular throughout. There is thus no clearly defined auricle and ventricle nor line of demarcation between it and the aorta. This last named vessel is of exceptionally large calibre, but its relation to the gonad and its route into the perivisceral sinus are normal. This last named space, owing to the unusually small number of muscle bundles binding the gut to the body wall, is of large size, but the course of the included blood into the median pedal sinus and posteriorly into the heart are typical. The blood corpuscles are thin, plate-like bodies, usually like a spearhead in shape, and rather closely resemble those of *Strophomenia scandens.*

The nervous system, as it is not especially favorable for study, has been studied in a general way only, but sufficiently to indicate that it is not essentially different in this regard from other species of the genus.

The gonad extends as far forward as the radula where its halves are widely separated by the large aorta, but more posteriorly they come in contact beneath this vessel. The animals are dioecious and the sex cells are developed normally. The coelomoducts take their origin from the extreme posterior border of the pericardium (Plate **11**, fig. 4) in the form of comparatively thin walled tubes in which the lining epithelium is low and seemingly ciliated. Extending anteriorly this dorsal division of the cloacal passage unites with the ventral section about the level of the anterior end of the pericardial cavity. At the intersection of these two divisions upwards of nineteen seminal receptacles are attached, in appearance and arrangement closely resembling those in *Strophomenia scandens.*

Each consists of a more or less pyriform sac with walls of median thickness to which the spermatozoa are attached in large numbers. In the ventral section, or shell gland, the walls are not so thick as is usual with the majority of Neomeniina and the central cavity is of greater size (Plate **17**, fig. 15). The component cells are long and contain multitudes of spherical granules staining intensely with haematoxylin. Posteriorly the halves of these glands do not unite with each other or at least not to any marked extent but open separately, though close together (Plate **17**, fig. 12), into a shallow depression in the anterior cloacal wall into which the rectum opens also. Immediately ventral to this depression there is an outpushing of the wall of the cloaca, that thus holds the same position as the diverticulum in *Strophomenia scandens*, but it is much more shallow and not so completely closed. The walls of the cloaca lack any folds of definite arrangement, but at three or four points bear slender finger-like outpouchings though without any special modifications to indicate their possible function.

Strophomenia spinosa, sp. nov.

Five specimens of this species were taken in southern Japan in the neighborhood of Misaki (4 from Sta. 4935–6 and 1 from Sta. 3748) at a depth of 73–200 faths., all were attached to the alcyonarian coral, *Acanthogorgia japonica*. Externally the appearance of these animals differs to a greater degree than in any other species described in the present paper. As may be seen (Plate **1**, fig. 3) some (the larger) specimens are almost smooth, while others present such a highly spinose appearance that at the outset they were supposed to be distinct species.[1] Here and there sections show that some of the great spines ordinarily protruding almost at a right angle above the cuticle have been withdrawn so that their bases invade the territory of the somatic musculature (Plate **33**, fig. 7); and it appears probable that this species is able to protrude or withdraw these spines and possibly adapt itself to a shifting habitat as *Echinomenia coralliophila* is known to do. The length of the body is approximately 28 mm. with an average diameter of 1 mm. Both ends of the body are similar, the anterior being distinguished usually by its slightly greater thickness. The color is grayish white.

The cuticle, 0.1 mm. in thickness (Plate **33**, fig. 7), is in reality rather scant

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[1] It is possible that these differences in external appearances are of specific value, and that we are dealing with two distinct forms. Plate **34**, figs. 8, 9, 10, show differences in the radulae, and in the "smooth," large form there are thirty-one seminal receptacles while there are twelve in the smaller, spiny type. Nierstrasz ('02), however, claims that these last named organs vary considerably in number in the same species. Additional material is necessary to settle the question.

in amount, forming as it does scarcely more than a thin sheath about the innumerable spicules imbedded in it. The latter structures are of two varieties shown (Plate **36**, fig. 16), the larger being directed radially.

The hypodermis, comparatively thin and not especially favorable for study, comprises so far as determined the usual types of cells. Those responsible for the development of the needle-shaped spine retain their attachment with it so long as the spicule remains in the cuticle. The formation of the spines with truncated base has not been followed, but in later stages each rests upon a small knob, probably the remains of a matrix cell, and as noted previously may be withdrawn deep into the somatic musculature. This appears to be a normal process for as noted in a previous paragraph some specimens are smoother externally than others; but the mechanism by which this is effected is by no means clear since in a few cases only do muscles attach to the base of the spine. The papillae are few in number.

The anterior pedal gland is a moderately developed organ extending from the level of the brain to the posterior border of its outlet into the pedal furrow. The cells are of the usual pyriform type and contain a secretion staining inky black with haematoxylin. The outlet is a simple sac-like indentation (Plate **8**, fig. 2, and Plate **11**, fig. 2), highly ciliated, with the foot springing as a well-developed fold from its dorsal wall. The cells of the posterior pedal gland are unusually numerous anteriorly and save that they are of a somewhat smaller size are not to be distinguished from those of the anterior pedal gland with which they are continuous. Posteriorly the furrow is continuous with the cloacal chamber.

The opening of the sensory atrium, subterminal in position, is comparatively wide, and as may be seen (Plate **11**, fig. 2 and Plate **8**, fig. 2), the atrium itself is imperfectly separated from the succeeding section of the gut. As usual three pairs of sensory ridges are present, the two bounding the cirrose area being well defined while the remaining more exterior one is only faintly outlined. The first two mentioned are comparatively low, not penetrated by blood sinuses, but by connective tissue and muscle fibres and a very few nerve fibres from neighboring ganglia. The cirri are slender, compact bodies united in groups of 3–6.

The mouth, a relatively wide opening, leads into a tube of great length, but of much the same size and appearance throughout its course. Its epithelial lining is usually fashioned into low longitudinal folds and rests upon a circular muscle layer of moderate thickness external to which are a few longitudinal bands and radial fibres attaching to the body wall. As may be seen in Plate **8**, fig. 2, numerous pyriform masses of cells attach to the pharynx throughout its entire extent and pour the secretion into the digestive canal through numerous intercellular openings. The ventral salivary glands are long tubular bodies with a very slender duct through which the attached gland cells pour their secretion. Their openings into the pharynx are exceedingly narrow but occur in normal position at the sides of the radula (Plate **17**, fig. 4). The long dorsal coecum, the fairly regularly pouched mid gut, and the relations of the rectum are all typical.

The radula is evidently in a highly degenerate condition, and differs considerably in different specimens. In the individual represented (Plate **34**, fig. 8), it is exceedingly minute and appears to be clearly monoserial. In Plate **34**, figs. 8, 9, it is considerably larger, biserial and the teeth next the median line are noticeably smaller than the others. Judging from the specimen possessing the larger radula (Plate **34**, fig. 10), there are eight transverse rows.

The heart is the usual long, tubular organ represented in cross section (Plate **17**, fig. 5) and the other features of the circulatory system are so typical of the genus that they require no further comment. The corpuscles are very similar in outline to the spines of *Limifossor talpoideus*, being pointed ovate in shape. The nucleus is superficially placed, and may protrude somewhat beyond the general level of the cell.

The gonad in its position and the development of the sex products is normal; and its connection with the pericardium is made, as usual with this genus, by means of canals of unusually large calibre (Plate **9**, fig. 4). Posteriorly the pericardial wall is produced into two pouches, separated by the sinus entering the heart, which are continuous with the coelomoducts. The lateral surfaces of these pouches and the pericardial wall for some distance in front of them, and especially the coelomoducts themselves as far as the seminal receptacles, are ciliated, the coat being especially heavy in these last named tubes. Roughly the height of the cells of these regions is proportional to the thickness of the ciliated coat, ranging from flat or cubical elements in the pericardium to those in the neighborhood of the seminal receptacles where the ratio of height to thickness is about 3: 1. The larger cells are developed into a few longitudinal folds and are endowed with a considerable degree of glandular activity.

The ventral section of the coelomoduct, or shell gland, is joined somewhat behind its anterior end by the dorsal section, and the blind sac thus developed serves for the attachment of a greater number of seminal receptacles than in any other species described in the present paper. On the side represented (Plate **9**, fig. 4), there are thirty-one and as may be seen these are of various sizes, ranging in diameter from 0.2 mm. to one fourth this size. On the other hand it is to be noted that another specimen from the same alcyonarian colony has but twelve receptacles (Plate **12**, fig. 3). The cells composing these organs are unusually large and in many situations are greatly vacuolated. This latter peculiarity, however, may be due to the fixing fluid since at all points where spermatozoa are attached to the walls the cells are more dense though of the same height as the others. The stalks connecting the receptacles are comparatively short, lined with low cubical cells and usually open separately into the coelomoduct (Plate **17**, fig. 5).

The shell gland is nowise peculiar except that it is of somewhat greater diameter than usual and more irregular in outline. Its cells are columnar and are partially filled with a darkly staining secretion that has escaped into the lumen in considerable quantities. It may be added that in specimens of this type ova occur in the pericardial cavity and the breeding season is therefore at its height. As usual the halves of the shell gland are not clearly united, but with the rectum open together into the cloaca.

Strophomenia triangularis, sp. nov.

Five specimens of this species were taken off the southern end of Honshu Island, Japan, two from Station 3716, two from Station 4935 and one from Station 4936 at depths of 65–125, 103 and 103 faths. respectively. The length of all is approximately 12 mm. with a width of 1.6 mm. The body is flattened ventrally, and the presence of a low broad keel extending along the dorsal side of the body and terminating about 1 mm. from each extremity, gives the animal a triangular appearance in cross section. Every specimen is coiled in a close spiral (Plate **1**, fig. 5) around the stem of an alcyonarian coral, Calicogorgia sp.

The color of preserved material is a dull grayish yellow. The opening into the atrium is subterminal, and is clearly separated from the ventral furrow. The foot, a single fold, extends from the hinder wall of the anterior pedal gland outlet to the cloaca. A dorso-terminal sense organ is present. The cuticle on the back and dorso-lateral surfaces measures 0.108 mm. in depth to twice this thickness on the ventral surface. In decalcified material the papillae extend more or less above the surface of the cuticle (Plate **33**, fig. 1), but in a natural state these are so surrounded or overlaid by spicules that they are usually invisible in surface view. The outer enlarged portion of each papilla is relatively small though considerably larger than in the case of others, apparently younger and more deeply imbedded in the cuticle. In almost every case the 10–15 cells comprising it are contracted into a mass in contact with the stalk that is very slender and rarely contains more than two nuclei.

The sensory atrium holds the usual position (Plate **36**, fig. 6) and contains the characteristic elements, of which the external ridge entirely surrounds the atrial cavity save posteriorly where it joins the internal ridge. This last named organ is likewise continuous across the mid line as a low inconspicuous elevation which more posteriorly becomes developed into a very sharply defined structure uniting with the outer ridge. The included area is beset with slender cirri, united into groups of 3–5 and composed of small cubical cells containing the usual yellowish pigment. In many cases muscle fibres pass up into the central cavity of each cirrus, and nerve fibres from neighboring ganglia may be traced to the basal portion. The opening from the atrium into the next section of the digestive tract is on the posterior atrial wall and leads into a relatively long pharyngeal tube developed internally into several longitudinal folds lined with a delicate cuticle and composed of slender columnar cells usually filled with some glandular secretion, especially in the section next to the atrium. In this same fourth groups of cells (shown against under surface of digestive tract, Plate **18**, fig. 6) appear in each section attached to the outer surface of what is probably the buccal epithelium. Directly opposite the outlet of the anterior pedal gland these elements, are in large measure replaced by others, likewise in groups, and filled with a darkly staining granular secretion or more posteriorly where they are larger, with a highly vacuolated substance but little affected by haematoxylin. These glands extend backward to the radula or at the point where the ventral salivary glands open. These last named organs are tubular, at least 1.5 mm. long and 0.15 mm. in average diameter, and open into depressions on the pharyngeal wall on each side of the radula (Plate **18**, fig. 9). A thin epithelial lining borders the lumen while the outer surface is in contact with gland cells, pyriform and filled with a secretion differing considerably in different specimens and parts of the same gland. At some points the cells are closely packed with a bluish or pinkish secretion or at others this material is collected into rounded particles, dark brownish yellow in color, surrounded by a vacuole of considerable size.

The radula, typically located, seemingly belongs to the distichous type, and yet is readily related to the polystichous form occurring in other genera if we assume that the bases of the once distinct teeth have secondarily fused.

From transverse sections it appears that there are fifteen rows of teeth whose general form is shown (Plate **34**, fig. 4). They are thin and delicate, or at all events are not easily displaced in sectioning, and stain readily in haematoxylin.

As usual with this genus the anterior intestinal coecum is of great length and considerably in front of its union with the pharynx exhibits most of the essential characters of the stomach-intestine, possessing fairly regular outpouchings and an epithelial lining of the customary glandular type, but lacking the cubical ciliated cells beneath the gonad. The coecum and most of the succeeding portions of the gut contain nettle and germ cells extracted from the host. Opposite the seminal receptacles the intestine narrows, becoming gradually smaller until it opens into the cloaca (Plate **18**, fig. 10). At the same time the dorsal ciliated epithelium gradually extends round the sides of the rectum, finally meeting in the mid ventral line shortly in front of the anal opening.

The pericardial cavity in this species is of very large size and the heart of unusual length. The posterior division, however, is unusually small and peculiar in being paired, save at its junction with the ventricle with which it communicates by a single small pore apparently furnished with a valve. The aorta, at its origin, is of the same calibre as the ventricle and occupies the entire though narrow space between the halves of the gonad. The branches, passing from it around the ventral and lateral surfaces of the gonad to unite with the visceral cavity, are likewise of large size and very distinct. More anteriorly these branches become much smaller and in the region of the head all but disappear in the present specimen. The course of the sinuses in the head, their union with the ventral sinus and the relation of the latter vessel with the heart are typical. The corpuscles are more than usually compact, but in their ellipsoidal form resemble those of other species of the genus.

The gonad extends as far forward as the radula and presents the usual features. Posteriorly it opens, in both specimens examined, by unusually large ducts into the pericardium, owing possibly to the fact that the time the animals were killed ova were present in considerable numbers in the pericardial cavity and along the cloacal passages. These canals, arising typically from the posterior end of the pericardium (Plate **9**, fig. 3), average approximately 0.095 mm. in diameter and are lined with cubical and low columnar richly ciliated cells. Toward the median line of the body these elements are more glandular and the secretion may direct the course of the sperms.

The seminal receptacles, numbering 10–12, vary in size as may be seen (Plate **9**, fig. 3), and possess unusually long stalks. Both vesicle and duct are composed of cubical cells, those of the latter being twice the height of the others. In the receptacle spermatozoa are numerous and are attached by their heads to the wall.

The anterior half of each ventral section of the cloacal passage (the shell gland) is composed of cells of the appearance represented (Plate **18**, fig. 8), filled with a distinctly granular, darkly staining secretion. In the remaining half the appearances are much the same save that the glandular material is of a pink or reddish color. The halves of the shell gland open into the cloaca by separate pores and a fold, distended with blood, separates in large measure these openings from that of the intestine.

The nervous system is typical in its general features. In the labio-buccal system two commissures unite the ganglia ventral to the pharynx; one of these bears a pair of small ganglia as in *Strophomenia scandens* (Plate **6**, fig. 6). One commissure likewise passes dorsal to the pharynx. The relations of this system are essentially the same as in Plate **6**, fig. 6, with the exception of the most posterior ventral commissure that appears to be lacking in the present species.

Lophomenia spiralis, sp. nov.

This species, represented by two specimens (Plate **2**, fig. 4), was taken in the vicinity of Niihau Island (Sta. 4176) at a depth of 537–672 fath.; bottom, gray sand and foraminiferous mud; temp. 38.3 F. Both individuals were closely wrapped about the stalk of a hydroid colony (*Cryptolaria operculata* Nutting) and sections disclose the presence of nettle and other cells in the alimentary canal from which we may infer that these forms, like *Drepanomenia vampyrella*, prey upon the polyps.

Both specimens were of almost identically the same shape and size, measuring approximately 24 mm. in length and 1.5 mm. in average diameter. Each end of the body terminates in a fairly sharp point but as the mouth is subterminal and surrounded by well-developed lips it may readily be distinguished from the cloacal opening that extends a short distance on to the dorsal surface. The ventral furrow holds the usual position, being continuous with the cloaca posteriorly and in front terminating immediately behind the atrial opening. In one individual where the pharynx was slightly retracted this groove appeared to be directly continuous with the atrium but sections prove conclusively that such is not the case.

The opening of the pedal gland as usual occupies the anterior end of the ventral furrow. Its position, shape, and general appearance are accurately represented (Plate 6, fig. 5). The hypodermal cells bounding the cavity are higher and more slender than the usual type and are richly ciliated. All contain spindle-shaped nuclei and lightly staining cytoplasm. Immediately behind the outlet of the anterior pedal gland the foot arises and extends to the opening of the cloaca. At the outset it is well developed but gradually decreases in size posteriorly until near the cloaca when it enlarges to twice its average size. A short distance behind its front end the hypodermal cells lateral to the base cease to develop spines and assume the form of a ridge (Plate 19, fig. 3) that increasing slightly in size continues to the cloaca where each like the foot enlarges somewhat before disappearing. At all points the cavity of the foot is very small, never spacious enough to permit the entrance of blood corpuscles.

The relations of the anterior section of the digestive tract are shown (Plate 6, fig. 5). Here the pharynx is somewhat protruded, but it is evident that the structures borne on the buccal wall are not unlike those of the other Neomeniina hitherto described. Immediately within the lips the usual ciliated atrial ridge is present. However it is relatively short, its contained blood sinuses small and the component cells low and very slightly pigmented. This is also true of the inner elevation with the exception that in both specimens it is of somewhat greater height. The cirri of the included area are relatively slender and are usually attached separately to the buccal wall. Their cavities are of extremely small calibre and it is only in exceptional cases that the contained nerve fibre may be determined. Also their cell boundaries are indistinct, but otherwise these organs are not unlike those in *Proneomenia hawaiiensis.*

The pharynx consists of two distinct portions, the first a relatively slender tube leading from the mouth into the second enlarged section that opens in turn into the stomach-intestine. Throughout the epithelial lining consists of columnar cells, forming at first low longitudinal ridges that gradually increase in height attaining their maximum size at the opening into the stomach.

At the junction of the first and second sections the pharynx is produced into a much folded diverticulum that affords an outlet for the dorsal salivary gland (Plate 6, fig. 5). This last named organ is relatively very voluminous, larger in fact than in most species of Solenogastres hitherto described. With the exception of two narrow lateral areas held by the anterior pedal gland it occupies the dorsal surface of the digestive tract, and to a much less extent, the lateral borders between the brain and stomach-intestine. In the most favorable sections the component cells are clearly pyriform and are connected by a narrow duct filled with granules that leads to the pharynx. Some of the smaller cells are fairly well filled with small particles which in the larger cells are applied to the cell membrane, the remaining contents consisting apparently in life of a fluid. In the majority of cases the nucleus is spherical, finely granular and contains a distinct nucleolus.

The position of the radula is shown in Plate **6**, fig. 5, while a cross section of the radula tube is represented (Plate **34**, fig. 1). From these it will be seen that this organ belongs to the distichous type and that there are about twenty rows of teeth. While the shape of each tooth is sufficiently shown in the figures it is worthy of note that in the radula tube the base of each tooth is connected by a narrow cuticular bridge. When the radula opens out into the pharynx each plate appears to split in half, at all events the exposed teeth in one specimen at least are fully three times farther apart than in the radula tube and they do not appear to be connected by a basal plate.

Immediately in front of the radula there is a pair of short diverticula of the pharyngeal wall which serve as outlets of the salivary secretion. The mass of the outlying gland comprises several divisions bounded by connective tissue and located chiefly at the sides of the pharynx. The cells themselves are pyriform, highly vacuolated and their ductules attach chiefly to the dorsal side of the main duct.

The stomach-intestine assumes its average diameter at once and gut pouches appear close to the anterior end. No forward coecum is present. The epithelial cells lining the tract at first form a flat surface but a short distance backward they become arranged in the form of longitudinal folds (Plate **19**, fig. 3) that continue to the neighborhood of the accessory reproductive organs. In the latter region the diameter of the intestine decreases, its lining walls are smooth, and wedged in between the cloacal passage and the pericardium, it makes its way to the cloaca. The cells of the rectum are pear shaped with basally situated dense nuclei and the distal portions are swollen with a secretion that in the form of a darkly staining finely granular mass fills the lumen of the gut.

In this species the pericardium is long and the contained heart is relatively slender (Plate **8**, fig. 6). The blood from the posterior part of the body enters the hinder extremity of the heart which here has the form of a very slender tube (Plate **19**, fig. 9), attached to the dorsal wall of the pericardium. About midway in the pericardial cavity this canal enters another section, of four or five times greater diameter, that for a short distance hangs freely in the pericardium but more anteriorly unites with the pericardial wall and with gradually diminishing calibre holds this relation until it passes into the aorta. This latter vessel supplies the gonad in the usual way and in the head region breaks up into a system of sinuses that become continuous with the blood spaces lying at the sides and beneath the intestine. In the region of the accessory reproductive organs the lacunae become very circumscribed, but so far as they have been traced they exhibit essentially the same relations as in *P. hawaiiensis*. The corpuscles of this species (Plate **36**, fig. 14) exhibit no features worthy of note.

The paired gonad extends forward to a point some distance behind the junction of the pharynx and stomach-intestine. Posteriorly it ends abruptly slightly in front of the pericardium with which it is connected by two short ducts. The arrangement of ova and sperms are the same as in the foregoing species. From the posterior end of the pericardial cavity the coelomoducts arise and proceeding forward (Plate **8**, fig. 6, and Plate **9**, fig. 5) almost horizontally unite with the shell gland. In one specimen the first section of these tubes is of small diameter and ill defined, while in the other it is well developed and is filled with spermatozoa that also crowd the pericardium. In this same individual there is a circumscribed area including the extreme posterior tip of the pericardial cavity and the neighboring section of the coelomoduct where numbers of spermatozoa are attached to the epithelial lining. Beyond this point for some distance the duct continues of small calibre, with an epithelial lining composed chiefly of goblet-shaped cells charged with a clear secretion, and then suddenly terminates in a bulb-like enlargement that in turn unites with the seminal receptacle and the slime gland proper. At first the cells in this swollen division are of greater height and more slender than those adjacent, and attach vast numbers of spermatozoa, but more anteriorly sex cells are lacking and the epithelium consists of goblet-shaped elements like those just described save that they are of larger size. The same type of cell also occurs in the elongated seminal receptacle except at its distal end where the cells are lower, more compact and also attach large numbers of spermatozoa.

The ventral limbs of each coelomoduct extend backward from the point of attachment of the seminal receptacle to a point a short distance in front of the cloaca where they unite and communicate with the exterior by a single opening. The epithelial lining in this part of the duct is relatively very high and gives evidence of forming two distinct secretions. The cells in the anterior third of the canal are much vacuolated and contain a small amount of some faintly staining secretion. More posteriorly they gradually shade into more slender and elevated elements that, in the posterior half of the cloacal passage, contain numerous granules densely crowded in their distal portions. Such cells are confined almost exclusively to the ventral and lateral walls. The dorsal side in both specimens consists entirely of cells whose entire substance, with the exception of a small basally placed nucleus imbedded in a scant amount of protoplasm, consists of a vacuolated homogeneous secretion staining like the muciparous cells of certain gastropods. It is possible that such a secretion is due to the transformation of products similar to those of the ventral granular cells, but there is no trustworthy evidence that such is the case.

On each side of the ventral furrow immediately in front of the cloacal opening are two indentations of the hypodermis each of which contains not less than fifty needle-shaped spicules that are clearly modifications of the spines produced in the adjacent territory. As is shown (Plate **19**, fig. 5) they are directed inward toward the mid line and sections show that multitudes of muscle fibres attach to the diverticulum chiefly on its blind extremity. Among the more prominent of these is a transverse band, another extending outwardly and attaching to the body wall and, most prominent of all, numerous strands that pass in a postero-lateral direction and attach to the body wall slightly behind the level of the cloacal opening.

In its broader features the nervous system of this species corresponds closely to that of the other species described in this paper. The brain is of the ordinary bilobed type and is placed above the buccal cavity (Plate **6**, fig. 5). From it six nerves arise that passing forward and downward probably innervate the buccal and body walls with the attendant sense organs. The relations of the pedal, lateral, and buccal connectives also conform to the usual type. The last named cord is exceedingly difficult to follow owing to its almost exact resemblance to the dense masses of muscle and connective tissue that accompany it, but with high magnification it may be traced to the elongated ganglia placed at the sides of the radula and a little below it. The commissure attaching to the posterior ends of the ganglia passes dorsal to the radula. No clearly defined subradular organ exists and no nerves or ganglia belonging to this system are present so far as it is possible to judge from the material in hand.

The lateral cords, holding the customary position at the sides of the animal, pass backward through the body and finally terminate in ganglionic enlargements on each side of the pericardium near the tip of the seminal receptacle. The commissure uniting them passes out from the hinder end of each ganglion and crosses dorsal to the intestine. One or two nerves also pass out from each enlargement, but in the confused mass of muscle they have been traced but a short distance.

The pedal cords after traversing the body gradually approach each other in the posterior end of the animal and terminate in two ganglionic masses on each side of the mid line a short distance in front of the two groups of spines that project into the ventral furrow. There are strong indications that these posterior ganglia are united by a commissure. Owing to the difficulties of observation no other pedal commissures have been discovered and for the same reason latero-pedal connectives have not been found with certainty though at various points there are indications that such exist.

The posterior sense organ is located at the extreme hinder end of the animal in the mid line. At this point the hypodermal cells, unchanged in appearance, approach near to the outer surface of the body and there become continuous with a sensory epithelium composed of slender fairly dense cells in which the elongated nuclei hold an almost median position (Plate **32**, fig. 11). Over the exact centre of this area the cuticle is exceedingly thin but gradually increases in thickness as the outer limits of the organ are approached, and contains considerable numbers of small spines that in both specimens overarch the sensory cup. Numerous muscles and connective-tissue fibres attach to its under surface and in the meshwork thus formed blood corpuscles and nerve cells occur in moderate quantity, the latter probably connecting with branches from a strong nerve that may be followed into close proximity to the posterior pallial commissure.

Alexandromenia agassizi, sp. nov.

Six specimens, one badly mutilated, of this species were dredged in 460 fathoms (Sta. 2992) near the Revillagigedo Islands off the coast of Mexico. All save one, clinging to a fragment of some land plant (Plate **2**, fig. 5), were unattached and nothing is known of their mode of life. The smallest specimen is yellowish white; the remainder, of larger size, are yellowish brown.

The largest individual measures 25 mm. in length and 5 mm. in average diameter in the middle of the body; and of the five remaining specimens three are of about this same size. The smallest is in an uncontracted state and is 22 mm. in length and 3 mm. in average diameter. As may be seen in Plate **2**, fig. 5, the head is not distinct, usually bluntly pointed, and readily distinguishable from the posterior end where the borders of the cloacal opening are widely expanded, in one specimen especially (Plate **5**, fig. 5), exposing the gill plates, about 40 in number. A dorsal sense organ is visible in sections but not in surface view.

The body is surrounded by a cuticle 0.108 mm. in thickness, and as in the preceding species, this is largely occupied by papillae (Plate **33**, fig. 5) and spicules of two varieties (Plate **37**, fig. 9). Of the latter those of one type project from the hypodermis, with which they remain connected, almost at right angles and protrude freely from the surface of the body. The others, needle-like, relatively small, and slightly curved, form from five to seven irregular layers almost at right angles to the first named spines.

The papillae are fully as numerous as in the succeeding species and the constituent cells are approximately half as abundant; but the differentiation into stalk and expanded part is not so sharply defined (Plate **33**, fig. 5). In many cases the base of the stalk is of great width and expands but slightly as the surface of the body is approached, the papilla in such circumstance having a club-shaped appearance. Even in the more typical forms the departure from such a state of affairs is not marked. The cells appear to be all of one type in the distal portion, at all events the nuclei are of essentially the same size, though they vary considerably in shape, and are surrounded by masses of yellowish green pigment.

On the ventral surface, especially in the region of the mouth, gland cells appear in the hypodermis. In their early stages each is pear-shaped, the stalk being inserted among the hypodermal cells, while the distal portion contains a lightly staining almost homogeneous secretion. Later this product becomes more abundant, swelling the cell to twice its original size, and a granular mass appears to make its way by a very delicate pore to the exterior, though this has not been demonstrated to my entire satisfaction.

The main portion of the anterior pedal gland is located between its outlet into the ventral furrow and the radula and its supports. At this point the cells are continuous across the mid line and laterally extend as thin plates compressed between the body wall and the prodigious salivary glands (Plate **20**, fig. 4). Posteriorly they separate into two groups which pass without any recognizable line of demarcation into the posterior pedal gland. The cells composing it are of the usual pyriform type, densely filled with intensely staining secretory products, and are arranged into irregular groups or lobules. In the customary fashion the ductules from each cell open by an intercellular canal into the anterior end of the pedal furrow.

At the point where the anterior pedal gland opens to the exterior the ventral groove becomes a deep excavation (Plate **7**, fig. 3) the area of whose walls is increased by the presence of extensive dorso-lateral outpouchings and numerous folds coursing from the roof half way down the sides. On the posterior face several folds arise and posteriorly extend along the groove to the cloacal cavity. These are not constant for at their first appearance they are eleven in number (Plate **20**, fig. 9), soon decreasing to nine and gradually to five in the posterior half of the animal. Each is penetrated by a loose meshwork of muscle and connective-tissue fibres, through which the multitudinous ductules of the pedal gland take their course, together with many corpuscles from the overlying sinuses. The component cells are high and columnar, especially the outermost which contain small quantities of yellow pigment.

The opening into the atrium, holding its customary subterminal position (Plate **7**, fig. 3), leads into the atrial cavity whose walls are differentiated into the usual ridges (Mundleisten) and cirrose area. As in *P. hawaiiensis* the outermost ridge is accompanied throughout its anterior half by a prominence, ill defined, and yet evidently sensory since it is composed of slender cells with basal nuclei resting upon a rod-like group of ganglion cells. In the posterior half of the lips this structure becomes more indistinct and finally blends indistinguishably with the outer atrial ridge.

Of the two large atrial ridges the outer is of large size and skirts the cavity save on its posterior face. It is supported by an abundance of connective-tissue fibres associated with a scant amount of muscle bands among which small blood sinuses make their way. The halves of the dorsal ridge arise independently of each other in the mid line on the roof of the atrial cavity. At first very low they rapidly increase in height (Plate **20**, fig. 1), but behind gradually disappear in the neighborhood of the opening into the pharynx. Blood sinuses penetrate into their interior and probably in life increase these organs to a very considerable degree. On each side of the mid line in front and hanging from the roof of the cavity are two pairs of large papillae springing from the outer and inner ridges respectively. The epithelial covering is composed of columnar cells whose distal half is filled with golden yellow pigment.

Each cirrus arises independently as a finger-shaped process of the atrial wall with an average length of 0.3 mm. It is composed of cells about twice as high as wide, closely packed with yellow pigment, arranged about a central cavity within which it is occasionally possible to follow a nerve fibre.

The opening of the mouth into the pharynx is guarded by a circular fold beyond which the canal passes dorsally until in the neighborhood of the radula where it bends at right angles and passes directly backward to join the stomach-intestine. Throughout its entire extent its internal lining is developed into many folds, large and small, often exceedingly wavy and of most complicated appearance in sections. In front of the radula especially, large projections appear and, as will be more fully described presently, afford an outlet for the two sets of salivary glands. The character of the pharyngeal epithelium undergoes minor modifications at various points, but in general it may be said that the constituent cells range in size from cubical bodies to others three times as high as wide, are devoid of cilia and are bounded by a well-defined cuticular sheet.

The salivary glands, which probably are homologous with the dorsal set in other Neomenina, are in this species remarkable for their size and extent. With the exception of a few scattered groups of cells the main portion is distributed in the form of a wide band encircling the pharynx from immediately behind the brain to the radula (Plate 7, fig. 3, ds). So far as may be determined from a single specimen all the cells are pear-shaped and are grouped into club-shaped lobules of various sizes. In the expanded part the cells are one layer thick and surround a central canal down which the ductules make their way to open by intercellular canals into the pharynx.

From transverse sections there are indications that a portion of the gland located on the dorsal side of the pharynx immediately behind the brain differs in character from the remaining portion. The follicles are more slender than those of adjoining regions and the glandular products in the early stages of their development are of lavender color and markedly different from the yellowish pink substance elsewhere. All the follicles of the dorsal salivary glands of whatever character are supported by numerous muscles forming the pharyngeal wall and by connective-tissue bands between which numerous blood sinuses are present.

The glands which probably correspond to the ventral salivary of other Solenogastres although in this species their outlet into the pharynx is somewhat more in front of the radula than usual, are enormously developed. As may be seen (Plate 7, fig. 3, sg.) they extend from the brain to a point considerably behind the radula where they entirely surround the alimentary canal and elsewhere overlap it to a very considerable degree. As in the dorsal group the gland is composed of thick-walled follicles, of large size, and from each pyriform cell a ductule leads to its intercellular outlet. Owing to the great bulk of the lobules and the remoteness of the greater number from the main duct (leading into the pharynx) this latter canal is provided with numerous branches (Plate 26, fig. 9) which come in contact with the majority of the follicles where each ends blindly. These minor ducts are lined by an epithelium in which the cells are of two distinct types. In the inner half, through which the ductules make their way, the cells are very high and slender and the cytoplasm vacuolated. In the outer half the cells are not over one third as high and the protoplasm is relatively compact.

As just noted the branching ducts of each side unite into a single tube, which opens into the bottom of a deep depression on the side of the pharynx. From the base of this pit a large conical papilla (Plate **36**, fig. 10), whose surface is thrown into five or six circular folds, projects inward, in life its tip probably extending as far as the opening into the pharynx. It is practically solid, consisting of connective tissue and several muscle fibres which probably act as retractors. The ductules of a very few adjacent follicles make their way into this protuberance and are accompanied by similar tubules from some of the dorsal salivary-gland cells. These slender canals make their exit at several points, from the tip and by means of pores ventrally placed on the circular folds. The last named openings connect with small canals (perhaps one sixth the length of the circumference of the fold), located between the cuticle covering the papilla and the underlying epithelium. There may be other exits but if so they are of small size and are invisible in the material in hand.

Attached to the pharynx, between these large glands (sg.) and the stomach-intestine another extensive set occurs (Plate **7**, fig. 3, and Plate **20**, fig. 2) that are difficult to homologize. They consist of numerous pyriform cells, highly vacuolated or containing masses of some secretion of a pinkish shade, arranged in the form of lobules bounded by muscle and connective-tissue fibres. The ductules pass to the pharyngeal epithelial lining through which they open by intercellular channels.

The radula is relatively small and is located on a tongue more than usually pointed. It is of the monoserial type (Plate **34**, fig. 5) and as far as may be determined from transverse sections, comprises between forty-five and fifty-three transverse rows. Each tooth is a narrow rectangular plate bent to form a very obtuse angle. The odontoblasts are of the usual columnar type. The radula sac is supported by ten or fifteen pairs of large cells, probably turgid in life, filled with a highly watery secretion, surrounded by connective tissue and muscle fibres. These last named elements are part of bands, too complicated to allow of reconstruction, that attach to the pharyngeal wall, the radula, or the sheath of the salivary glands.

The gonad, with the usual relations, extends from a short distance posterior to the radula to within a short distance of the front end of the pericardial cavity. In common with other hermaphroditic Solenogastres the organ in this species is paired and the eggs are developed along the septum while the spermatozoa arise more externally where the walls are often greatly folded. Posteriorly the halves of the gland narrow greatly and assume the form of comparatively slender canals (Plate **7**, fig. 5), which communicate with the pericardium by wide openings. Their epithelial lining is apparently ciliated and is fashioned into several low longitudinal ridges.

The coelomoducts arise from the postero-lateral borders of the pericardium as comparatively wide canals, which first extend downward and then forward to join the so-called shell gland at the point where the seminal receptacles are located. As usual the shell gland of one side joins the corresponding organ of the other and after narrowing to a slender tube opens into the cloaca in the mid line.

The walls of the coelomoduct (see Plate **20**) in the region of the pericardium are comparatively thin, but one third the distance to the seminal receptacle they become thicker, the cells more slender and the ten to fifteen longitudinal folds more pronounced, a state of affairs which continues to the shell gland. Cilia are certainly present at various points and it is probable that they exist throughout the duct between the pericardial cavity and the seminal receptacle. In the same section small quantities of a glandular secretion are developed having the form of minute granules which show at first a distinctly acid reaction but after their discharge become more or less confluent and alkaline. Minute quantities of spermatozoa are also distributed throughout this same division of the duct.

In the single specimen examined the seminal receptacle is a small disc-shaped sac attached to the coelomoduct where the inner and outer portions meet. It is wedged between the body musculature and the shell gland and the slit-like lumen contains a few spermatozoa only. The cells composing the walls are comparatively low and are glandular, the clear secretion, small in amount, giving the cytoplasm a vacuolated appearance.

In this species the shell gland is of enormous size, filling practically all the space between the digestive tract and pericardium dorsally and the body musculature ventrally and laterally. As figured, Plate **20**, each half is penetrated by a duct, of about the diameter of the foregoing section, through which the secretion from the surrounding glandular portion makes its way. In the neighborhood of the cloaca these ducts emerge from the gland, unite with each other, and forming an S-shaped loop in side view open into the cloaca by a very narrow pore.

The component gland cells are arranged into numerous lobules, which generally extend from the surface of the gland to the main central duct. These are separated from each other by delicate connective-tissue sheaths, which frequently contain small blood sinuses, and are traversed by a slender canal which apparently does not function as a duct. The evidence is not altogether conclusive but from a careful study of sections it appears that the secretion does not pass through the cavity of the lobule, but is contained in delicate ductules which arise in the gland cells. Arriving at the central cavity of the gonoduct the darkly staining secretion makes its escape through the lining epithelium by means of intercellular openings.

The epithelium of the main duct is composed of high columnar cells which contain a finely granular lightly staining glandular substance. About the terminal section of the coelomoduct, where the epithelium become lower and the secretion scant in amount, a heavy sheath of circular muscles appears and continues to the cloacal cavity.

As might be expected in an animal of the size of this species the circulatory system is well developed and of more than ordinary complexity owing to the large number of sinuses which hold positions in and around the various systems. The heart, having the usual position, consists of two distinct divisions (Plate 7, fig. 5), an auricle and ventricle. The walls of both of these are of uncommon thickness, but otherwise present no especially noteworthy features. They are connected by a tubular stalk which projects slightly into the cavity of the ventricle and may serve as a valve.

From the front end of the ventricle blood passes through numerous openings in the somatic musculature to unite into one tube, the aorta, which from the outset appears to lack any trace of an endothelial lining. As it courses forward dorsal to the reproductive gland it originates numerous vessels which ramify through the body wall or passing ventrally between the halves of the gonad forms a subgenital sinus. In the head region it expands considerably and communicates with extensive lacunae in and between the body wall and the alimentary canal. The blood in these spaces makes its way to the ventral surface where it unites into one main canal, immediately ventral to the gut, which connects also with several small channels coursing along the folds in the ventral furrow. At the posterior end of the body this ventral sinus courses dorsally, keeping close to the under surface of the gut, and when opposite the junction of the auricle and ventricle it divides into two short branches which pass backward on each side of the rectum. These last named vessels are very short and soon divide into a large number of minor sinuses communicating with the gill folds.

Each gill plate is merely a ciliated fold of the cloacal wall with which it connects anteriorly and laterally. The blood enters the anterior border usually, and coursing through the narrow enclosed spaces finally makes its way laterally to the body wall. Here it unites with other vessels of similar origin and finally by means of a large canal passes dorsally and enters the heart immediately after uniting with the corresponding sinus from the other half of the body.

The blood corpuscles are spherical bodies, .0074 mm. in diameter, hyaline in appearance and containing a small, dense nucleus. The leucocytes are remarkably infrequent, unusually compact, but otherwise devoid of any noteworthy features.

About the bases of the gills there are great accumulations of gland cells (Plate **36**, fig. 19) occupying spaces in the meshwork of muscle strands between the folds and the body wall. They project somewhat into the sinus of each gill plate, and are occasionally penetrated by blood sinuses, but there is no trace of any outlet nor is there any indication of their possible function. Each cell is approximately 0.01 mm. in diameter, and contains a small, spherical nucleus imbedded in slightly vacuolated, granular cytoplasm.

The nervous system of this species is in an excellent state of preservation, and as the nerves in many parts of the body are more than usually well defined considerable attention has been devoted to this portion of the anatomy. The location of the brain and principal ganglia are the same as in *Dorymenia acuta* for example, but in the distribution of certain of the nerves differences appear which are here described. The brain (Plate **12**, fig. 5) is relatively small, but anteriorly gives rise to the usual number of nerves distributed to the atrial cavity and the neighboring body wall. The united connectives of the lateral, pedal, and labio-buccal systems enter from the side. The first two connectives become differentiated a short distance laterally and pursue their usual course through the body. The labio-buccal connective springs from the lateral connective posterior to the union with the pedal and holds its customary position at the sides of the pharynx.

In Dorymenia there is a large nerve fibre arising from the anterior end of the lateral ganglion and is distributed to the precerebral ganglia about the bases of the cirri; in the present species it is totally lacking. In both species nerves arising from the pedal ganglia are distributed to the walls of the pedal-gland outlet. Numerous connectives unite the lateral and pedal ganglia, and are far from being regular, in several cases uniting with neighboring connectives by delicate branches. Usually the most anterior connective is of the largest calibre, but in the present instance the first two or three are extremely tenuous, not over one third the diameter of the succeeding connectives. Dorsal nerves from the lateral ganglia are numerous but in no instance have they been traced to the mid dorsal line.

The labio-buccal system is probably more extensive than is shown in Plate **12**, fig. 5, for owing to the great width of the muscular pharynx and the abundance of salivary glands closely crowded together it is very difficult to trace nerves for any considerable distance. The connectives may be readily followed to the ganglia at the sides of the pharynx, and the commissure uniting these is as readily demonstrated, but a different state of affairs is met with elsewhere. Before uniting with the labio-buccal ganglia the connectives far out on the external face of the salivary glands enter a ganglionic enlargement on each side from which two nerves originate. One of small size disappears almost immediately among the glands; the other of much larger size passes in toward the mid line, but becomes lost in the darkly staining secretion of these same glands. From the dorsal side of each labio-buccal ganglion a small nerve arises that gradually extends to the lateral border of the pharynx which it crosses to form a commissure. At various points throughout this entire system exceedingly small nerves arise and probably innervate the neighboring regions but their destination is not certain.

In the posterior end of the body the lateral nerves become so crowded against the body wall, owing to the huge shell gland, that it has been impossible to trace connectives in this region. Opposite the posterior end of the heart they expand greatly (Plate **12**, fig. 6), and originate several nerves distributed more posteriorly as well as the suprarectal commissure. Two connectives, the posterior one of large size, unite with the posterior end of the pedal cords. In the mid line the suprarectal commissure develops a nerve that passes to the base of the dorso-terminal sense organ, to which it sends a small nerve, whereupon it proceeds backward distributing fibres to the dorsal gill plates. The large branches, springing more laterally from the posterio-lateral enlargements, branch repeatedly and in many places delicate offshoots have been found entering the branchial folds. Plate **12**, fig. 6 represents the more important of these whose number and origin is correctly shown though the branching is somewhat diagrammatic. With this exception the nerves and ganglia shown are reconstructed carefully from micrometric measurements.

The pedal ganglia have not been examined in the middle of the body, but elsewhere they are united by strong commissures. In the region of the shell gland this organ is entered, and probably innervated, by several fibres which arise from these ganglia. Posterior to the last of the latero-pedal connectives three or four small branches pass into the muscles about the external reproductive opening. No nerves have ever been followed from this source into the region of the branchial lamellae, and if any are derived from this source they are of very small size.

Alexandromenia valida, sp. nov.

Four specimens of this species (Plate **3**, fig. 3) were collected off the coast of southern California from the following Stations: 2980, 4382, 4389, 4391. The depth ranges from 603–1350 fms. and in every case the bottom was green mud. All the specimens were unattached so that nothing was learned of their habits. The measurements of the largest specimen (Sta. 4389) are as follows: length 32 mm., dorso-ventral diameter of head 3 mm., of cloacal region 3 mm., average diameter of body 3.5 mm.

The head is not distinct from the body but is characterized by a more pointed appearance than the posterior end, and in all the specimens the borders of the cloacal opening are slightly expanded, exposing, to a slight extent, the gill folds. The atrial opening is relatively small and its forward border is almost level with the front end of the animal. A pedal furrow extends along the ventral surface of the body and posteriorly becomes continuous with the cloacal cavity. Anteriorly, for about 1 mm. extent, it expands and allows the escape of the anterior pedal gland secretion (Plate **21**, figs. 2, 4) which, in the type, fills the opening and extends posteriorly some distance along the ventral furrow. The general color of the body is light yellow.

A well-developed dorsal sense organ is present, situated in the type about 2 mm. from the posterior end of the animal. It is in the form of a shallow pit and is especially conspicuous in surface view on account of the numerous hypodermal papillae which surround it.

The body is surrounded by a cuticle, 0.16 mm. in thickness, which is crowded with innumerable spicules and papillae of large size (Plate **33**, fig. 8). The hypodermal layer is concerned almost wholly with the development of these structures, the portion probably responsible for the formation of the cuticle being limited to a few cells packed between the bases of the papillae and developing spines. Everywhere the hypodermal elements are of small size, and though excellently preserved are not favorable for study.

As just noted the papillae are of enormous size and in a fully developed condition contain not less than 100 cells. Of these fully twenty-five are located in the stalk while the remainder hold positions in the expanded portion. This last named section is relatively compact and lacks the spaces and pseudopodia-like processes characteristic of the majority of Solenogastres. The cells composing it are of two distinct types, one containing small spherical dense nuclei and another in which the nuclei are of twice the diameter of the first, and stain but faintly in haematoxylin. The cell boundaries are invisible and it is consequently impossible to determine if these differences are correlated with others. The cells with the small nuclei contain a few relatively large yellowish pigment granules, and there is some evidence, though not wholly conclusive, that this secretion is absent from the cells of the remaining type.

Of the two kinds of spicules the larger (0.189 mm. long) projects from the hypodermis almost at right angles and its pointed extremity projects slightly above the surface of the body. As Plate **37**, fig. 11 shows these spicules are hollow and remain constantly in contact with their matrix cells, which are several in number and in their general appearance and relations are not unlike those of *P. hawaiiensis.*

The second type of spine is many times more numerous than the one just described. Over the body generally all are of essentially the same size (0.135 mm. average length) and in their needle-like appearance resemble the long spines of Proneomenia, Strophomenia, etc., with which they are probably homologous. Without any very definite arrangement they form several layers parallel with the hypodermis.

The anterior pedal gland occupies practically all the space between the body and pharyngeal walls between the brain and the radula. The cells are of various sizes but average 0.189 mm. in diameter and are so densely filled with secretory products that all other elements of the cell are invisible. From each a duct leads to its intercellular opening into the anterior end of the ventral furrow.

The outlet of the anterior pedal gland, the widened end of the pedal furrow, is of large size, and its walls are fashioned into numerous folds (Plate **21**, fig. 2) to afford sufficient surface for the exit of the many ductules. On the roof of the cavity two short longitudinal ridges, almost papilla-like, are present and from these numerous much smaller folds extend down the sides of the chamber to the external opening. After treatment with haematoxylin the secretion of the pedal gland becomes almost black, indicating an alkaline reaction, while the cells lining the outlet of the pedal gland (between which the ductules make their exit) are bright pink in color and therefore distinctly acid in their reaction.

The cells of the posterior pedal gland are of comparatively small size, but otherwise are essentially the same as those of the anterior pedal gland. As usual they open by separate intercellular exits into the pedal furrow.

In several species of Solenogastres the foot is accompanied by two longitudinal ridges, modifications of the hypodermis. In the present species the median projection is bordered by two prominences on each side. All are of essentially the same size and appearance, being thin folds of epithelium into which a few muscle and connective-tissue fibres project. No blood spaces occur within them and at their bases the secretion from the pedal gland finds its outlet.

The atrial cavity in the only specimen examined is of limited extent (Plate **11**, fig. 3), but it possesses ridges of large size that together with the cirrose area presents a very characteristic appearance. The indistinct prominence, which in some species accompanies the outer ridge, is not sharply defined, being recognizable solely by the rod-like group of ganglion cells in the customary position. The outer atrial ridge proper is of large size, and as a much folded, horseshoe-shaped elevation surrounds the atrial cavity except posteriorly. The inner fold is of inferior size and consists of two ridges which arise independently on the roof and posteriorly diminish in size and gradually disappear. Their epithelial covering consists of high slender cells with elongated subcentrally placed nuclei distal to which the cytoplasm contains quantities of light yellow pigment. Internally the folds are supported by strands of connective tissue with a small admixture of muscle fibres among which well-defined blood sinuses pursue their course.

The cirri arise singly from the atrial wall and are of more than ordinary thickness. As usual each consists of an outgrowth of the buccal wall, composed of more or less cubical cells in which the yellowish brown pigment is so abundant that it usually conceals the nucleus. The cavity of each cirrus is very narrow, allowing the passage of a nerve strand but not of the blood.

The buccal cavity or pharynx, separated from the atrial cavity by a circular fold (Plate **11**, fig. 3), is an irregular cavity whose general appearance and relations are represented in Plate **21**. The walls throughout are produced into numerous wavy, more or less longitudinal folds, lined with a thin cuticular sheet. In the middle third, which contains the radula, the folds become more distinctly longitudinal, but more posteriorly they once more become very irregular.

As in *A. agassizi* there are three sets of salivary glands, and as may be seen in Plate **21**, figs. 2, 4, in arrangement and size, they are essentially the same as in the foregoing species. The smallest dorsal glands (dsg) are more or less imbedded in the pharyngeal wall from the cirrose cavity to the posterior end of the radula sac. Each consists of an aggregation of well-marked pyriform cells usually charged with a finely granular darkly staining secretion. In some of the larger groups the secretory products are not so clearly granular and have a more reddish cast, in this respect and in general appearance resembling the second type of dorsal salivary gland.

The second species of gland (sg) is in reality a paired structure each half consisting of about two dozen lobulate glandular bodies united by as many branches of a main duct which opens into the pharyngeal cavity. It appears probable that each organ arose in the embryo as a diverticulum of the gut, and subsequently developed outgrowths in which some of the cells became glandular. These retaining their connection with the lumen of the duct elongated greatly, became pyriform and formed the lobule of the completed gland. As in *A. agassizi* the canal in each lobule develops small lateral branches and in any case the duct holds a superficial position.

The course of the main duct, which lies to the outside of the glands is shown in Plate **21**, fig. 2. It opens at the base of a corrugated papilla enclosed in a diverticulum of the pharynx that in turn opens at the forward border of a broad papilla on the pharyngeal wall (Plate **11**, fig. 3). As in the foregoing species the papilla contains a few small canals which open on its surface, but their inner connections are difficult to trace. They appear to be the outlets of a number of small glands belonging to the first type which, as noted above, approach the second in the form of the cells and the character of their secretion.

The tubules of the third set (gl) are in form and position like those of *A. agassizi.* The secretion is more abundant and more granular and darkly staining, giving them a denser, more compact appearance, but this set is not voluminous as in the preceding species.

The radula is of the distichous type (Plate **11**, fig. 3, Plate **34**, fig. 14) and contains approximately thirty-four rows of teeth. These are developed by large numbers of exceedingly slender odontoblasts, and immediately after their formation are enveloped in sheaths composed of numerous so-called enamel cells. Both of these groups blend with cells that become smaller as the opening of the radula sac is approached.

At the forward border of the radula the cells of the pharyngeal wall become more columnar, less dense, and their nuclei assume a more slender shape. Appearances suggest a subradular sense organ, but it lacks the definiteness of this structure in *Proneomenia hawaiiensis* for example, and is apparently not innervated by a well-defined subradular nervous system.

The oesophagus opens at the summit of a papilla (Plate **11**, fig. 3) into the stomach-intestine, which manifests no especially noteworthy features save that its lining is of such thickness that in preserved material it reduces the cavity to a narrow slit. In the posterior end of the body the gut narrows to a vertical slit as it passes between the anterior ends of the shell gland then becomes a circular canal of small size that opens into the cloacal cavity dorsal to the external reproductive opening.

The circulatory system is almost the exact counterpart of that in *A. agassizi.*

The reproductive system is likewise practically identical with that of the foregoing species. The pericardial cavity is smaller, and the inner ends of the coelomoducts are more slender, but they rapidly increase in size and their walls become more than usually folded. The shell gland, especially its posterior half, is more distinctly lobulate and somewhat more acid in reaction. The seminal receptacles are considerably larger; but neglecting these differences the two species agree closely so far as this system is concerned.

The nervous system is not especially favorable for study and for this reason only the more obvious portions have been examined. In all essential particulars these closely resemble homologous structures in the foregoing species.

Halomenia gravida, sp. nov.

This species is represented by two individuals taken off Simushir Island of the Kurile group at a depth of 229 fathoms (Sta. 4804). Both were discovered in dead barnacle shells and are evidently free roving forms. The larger specimen is 11 mm. long by 1.6 mm. average diameter and the length index 7:1 is characteristic also of the smaller one. The anterior cirrose section of the gut, or the atrium, is separated from the succeeding portion by a ridge (Plate **5**, fig. 3) covered with the spiculose cuticle investing the body. Posteriorly the pedal groove is continuous with the cloaca which like the atrial opening, extends far up toward the dorsal surface of the body. The color is light yellow shading to nearly white in the head and cloacal regions (owing to compact muscles) and along the mid dorsal line where the gonad is situated. A dorsal sense organ is present (Plate **22**, fig. 12), and is remarkable for its large size and from the fact that it is more anteriorly located than is usually the case with other species, being placed opposite the forward cloacal wall.

The cuticle, surrounding the body, is of average thickness (Plate **32**, fig. 4), but is actually rather scant in amount owing to the large numbers of spicules (Plate **22**, fig. 13) imbedded in it and to the papillae many of which are of unusual size. On the ventral side of the body the unmodified hypodermal cells, those which are probably largely responsible for the development of the cuticle, are comparatively few in number and are crowded between the bases of the papillae, but dorsally they become more numerous and may be seen to possess a cubical form and no especially noteworthy features. Owing possibly to differences in age the papillae vary greatly in size but all are constructed on essentially the same plan. As may be seen (Plate **32**, fig. 4) the stalk is composed of an outpushing of hypodermal cells and is usually shorter in the larger papillae. It is surmounted by the usual balloon-shaped group of cells, which certainly number not less than one hundred in the larger organs. Each cell is greatly elongated, vacuolated in its outer portion in preserved material, and contains a spindle-shaped, basally placed nucleus. In several cases the cavity of the stalk is traversed by a delicate fibre, sometimes enclosing a nucleus, which appears to be a nerve.

In this species the stomach-intestine is related in a remarkable way to the cuticle and papillae but for what purpose I cannot say. On the dorsal surface of the smaller specimen and in the region traversed by the mid gut there are not less than twenty pairs of small rounded knobs of light yellow color, forming one longitudinal line on each side of the mid line. These are not distinctly visible in surface views of the larger individual, but in sections they are seen (Plate **22**, fig. 1) to be evaginations of the dorsal wall of the intestine which protrude through definite openings in the somatic musculature and extend half way to the outer surface of the body. Each is in contact with the under surface of a circular disc-like patch of hypodermal cells having the appearance of a modified papilla. The stalk is absent and the cells are relatively low, but some are distally vacuolated and are not the compact, cubical elements of the unmodified hypodermis. Surrounding the point of attachment of gut and papilla is a small ring-shaped blood sinus, frequently containing corpuscles. The relations of these various elements are represented in a typical condition in Plate **32**, fig. 5. Concerning their mode of operation it appears probable that the pressure of the blood in the sinus causes a protrusion of the papillae and the attached liver lobe, but for what possible reason I cannot say.

The spicules, whose general shape is shown (Plate **22**, fig. 13), are of various sizes in a mature condition even in the same locality. These are intermingled and lack any very definite arrangement further than that they encircle the enormous papillae, giving the animal as seen under low magnification, a mottled appearance.

The anterior pedal gland occupies the major portion of the space included between the gut (Plate **22**, fig. 1), and body wall from the level of the brain to the stomach-intestine. Its cells are comparatively small but the secretion is abundant, enabling one to follow in many cases the slender ductule to its opening into the anterior end of the pedal furrow. The walls surrounding this external outlet are unfolded (Plate **22**, fig. 1), highly ciliated and form a cavity of more than usual size. From its posterior border two ridges develop (Plate **22**, fig. 2) and extend along the pedal furrow to within a short distance of the cloaca, where they disappear though the furrow, reduced in size, becomes continuous with the cloacal cavity.

In surface view it is possible to detect slight folds in the exposed cloacal wall which in sections may be seen to become of much greater height within. These, twenty-six to thirty in number, at first hang freely in the cloacal chamber (Plate **22**, fig. 11), but more anteriorly they become attached to the wall of the rectum, and yet farther forward some of the dorsal ones extend into the cavity above the rectum dividing it into a corresponding number of small crypts (Plate **22**, fig. 8). In these last named spaces, and between the folds for some distance more posteriorly, upwards of twenty embryos have taken refuge and undergone the first stages of their development protected by the parent. The epithelium of the basal half of each fold in contact with the embryo is low and seemingly non-ciliated, while that of the distal half assumes the high columnar, ciliated appearance characteristic of such organs in several other species.

As noted previously the cirrose section of the gut, or the atrium, opens subterminally and has no direct connection with the remainder of the digestive tract. Its cavity is largely obscured by the thick-walled, large ciliated ridges which hold the usual position and define the cirrose area. The cirri are comparatively short and thick set and are usually united by their bases in groups of two or four. Their cells are of the customary pigmented type and surround a lumen of exceedingly small calibre.

Immediately behind the opening into the atrium the cuticle surrounding the body becomes continuous across the mid line for a short distance, and still more posteriorly breaks through to form a second opening, probably the true mouth. This aperture leads into an irregularly shaped cavity (the general arrangement shown (Plate **5**, fig. 3), whose walls, seemingly ciliated throughout, are developed into a complicated series of ridges. In the customary position a distichous radula is present and though of small size is typical in all essential respects. It rests upon a delicate though perfectly distinct basement membrane and is produced by odontoblasts at the bottom of a shallow sac. There are, so far as may be determined from cross sections, about twenty-four rows of teeth which present the appearance represented (Plate **34**, fig. 12).

On each side of the forward limits of the radula sac the narrow ducts of the ventral salivary glands open into the digestive tract and on the other hand lead right and left into a reservoir extending far toward the dorsal side of the pharynx. Each of these cavities is surrounded by a gland (Plate **22**, figs. 2, 5), composed of multitudes of small, pyriform cells grouped, by means of delicate connective-tissue septa, into lobules of various sizes. The ductule from each cell makes its way to the wall of a reservoir into which it pours its granular, moderately staining secretion by way of an intercellular opening.

Beyond the radula the alimentary canal courses dorsally and opens into the stomach-intestine. In front of this junction a coecum extends far forward and as noted previously develops on each side of the mid line diverticula which pierce the body wall and come in contact with the under side of what appear to be modified papillae. These are developed also by the stomach-intestine throughout its entire extent. A further peculiarity of the mid gut exists in the form of numerous small secondary outpouchings of the wall of the ordinary gut pouches which give in cross section a complicated appearance to this region (Plate **22**, fig. 3). The dorsal wall of the intestine, in contact with the gonad, is relatively low and heavily ciliated. At the level of the forward pericardial wall the gut narrows rapidly, loses its glandular character, becomes ciliated and by a relatively small pore opens into the cloaca.

The position of the heart, its relation posteriorly to the branchial folds and anteriorly to the aorta are typical. As is seen (Plate **3**, fig. 5) it consists of two divisions united by a small canal apparently provided with a valve. Both portions are moderately muscular, and lodge in the meshes of the muscle bands numerous large, irregular cells which have the appearance of blood forming elements. The aorta, extending anteriorly and dorsal to the gonad, supplies the last named organ with many well-defined ventral branches which, as in *P. hawaiiensis*, pass ventrally along the mid line and reaching the neighborhood of the gut course outwardly and then dorsally to unite with the larger spaces beside the aorta. In the head region this main vessel communicates as usual with sinuses which carry the blood in turn to spaces between the gut and body wall. Opposite the anterior end of the shell gland the ventral sinus enlarges, and divides, each branch passing dorsally, then posteriorly along the sides of the rectum. Upon arriving at the bases of the cloacal folds they break up into numerous branches each of which enters a fold, passes through it to the neighborhood of the body wall whereupon it makes its way forward to enter the heart.

In appearance, position, and extent the gonad is nowise peculiar. The reproductive elements in the anterior third are wholly male, and in the neighborhood of the pericardium also are great accumulations of spermatozoa while in an intermediate position the great ova, 0.26 mm. in diameter, are most conspicuous objects. Correlated with their great size the ducts leading into the pericardial cavity are of unusually large calibre, being 0.175 mm. in their greatest diameter. The lining cells are low and heavily ciliated.

From the postero-lateral borders of the pericardium the coelomoducts arise, extend outward and forward and enlarging somewhat unite with the shell gland (Plate **3**, fig. 5). In the early part of their course the cells, like those lining the pericardium, are low, but more outwardly they become more columnar and form longitudinal ridges of considerable height. At the anterior limits of the shell gland is the opening of the seminal receptacle, which is a simple unbranched tube, empty in the present instance, and is provided with a high ridge extending, like a typhlosole, throughout its length. The cells composing this latter organ are slender, triangular elements which when combined form a fan-shaped structure in cross section. A heavy layer of circular muscles ensheaths the seminal receptacle, and a few radiating bands extend from it chiefly to the body wall.

As usual the shell gland is U-shaped and in the present example is fully functional. In the neighborhood of the seminal receptacle its cells are rather low and their secretion small in amount, but half way down toward the mid line they become greatly elongated, and distally contain a finely granular secretion which escapes in large quantities into the lumen of the duct. Upon the fusion of these tubes in the mid line the dorsal wall of the undivided section is composed of cells, also high in form, which during the early stages of glandular activity are filled with a darkly staining vacuolated secretion (Plate **15**, fig. 8 and Plate **22**, fig. 6). This condition of affairs, mucous cells dorsal and albumen forming elements below, continues to the single median opening in the cloacal cavity.

As noted previously this species broods its young. The eggs, about two dozen in number, have been retained in spaces between the great branchial folds in the cloacal wall and evidently they have come down at different periods as all stages of development are represented from a 4-cell condition to advanced larvae where the shell and foot are indicated, the fore and mid gut clearly differentiated, the anterior pedal gland developed and to some extent functional, the central nervous system partly outlined (Plate **22**, fig. 7). A fuller account of the embryology is planned for a later paper.

The brain, of usual size, holds the customary position above the pharynx. The anterior nerves passing to the cirri, etc., and the pedal, lateral, and buccal connectives have the usual relations. Anteriorly the pedal cords enlarge and are united by a more than usually heavy commissure, and each gives rise to a nerve that passes to the wall of the outlet of the anterior pedal gland. Here and there pedal commissures may be detected, as well as connectives with the lateral cords, but these are usually small and often very difficult to follow.

The labio-buccal connectives are imbedded in the walls of the pharynx and connect with ganglia, of rather small size, located at the sides of the radula. These ganglia are united by a commissure ventral to the pharynx posterior to the radula. The ganglia, and more anteriorly the connectives, give rise to small fibres that may form commissures, as in other species, but their lack of sharpness renders it impossible to trace them more than a short distance into the pharyngeal wall.

In the posterior end of the body the pedal nerves diminish in calibre and disappear beneath the shell gland. The lateral nerves, upon reaching the forward border of the shell gland, pass diagonally inward toward the mid line until they reach the level of the outlets from the pericardium. Here they enlarge (Plate **3**, fig. 5) and are united by a commissure passing dorsal to the rectum. The last two connectives between the pedal and lateral cords are of about twice the usual diameter and pass to the inner side of the shell gland. From the posterior superior ganglion several nerves arise that course over the cloacal passage to which they give off delicate fibres, then extend into the somatic musculature and probably are distributed in part to the hypodermis. Near the mid dorsal line two other nerves originate and attached to the forward wall of the cloaca pass dorsally and are distributed through the somatic musculature in close proximity to the hypodermis.

Herpomenia platypoda, sp. nov.

Eleven specimens of this species were taken in the neighborhood of Agattu Island of the Aleutian chain (Sta. 4781) in water 482 fath. in depth. All were attached (Plate **1**, fig. 4) to a colony of some unidentified campanularian hydroid and varied in size from 11 mm. in length and 0.6 mm. diameter to 18 mm. long and 0.9 mm. in thickness. A well-defined dorsal keel extends throughout the entire length of the animal with the exception of the extreme posterior end. In a contracted state both ends are pointed and quite similar, but usually the atrial cavity is opened so that the outer ridges are exposed, thus giving the front end a blunt appearance. The color is white or yellowish white, depending to considerable degree upon the food contained in the alimentary canal. A single layer of spicules envelops the body, the majority being leaf-like in form and biconvex in cross section. A second type with a short stem occurs in the neighborhood of the ventral furrow, and to a less extent over the body generally. The cuticle is more highly developed than is usual with species in this family, and is underlaid by a hypodermal layer of more than usual height beneath the dorsal keel. In their general appearance the component cells resemble those of some of the Chaetodermatidae, being of cubical or rectangular shape, or in the case of what appear to be spicule matrix cells more or less globular except in the region of the keel where they are much elongated.

The anterior pedal gland (Plate **19**) occupies practically all of the head region not held by the ventral salivary glands from slightly in front of the middle of the pharynx to the forward end of the body. The crypt into which it opens is typically placed (Plate **8**, fig. 1), possesses unfolded walls and is profusely ciliated. Posteriorly the anterior gland joins, without any sharp line of demarcation, the posterior one which continues to the cloaca.

In the anterior end of the body the foot is the merest fold or it may be entirely smoothed out. This latter condition obtains in the posterior half of the body (Plate **19**, fig. 10). However, all of the cells retain their ciliated condition though they are more columnar than the ordinary pedal cells of other species.

The atrial cavity is unusually small (Plate **8**, fig. 1) and the outer ridges are lacking or are without clearly defined boundaries. The inner elevation on the other hand is a prominent fold, penetrated by blood sinuses, and is composed of cubical cells save along the free border where they are higher, more spongy and heavily ciliated. The cirri, presenting the customary appearance, are arranged in groups of 3–7. The opening from the atrium into the buccal-pharyngeal section is comparatively narrow, being reduced by a large fold springing chiefly from the dorsal side of the digestive tract. Beyond this the canal widens, its lining epithelium becomes considerably folded, and is composed of columnar cells endowed with considerable glandular activity. Still farther inward the wall again develops a circular fold which forms the outer boundary of another circular groove between it and the muscular pharynx. Through the posterior wall of this groove the ventral salivary glands find their outlet by means of two ducts very closely situated to the mid line (Plate **8**, fig. 1, Plate **19**, fig. 8).

The ventral salivary glands are unusually large organs completely encircling the gut for part of their course, and occupying most of the space between it and the body wall from their outlet to the junction of the pharynx and stomach-intestine. The cells composing them are pyriform, 0.024 mm. in greatest diameter and are filled with a homogeneous, moderately staining secretion in which the relatively large nucleus holds a more or less central position. The cells are arranged in lobules, and their delicate ductules open by intercellular channels (Plate **19**, fig. 13) on each side of the body into a reservoir whose superficial extent is much increased by several folds. The outlet from each reservoir passes to a small diverticulum of the pharyngeal wall into which it opens opposite its fellow and very close to the median plane.

The pharynx is a prodigiously heavy tube whose walls are composed of a compact mass of muscle fibres chiefly circular (Plate **19**, fig. 7) lined with high columnar cells developed into upwards of a dozen longitudinal folds. These last named elements contain a weakly staining secretion and are in contact distally with a distinct cuticular membrane. Posteriorly this tube projects some distance into the stomach-intestine, Plate **8**, fig. 1. A radula is completely lacking in this species, and it is probable that, as in *Drepanomenia vampyrella*, the secretion of the salivary glands exercises a solvent action on the tissues of the host that are then sucked up by the powerful pharynx though its exact mode of operation is difficult to understand. Nettle cells, from the host, are present in the intestine, in some cases seemingly imbedded in the epithelial cells.

The lining of the stomach-intestine, where the distal portions of the cells bearing the secretion have not been detached, is excessively high, in one specimen almost occluding the lumen. Beneath the gonad is a small median fold apparently ciliated, and showing evidence of slight glandular activity. Ventral to the pericardial cavity the gut rapidly narrows to an almost circular tube of small calibre and opens with the shell gland into the cloaca.

The pericardial cavity, as may be seen (Plate **8**, fig. 3), is of moderate size only, and is in large measure filled by the simple tubular heart. The aorta is exceptionally small as are the sinuses generally with which it connects, yet so far as they have been traced their relations appear to be perfectly normal.

The gonad holds the customary position, but is remarkable in several respects. In the first place it is sharply differentiated into two zones in the two specimens examined, a forward section in which the sex products originate, and a posterior division that serves merely as a duct. This latter portion is exceedingly narrow (Plate **8**, fig. 3), upwards of twice the bodily diameter in length, is without any signs of developing germ cells and contains throughout fully developed sperms. The ova and sperms develop in the customary position, but the former are scant in amount and unusually large, almost completely filling the gland.

Especially about the periphery each ovum contains imbedded in the yolk large numbers of clear vesicular bodies (Plate **35**, fig. 9), approximately 0.0068 mm. in diameter with an eccentrically placed darkly staining mass usually superficially placed. At first these bodies appeared to be remnants of nutritive cells, possibly modified follicle cells, but subsequent study leads strongly to the conviction that they are portions of fragmented nuclei. In the early stages of ova development these same bodies occur, but are of extremely small size (Plate **35**, fig. 6). Still earlier (Plate **35**, fig. 7) it has been possible in several cases to find imbedded in very small ova from one to three cells resembling primordial germ cells, and probably corresponding to follicle cells that are known to occur in a few Solenogastres. These nuclei in a slightly older stage become somewhat larger and stain blue instead of light red or pink. The granules assume the vesicular appearance characteristic of later stages and slightly later upon the rupture of the nuclear membrane become scattered throughout the egg. Against the belief that these structures are cells may be urged the fact that in their early development they are much smaller than any cell of the body, measuring not more than 0.0008 mm. in diameter, and secondly there is at no time any sign of a cytoplasmic mass. These granules correspond closely in size and number to the chromatin bodies, possibly chromosomes, that occur normally in the spermatocytes.

In the pericardial cavity the spermatozoa are attached in considerable numbers to the wall especially along the dorsal surface, or at the time of the animal's capture were being swept along in a current passing beneath the heart and outward through the coelomoducts arising from the posterior wall. The dorsal section of each duct (Plate **8**, fig. 3) is a simple tube of even calibre throughout, passing downward and forward from the pericardium to unite with the shell gland. Shortly before this union it unites with the duct of the seminal receptacle, which resembles a flask with a long curved neck. This last named organ like the dorsal limb of the coelomoduct is lined with cubical cells possibly ciliated, to which are attached a small number of spermatozoa.

The shell gland is a globular body and almost totally lacks the cornua prominent in the majority of species. On the sides of the organ the epithelium is comparatively thin but it rapidly becomes thicker above and below owing to the excessive development of numerous gland cells. In this highly developed condition each cell is a goblet-shaped body with very slender stem and a slightly expanded base in which the nucleus is placed. The secretion consists of a granular mass much like yolk in appearance and staining reaction. Among these larger elements slender supporting cells, usually with subcentrally placed spindle-shaped nuclei, occur in considerable numbers. Both of these elements occur on the sides of the organ but as mentioned previously they are very low and cubical or rectangular. Since the distal portions of these cells are dislodged in the apparently normal process of liberating the secretion it is probable that at times these lining cells are of greater height. At the postero-ventral surface of the gland a short narrow duct, whose position and general appearance are represented (Plate **8**, fig. 3), makes its way into the cloaca.

Owing to the similarity of the nerves and connective tissue, and muscle fibres, and the consequent difficulty of tracing these to any extent, the nervous system has not been examined.

Dondersia californica, sp. nov.

One immature specimen taken at a depth of twenty-one fathoms off southern California (Sta. 4303) is the sole representative of this species. Owing to the fact that it bore a superficial resemblance to several small nemerteans it was killed with them in corrosive acetic destroying totally all traces of calcareous structures.

The general form of the body is shown (Plate **3**, fig. 9). The length is 7 mm. and the greatest diameter 1.2 mm. The pedal groove, and single, included fold, is continuous with the cloaca though at the point of union the former has become very indistinct. The outlet of the anterior pedal gland is a well-marked invagination with highly folded, ciliated walls. In this genus more than one dorso-terminal sense organ is present, two being found in *D. festiva* and three in *D. annulata* according to Nierstrasz ('02). In the present species eleven exist, all constructed on the same plan (Plate **35**, fig. 12). Of these five occur along the mid line, and the others are not far removed from it. As Plate **6**, fig. 2, shows they are not symmetrically disposed for of the six not in the mid line five are on the left side of the body. Each organ consists of a globular mass of slender cells, with elongated mesially placed nuclei, covered distally with a thin continuation of the cuticle investing the body. From the bases of the cells fibres, probably muscle and nerve, judging from other species, pass into the underlying tissue.

It is evident from the thinness of the cuticle (Plate **32**, fig. 8) that but a single layer of spicules exists in this species and from spaces in the decalcified cuticle it is evident that they are of small size. The hypodermis is comparatively thick and comprises several classes of cells. The most conspicuous, and at the same time the most rare, are gland cells which are generally more deeply placed than the other elements between which their delicate ductules pass to the exterior. These are most abundant on the ventral surface.

At all points there are almond-shaped spaces in the hypodermis which appear to have been filled with a calcareous product, and judging from the cell remnant usually in connection with them, it is probable that they are spicules in process of formation. The cells apparently responsible for the formation of the cuticle are columnar, non-staining elements containing a centrally placed nucleus. Between them are very slender cells with spindle-shaped mesially placed nuclei which may possess a sensory function though this is not definitely established. No papillae are present.

In this species the atrial cavity, provided with cirri and ridges, is entirely distinct from the radula-bearing region which communicates with the exterior by an opening immediately in front of the outlet of the anterior pedal gland (Plate **5**, fig. 4). In this forward division the dorsal or innermost of the buccal ridges is lacking; the external one on the other hand is prominent and abundantly ciliated. The cirri are united by their bases into groups of three or four or rarely six. In this enlarged basal part it is sometimes possible to distinguish a few bipolar cells which connect with fibres passing distally through the cavity of each cirrus, and in a reverse direction become lost to view in the vicinity of the ganglionic masses surrounding the cirrose division of the digestive tract.

As just noted this anterior end of the alimentary canal is separated from the succeeding portions by a narrow tract bounded by hypodermal cells and covered with a spiculose cuticle. Whether this division line disappears later in life, the cirrose section then communicating with the remainder of the gut, as is usually the case, it is impossible to say, though judging from the size of the specimen and the profound changes required to bring about such a state of affairs it seems probable that the present arrangement obtains in the sexually mature individual. From the foregoing it develops that what Thiele assumes to be the true mouth is an independent opening communicating in the present instance with a comparatively narrow plicated tube leading into the larger pharyngeal, radula-bearing portion which in turn connects with the stomach-intestine by a short oesophagus.

Dorsal salivary glands are represented by a small number of pyriform cells communicating with the pharynx immediately behind the level of the brain. Slightly more posteriorly there are other similar cells, but they cannot with certainty be differentiated from the anterior pedal gland. The ducts of the ventral salivary glands open close to the mid line on each side of the forward end of the radula (Plate **23**, fig. 5). Distally they make their way, as slender tubes, in a lateral direction and then expanding to twice their initial diameter proceed for a short distance posteriorly. To this expanded portion are connected multitudes of pyriform gland cells arranged somewhat indefinitely into lobules attached to the lateral and ventral walls of the pharynx. In *D. annulata* Nierstrasz ('02) finds numerous cells situated about the ventral ducts; it is probable that they are the salivary cells whose ductules have been destroyed owing to faulty fixation.

The radula is comparatively small and the teeth very transparent so that it is somewhat difficult to discover their exact form. Judging from cross sections each tooth consists first of a basal plate (Plate **8**, fig. 8), narrow rectangular in form, and without any connection with the plates of neighboring teeth. This basal bar supports what appears to be a triangular median tooth, but high powers resolve this into a pair of elements closely appressed. It thus appears that the radula is monoserial, each bar bearing a pair of conical cusps. On the other hand the radula may be considered biserial, the basal bar representing a basement membrane, but against this is the fact that the bars are not united with each other. There are not less than twelve teeth if the radula be considered monoserial.

Beyond the radula the digestive canal narrows, becomes folded longitudinally and opens abruptly into the stomach-intestine that after forming a short dorsal and ventral coecum develops the deep, characteristic lateral pouches with glandular walls. In the mid dorsal line the epithelium is differentiated into a fold composed of high, richly ciliated cells which laterally become reduced in height and gradually shade into the non-ciliated digestive cells. The relations of the gut to the cloacal cavity are indicated (Plate **6**, fig. 2).

The pericardium is spacious and the heart is of more than average size. The blood from the posterior regions of the body pours into its posterior division corresponding to an auricle (Plate **6**, fig. 2), thence into a ventricle-like portion and from there is driven into the aorta. This vessel throughout its entire extent develops branches, in reality openings, communicating with numerous lacunae in the dorsal crest-like portion of the body. These in turn connect with others of less extent in the lateral regions and through these with the pedal sinus. In the head region the aorta breaks up into several sinuses which make their way through the anterior pedal gland to connect with the pedal sinus and the more lateral spaces just described. In the posterior end of the animal the blood accumulates in large spaces surrounding the intestine and coelomoducts and pours into the heart by means of a sinus passing dorsally on each side in the neighborhood of the reno-pericardial openings. The pedal sinus continues backward to the cloaca then passes dorsally into a space beneath the shell gland and from there into vessels leading to the heart.

The gonad is distinctly paired, the two divisions being in contact only in the middle of the body. Elsewhere they are widely separated by means of the dorsal aorta. In the mid section spermatogonia are fairly numerous and at all points ova are commencing to develop. In the heart region the glands narrow and communicate with the pericardium, which posteriorly communicates also with the coelomoducts opening into the cloaca. The dorsal division of these tubes is comparatively slender and is composed of cubical ciliated cells without signs of glandular activity. No trace of a seminal receptacle is visible unless what appears to be the anterior end of the ventral section may be so considered. This lower division, or shell gland, is composed of rather low columnar cells, tending to form longitudinal ridges, but they likewise are inactive.

Beneath the single opening of the coelomoducts the cloacal wall is developed into an outpouching which in the adult animal may develop copulatory spicula or some gland connected with the egg-laying process, though in the present specimen such functions are purely hypothetical. In shape this outgrowth resembles a thick set **Y**, having a median undivided section which opens into the cloaca and on the other hand connects with a blind pouch on each side of the mid line. The walls are not unlike those of the shell gland, consisting of columnar cells which are richly ciliated.

The cloaca or mantle cavity in this specimen is of unusually small size though it may increase in diameter as the mature condition is approached. A glance at Plate 6, fig. 2, will show that in this species the dorsal commissure uniting the lateral nerve cords is placed uncommonly near the cloacal opening. If in the adult the commissure is customarily placed it might readily be shifted by the active growth and enlargement of the cloaca.

The nervous system is typical. The brain is situated posterior to the atrial cavity, or cirrose portion of the digestive tract, but with reference to the pharynx it is normally situated. As usual branches pass out from the anterior surface of the brain to unite with ganglionic masses about the bases of the cirri which they appear to innervate and three pairs of connectives unite with the labio-buccal, pedal, and lateral nervous systems. Connectives and commissures, agreeing closely in number with the gut pouches, join the pedal and lateral cords throughout the body. In the region of the cloaca the pedal cords diminish in size and finally disappear, and the lateral cords likewise diminish considerably in calibre, and are united by a commissure which unlike the usual type, is devoid of ganglion cells.

The labio-buccal connectives, imbedded in the pharyngeal wall, attach to large ganglia lateral to the salivary ducts. Owing to the numbers of salivary ductules it is very difficult to trace nerves in this region and determine if there be more than the one commissure uniting these ganglia beneath the pharynx.

Ichthyomenia porosa, sp. nov.

Upwards of twenty individuals of this species were taken in one dredge haul (Sta. 4400) off the coast of southern California, and two additional specimens were captured in the same locality at Station 4402. In both cases the bottom consisted of green mud at a depth of 500–507 and 542 fathoms respectively. All were unattached and there is no evidence whatever regarding their mode of life though it is possible that they may be parasitic upon some of the sea pens (Pennatulidae), of which three species abound in this locality.

There are slight inequalities in size due to differences in age and sexual maturity but the average length is approximately 16 mm. with a diameter of 1.2 mm. The head region is indistinct (Plate **3**, fig. 4) and externally is characterized merely by a very slightly greater diameter than that of the body. Posteriorly, in an uncontracted state, the body terminates in a pointed extremity, but in other cases it may become blunt and where the cloaca is opened widely, trumpet-shaped. A pedal groove is present and as usual extends from the hinder border of the mouth to the cloacal opening with which it is continuous. The opening of the anterior pedal gland is usually very distinct, having the appearance shown in Plate **5**, fig. 6.

Of the spines covering the body by far the most abundant are exceedingly delicate, of a pointed ovate shape (Plate **37**, fig. 1), 0.024 mm. long, and are imbricated, forming a single layer. In the neighborhood of the ventral furrow these are associated with a somewhat similar type, 0.0594 mm. long, with thickened edges especially on the rounded extremity. Scattered fairly regularly among the first variety are those of the second type, paddle shaped, with short handle and a length of 0.054 mm. Along the ventral furrow they are of a greater length, 0.01 mm.

The hypodermis is apparently one cell thick but the species is peculiar in having the layer developed into many transverse folds (Plate **32**, fig. 7) especially on the dorsal surface, and in section these ridge-like elevations render the cell relations obscure. These wrinkles are more pronounced in some specimens than in others, and are usually more prominent in the anterior half of the body. In some cases they are doubtless due to reagents but usually they are certainly normal. The ordinary type of hypodermal cell is very slender, especially in the ridges and is provided with a relatively dense subcentrally placed nucleus. Accompanying these are numerous larger, more globular cells, apparently in large measure empty in preserved material. This may be due to the precipitation of some highly watery secretion, or more probably to the decalcification of some calcareous product.

This species possesses upwards of fifty remarkable organs, apparently sensory, located chiefly about the anterior end of the body in front of the outlet of the anterior pedal gland. All are situated in the ventral half of the animal. Each consists of an invagination of the hypodermis (Plate **24**, fig. 12) with an average depth of 0.1 mm. The lining cells are low, very indistinct and are provided with what appear to be very long cilia, which in most cases extend slightly beyond the general body surface. In the most favorable specimens delicate fibres attach to some of the cells but on the other hand they have never been traced to any undoubted nerve. It is impossible to determine their function yet it may be that in life they act as tactile organs like the apical tuft in the trochophore larva.

The anterior pedal gland is comparatively large (Plate **24**, fig. 1) and occupies much of the visceral cavity between the atrium and the forward boundary of the stomach-intestine. Its cells are arranged in large groups and are filled with a uniformly granular, lightly staining secretion that after its escape appears as a viscous, darkly staining substance. The posterior pedal gland consists of cells filled with a darkly staining, finely granular secretion clearly distinguished from that of the foregoing group. Anteriorly it rests against, and opens through, the posterior wall of the outlet of the anterior pedal gland, and more posteriorly forms a thin sheet resting against the ventral body wall and opening between five folds in the ventral furrow. Posteriorly these folds very soon disappear save one, the foot, and the accompanying glands diminish greatly.

The atrial opening is subterminal and opens into a comparatively large sized cavity (Plate 5, fig. 6) in which the ridges (Mundleisten) appear to have no existence. On the other hand cirri are present in great abundance and in some specimens project from the mouth for a short distance. These organs may spring directly from the buccal wall, but especially on the sides of the mouth they are borne in groups of from three to seven on stalks containing muscle and connective-tissue fibres between which there are extensive blood sinuses, enabling the animal to project the cirri through the mouth opening. Each cirrus is an unbranched process consisting of small cells with very indistinct nuclei and cell boundaries owing to the large amount of yellowish brown pigment. In all of the specimens sectioned numerous pigment granules have escaped from the cirri and at various places form small accumulations, but whether this is a normal process it is impossible to say. This secretion renders it also impossible to determine their innervation, a difficulty that is increased by the small calibre of the contained canal which in preserved specimens is too narrow to permit the entry of blood corpuscles.

The cirrus-bearing section of the digestive tract passes abruptly into the succeeding region, the junction in every case being guarded by a distinct fold which thus appears to be a permanent structure. At first the buccal-pharyngeal walls are almost smooth and the epithelial lining, composed of cubical cells, is thin but opposite the mid section of the brain the lumen narrows, becoming trefoil shaped in section, and numerous small transverse folds have developed which now are of greater thickness. This condition of affairs continues with slight modifications to the region of the ventral salivary glands where the canal becomes increasingly narrower and the corrugations more pronounced. As Plate 5, fig. 6, shows a clearly defined fold is present at the junction of the pharynx and stomach.

Throughout its entire extent the walls of the pharynx are thick and are composed internally of heavy circular muscles to which are attached numerous radiating bands inserted on the other hand to the body wall. All signs of a radula are absent and appearances suggest that this species like *Drepanomenia vampyrella* subsists on some delicate organism, such as the sea pens, whose juices are extracted by powerful sucking movements of the pharynx.

Two ventral salivary glands are present in the form of small tubular outgrowths opening on the underside of the pharynx about opposite the level of the hinder border of the brain. The cells are small but are filled with an abundant secretion, indicating that though these organs are diminutive they are functionally active.

As indicated (Plate **5**, fig. 6), a dorsal coecum is but slightly developed, and the intestine from its junction with the pharynx to the cloaca is of uniform size and character, and is pouched in regular and characteristic fashion. Its walls are composed of high club-shaped cells in which the small nuclei are basally situated while the remaining portions are filled with large droplets of some secretion unaffected by haematoxylin. Immediately beneath the gonad the cells are much reduced in size, and are possessed of little if any glandular activity but bear a heavy coat of cilia. Near the anterior end of the coelomoducts the digestive canal narrows abruptly (Plate **6**, fig. 1) to form a small canal which arising near the ventral side of the animal makes its way dorsally on the under side of the pericardium (Plate **24**, fig. 5) to open into the cloaca. The cells composing it are essentially the same as those lining the intestine beneath the gonad.

The hermaphrodite gland extends forward as far as the posterior limits of the pharynx or slightly beyond (Plate **24**, fig. 4) and in a sexually mature animal contains ripe sex products throughout its entire extent. These originate in the usual fashion and are in no wise peculiar save that the fully developed eggs are unusually large, measuring 0.176 mm. Clearly defined tubes lead from the gonad into the pericardium, which in the specimen represented in Plate **6**, fig. 1, contains both ova and sperms. The antero-ventral pericardial wall is ciliated and elsewhere cilia appear to be present though the true condition of affairs is masked by the abundance of precipitated secretion.

From the posterior end of the pericardium the coelomoducts arise as relatively narrow canals lined with almost cubical cells bearing a coat of cilia similar to those of the pericardium. Coursing downward and forward they gradually increase in size and the walls, retaining their ciliated coat, develop several folds before they unite with the limbs of the huge gland a short distance behind their anterior boundaries. At about one fourth of the distance from the pericardial opening to its outlet into the shell gland each tube originates what probably functions as a seminal vesicle (Plate **6**, fig. 1). In calibre and histological features each is similar to the neighboring parent canal with the exception of the distal extremity which forms an enlarged, almost globular dilation. From beginning to end the *vesicula seminales* contain spermatozoa in most cases attached by their heads to the epithelial lining. Distal to the openings into the vesicles the coelomoducts contain small quantities of spermatozoa, unattached.

At the junction of the dorsal and ventral limbs of the coelomoduct on each side a very large seminal receptacle is attached. Each originates as a slender duct, which pursues a tortuous course anteriorly, and opens on the lateral or latero-ventral surface of a vesicular enlargement with folded walls. The cells composing the duct are histologically essentially the same as those of the seminal vesicles save that they are of almost twice the height. Those of the dilation are likewise columnar and contain a glandular secretion which escapes distally in the form of moderately staining droplets. In addition to this secretion the receptacle contains numbers of sperms some of which are deeply imbedded in the walls. Whether these last named structures are intact or not it is impossible to state; they show no clear signs of disintegration.

The Y-shaped ventral section, or shell gland, is of large size and its walls, developed into many irregular folds, are unusually thin. Distal to the median, undivided section the cells of the epithelial lining are chiefly glandular, hemmed in by slender supporting cells, and are filled with a violet colored vacuolated secretion in haematoxylin preparations. In the adjacent undivided region this type of cell is replaced by another of much greater length (Plate **24**, fig. 2) in which the secretion is more vacuolated and stains less deeply. Associated with these are comparatively few elongated cells filled with a dark, coarsely granular secretion and very many containing in each a granule of a dark brownish color. These occur in the anterior half of the undivided part of the shell gland; from it the transition to the posterior half is very abrupt, especially dorsally where the cells become higher and are filled almost completely with a substance of varying character, depending probably on the nearness of the egg-laying season. In one specimen with sex products in the pericardial cavity these cells near their free surface contain one or two large spherical dark blue or violet globules, while the remaining cytoplasm, is packed with an almost homogeneous mass. Ventrally the secretion is more granular and the more distal products are yellowish brown in color. In another specimen treated in identically the same manner these products have much the same appearance, but stain slightly. The lumen of the shell gland is spacious and opens in the dorsal part of the cloacal cavity near the anus.

Opening by a wide pore posterior to the reproductive outlet is a large diverticulum of unknown function (Plate **6**, fig. 1). Its walls are somewhat folded and are reinforced by a thick muscular coat (Plate **24**, fig. 2). The epithelial lining consists of columnar cells of average height covered externally with a thin, sharply defined cuticular layer. Among the cells of this character are others, fairly numerous, very slender, with dense elongate nuclei, that in especially favorable material may be seen to terminate proximally in fibres passing into the muscle layer. Distally they attach to the bottom of minute depressions in the cuticle and therefore probably are sensory elements.

In two specimens the cloacal cavity has been widened greatly, completely exposing the anus and the openings of the shell gland and the more ventral diverticulum. This last named organ has been almost completely everted. These individuals appear in all respects to be normal.

With the stains employed the nervous system is not sharply differentiated from the surrounding tissue, and accordingly but little has been determined save that relating to the larger ganglia and nerves. As may be seen (Plate 5, fig. 6), the brain holds the usual position and gives rise to the customary nerves distributed to the atrium and the body wall and more posteriorly to the pedal, lateral, and labio-buccal connectives. The pedal cords are considerably enlarged at their anterior ends, while the lateral show scarcely any modification. Pedal commissures and latero-pedal connectives occur at fairly regular intervals throughout the entire length of the animal. The labio-buccal ganglia are located at the sides of the pharynx a short distance behind the level of the salivary glands, and are united by at least one ventral commissure. In the posterior end of the body the relations of ganglia and nerves are not especially clear, but the pedal cords appear to end in small enlargements, united with the termination of the lateral ganglia by one or two slightly enlarged connectives. As usual nerves pass into the hinder part of the animal from the ends of the lateral ganglia which are united by the usual suprarectal commissure.

GENERAL CONSIDERATIONS.

If unanimity of opinion be any criterion whereby we may judge the correctness of a theory it must be admitted that we are yet a long way from the solution of the origin of the Mollusca, for scarcely any two investigators hold identically the same views. In their development or in their adult organization many of the members of the phylum exhibit features which are the close counterpart of others in the flatworms and annelids and it may well be that, generally speaking, those students are correct who hold to the idea that all have descended from a common ancestor, though the details of the process are most obscure. Narrowing down the problem to the Solenogastres there are few who dissent from the opinion that they are true molluscs, though it cannot be said their position within the group is definitely established. However it is becoming increasingly evident that they possess more characters in common with the Chitons than with the other classes, and these characters, interpreted in the light of community of descent of the two groups, are more readily understood than from any other viewpoint.

It is little more than waste effort at the present time to attempt to reconstruct the external characters of the ancestral Solenogastre, for it is generally agreed that the present day species, worm-like in form and without shell or well-developed foot, are highly modified in these respects. The aggravatingly few facts of their embryology are also without much value for the solution of the problem. As the matter now stands there is no positive evidence that they ever had a shell, but in view of the fact that these animals show a close resemblance to the Chitons in several other respects it is not unreasonable to believe that one was formerly present. It must be admitted that Pruvot's figure and description regarding the shell in the larvae of *Dondersia banyulensis* are very indefinite, and have led some authors to claim that the seven valves of the dorsal side are in reality greatly enlarged scales. There are some evidences that such is indeed the case in the young of *Holomenia gravida,* at all events the plates do not develop exactly as does the Chiton shell. It is possible that we have here the confirmation of Blumrich's theory that the original shell arose by the excessive development of flattened spines along the dorsal surface of the animal.

It is a significant fact that the mantle of the Solenogastres has no counterpart save in the Chitons. In the least modified condition it consists primarily of a single layer of epithelial cells overlaid by a cuticular covering often of enormous thickness. Those probably responsible for the formation of the cuticle, and of pigment when such is present, are comparatively simple, unmodified, more or less columnar cells. At frequent intervals throughout the layer spicule-matrix cells arise and develop a single stratum of spines, or several layers imbedded in the cuticle. In their mode of origin the spines of the Solenogastres are essentially similar to those of the Chitons (see p. 29). Thiele declares that the Solenogastre spicule is produced from one matrix cell, but this method is certainly not frequent, and Plate states that it is rare among the Chitons. Wiren reports that in Chaetoderma there is one basal cell and three smaller ones encompassing the young spine. Hubrecht discovered that in *Proneomenia sluiteri* the base of each spicule is grasped by a considerable number of matrix cells, and as the spine is carried outward by the continued growth of the cuticle they continue to retain their attachment for a long period. Pruvot ('90) finds in a few species that during the early development of the spicule four or five cells are in contact with it, and the attachment may persist for a considerable period. In *Proneomenia hawaiiensis* and a number of other species I have found that there is one basal cell, apparently responsible for the formation of calcareous material, surrounded by seven or eight smaller cells attached also to the base of the spine and perhaps responsible for the formation of the cuticular sheath. This last named mode of formation is almost the exact duplicate of the most common method of spine development of the Chitons (Plate, 1901, p. 372).

Among the Chitons the matrix cells retain their connection with the spicule as long as it exists. In the Chaetodermatidae, and in those Neomeniina with a single layer of spines, there is a tendency to follow this primitive method. The same is true, though in some cases to a more limited extent, in a few species with thick cuticle and several layers of spicules, notably *P. hawaiiensis* and *Strophomenia scandens.*

The balloon-shaped papillae developed from the hypodermis and in a fully developed condition extending to the free surface of the cuticle are of problematical significance. It has been suggested (Kowalevsky & Marion, Wiren) that they may be spicule-matrix cells that have assumed some new function after the formation of the spine; but the fact that in *P. hawaiiensis* the matrix cells retain their attachment, at least in part, as long as the spine is imbedded in the cuticle, precludes such a possibility. In Alexandromenia there are many times more spines than papillae. Heuscher on the other hand describes their origin as simple outgrowths of the hypodermis. Regarding their homologue in the Chitons nothing may be claimed definitely. They may correspond to the packets or papillae (Plate) or, with a greater degree of probability, to the aesthetes as several authors have claimed.

That a foot of much larger size existed in the ancestral Solenogastre and that the ventral groove of the Neomeniidae does not "represent the first stage in the formation of that pedal surface of the body which is seen in the lowest mollusca" (Gegenbaur) is indicated by a number of facts. In the first place although no external trace of a foot exists in the Chaetodermatidae there is a space along the mid ventral line between the longitudinal somatic muscles which are thicker here than elsewhere, and in Limifossor this same space is occupied by a sinus exactly similar to the pedal sinus of the Neomeniidae. In Limifossor the pedal sinus anteriorly penetrates a clearly defined septum and communicates with the head cavity as in the Chitons. It is much more reasonable to consider that the pedal sinus is the remnant of the foot of the ancestral Solenogastre than that it is the first sign of the appearance of a definite creeping surface.

In the Neomeniina there is the same cleft in the ventral musculature, thickened as in the Chaetodermatina, and the foot is present as a small fold extending along the mid ventral line. Anteriorly it affords an outlet for the enormously developed anterior pedal gland which in position and development as far as this has been traced (see Heath '05), is homologous with the pedal gland of young Chitons. The remainder of the foot is supplied with the posterior pedal glands which are present in a diffuse condition in the Chiton foot.

In the Solenogastres there are no eyes, tentacles and even the proboscis or snout of the Chitons is believed generally to have no homologue in the group. Concerning this last named organ however Thiele claims (and in this he is followed by Nierstrasz and Pelseneer) that it is present, though in a highly modified condition and I am strongly convinced of the force of his argument. In the first place it is a well-known fact that the first section of the alimentary canal in the Neomeniina contains the atrial ridges (Mundleisten) and the enclosed cirrose area, all innervated by fibres originated directly by the cerebral ganglia. In *Rhopalomenia aglaopheniae*, *Dinomenia hubrechti*, etc., and I have found the same state of affairs in *Driomenia pacifica*, this portion of the canal exists in the form of a depression in front of the mouth, and is separated from it by a narrow bridge of spicule bearing cells continuous with the general covering of the body. Owing chiefly to its innervation Thiele considers that this "sensibles Atrium" is the homologue of the Chiton snout which is now withdrawn into a depression. Where this atrium is a direct part of the digestive tube the true mouth has been drawn into the body and is located immediately behind the most posterior atrial ridge. It now becomes an interesting fact that in the Chiton development the mouth at first is posterior to the snout and but slowly takes up its final central position (cf. Heath '99). It lends support to the belief that in these molluscs with isolated atrial cavity the position of these organs does not represent a highly modified condition but a relatively primitive state of affairs.

In the Chaetodermatidae the nerves which originate from the anterior surface of the brain pass at once into the huge, compact ganglionic bodies homologous, I believe, with the more diffuse nerve masses in contact with the bases of the cirri and buccal sensory ridges in the Neomeniidae. From these a relatively enormous number of fibres pass into the Mundschild or buccal plate, just as the cirri and ridges are innervated by nerves from the neighboring ganglia. There is thus little doubt that the buccal plate and sensory atrium are homologous and if the above line of reasoning be correct, they are the homologue also of the Chiton snout, which is likewise innervated by nerves from the cerebral ganglia.

Regarding the mantle cavity I believe that it as truly exists in the Solenogastres as in the Chitons or prosobranchs, for example. The sole reason for considering that the so-called branchial or cloacal cavity is a secondary modification appears to have chiefly originated with Thiele who claims that the branchial lamellae of various neomenians are highly developed rectal folds and accordingly the branchial cavity is nothing more than a greatly expanded rectum. The same is true of the Chaetodermatidae, for the plume-like respiratory organs are said to have been developed from similar rectal folds, and accordingly their remarkable resemblance to true ctenidia is of no especial significance. Furthermore the fact that the nephridia open into this space is likewise of no importance for it is of coenogenetic origin.

Regarding the branchial plates of the Neomeniina, they certainly have every appearance of being merely folds of the walls of the branchial cavity, but that they are closely related phylogenetically to the respiratory organs of the Chaetodermatidae is an entirely different matter and one most difficult to substantiate. On the other hand it seems to me that the gills of this last named family are not clearly homologous with the neomenian respiratory organs. In a former paper I have called attention to the fact that in gross and microscopic appearance, blood supply, and innervation they are practically identical to the Chiton gill. Such an idea brings us without violence to the belief that in the original ancestor of the Solenogastres and Chitons there was a true mantle cavity containing at least two ctenidia, the separate outlets of the urogenital system and possibly an osphradium though such an organ may well have been in a diffuse condition as in some of the modern lamellibranchs. Accordingly the connection between the pedal furrow and the mantle cavity is not secondary but primitive and similar in its broader features to what is found in the Chitons. The polybranchiate character of this last named group yet remains a puzzle for as I have pointed out ('05) there is nothing in the development of these organs to indicate if it be primitive or not.

While several fundamental differences between the circulatory systems of the Solenogastres and the Chitons have been found to exist these may be explained to some extent on the supposition that originally the foot was of larger size, and in any event they do not outweigh several remarkable resemblances. In both the pericardium is dorsal, posterior, and communicates with the exterior with paired ducts. In present day species it contains the heart, a simple tubular organ or differentiated into a ventricle and single auricle, which may originally have been paired as Wiren has ingeniously suggested. From the anterior end of the heart the aorta arises and passing along the dorsal side of the gonad, that it supplies in Chiton-like fashion, it reaches the head cavity. In the great majority of species this last named organ is not clearly defined, but in Limifossor it is separated from the visceral cavity by a connective-tissue septum as clearly defined as in the Chitons and having essentially the same relations. Within the head sinus the blood makes its way by irregular channels into the visceral cavity and passes backward. In Limifossor the septum is perforated ventral to the intestine and through this the blood makes its way into the ventral sinus. A special visceral artery or sinus is lacking within the group, its function being taken by the general visceral cavity and ventral sinus. This last named space communicates freely at many points with the visceral cavity and posteriorly both unite and the combined vessel makes its way to the ctenidia and from thence into the heart.

Hansen years ago noted the presence of crystals in the coelomoducts of Chaetoderma, and considered it possible that they may function as kidneys. From much more extensive studies Wiren has taken the same position, showing the close similarity of the tissue to that of the Chiton kidney. Another fact of the greatest importance is that in *Chaetoderma erudita* for example, where the sexes are separate *the nephridia of the male are exactly the same as those of the female.* If the coelomoducts here act in the capacity of shell, mucous or other glands intimately connected with the egg-laying process it is reasonable to suppose that it would be more highly developed in the female than in the male. Since it is not it becomes much more probable that the resemblance of the cells of the duct to those of the Chiton kidney is not accidental, but that they are true excretory elements and the ducts therefore have retained the excretory function derived from the ancestral form.

Stating the matter in another way it appears that the coelomoducts are, from the standpoint of both structure and function, of a more primitive character in the Chaetodermatina than in the Neomeniina. In the latter family the ducts have assumed an important rôle in the storage of sperms, or in the development of envelopes for ova and perhaps other processes connected with egg-laying, so that the original function of excretion is effectually masked, if it exist at all. In the Chitons the kidneys become active excretory organs long before any trace of the gonad or its ducts appear, and if these tubes in the Neomeniina act as kidneys they likewise would probably assume their duties at an early stage. In *Dorymenia acuta*, however, there are no signs of such activity in individuals 14 mm. in length. The reproductive glands are present, though in a very immature condition, and the coelomoducts, having the form of canals of about equal calibre throughout, lead in the usual fashion to the exterior. Their lining epithelium is composed of low, usually cubical cells, non-vacuolated, without any traces of concrements or crystals, and indications of any glandular activity whatsoever are totally absent. I am therefore strongly of the belief that the coelomoducts in the Neomeniina are solely concerned in the reproductive process.

Granted that the section of the alimentary canal, including the cirrose area and the buccal sensory ridges, is the homologue of the Chiton snout, or at all events a comparatively late formation, the remaining portions are decidedly Chiton-like. In most species there are both dorsal and ventral salivary glands which show a surprising amount of variation, ranging from scarcely distinguishable bodies to others of great size and a high degree of complexity. As in the case of the Chitons the dorsal set typically opens through the dorsal buccal wall while the outlets of the ventral pair are in the neighborhood of the radula.

The radula, in a number of species is lacking, and in several others it is in a degenerate state, being reduced to a peg-like body (Chaetoderma) or to a very few teeth which are reported to lack a basement membrane. On the other hand there are species, such as Kruppomenia (Nierstrasz, '05) and Limifossor (Heath, '05) which have typical radulae, as regards location and component parts. Odontoblasts, cells which form the basement membrane, and enamel cells are all present, and the resemblance to the radulae of other molluscs, as figured by Rossler for example, is surprisingly complete.

The fate of the subradular organ appears to depend closely upon that of the radula. In every case that has come under my observation it is lacking or is reduced to the merest rudiment when the radula has disappeared, and in some species it is in a highly degenerate state when the radula is in a similar condition. It is to be noted that the nerve supply to this organ may be a much more conservative set of organs, persisting in *Strophlomenia scandens*, for example, after the organ has ceased to exist as a well-defined structure.

The limits of the posterior end of the pharynx and consequently of the anterior end of the oesophagus are not sharply defined histologically and in the absence of embryological evidence they remain problematical. In fact the oesophagus is sometimes disregarded as a definite section of the gut or is included in the description of the pharynx. In some species it appears to be bounded anteriorly by a circular fold and posteriorly it is probably terminated at the commencement of the stomach-intestine.

The intestine is differentiated into a well-defined stomach and intestine, in the Chaetodermatina and as is well known this latter organ is practically straight. In the Neomeniina it is unique in possessing an anterior dorsal coecum that extends forward to the neighborhood of the brain; and the liver is not sharply differentiated from the gut. The opening of the rectum into the mantle cavity and its relation to the nervous system may be derived without serious difficulty from a condition similar to that of the Polyplacophora.

In their broader features the nervous systems of the Solenogastres are all reducible to one type, as Thiele and Nierstrasz maintain. In practically every species described in the present paper, the brain is bilobed and always connects with the pedal, lateral, and labio-buccal systems. In the Neomeniina three pairs of nerves, often associated with small ganglia of problematical homology, are distributed to the anterior end of the body and attach to numerous ganglionic masses applied to the walls of the atrial cavity. In the Chaetodermatina a larger number of nerve bundles arise from the anterior surface of the brain and connect with great ganglionic bodies often almost enveloping the brain. From these ganglia branches pass to the buccal plate. Judging from its innervation the atrial cavity is thus the homologue of the buccal sensory plate (Mundschild), and both are homologous with the Chiton snout. Accordingly the ganglia attached to the brain are the counterpart of those applied to the bases of the cirri. Thiele has called attention to the inappropriateness of the term "buccal" in speaking of these ganglia, and accordingly the term precerebral may be used.

In a primitive condition the lateral, pedal, and labio-buccal connectives probably arose as independent trunks, but in many species they are more or less fused for some distance. The ventral and pedal ganglia are usually enlarged at the point of union with the connectives, and may originate nerves distributed to the walls of the pedal-gland outlet, atrium and to some extent of the body. Commissures at fairly regular intervals attach the pedal ganglia and may develop small branches distributed to the tissue in the vicinity of the ventral fold or foot. About the same number of connectives unite the pedal and lateral ganglia, and likewise give rise to small offshoots passing into the somatic musculature. Other nerves, with seemingly the same destination, form from the upper surface of the lateral ganglia and course dorsally. In the posterior end of the body the lateral ganglia usually enlarge and invariably are united by a suprarectal commissure. From these enlargements branches pass to the body and cloacal walls, and from the commissure in the mid line a fibre arises, in some species, that is distributed to the dorso-terminal sense organ. The pedal ganglia may gradually diminish in size posteriorly or become attached to the lateral by means of one or more enlarged connectives; and in a few species a posterior commissure may complete a circumrectal ring. In the Neomeniina fibres from the dorso-posterior enlargements have been traced into the tissue surrounding the shell gland, into the body wall and in *Strophomenia ophidiana* delicate nerves have been traced from the enlargements of the lateral ganglia into the heart. In the Chaetodermatidae practically all of the nerves innervating the posterior end of the body spring from the suprarectal commissure or in close proximity to it. In Limifossor the gills are innervated by two pairs of branches from the commissure and in *Chaetoderma attenuata*, *C. erudita* and probably others the same is true. I have been unable to find a circumrectal ring described by Wiren ('92).

The labio-buccal system has been examined critically in a few species only, yet the few facts gleaned indicate that in a typical condition it is not unlike what is found in the Chitons. For many years the so-called buccal ring has been known both in the Chaetodermatina and in the Neomeniina, consisting of two connectives coursing along the sides of the pharynx and uniting with two ganglia in the neighborhood of the radula or the outlet of the ventral salivary glands. These ganglia, which I have termed labio-buccal, are in turn connected by means of a ventral commissure, which in the genus Chaetoderma bears two small ganglia. In *Proneomenia hawaiiensis* there is a very distinct subradular organ, consisting of two clearly defined circular patches of high epithelial cells on each side of the mid line in front of the radula. In close proximity to these are small ganglia, united by a commissure, and on the other hand joined with the labio-buccal ganglia by connectives. In addition there is a dorsal commissure uniting the labio-buccal connectives and possibly another ventral one. These same elements in a more compact form, exist in *Strophomenia scandens*. In the genus Chaetoderma I have recently shown that in front of the radula connectives attached to the labio-buccal connectives, and, after giving off nerves which pass directly to modified epithelial patch in the pharynx, are united with a single ganglionic mass. In Limifossor there is in addition to the well-known commissure a dorsal one and probably a second ventral one. In *Dorymenia acuta* there are two dorsal commissures and two ventral, one of which bears a pair of small ganglia. The radula is certainly in a degenerate condition in several species of Solenogastres; it has disappeared in others and the same extremes exist in the case of the subradular organ. Consequently it is not remarkable that the system of ganglia and nerves associated with these sensory areas exhibit marked differences in the various species.

Comparing the labio-buccal systems of *Proneomenia hawaiiensis* and a Chiton (*Trachydermon raymondi*) it is seen that in the Solenogastres the connectives attaching the subradular, buccal, and labial systems with the brain are of great length; in the Chitons they are very short. In the Chitons the buccal ganglia are clearly differentiated; in the Solenogastres they are fused with the labial. These homologies have been treated in another paper (Heath '05), and offer, so far as I can see, no serious difficulty.

Nerves from the labio-buccal ganglia have been seen in both of the divisions of the Solenogastres to pass into the pharynx which they doubtless innervate. In *Chaetoderma erudita* they have been traced as far as the end of the pharynx. In the Chaetodermatidae practically all of the nerves innervating the posterior end of the body arise on the suprarectal commissure or in close proximity to it. In Limifossor the gills are innervated by two pairs of branches from the commissure and in *Chaetoderma attenuata*, *C. erudita* and probably others the same is true.

While the facts discussed in the foregoing paragraphs appear to justify the conclusion that the Solenogastres are most closely related to the Chitons, they do not as certainly settle the question as to which group has retained the greater number of ancestral characters. The condition of the coelom in the first named division appears to be very primitive and probably palingenetic; and, generally speaking, the musculature is more simple, and this is true to some extent of the digestive tract, though these may have been secondarily modified. The absence of a shell and well-developed foot, the relatively simple condition of the circulatory apparatus, the concentration of the nervous system, and, in the Neomeniina, the high degree of development of the coelomoducts point more clearly to modifications of a more primitive type. Without entering into further detail it would appear that, with the data now available, the Chitons are to be considered the more primitive, in fact the most primitive of all molluscs.

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'92. Studien über die Solenogastres. I. Monographie des *Chaetoderma nitidulum* Loven. Svenska vet. akad. Handl., **24**, p. 1–66, pl. 1–7. II. *Chaetoderma productum*, Neomenia, *Proneomenia acuminata.* Svenska vet. akad. Handl., **25**, p. 1–100, pl. 1–10.

EXPLANATION OF THE PLATES.

a	anus.
aor	aorta.
ap	anterior pedal gland.
b	brain.
bc	buccal commissure.
bg	labio-buccal ganglion.
br	gill.
brn	nerves to gills.
c	intestinal coecum.
cl	cloacal chamber.
co	cloacal coecum.
cp	coelomoduct.
da	dorsal aorta.
dsg	dorsal salivary gland.
fo	buccal plate.
gl	glands of pharynx.
gon	gonad.
ht	heart.
int	intestine.
lbc	labio-buccal connective
liv	liver.
m	mouth.
n	nerve to buccal plate.
oe	oesophagus.
pe	pedal ganglion.
peg	precerebral ganglion
pem	pericardium.
ph	pharynx.
pl	lateral ganglion.
ps	pedal sinus.
r	radula.
re	seminal receptacle.
rs	radular support.
s	anterior vertical septum
sc	subradular commissure.
sg	ventral salivary gland
sgl	shell gland.
sn	subradular ganglion.
so	sense organ.
sp	spicule.
sr	dorsal gill retractor.
sro	subradular organ.
sto	stomach.
sv	seminal vesicle.
vr	ventral gill retractor.
vs	ventral diaphragm.

PLATE I.

PLATE 1.

Fig. 1. Strophomenia farcimen. × 3.
Fig. 2. Strophomenia ophidiana. × 3.
Fig. 3. Strophomenia spinosa. × 5.
Fig. 4. Herpomenia platypoda. × 10.
Fig. 5. Strophomenia triangularis. × 8.

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PLATE 2.

PLATE 2.

Fig. 1. Strophomenia scandens. × 4.
Fig. 2. Drepanomenia vampyrella. × 7.
Fig. 3. Chaetoderma hawaiiensis. × 8.
Fig. 4. Lophomenia spiralis. × 7.
Fig. 5. Alexandromenia agassizi. × 4.
Fig. 6. Limifossor fratula. × 5.

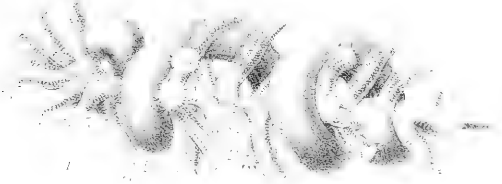
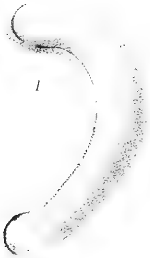


PLATE 3.

PLATE 3.

Fig. 1. Halomenia gravida. × 6.
Fig. 2. Strophomenia farcimen; unusually thick specimen. × 7.
Fig. 3. Alexandromenia valida. × 3.
Fig. 4. Ichthyomenia porosa. × 9.
Fig. 5. Reconstruction of posterior end of Halomenia gravida.
Fig. 6. Halomenia gravida. Anterior end. × 10.
Fig. 7. Chaetoderma japonica. × 4.
Fig. 8. Head of Chaetoderma japonica. × 16.
Fig. 9. Dondersia californica. × 9.
Fig. 10. Proneomenia hawaiiensis. × 2.
Fig. 11. Dorymenia acuta. × 3.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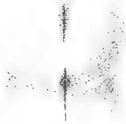
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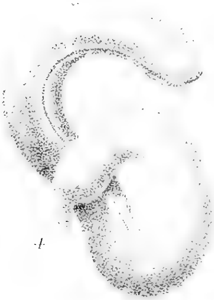
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H. Heath del.

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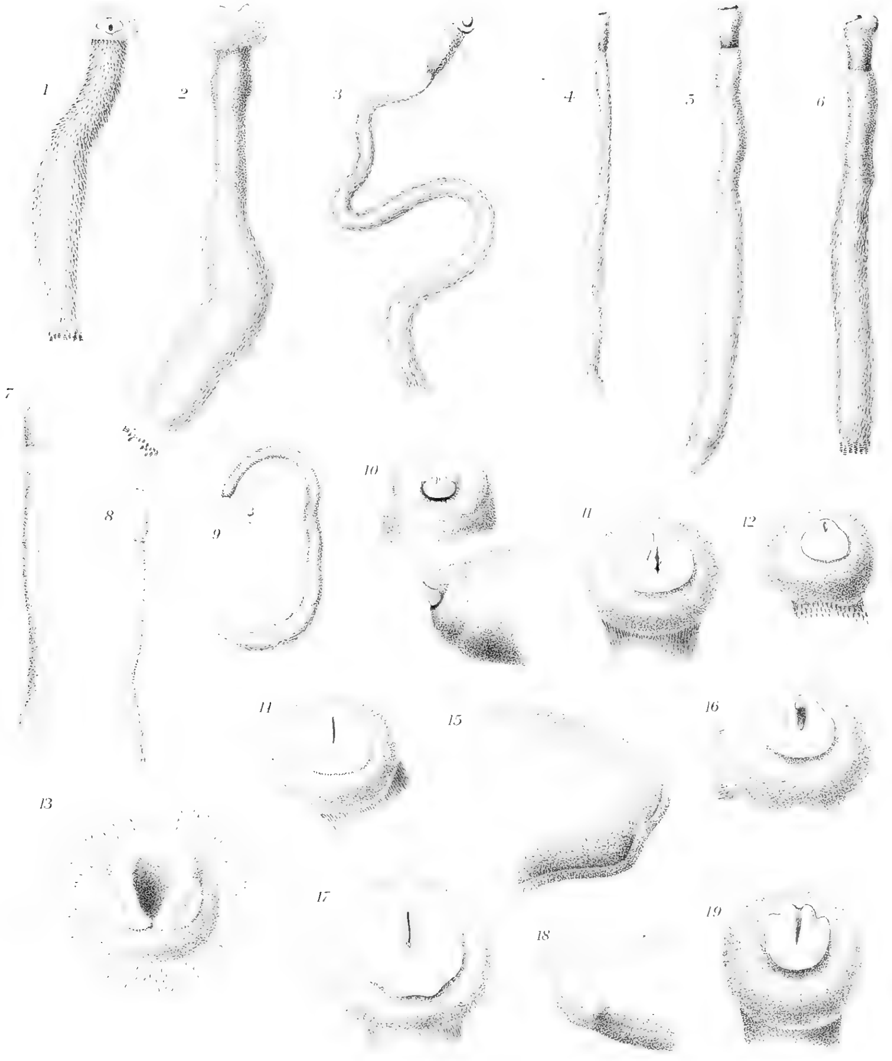
PLATE 4.

PLATE 4.

Fig. 1. Chaetoderma nanula. × 7.
Fig. 2. Chaetoderma scabra. × 7.
Fig. 3. Chaetoderma attenuata. Living specimen. × 2.
Fig. 4. Chaetoderma montereyensis. × 1.3.
Fig. 5. Chaetoderma robusta. × 1.3.
Fig. 6. Chaetoderma californica. × 3.
Fig. 7. Chaetoderma argentea. Living specimen. × 2.5.
Fig. 8. Chaetoderma montereyensis. × 2.
Fig. 9. Chaetoderma erudita. Living specimen. × 2.
Fig. 10. Chaetoderma attenuata, front and side views. Living specimen. × 10.
Fig. 11. Chaetoderma erudita. × 15.
Fig. 12. Chaetoderma nanula. × 15.
Fig. 13. Limifossor fratula. × 13.
Fig. 14. Chaetoderma montereyensis. × 15.
Fig. 15. Dondersia californica. Anterior end. × 22.
Fig. 16. Chaetoderma scabra. × 15.
Fig. 17. Chaetoderma montereyensis. × 10.
Fig. 18. Dondersia californica. Posterior end. × 22.
Fig. 19. Chaetoderma robusta. × 8.

"ALBATROSS" PACIFIC SOLENOGASTRES

PLATE 4



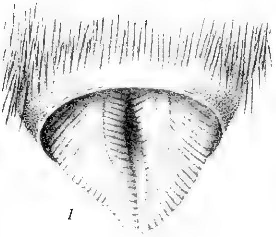
H Heath del.

B. Meisel lith. Boston

PLATE 5

PLATE 5.

Fig. 1. Posterior end of Chaetoderma attenuata, living specimen.
Fig. 2. Reconstruction of anterior end of Proneomenia hawaiiensis.
Fig. 3. Same of Halomenia gravida.
Fig. 4. Same of Dondersia californica.
Fig. 5. Posterior end of Alexandromenia agassizi.
Fig. 6. Anterior end of Ichthyomenia porosa.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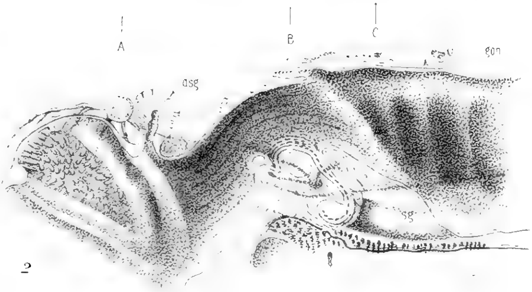

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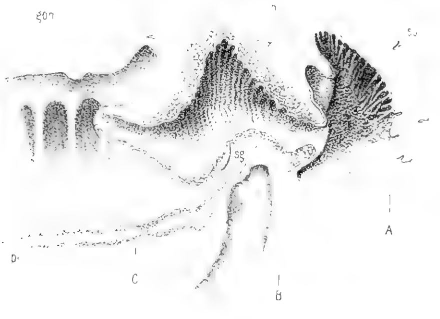

H Heath del

B Meisel lith Boston

PLATE 6.

PLATE 6.

Fig. 1. Reconstruction of posterior end of Ichthyomenia porosa.

Fig. 2. Same of Dondersia californica.

Fig. 3. Same of Drepanomenia vampyrella.

Fig. 4. Same of Dorymenia acuta.

Fig. 5. Same of anterior end of Lophomenia spiralis.

Fig. 6. Junction of pharynx and stomach-intestine in Strophomenia scandens, showing opening of the ventral salivary gland and a portion of the labio-buccal system.

Fig. 7. Reconstruction of posterior end of Strophomenia scandens.

Fig. 8. Same of Chaetoderma hawaiiensis. dso dorso-terminal groove; gn suprarectal commissure; nd. coelomoduct; rpo reno-pericardial opening.

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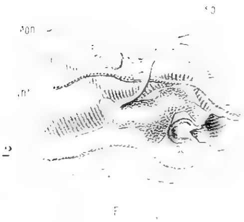

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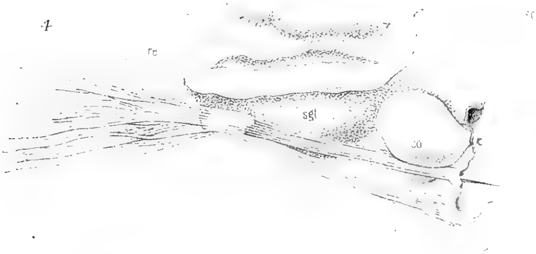

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H Heath del.

B Meisel lith Boston

PLATE 7.

PLATE 7.

Fig. 1. Reconstruction of anterior end of Strophomenia farcimen.
Fig. 2. Same of anterior end of Chaetoderma hawaiiensis.
Fig. 3. Same of anterior end of Alexandromenia agassizi.
Fig. 4. Same of anterior end of Drepanomenia vampyrella.
Fig. 5. Same of posterior end of Alexandromenia agassizi.

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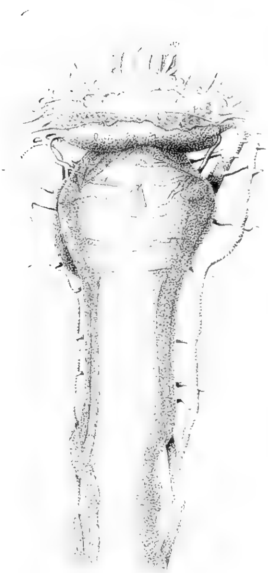

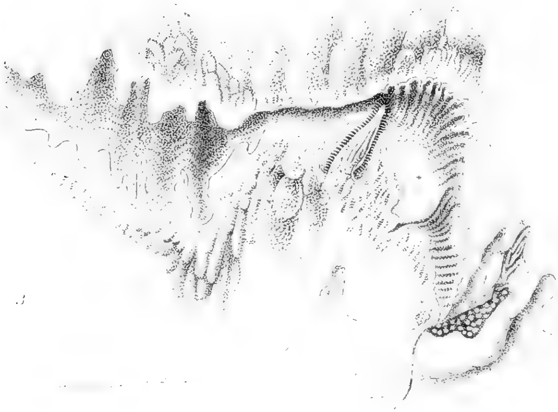

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H Heath del

E Meisel [illegible]

PLATE 8.

PLATE 8.

Fig. 1. Reconstruction of anterior end of Herpomenia platypoda.
Fig. 2. Same of anterior end of Strophomenia spinosa, small specimen.
Fig. 3. Same of posterior end of Herpomenia platypoda.
Fig. 4. Same of anterior end of Proneomenia insularis.
Fig. 5. Same of anterior end of Strophomenia ophidiana.
Fig. 6. Same of posterior end of Lophomenia spiralis.

PLATE 8

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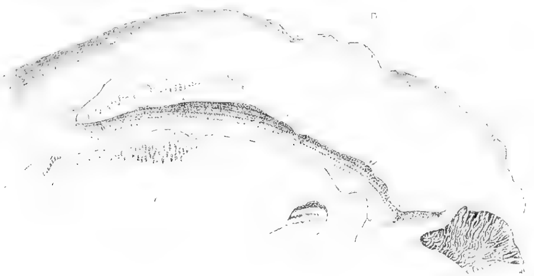

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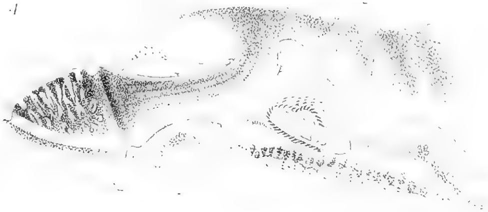

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H Heath del

B Meisel · lith Boston

PLATE 9.

PLATE 9.

Reconstruction of the posterior end of the body from transverse sections.

Fig. 1. Strophomenia ophidiana.
Fig. 2. Dorymenia acuta.
Fig. 3. Strophomenia triangularis.
Fig. 4. Strophomenia spinosa.
Fig. 5. Lophomenia spiralis.

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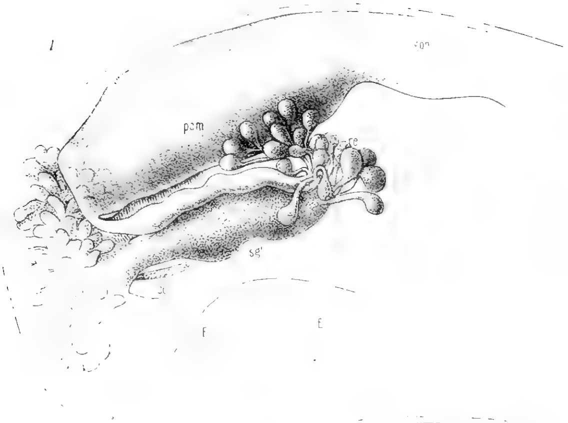

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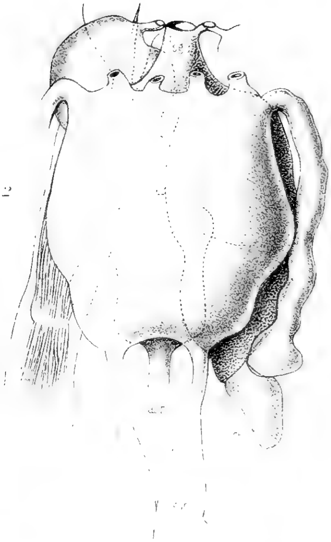

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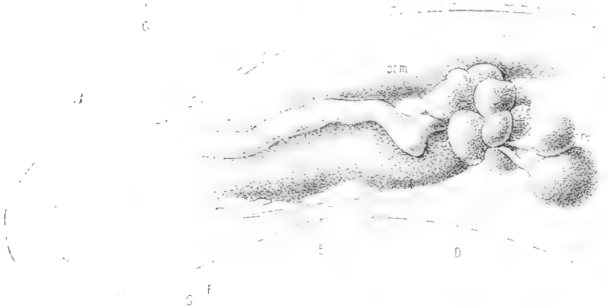

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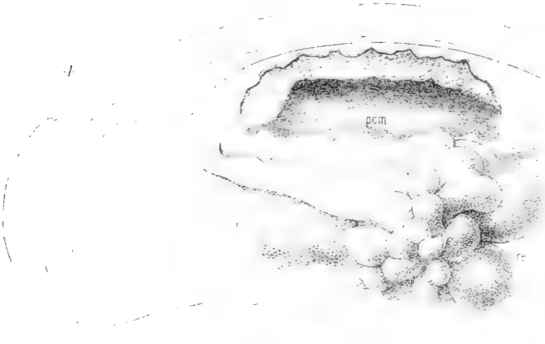

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H. Heath del.

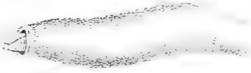
B. Meisel lith. Boston

PLATE 10.

PLATE 10.

Figs. 1–7, 9–10. Sections of Limifossor talpoideus; Fig. 8. Chaetoderma erudita.

Fig. 1. Side view, living specimen. × 5.
Fig. 2. Anterior end, living specimen, showing extremes of motion of frontal sense organ.
Fig. 3. Lateral view of organs of posterior end of body.
Fig. 4. Same of organs in anterior part of body.
Fig. 5. Diagram of radula and muscles that open and close the teeth.
Fig. 6. Section through dorsal sense organ. × 135.
Fig. 7. Lateral view of buccal mass, showing more important muscles that operate the radula and its supports.
Fig. 8. Brain and labio-buccal nervous system.
Fig. 9. Spicules from middle of body, front and side views. × 110.
Fig. 10. Dorsal view of radula and its supports; portion of dorsal pharyngeal wall removed.



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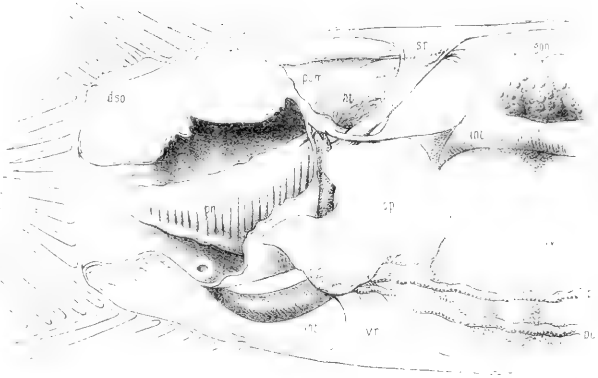

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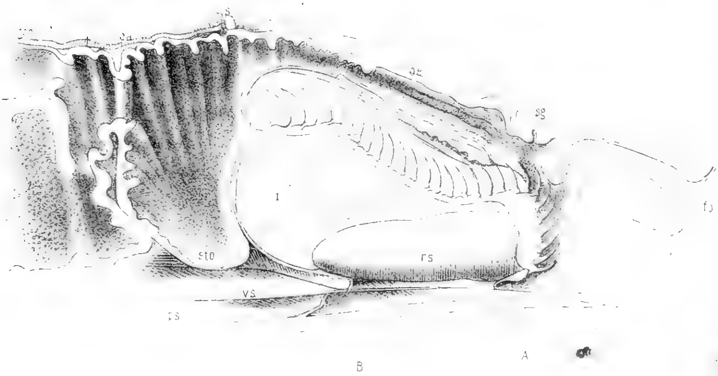

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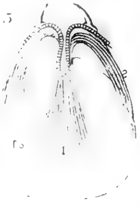

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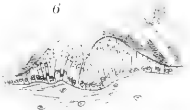

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H. Heath del.

B. Meisel lith Boston

PLATE 11.

PLATE 11.

Fig. 1. Reconstruction of the posterior end of Drepanomenia vampyrella.
Fig. 2. Same of anterior end of Strophomenia spinosa, large specimen.
Fig. 3. Same of anterior end of Alexandromenia valida.
Fig. 4. Same of posterior end of Strophomenia farcimen.
Fig. 5. Same of posterior end of Proneomenia hawaiiensis.

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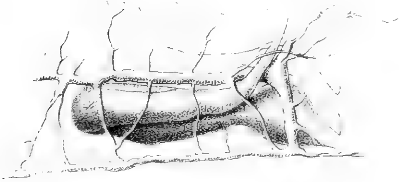

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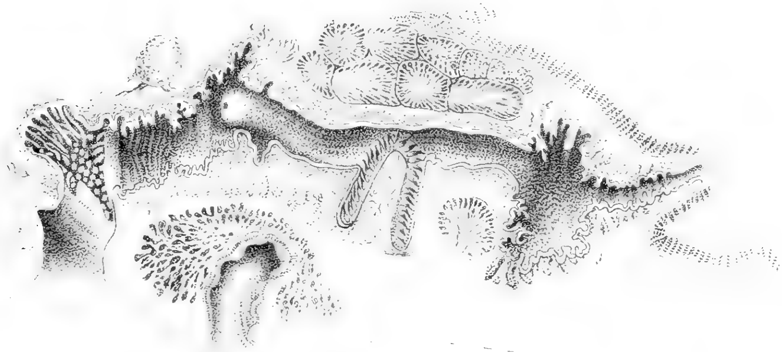

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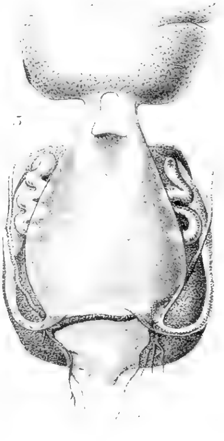

H Heath del

B Meisel lith Boston

PLATE 12.

PLATE 12.

Fig. 1. Reconstruction of anterior end of Strophomenia scandens.

Fig. 2. Section through dorso-terminal sense organ of Alexandromenia valida.

Fig. 3. Reconstruction of posterior end of Strophomenia spinosa, small specimen.

Fig. 4. Reconstruction of posterior end of Chaetoderma attenuata, showing principal nerves, two (brn) passing into the gill.

Fig. 5. Reconstruction of anterior part of nervous system of Alexandromenia agassizi.

Fig. 6. Same of posterior end.

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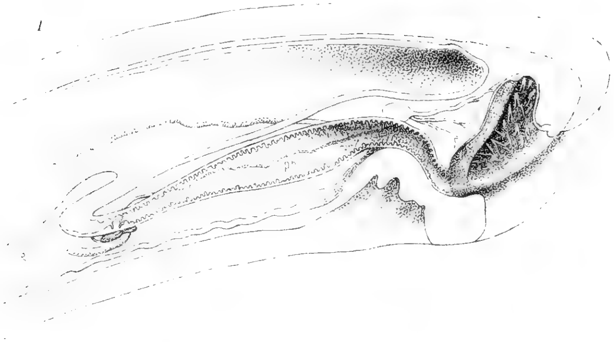

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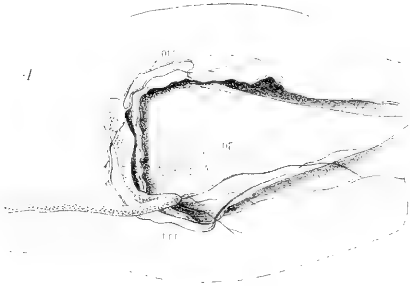

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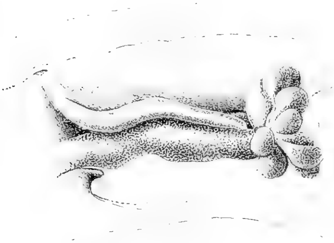

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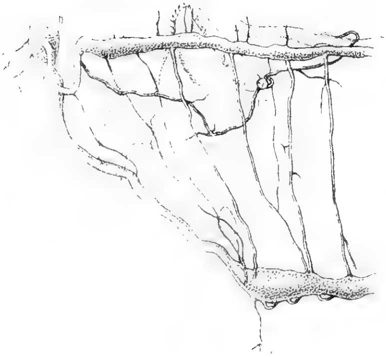

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H.Heath del.

E.Meisel lith. Berlin

PLATE 13.

PLATE 13.

Fig. 1. Reconstruction of anterior end of Dorymenia acuta, showing nervous system. Labiobuccal system heavily shaded.

Fig. 2. Same of posterior end of Strophomenia scandens.

Fig. 3. Same of anterior end of Chaetoderma erudita.

Fig. 4. Same of posterior end of Proneomenia hawaiiensis.

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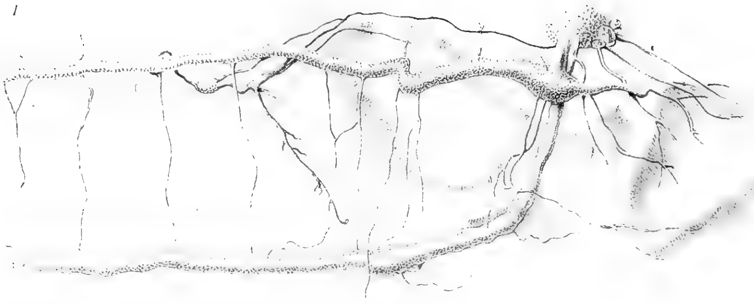

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H. Heath del.

B. Meisel lith. Boston.

PLATE 14.

PLATE 14.

Cross sections of Proneomenia hawaiiensis. × 33.

Figs. 1, 2, 7 correspond to lines A, B, C in fig. 2, pl. 5 (anterior end) and figs. 5, 6, 8 to D, E, F in fig. 4, pl. 13 (posterior end). In fig. 1. im, om represent inner and outer atrial ridge; os, external sensory ridge.

Fig. 3. Section through middle of body.

Fig. 4. Section through animal about one fifth body length from anterior end.

Fig. 9. Section through body a short distance behind pharynx.

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B Meisel lith Boston

PLATE 15.

PLATE 15.

Figs. 1–7, 9–12. Sections of Dorymenia acuta. × 50; Fig. 8. Halomenia gravida.

Figs. 1, 2 correspond to lines A, B indicated in fig. 7, pl. 15 (anterior end), and figs. 4, 6 to D, C, in fig. 4, pl. 6 (posterior end).

Fig. 3. Section through dorso-terminal sense organ.
Fig. 5. Cross section of penial spine. × 205.
Fig. 7. Longitudinal section of anterior end of body.
Fig. 8. Cross section corresponding to line D, fig. 5, pl. 3.
Fig. 9. Cross section of young animal, posterior end.
Fig. 10. Longitudinal section through base of penial spine. × 205.
Fig. 11. Section through dorso-terminal sense organ. × 205.
Fig. 12. Section through atrial cavity.

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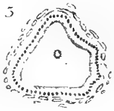

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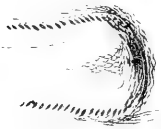

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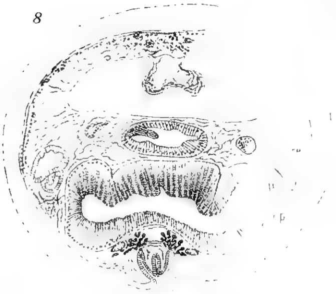

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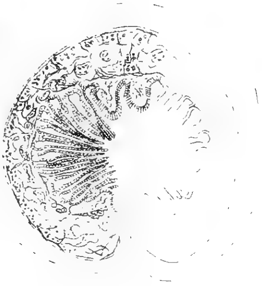

H. Heath del.

B. Meisel lith. Boston.

PLATE 16.

PLATE 16

Cross sections of Strophomenia scandens. × 33.

Fig. 1. In region of brain.
Fig. 2. Behind pharynx.
Fig. 3. In middle of body.
Fig. 4. Through pharynx opposite anterior pedal gland outlet.
Fig. 5. Through seminal receptacles.
Fig. 6 Through mid section of coelomoducts.
Fig. 7. Opposite junction of pharynx and mid gut.
Fig. 8. Through junction of coelomoducts.
Fig. 9. Through outlet of coelomoducts into cloaca.

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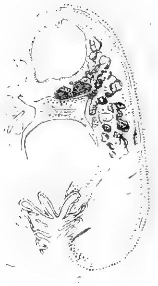

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J. Heath del. B. Meisel, lith. Boston

PLATE 17.

PLATE 17.

Figs. 1–7. Strophomenia spinosa, × 33. Figs. 8, 9, 13. S. ophidiana, × 24. Figs. 10–12, 14–17, S. farcimen, × 33.

Figs. 1, 2, 3 cross sections of S. spinosa (large specimen) along lines A, B, C indicated in fig. 2, pl. 8 (the lines A, B should be perpendicular to the cuticle).

Fig. 4. Cross section through radula and salivary gland outlet, S. spinosa.

Figs. 5, 6, 7 are through fig. 4, pl. 9 (posterior end).

Figs. 8, 9, 13 are cross sections of S. ophidiana along lines A, B, C of fig. 5, pl. 8.

Figs. 10, 11, 16 are cross sections of S. farcimen along lines, A, B, C indicated in fig. 1, pl. 7 (anterior end).

Figs. 14, 15, 12, of same species, correspond to lines D, E, F, of fig. 4, pl. 11 (posterior end).

Fig. 17. Spines of Strophomenia farcimen. × 210.

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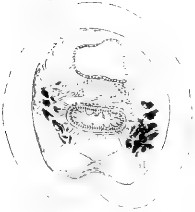

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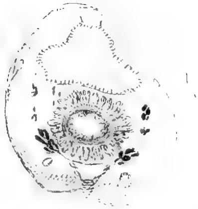

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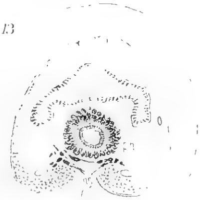

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H. Heath del.

B. Meisel, lith. Boston.

PLATE 18.

PLATE 18.

Figs. 1–4. Strophomenia ophidiana × 24. Figs. 5–12. S. triangularis. × 55. Fig. 13. S. farcimen. × 60.

Fig. 1. Cross section of S. ophidiana along line D of fig. 5, pl. 8.

Figs. 2, 3, 4 of same species are along lines, E, F, G, fig. 1, pl. 9.

Figs. 8, 12, 10, 11 of S. triangularis correspond to lines D, E, F, G, fig. 3, pl. 9.

Figs. 5, 6, 9 correspond to lines A, B, C, fig. 6, pl. 36.

Fig. 7. Section through mid gut behind pharynx.

Fig. 13. Section through mid gut of S. farcimen in region of salivary glands.

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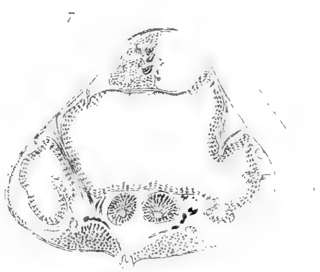

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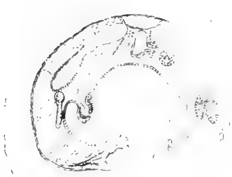

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H Heath del.

B.Meisel [illegible] Boston

PLATE 19.

PLATE 19.

Figs. 1-3, 5, 6, 9. Lophomenia spiralis. × 35; Figs. 4, 7, 8, 10–15. Herpomenina platypoda. × 60.

Figs. 1, 2, cross sections of much curved specimen of Lophomenia spiralis. × 45.

Fig. 3. Section behind pharynx.

Figs. 5, 6, 9 (same species) correspond to lines B, C, A, fig. 6, pl. 8.

Figs. 4, 7, 8, cross sections of Herpomenia platypoda along lines A, C, B in fig. 1, pl. 8. × 60.

Figs. 10, 14. Sections through posterior end of H. platypoda along lines D, E, (which should incline to left) fig. 3, pl. 8.

Fig. 12. Section through dorso-terminal sense organ. × 205.

Fig. 13. Section through salivary ducts, showing entrance of ductules from gland cells.

Figs. 11, 15. Longitudinal sections through posterior end of H. platypoda.

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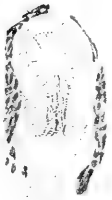

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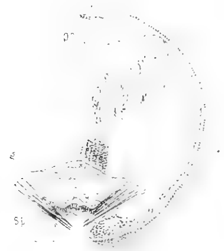

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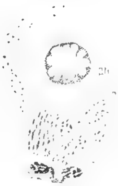

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PLATE 20.

PLATE 20.

Alexandromenia agassizi. × 25.

Figs. 1, 2, 4, 9 correspond to lines A, D, B, C of fig. 3, pl. 7 (anterior end).
Fig. 3, 5, 7, 8, are along lines F, G, H, E, of fig. 5, pl. 7 (posterior end). Fig. 7, × 20.
Fig. 6. Cross section of heart at junction of its two divisions.


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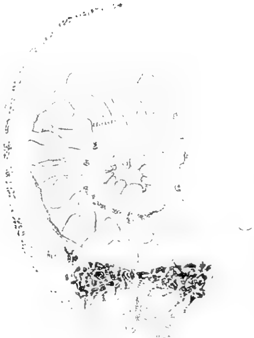
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H Heath del.

B Meisel lith Boston

PLATE 21

PLATE 21.

Figs. 1–6. Alexandromenia valida. × 28. Figs. 7–13. Limifossor talpoideus. × 33.

Figs. 1, 2, 4. Cross sections along lines A, B, C in fig. 3, pl. 11 (anterior end).

Figs. 3, 5, 6. Through posterior end of body.

Figs. 7, 8, 9 correspond to lines A, B, C in fig. 4, pl. 10 (anterior end).

Fig. 10. Chlorogogue or concrement bearing cells of L. talpoideus, from sides of ventral sinus. × 555.

Fig. 11. Section through brain.

Fig. 12. Hypodermis of L. talpoideus. × 255.

Fig. 13. Section through heart and pericardium. × 50.

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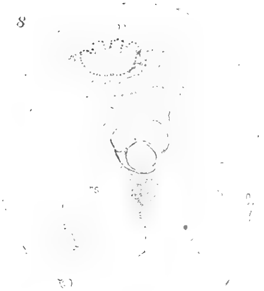

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PLATE 22.

PLATE 22.

Cross sections of Halomenia gravida. × 55.

Figs. 1, 2, 3 correspond to lines A, B, C in fig. 3, pl. 5 (anterior end).

Fig. 4. Section through body behind pharynx.

Fig. 5. Salivary gland lobules opening into main duct.

Figs. 6, 8, 11 (see fig. 8, pl. 15) correspond to lines E, F, G in fig. 5, pl. 3 (posterior end).

Fig. 7. Longitudinal section through advanced larva, showing cerebral ganglion chain of nuclei, stomodaeum, st, and early stage in the development of the anterior pedal gland and outlet, f.

Fig. 9. Section through anterior division of heart.

Fig. 10. Section through junction of two divisions of heart.

Fig. 12. Section through dorso-terminal sense organ

Fig. 13. Spines from middle of body. × 300.

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PLATE 23.

PLATE 23.

Cross sections of Dondersia californica. × 60.

Figs. 1, 2, 3, 5 correspond to lines A, B, C, D, fig. 4, pl. 5 (anterior end).
Fig. 4. Through anterior end of mid gut.
Figs. 6, 9 are along lines G, F of fig. 2, pl. 6 (posterior end).
Fig. 7. Though middle of body.
Fig. 8. Section through radula. × 555.

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H. Heath del.

PLATE 24.

PLATE 24.

Figs. 1–5, 11. Sections of Ichthyomenia porosa. × 55. Fig. 6–10, 12–14. Strophomenia regularis. × 55.

Figs. 1, 4, 11 of I. porosa, correspond to lines B, C, A, fig. 6, pl. 5.

Figs. 2, 5 are along the lines E, D, fig. 1, pl. 6 (posterior end).

Fig. 3. Section through middle of body.

Figs. 6, 8, 9, 10, of S. regularis, are along the lines, C, D, B, A in fig. 8, pl. 26 (in fig. B read cl in place of ct).

Fig. 7. Section of cuticle and hypodermis of S. regularis. × 205.

Fig. 12. Section through one sense organ of anterior end of I. porosa. × 555.

Fig. 13. Section through one seminal receptacle and several stalks of S. regularis. × 255.

Fig. 14. Blood corpuscles of S. regularis. × 555.

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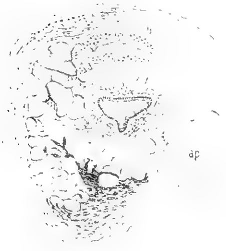

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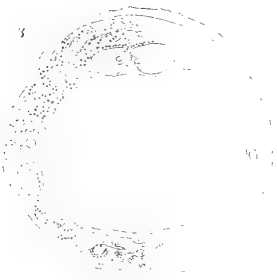

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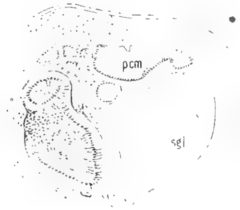

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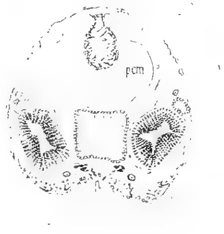

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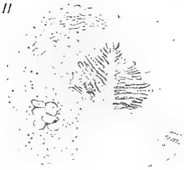

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H Heath del.

B Meisel lith Boston

PLATE 25.

PLATE 25.

Sections of Chaetoderma attenuata. × 33.

Fig. 1. Section through brain.
Fig. 2. Section through radula.
Fig. 3. Section through junction of stomach and intestine.
Fig. 4. Section through suprarectal commissure.
Fig. 5. Section through outlet of coelomoduct (pores omitted in figure).
Fig. 6. Section through posterior end of prothorax. × 60.
Fig. 7. Hypodermis, showing gland cells and attached fibres. × 555.
Fig. 8. Section through heart.
Figs. 9, 10. Two successive sections through the subradular ganglion and connectives. × 135.

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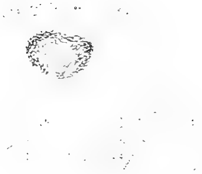

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PLATE 26

PLATE 26.

Figs. 1–7. Chaetoderma argentea. × 33; Fig. 8. Strophomenia regularis. Fig. 9. Alexandromenia agassizi.

Fig. 1.	Through brain region.
Fig. 2.	Through radula.
Fig. 3.	Through heart and coelomoducts.
Fig. 4.	Through suprarectal commissure.
Fig. 5.	Through region of outlet of coelomoducts.
Fig. 6.	Through posterior end of prothorax.
Fig. 7.	Through junction of pharynx and stomach.
Fig. 8.	Reconstruction of posterior end of Strophomenia regularis.
Fig. 9.	A portion of the ventral salivary glands and duct in Alexandromenia agassizi.

"Albatross" Pacific Solenogastres

PLATE 27.

PLATE 27.

Figs. 1, 2, 4–11. Cross sections of Chaetoderma montereyensis. (× 40.) Fig. 3. C. nanula.

Fig. 1. Through brain region.
Fig. 2. Through heart and coelomoducts.
Fig. 3. Through junction of pharynx and stomach.
Fig. 4. Through radula.
Fig. 5. Through labio-buccal ganglia and glands entering pharynx.
Fig. 6. Through heart and coelomoducts.
Fig. 7. Dorso-terminal sense organ.
Fig. 8. Through suprarectal commissure.
Fig. 9. Through outlet, on left, of coelomoduct.
Fig. 10. Through junction of pharynx and stomach.
Fig. 11. Through brain and anterior buccal plate of small specimen.

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PLATE 28.

PLATE 28.

Figs. 1–6, 8, 9. Cross sections of Chaetoderma hawaiiensis. × 55; Figs. 7, 10–12. Chaetoderma nanula. × 33.

Fig. 1. Through brain and buccal plate.
Fig. 2. Through radula.
Fig. 3. Through junction of pharynx and stomach.
Fig. 4. Through suprarectal commissure.
Fig. 5. Through heart and coelomoducts.
Fig. 6. Through outlet of coelomoduct, on left, and origin of pericardial opening.
Fig. 7. Through brain region.
Fig. 8. Through posterior end of prothorax.
Fig. 9. Longitudinal section of posterior end.
Fig. 10. Section through outlet of coelomoduct, on left.
Fig. 11. Through radula.
Fig. 12. Through suprarectal commissure.

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PLATE 29.

PLATE 29.

Figs. 1–5, 8, 12. Cross sections of Chaetoderma erudita. × 33. **Figs. 6, 7, 9–11. Chaetoderma** scabra. × 20.

Fig. 1. Through heart and coelomoducts.
Fig. 2. Close to junction of pharynx and stomach.
Fig. 3. Posterior end of prothorax.
Fig. 4. Through brain.
Fig. 5. Through outlet, on right, of coelomoduct.
Fig. 6. Suprarectal commissure.
Fig. 7. Through gills and cloacal chamber.
Fig. 8. Through radula.
Fig. 9. Through junction of pharynx and stomach.
Fig. 10. Through heart and coelomoducts.
Fig. 11. Through posterior end of prothorax.
Fig. 12. Through suprarectal commissure.

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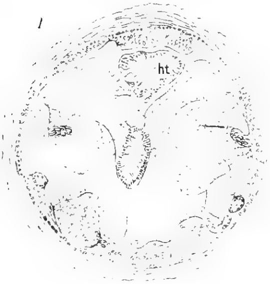

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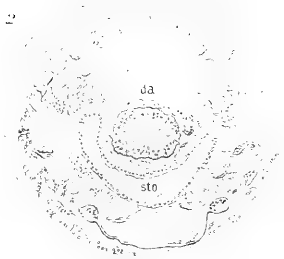

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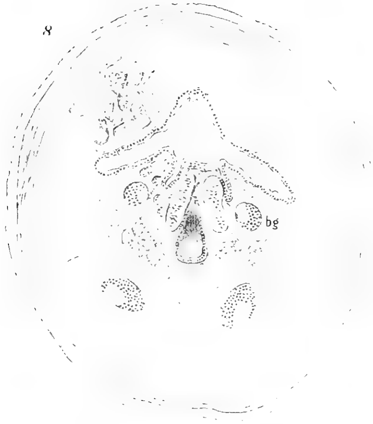

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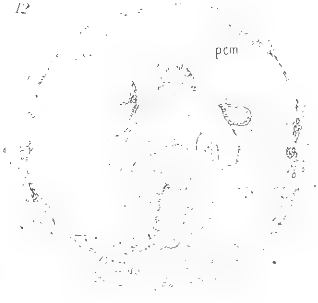

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PLATE 30.

PLATE 30.

Figs. 1, 3. Chaetoderma scabra. × 33. Figs. 2, 4–6, 10, 13. Cross sections of Chaetoderma robusta. × 33. Figs. 7–9, 11, 12. Chaetoderma japonica. × 33.

Fig. 1. Through brain region.
Fig. 2. Through radula.
Fig. 3. Same. Through radula.
Fig. 4. Through brain region.
Fig. 5. Through suprarectal commissure.
Fig. 6. Through posterior end of prothorax.
Fig. 7. Though outlet, on left, of coelomoduct.
Fig. 8. Through heart and coelomoducts.
Fig. 9. Through suprarectal commissure.
Fig. 10. Through junction of pharynx and stomach.
Fig. 11. Through posterior end of prothorax.
Fig. 12. Through junction of pharynx and stomach.
Fig. 13. Through outlet, on left, of coelomoduct.

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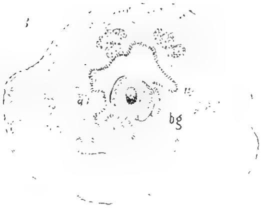

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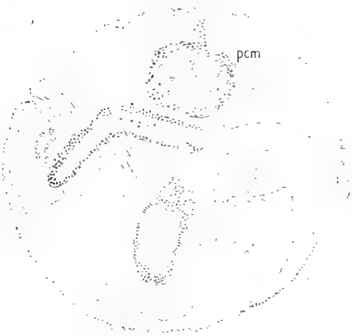

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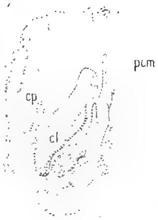

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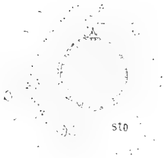

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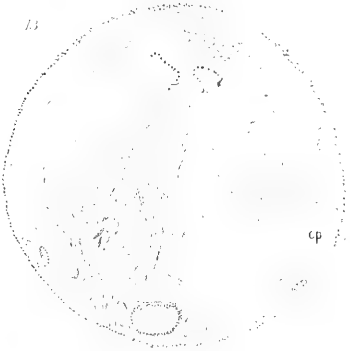
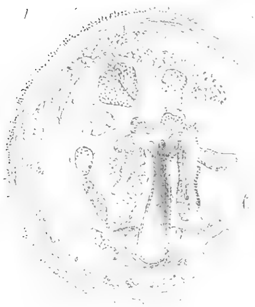


PLATE 31.

PLATE 31.

Figs. 1–4, 7, 8, 10. Cross sections of Chaetoderma californica. (× 33.) Figs. 5, 6. Chaetoderma japonica. × 33. Fig. 9. Proneomenia hawaiiensis.

Fig. 1. Through radula.
Fig. 2. Through junction of pharynx and stomach.
Fig. 3. Through heart and coelomoducts.
Fig. 4. Through brain region.
Fig. 5. Through brain of Chaetoderma japonica.
Fig. 6. Through radula, same species.
Fig. 7. Through outlet of coelomoduct, on left.
Fig. 8. Pharynx and glands in front of radula.
Fig. 9. External sensory atrial ridge of Proneomenia hawaiiensis; os, ridge resting upon ganglion cells; om, outer atrial ridge; c, cirrus.
Fig. 10. Through suprarectal commissure.



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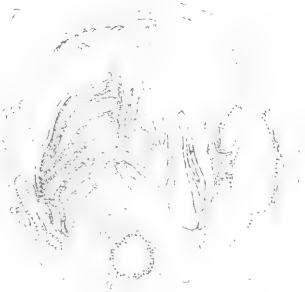

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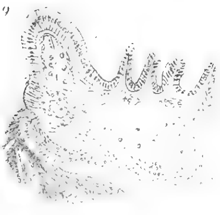

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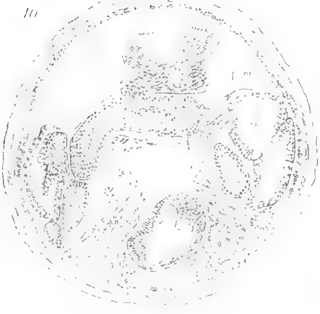

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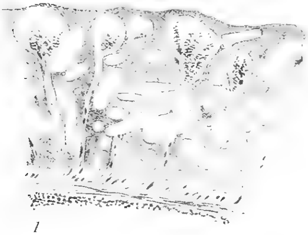
PLATE 32.

PLATE 32.

Cuticle and hypodermis from side of head unless otherwise stated.

Fig. 1. Hypodermis and its products in Strophomenia spinosa, large specimen. × 205.
Fig. 2. Same in Lophomenia spiralis. × 255.
Fig. 3. Same in Strophomenia scandens. × 155.
Fig. 4. Same in Halomenia gravida. × 225.
Fig. 5. Perforation of the somatic musculature in H. gravida by a diverticulum of the mid gut which comes in contact with a modified hypodermal papilla; s, blood sinus. × 255.
Fig. 6. Hypodermis of Drepanomenia vampyrella. × 255.
Fig. 7. Same of Ichthyomenia porosa. × 330.
Fig. 8. Same of Dondersia californica. × 555.
Fig. 9. Section through the dorsal sense organ of Strophomenia scandens. × 300.
Fig. 10 Same of Proneomenia hawaiiensis; ne, nerve. × 180.
Fig. 11. Same of Lophomenia spiralis; ne, nerve. × 150.



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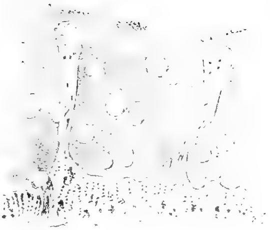

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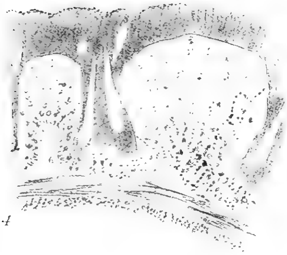

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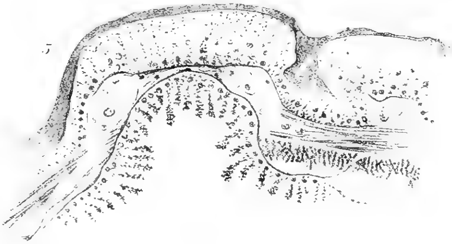

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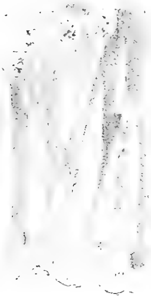

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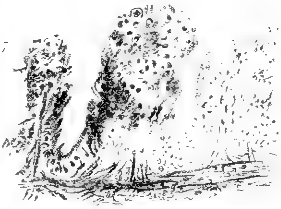

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PLATE 33.

PLATE 33.

Cuticle and hypodermis from side of head unless otherwise stated.

Fig. 1. Strophomenia triangularis. × 200.
Fig. 2. Strophomenia farcimen. × 300.
Fig. 3. Proneomenia hawaiiensis. × 300.
Fig. 4. Dorymenia acuta. × 330.
Fig. 5. Alexandromenia agassizi. × 200.
Fig. 6. Proneomenia insularis. × 400.
Fig. 7. Strophomenia spinosa, dorsal side. × 200.
Fig. 8. Alexandromenia valida. × 260.
Fig. 9. Strophomenia ophidiana. × 200.


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PLATE 34.

PLATE 34.

Fig 1. Cross section through radula sac of Lophomenia spiralis. × 57.

Fig. 2. Longitudinal section through radula and subradular organ of Proneomenia hawaiiensis. × 80.

Fig. 3. Dorsal view of radula of Limifossor talpoideus. × 135.

Fig. 4. Two rows of teeth of Strophomenia triangularis. × 330.

Fig 5. Portion of radula of Alexandromenia agassizi. × 255.

Fig. 6. Side view of radula of Limifossor talpoideus. × 135.

Fig. 7. Teeth of Dorymenia acuta (mid line to left). × 330.

Fig 8. Teeth of Strophomenia spinosa, large individual. × 555.

Fig. 9. Same species, small individual. × 330.

Fig. 10. Same species, small individual. × 330.

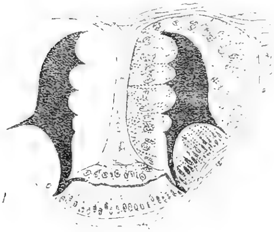
Fig. 11. Side view of teeth of Dorymenia acuta. × 330.

Fig. 12. Cross section of radula of Halomenia gravida. × 330.

Fig. 13. Proneomenia hawaiiensis, showing 7 of the 40 teeth of each transverse row; m, mid line. × 255.

Fig. 14. Tooth of Alexandromenia valida. × 200.

Fig. 15. Portion of radula of Strophomenia farcimen. × 255.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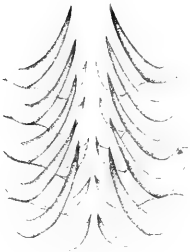
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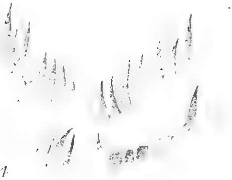
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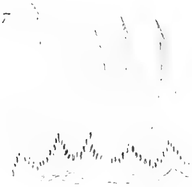
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H. Heath del.

E. Meisel, lith. Boston

PLATE 35.

PLATE 35.

Fig. 1. Limifossor fratula. Section through region of salivary glands. × 28.

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PLATE 36.

PLATE 36.

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PLATE 37.

PLATE 37.

Fig. 1. Spicules of Ichthyomenia porosa. × 480.
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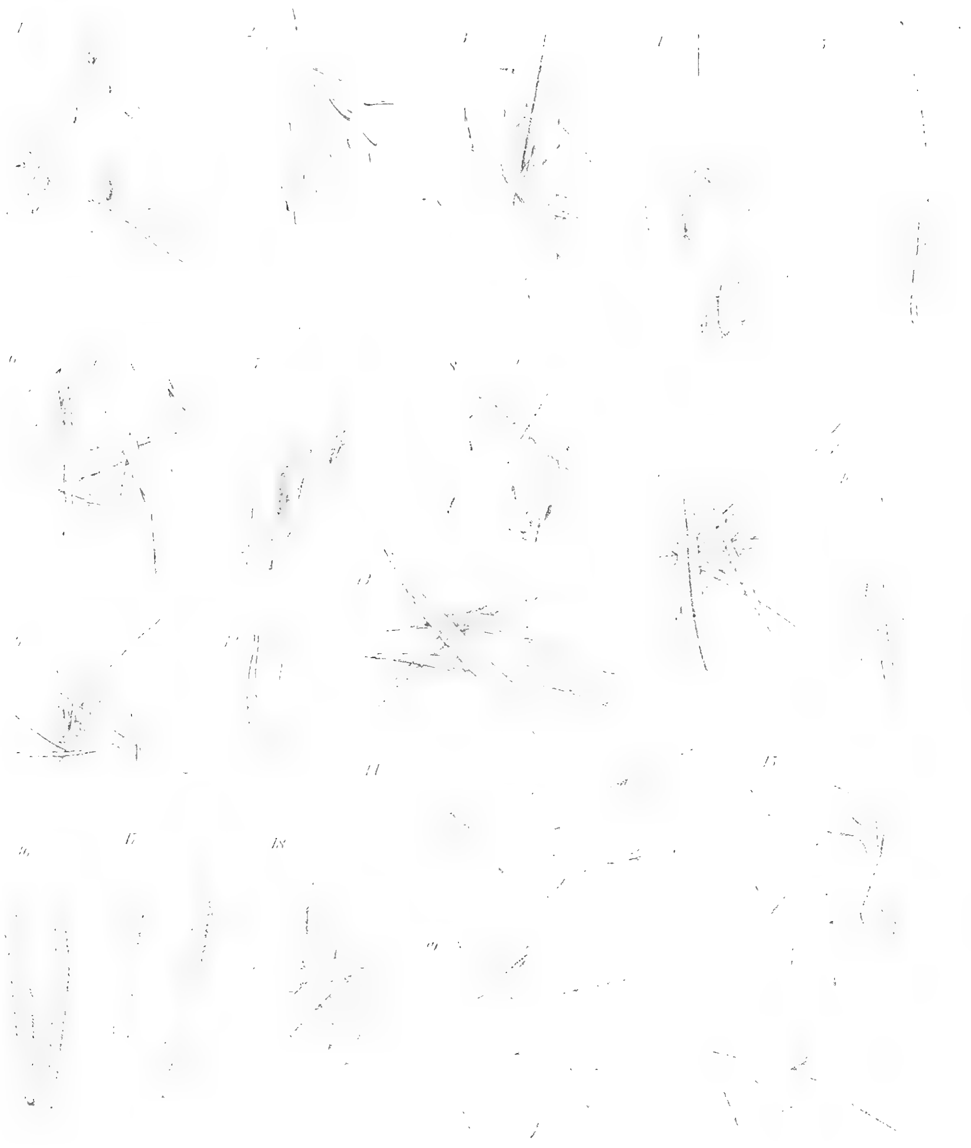

PLATE 38.

PLATE 38.

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[illegible]

PLATE 39.

PLATE 39.

Fig. 1. Reconstruction of anterior end of Pachymenia abyssorum.
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PLATE 40.

PLATE 40.

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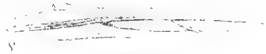


Memoirs of the Museum of Comparative Zoölogy
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SOLENOGASTRES FROM THE EASTERN COAST OF NORTH AMERICA.

BY HAROLD HEATH.

WITH FOURTEEN PLATES.

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SOLENOGASTRES FROM THE EASTERN COAST OF NORTH AMERICA.

INTRODUCTION.

The present report deals with a collection of upwards of one hundred and twenty-five Solenogastres dredged at various times by Coast Survey or U. S. Fish Commission vessels along the eastern coast of the United States. The greater number of these were placed at my disposal by the late Mr. Alexander Agassiz, who generously granted permission to include the descriptions of additional species based upon material kindly forwarded by Prof. A. E. Verrill and by the officials of the National Museum.

The territory embraced by these explorations, with the exception of a single station off the south coast of Florida, another in the Gulf of St. Lawrence and a third off the coast of Newfoundland, extends from the Gulf of Maine on the north to the mouth of Chesapeake Bay on the south. The larger number of dredge hauls were made along shore in comparatively shallow water; thirty-four were at depths ranging from one hundred to five hundred fathoms, three were from five hundred to one thousand fathoms, two from one thousand to fifteen hundred fathoms and one from seventeen hundred and fifty-three fathoms. The appended table indicates the habitat with greater exactness. The following abbreviations have been employed to indicate the vessels engaged: A Albatross, B Bache, Be Blake, Bt Bluelight, Fk Fishhawk, Sp Speedwell.

Species	Station	Number of Specimens	Depth in Fathoms	Locality		
				Lat. N.	Long. W.	
				° ′ ″	° ′ ″	
Chaetoderma bacillum	2076A	3	906	41 13 —	66 — 50	200 m. E. of Cape Cod.
“ caudatum	2588A	8	479	39 02 —	72 36 —	240 m. E. of Cape May.
“ lucidum	2212A	15	428	39 59 30	70 30 45	240m.N.E.of Cape May.
“ “	2588A	15	479	39 02 —	72 36 —	240 m. E. of Cape May.

Species	Station	Number of Specimens	Depth in Fathoms	Locality Lat. N.	Long. W.	
				° ′ ″	° ′ ″	
Chaetoderma nitidulum	2458A	50	89	46 48 30	52 34 —	S. E. of Newfoundland.
" "	20B		95	43 01 —	70 10 —	Near Boon Is. Light, Me.
" "	31B		56	42 19 —	70 29 —	Massachusetts Bay.
" "	38–43B		27–68	42 57 —	70 35 —	Gulf of Maine.
" "	62–65B		42–58	43 38 —	69 22 —	Gulf of Maine.
" "	69B		32	43 11 —	69 35 —	Off S. coast of Maine.
" "	892Fk.		36	40 33 —	70 45 —	Off Martha's Vineyard.
" "	895Fk.		238	39 56 30	70 59 45	Off Martha's Vineyard.
" "	898Fk.		300	37 24 —	74 17 —	Chesapeake Bay, Mass.
" "	943Fk.		157	40 — —	71 14 30	Off Martha's Vineyard.
" "	18Sp.		45	42 29 —	70 38 —	Near Salem, Mass.
" "	293Sp.		27	42 03 —	70 19 —	Cape Cod Bay, Mass.
" "	296Sp.		26	42 02 —	70 26 —	Cape Cod Bay, Mass.
" "	301Sp.		27	42 01 —	70 20 —	Cape Cod Bay, Mass.
" "	317Sp.		25	42 02 —	70 14 —	Cape Cod Bay, Mass.
" "	322Sp.		67	42 12 —	70 01 —	Off Cape Cod, Mass.
" "	350Sp.		31	42 08 —	70 25 —	Massachusetts Bay.
" squamosum	2534A	1	1234	40 01 —	67 29 15	200 m. S.E. of Cape Cod.
" vadorum	—	5	—	— — —	— — —	Casco Bay, Me.
" "	3B	1	64	43 38 —	69 17 —	Off S. coast of Maine.
" "	20B	1	95	43 10 —	70 10 —	Near Boon Is. Light, Me.
" "	317Sp.	1	25	42 02 —	70 14 —	Cape Cod Bay, Mass.
Neomenia verrilli	—	1	313	— — —	— — —	Gulf of St. Lawrence.
Proneomenia acuminata	5Be	1	150–229	24 15 —	82 13 —	Straits of Florida.
" "	893Fk.	1	372	39 52 20	70 58 —	S. of Martha's Vineyard.
" "	2547A	1	390	39 54 30	70 20 —	S. of Rhode Island.
Dorymenia peroneopsis	2715A	1	1753	38 29 30	70 54 30	S. of Martha's Vineyard.
Strophomenia agassizi	2046A	5	407	40 02 49	68 49 —	S.E. of Nantucket, Mass.
" "	2528A	4	677	41 47 —	65 37 30	E. of Cape Cod, Mass.
Nierstrassia fragile	2588A	11	479	39 02 —	72 36 —	Off coast of New Jersey.

Up to the present time very few Solenogastres have been collected along the Atlantic coast of North America. *Chaetoderma canadense* Nierstr. has been taken off Port Hood, Canada, *Neomenia carinata* Wiren came from the North Atlantic, and *Neomenia microsolen* Koren & Danielson is recorded from the West Indies; but none of these species is represented in the present collection, and accordingly nothing further can be said regarding their geographical range. The discovery of *Chaetoderma nitidulum* off the New England coast indicates that this species is relatively abundant throughout the North Atlantic Ocean north of the fortieth parallel. *Proneomenia acuminata* was originally described from specimens collected in the West Indies. The material in hand extends its distribution along the Florida coast and the Atlante seaboard as far north as Rhode Island. Other species in the present collection are new, and thus far their known range is very limited.

CLASSIFICATION.

Judging from the material already described, it is evident that not only is the genus Chaetoderma very widely distributed, but the individual species are difficult to differentiate, especially where we are compelled to rely solely upon descriptions and figures. Externally and internally there is considerable variation within a given species, and suitable diagnostic characters are difficult to discover. The relations of the gut to the somatic musculature and the ventral blood sinus at the junction of the pro- and metathorax are of considerable value in the specimens I have thus far examined, and with figures of this region and others of characteristic sections it is believed that it will be possible, without great difficulty, to recognize the species described in this and the earlier Pacific Ocean report.

The validity of the genus Dorymenia Heath has been questioned by certain investigators, but the discovery of a second species, with all of the characteristic features of the first (*Dorymenia acuta*), indicates that the genus was well founded.

Order APLACOPHORA v. Ihering.

Suborder I. Chaetodermatina Simroth.
  Spiculose integument continuous all around the body.
    Chaetodermatidae, p. 189.
Suborder II. Neomeniina Simroth.
  Spiculose integument interrupted beneath by a longitudinal ventral furrow.
    Neomeniidae, p. 191.
    Proneomeniidae, p. 191.
    Dondersiidae, p. 192.

CHAETODERMATIDAE SIMROTH.

Opening of mouth and anal chamber terminal. Body with more or less sharply marked regions. Ventral furrow and fold lacking. Two highly developed plume-like gills. Radula distichous, polyserial or strongly reduced to a large unpaired cuticular tooth. The mid-gut possesses, in most cases, a well-developed digestive gland. Copulatory apparatus lacking. Coelomoducts remain separate. Cuticle thin, spicules flat, often needle-form, but solid. Inhabit bottom ooze.

CHAETODERMA Loven, 1845.

Body vermiform, without ventral groove; mouth and anal chamber terminal. Two gills. Sexes separate. Radula reduced to conical peg. Type of genus

C. nitidulum Loven.

Head, cylindrical or pear-shaped, bounded posteriorly by a circular groove. Spines with keel absent or but slightly developed. North Atlantic (p. 193).

C. caudatum, sp. nov.

Length from 3.3 mm. to 7.75 by 1.3 mm. greatest diameter. Greatest thickness of body in preabdomen; the postabdominal region narrows abruptly to a tail-like appendage. Northeast coast of the United States at a depth of 428–499 fathoms. (p. 193).

C. vadorum, sp. nov.

Length 12.5 mm. by 1.1 thickness of preabdomen to 15.2 by 1.45 mm. Spines strongly keeled and at junction of metathorax and abdomen measure from 0.1 to 0.14 mm. in length. Mouth occupies a cleft in the buccal plate. Off coast of Maine at a depth of 25–95 fathoms. (p. 195).

C. lucidum, sp. nov.

Body size variable, ranging from 1.2 mm. width by 11.25 length to 0.75 mm. width by 25 mm. length. Spines with keel slight or undeveloped, with average length on preabdomen of 0.12 mm. Mouth occupies a cleft in the buccal plate. Off coast of New Jersey at 428–479 fathoms depth. (p. 198).

C. bacillum, sp. nov.

Length 11–17 mm. length by 0.9–1.07 mm. greatest diameter. Spines moderately keeled with a length of 0.11–0.16 mm. at the junction of the pro- and metathorax. Mouth perforates the buccal plate. Off the Massachusetts coast at a depth of 900 fathoms. (p. 201).

C. squamosum, sp. nov.

Length 25.7 mm. length by 1.3 mm. greatest thickness. Mouth pierces the buccal plate. Spines unusually thin, weakly keeled. Off Massachusetts at 1,234 fathoms depth. (p. 204).

NEOMENIIDAE Simroth.

Body compressed, more or less crescent-shaped, without distinct divisions. Index 7 at most. Opening of atrium ventral, of the anal chamber ventral or terminal. Ventral furrow present, usually with several folds. Cuticle sometimes comparatively thick, spines mostly needle-like, flat, grooved or hollow. A circlet of gills in the anal chamber. Radula and salivary glands usually lacking. Epidermal papillae, of simple structure, usually present. Fore gut protrusible, coelomoducts separate or united to form a shell gland or copulatory organ. Digestive gland lacking. Penial spines usual present. Free, creeping about over bottom.

NEOMENIA Tullberg, 1875.

Body thick-set and usually compressed laterally, 2–3 cm. long, with anterior and posterior ends similarly shaped. Cloacal opening subterminal. Ventral fold present with the groove extending to the cloacal chamber. Spicules needle- or spearhead-shaped, projecting from the cuticle. Broad stalked papillae present. Branchial folds in the cloacal chamber. Copulatory spines usually present. Radula absent. Type of genus, *N. carinata.*

N. verrilli, sp. nov.

Body thick-set, unkeeled, 25 mm. in length by 8 mm. greatest thickness. 8 ventral folds, 30–40 branchial folds. Accessory copulatory apparatus present. Gulf of St. Lawrence, 313 fathoms. (p. 206).

PRONEOMENIIDAE Simroth.

Worm-like. Radula distichous or polystichous, sometimes lacking. Salivary glands tubular, lobed or lacking. Cuticle thick, spicules mostly needle-like in several layers. Epidermal papillae present. Gills usually lacking. Coelomoducts usually united into a shell gland, sometimes separated. Copulatory spicules may be present. Free living, partly or entirely parasitic.

PRONEOMENIA Hubrecht, 1880.

Body elongated, vermiform, the length 9–50 times the diameter. Cloacal opening ventral. Foot present, the groove passing into the cloacal chamber. Cuticle thick with crowded spicules in several layers. No gills. Radula multidentate. Two salivary glands. Copulatory spines present or absent. Type of genus, *P. sluiteri*.

P. acuminata Wiren.

Length index 9.3. Radula present. (p. 215).

DORYMENIA Heath, 1911.

Vermiform, body terminating posteriorly in a finger-shaped elongation. Radula multidentate with 9–51 longitudinal rows of from 9–22 teeth in each transverse row. One pair of seminal receptacles. A pair of long copulatory spicules closely associated with a pair of globular coeca or deep pits likewise opening separately into the cloacal chamber. Type of genus, *D. acuta*.

D. peroneopsis, sp. nov.

Body 25 mm. in length by 2 mm. in greatest thickness. Radula with 9 longitudinal rows of teeth and 22 teeth in each transverse row. Accessory copulatory apparatus present. Off the Massachusetts coast at a depth of 1,753 fms. (p. 222).

STROPHOMENIA Pruvot, 1899.

Body elongated, cylindrical, the thick cuticle penetrated by acicular spicules and closely crowded vesicular papillae. Radula and salivary ducts present. Two distinct genital openings into the cloacal chamber usually present. Type of genus, *S. lacazei*.

S. agassizi, sp. nov.

Worm-like, 22–37 mm. in length by 1.1–1.5 mm. average diameter. Papillae stalked, numerous; spicules needle-like. Radula very small. Ventral salivary glands tubular. Nine pairs of seminal receptacles. Off Massachusetts coast, 677 fms. (p. 229).

DONDERSIIDAE Simroth.

Body often worm-like; cuticle thin; spines flat and solid. Papillae lacking. Radula distichous, monoserial or lacking. Salivary glands globular, sac- or tube-like. Gill folds lacking. Coelomoducts united or separate. Copulatory apparatus may be present. Ventral fold and furrow may be absent. Living free upon corals, etc.

NIERSTRASSIA, gen. nov.

Body short, 2.5–5 mm. in length by 0.75–1 mm. thick. Single layer of leaf-like keeled spines as in Chaetoderma; no papillae. Epithelium of atrium (?) composed of long, slender cells without cirri and ciliated ridges. Radula distichous, 15 transverse rows. Dorsal salivary glands diffuse, ventral small, lobulated. Coelomoducts with three pairs of diverticula, two bundles of copulatory spines (5 in each bundle) opening into terminal part of shell gland. Reproductive opening on large papilla. Posterior walls of cloaca with 5–6 glandular folds. Type of genus *N. fragile,* sp. nov. with characters of the genus. Off New Jersey coast, 479 fms. (p. 235).

DESCRIPTION OF SPECIES.

Chaetoderma nitidulum Loven.

This species is represented by over fifty specimens dredged from various comparatively shallow water stations between Newfoundland on the north to Virginia on the south. Whether this last named locality represents the southernmost limit of distribution it is impossible to state as the work of exploration south of 37° north latitude is largely confined to deep water. In the present case the bathymetrical distribution ranges from 25 to 300 fathoms; elsewhere it is reported to range from 25 to 2,250 meters. Specimens in the present collection have been taken at the stations noted on page 183.

A careful comparison of these western Atlantic specimens with the descriptions given by various authors and with a single individual from the Kara Sea discloses no essential differences. One of the Atlantic specimens is unique in being monocious. Throughout its entire extent the gonad is distended with vast numbers of spermatozoa, mature and in various stages of development. The ova are also in different stages of growth, and roughly speaking are developed on the surface of an inconspicuous septum separating the halves of the ovotestis, while the sperms arise from more lateral positions.

Chaetoderma caudatum, sp. nov.

Eight specimens of this species were dredged off the coast of New Jersey (Sta. 2588A) in 479 fathoms of water where the bottom consisted of green mud. In every case the posterior end of the body rapidly narrows in the vicinity of the cloaca to form a tail-like appendage of approximately even calibre throughout. The largest specimen (Plate 9, fig. 1), measures 7.75 mm. in length by 1.3 in greatest diameter, while the smallest is 3.3 by .75 mm. In several individuals the anterior end of the prothorax is considerably swollen, giving the entire body a decided trumpet-shape.

The color, especially of the older individuals, is a slaty gray in the mesothorax and the posterior part of the prothorax, owing to the dark colored liver showing through the translucent body wall. The postabdomen is of the usual light yellow tint save the posterior half or third which is very dark brown owing to an incrustation consisting apparently of faecal matter or substances from the coelomoducts. A dark brown or black band encircles the prothorax and this peculiarity together with the shape of the body readily distinguishes the species.

The dorsal sense organ, in the form of a deep groove, holds the customary position at the posterior end of the body, but owing to the overarching spines it is in large measure invisible in whole specimens. In sections it is seen to be composed of slender cells whose general arrangement and appearance are typical of the genus.

The mouth opens through the centre of the buccal plate whose general appearance is represented (Plate 9, fig. 4). Between this point and the anterior border of the brain the buccal tube is of moderate size, is folded to form four or five longitudinal ridges, and supports a considerable number of gland cells attached to its outer surface. These last named organs, grouped into lobules (Plate 8, fig. 7), whose general size and shape depend upon the spaces between the longitudinal and radial muscles of the buccal tube, are composed of small cells containing after treatment with Delafield's haematoxylin an abundance of some golden yellow, finely granular secretion.

The subradular organ is moderately distinct and the tooth (Plate 9, fig. 5) of average size. Behind the radula the canal rapidly narrows, becomes thick walled and the component cells, slender in form, are filled with a dense, finely granular secretion. This condition of affairs continues to the opening borne on the summit of a short papilla (Plate 8, fig. 10) projecting into the gastric cavity. The stomach is a capacious sac, with highly folded walls especially in the neighborhood of the oesophageal opening where the cells are packed with a finely granular, yellowish secretion. In the vicinity of the bile duct the walls are much thinner, nearly smooth and the epithelial cells are approximately cubical and contain but a small quantity of secretory products.

The liver presents in general the usual appearance, possessing yellowish brown Körnerzellen and moderately staining Keulenzellen. The intestine, with walls of the usual character, pursues its course to the end of the preabdomen where it becomes unusually narrow and contorted before opening in the customary fashion into the cloacal chamber. Food products, among them relatively long and slender tubular fragments of some unknown organism, are present in considerable quantities in the stomach and the proximal part of the hepato-pancreas and in a more or less digested condition throughout the intestine.

So far as could be determined the circulatory system is typical of the genus. As noted in connection with the reproductive system the aorta at its origin is unusually heavy walled and of large calibre. In the region of the gonad its walls become thinner yet distinct so that they may be traced readily to the neighborhood of the radula where it disappears as a distinct vessel.

The nervous system is very distinct and has been examined with more than usual care, but in all essential respects it is practically the same as in *C. attenuata* for example.

The single specimen sectioned is a female with the sex gland, filled with ova in all stages of development, holding the customary position. At the junction of the preabdomen with the tail-like postabdomen the ovary rapidly narrows to form the paired canals leading into the pericardium. These, however, are of unusual extent, traversing almost the entire extent of the postabdomen, and are separated from each other by the large dorsal aorta (Plate **8**, fig. 11) whose walls in this region are relatively heavy. In the neighborhood of the pericardial cavity they become somewhat enlarged but otherwise they exhibit no unusual features.

The pericardium is of moderate size and the coelomoducts open in the usual position (Plate **9**, fig. 6) by very distinct, ciliated funnels connected with a short non-glandular section directed anteriorly. At the level of the dorsal commissure they unite with the glandular portion which though it is of large size relatively, lacks the sacculations and tortuous course characteristic of larger species and passes directly backward to open at the usual point in the cloacal chamber. The cells lining this main division of the canals are composed of highly vacuolated protoplasm frequently in the process of liberating its products by means of constriction of the distal end of each cell.

Chaetoderma vadorum, sp. nov.

One specimen (Plate **13**, fig. 1) of this species was taken off the south coast of Maine (Sta. 3B) at a depth of 64 fms., another from the same general locality

(Sta. 20B) was dredged at a depth of 95 fms., and a third came from Cape Cod Bay, Mass. (Sta. 317 sp.) at a depth of 25 fms. Two additional specimens, of approximately the same size, bear the label "Casco Bay, Maine, U. S. Fish Com., Aug. 5th. 1873." No other data are forthcoming but it may be assumed that they are shallow water forms. The length of the largest (sectioned) specimen was 15.2 mm. with a diameter through the abdomen (Wiren) of 1.45 mm.; the smaller specimen is 12.5 mm. long by 1.1 in diameter. The color is light brownish yellow though this may be due to long preservation or to tannin from the cork. The buccal plate (Plate **13**, fig. 2) is somewhat distorted, but appears to be elliptical in outline or broadly shield-shaped with the mouth occupying a deep indentation in the dorsal two thirds.

The spines examined were taken from the neighborhood of the union of the metathorax and abdomen, and range in length from 0.1 to 0.14 mm. They present the usual spearhead appearance (Plate **12**, fig. 3), and are strongly keeled throughout nearly their entire length. The cells composing the hypodermal layer (Plate **13**, fig. 8) comprise two distinct types, the matrix cells of the spicules, and those probably responsible for the development of the cuticle. The first exist in the form of flattened disc-like bodies attached to the basal portion of the spine, and indicate that in this genus every spicule is the product of a single cell. The cells of the second class possess spherical nuclei, and a columnar form though as a general rule they are without clearly defined boundaries.

In the region of the union of the pro- and metathorax especially the hypodermal layer is seen to rest upon a felt-work of connective-tissue fibres, forming a species of basement membrane that stains intensely in haematoxylin. A short distance removed from this region the meshwork becomes less compact and less darkly staining. Under fairly high magnification fibres may be seen to traverse the underlying somatic muscles and to enter the basement membrane whose elements they resemble closely; but in no case have they been seen to extend into the hypodermal layer, and it may be added the material appears to be excellently preserved.

As usual the buccal plate is composed of a heavy cuticular layer (Plate **13**, fig. 4) resting upon the hypodermis in which the cell elements are very indefinitely defined. About the margins of the plate the cells possess fairly distinct nuclei and cell boundaries, but in the more central regions bordering the mouth they become distorted, owing apparently to numerous nerve and muscle fibres that either attach to or pass between them to the cuticular plate.

Darkly staining ductules open to the exterior close to the margins of the plate, and for the first time in my experience have been traced to definite cells.

In sections these are seen to occupy a position adjacent to the buccal tube, and along the path traversed by the nerves destined to the buccal plate and originating in the great precerebral nerve masses (buccal ganglia of Wiren). In several other species of the genus ductules lead to cells in the same general position, but the lack of a clearly defined secretion in these cells and owing to their resemblance to ganglion cells it has never been possible heretofore to make the identification certain. In the light of the state of affairs in the present case it is altogether probable that gland cells are normally present and in the position described above.

These gland cells are usually arranged in the form of lobules, though separate cells are occasionally met with in the neighborhood of the buccal plate. Each, in a fully developed condition contains numbers of darkly staining granules, though not in sufficient numbers to mask the nucleus. This last named body occupies a central position, and contains a well-defined though faintly staining nucleolus. In a few instances the ductules perforate the margins of the buccal plate; more generally they pass to the exterior without the borders of the plate but in close proximity to it.

As noted previously the mouth occupies a cleft in the buccal plate, and sections show that it leads into a canal of average dimensions and with typical relations. Generally speaking the epithelial lining rests upon a circular muscle layer, but as this is pierced by numerous radial or diagonal fibres the line of demarcation is by no means sharp, a state of affairs that is accentuated by the presence of several glands. These last named organs (Plate **12**, fig. 2), in the form of lobules, encircle the tube and are in all stages of glandular activity. Those in an inactive state bear a fairly close resemblance to the neighboring ganglion cells, but in a fully developed condition they become distended with a vacuolated, moderately staining secretion that escapes into the buccal tube or pharynx by intercellular canals, though these are usually difficult to demonstrate.

The radula of this genus, together with its supports and muscles, is a remarkably constant structure, and this species is no exception to the rule (Plate **12**, fig. 1), there being no marked characteristics of diagnostic value.

Immediately posterior to the radula the digestive tract narrows rapidly, and becomes elliptical in outline (Plate **12**, figs. 9, 12). The cells of the lining are greatly elongated and glandular, the secretion appearing as a finely granular, moderately staining mass that may in rare instances become so abundant and closely packed that it appears to be homogeneous. This state of affairs rapidly changes as the canal is followed backward. The cells become lower, and in most instances have been dislodged, evidently due to the decreased pressure attendant upon coming to the surface. Where they have remained they are likewise glandular, and continue in this condition for a considerable distance beyond the union of the pro- and metathorax (Plate **12**, fig. 14) where the alimentary canal attains a greater diameter (Plate **12**, fig. 5). Sections were not made of the mid region of the body. Posteriorly the intestine pursues the usual course and opens in typical fashion into the cloacal chamber.

The cloacal cavity, so far as shape and relations are concerned, is not unusual, but its epithelial lining, especially near the posterior end of the animal, is highly glandular, the cells staining intensely in haematoxylin. Gland cells with similar staining reaction occur in the branchiae, and are limited to very definite zones (Plate **12**, fig. 13). A comparatively small number occur in the external epithelial layer immediately dorsal to the dorsal branchial sinus, and a much larger proportion is imbedded in the lamellae, forming in sections a horizontal band passing through the dorsal limit of the ventral gill retractors.

The circulatory system presents no unusual features. The sinus returning the blood from the branchiae to the heart is unusually large and clearly defined and the pericardial chamber (Plate **12**, fig. 15) is more spacious than common, but otherwise the heart, aorta, and sinuses are fashioned upon the usual plan.

The coelomoducts open into the pericardial cavity beside the posterior dorsal commissure by means of well-defined, ciliated mouths, and from this point extend anteriorly, rapidly losing the ciliated coat and assuming the characteristic vacuolated appearance, until they have traversed on half of the length of the main or ventral portion of the organ with which they unite. This main division presents no especially noteworthy peculiarities. The lining epithelium is composed of very clearly defined cells with basal nucleus, and in living material the distal two thirds was evidently filled with some non-staining material that in sections has escaped leaving only the ruptured cell membrane. The openings into the cloaca (Plate **12**, fig. 13) are normally placed and are not surrounded by the high columnar cells encountered in several species of this genus.

The nervous system, in its broader details at least, conforms closely to the usual type, and therefore calls for no description beyond that afforded by the figures.

Chaetoderma lucidum, sp. nov.

Fifteen specimens of this species, the majority of them mutilated, were dredged approximately one hundred and forty miles to the eastward of Cape May, New Jersey (Sta. 2588A) at a depth of 479 fathoms. Fully as many more were taken on another occasion slightly to the northeast of this point (Sta. 2212A) at a depth of 428 fathoms, but unfortunately all from this last named locality had dried prior to coming into my possession and are useless for the study of the internal anatomy. The smaller specimens from both stations agree in being relatively slender, and the larger specimens may retain this characteristic or become relatively thick-set (Plate 9, fig. 12).

The longest specimen measures 25 mm. in length by 0.75 mm. in greatest diameter, while the individual with the greatest diameter, 1.2 mm., is 11.25 mm. long. The color of the specimens from the two stations is strikingly different, though I am of the opinion that this is due to methods of preservation and not to habitat. What appears to be the normal shade in a preserved state is a glistening light yellowish white somewhat darkened by the slaty gray liver shining through the translucent body walls. A reddish yellow or reddish brown incrustation, usually shading into dark brown in the larger individuals, gathers on the spines about the cloacal opening.

Bordering on the union of the pro- and metathorax the spines are in the form of very thin flattened scales without any well-defined keel (Plate 9, fig. 15). In length they range from 0.094 to 0.13 mm., while the width, even in spines of the same length, varies as much as 30 per cent.

The hypodermal layer presents no peculiarities whatever save that the giant cells of Wiren are more abundant than is usual in the region of the pro- and metathorax where the hypodermis shows to the best advantage. In these cells the nucleus is usually basally placed while the cell body contains little save a finely granular coagulum adhering to the cell wall. As the spines in this species have no clearly defined matrix cells in this species the possibility presents itself that these larger hypodermal elements may play a part, but there is nothing to prove conclusively that such is the case. On the other hand they may correspond to the gland cells occurring in *Chaetoderma attenuata*, but the absence of attached fibres penetrating the somatic muscles renders the identification uncertain. The remaining hypodermal elements are generally cubical in form though the cell boundaries, unlike the sharply defined spherical nuclei, are very indistinct.

The buccal plate is broadly shield-shaped with the mouth occupying a deep cleft in the upper two thirds (Plate 10, fig. 11). In sections it is bounded as usual by a heavy cuticular plate (Plate 10, fig. 2) resting upon a modified hypodermal layer in which the cells appear with marked clearness though without any especial peculiarities. In a number of different species of this genus there is a muscle bundle, probably acting as a sphincter oris and appearing clearly in cross sections, and in the present species it is situated immediately internal to a well-defined sensory area that likewise encircles the mouth.

The sense cells are exceedingly long and slender with spindle-shaped nuclei, and internally may be followed into the vicinity of the great nerve bundles passing from the brain into the region of the buccal sensory plate.

Gland cells, attached to the great ganglionic masses applied to the brain or scattered irregularly anterior to the mouth opening, communicate with clearly defined ductules leading to the margins of the buccal plate. Even in moderately stained (Delafield's haematoxylin) material these cells are almost black while the ductules are purple.

The mouth, whose position has been described in a foregoing paragraph, communicates with a canal of moderate size in which the elements, muscular and epithelial, present the customary appearance. Buccal or pharyngeal glands are present in an unusually restricted area. On each side of the mid line a very short distance posterior to the brain they appear as a single lobule (Plate **9**, fig. 13) or as two or three closely appressed lobules in which the cells are unusually compact owing to an abundance of a finely granular, moderately staining secretion.

A median ventral ridge immediately anterior to the radula probably represents the subradular organ of other species. The cells are not so distinctly columnar as in *Chaetoderma attenuata* for example, and consequently are not sharply differentiated from the adjoining cells. Nevertheless the absence of folds in the ridge and the fact that it rests upon a typical ganglion with connectives marks it as a definite sense organ.

In several species where the subradular organ and the related nerve supply have been well preserved a lobule of gland cells attaches to the ventral side of the digestive tract on each side of the subradular ganglion. This happens so invariably that it furnishes some evidence for the belief that these organs correspond to the ventral salivary glands in the neomenians, while the scattered yet compact glands attached to the dorsal or even lateral surface represent the dorsal salivary glands. There is at present no more cogent reason than their position for such an opinion, but their constancy indicates that they are structures of long standing.

The radula and its supports and musculature are relatively heavy (Plate **10**, fig. 1) but otherwise typical.

Posterior to the radula the alimentary canal narrows rapidly and unites with a highly enlarged section with very thin walls. The outer or proximal boundaries of the lining cells are clearly defined, but the presence of large quantities of a granular secretion in the neighboring lumen suggests that in the act of bringing the animal to the surface or owing to the method of fixation the distal, glandular products of the cells have become dislodged. Passing through the union of the pro- and metathorax (Plate **9**, fig. 18) the epithelial lining becomes thicker. In the anterior end of the metathorax it again grows thin (Plate **9**, fig. 16) save in the immediate neighborhood of the dorsal aorta, and where folds appear, especially on the ventral side, the cement substance between the cells assumes the form of minute granules (Plate **10**, fig. 7). Intercellular bridges may exist, judging from certain cells, but the state of preservation of the material renders this uncertain.

The liver, gonad, and intestine arise at practically the same level in the posterior end of the metathorax (Plate **10**, fig. 4), and are of typical structure and arrangement. The latter statement is likewise true of the entire intestine and of its outlet into the cloacal chamber.

A careful examination has been made of the nervous and circulatory systems, but the results do not call for a description beyond that afforded by the figures. The single specimen sectioned was a male with mature sex products in the gland itself and to a slight extent in the pericardial cavity.

The cloacal chamber may likewise be passed with a few words only. Generally speaking the epithelial lining is composed of low cubical cells that become somewhat more elongated in the neighborhood of the external openings of the coelomoducts. There are, however, no extended patches of columnar epithelium in this region such as occur in *Chaetoderma nitidulum* for example. Each branchia is provided with 11–12 plates so far as can be determined from cross sections.

The coelomoducts communicate with the pericardial chamber by clearly defined ciliated openings in the customary position beside the strong dorsal commissure. Extending anteriorly each canal rapidly loses its ciliated coat, assumes the characteristic glandular appearance and extends anteriorly about one third the entire length of the ventral section with which it then unites. The ventral division is provided with comparatively simple walls, the greatest outpouching occurring at the level of the pericardial openings. The external pores (Plate **10**, fig. 3) are located in the usual position in the cloacal cavity.

Chaetoderma bacillum, sp. nov.

Three specimens (one mutilated) of this species were dredged in 906 fathoms in the neighborhood of 200 miles southeast of Cape Cod, Massachusetts (Sta. 2076A). All were silvery gray in color with a slight tinge of buff due to the underlying somatic musculature, and are further characterized by a bright brick-red incrustation restricted to the spines surrounding the cloacal opening. The two perfect individuals measure 11 mm. and 17 mm. respectively in length by 0.9 mm. and 1.07 mm. in greatest diameter; the mutilated specimen was approximately 13 mm. in length by 1.2 mm. greatest diameter.

The spines are of the customary spearhead-type (Plate **11**, fig. 4), with moderate keels, and in the immediate neighborhood of the junction of the pro- and metathorax range from 0.11 mm. to 0.16 mm. in length. In this same region, at least, the hypodermal layer is clearly one cell thick, and generally speaking is composed of cells with clearly defined nuclei but invisible cell boundaries (Plate **10**, fig. 13). Among these are nuclei of the same general appearance, but of twice the bulk, that are in contact with, and appear to belong to, spherical or spheroid cavities containing in a preserved state a very small quantity of a finely granular coagulum. What these spaces are it is impossible to state definitely. They may contain calcareous salts in life or, as in several other species, notably *Chaetoderma attenuata*, they may be gland cells. At the base of each is a disc-like darkly staining body, presenting the appearance of a nucleus though this is not conclusive.

Delicate fibres traverse the underlying muscle layer at frequent intervals, and come in contact with the hypodermal layer and at several points appear to pass between the cells and then become lost to view. The nature of these fibres has not been determined. They react somewhat as connective tissue elsewhere in the body, and it may be mentioned are distributed to all of the hypodermal elements alike.

The buccal plate is partially exposed in one specimen only (Plate **11**, fig. 6), and appears to resemble a shield in form with the mouth holding a central position. In sections the shield consists of the usual thick cuticular plate resting upon cells of several different types, judging by their form and arrangement. Numerous muscle and large sized nerve fibres pass into the neighborhood of the epithelial cells, but the absence of distinct cell boundaries renders it impossible to determine their exact relations. Darkly staining masses, probably cells though their details are aggravatingly difficult to determine, are attached to the precerebral masses of ganglion cells, and from them delicate ductules make their way to the margins of the buccal plate. In some instances they open through the cuticular plate; in other cases they pass to the outside of its borders.

The mouth opens into a tubular canal without any particularly characteristic features. The lining epithelium, consisting of columnar epithelium fashioned into a few rather ill-defined folds, is surrounded by the customary muscle sheath in which a relatively few gland cells find lodgement. These last named elements are arranged in small lobules, and the component cells are occasionally charged with considerable quantities of a darkly staining secretion, though this is much more often greatly limited in quantity.

Immediately anterior to the radula a prominent fold appears in the mid ventral line of the digestive tract that is probably a subradular organ. The cells, unlike those elsewhere in the neighborhood, are sharply defined externally and are separated here and there by ductules from two masses of gland cells situated immediately ventral to the ridge in question. That the organ is sensory is evidenced by the fact that it rests upon a ganglion resembling in every important respect the one found in *Chaetoderma attenuata* for example.

The radula (Plate **10**, fig. 9) comprises the single tooth, relatively heavy in this species, and the wing-like supports together with matrix cells and muscular attachments that follow closely the arrangement of these organs in other species of the genus.

Posterior to the radula the digestive canal narrows rapidly, becomes circular in outline and after a brief course posteriorly unites with a more expanded portion, probably the commencement of the endodermal section. This enlarged division rapidly develops a variable number of small longitudinal folds — from 18 to 25 — that as the gut gradually narrows upon approaching the metathorax (Plate **10**, fig. 12), become correspondingly reduced, finally disappearing altogether. The cells throughout are clearly defined elements with spherical nuclei, and especially on the dorsal side beneath the aorta are distinctly glandular. This state of affairs continues for at least 1.5 mm. into the metathorax. Beyond this point sections were not made of the central portion of the body.

In the posterior end of the animal the intestine, somewhat larger in cross section than common, maintains the usual relations and opens into the cloaca. Its cells, in favorable situations, appear to be more cubical than those of the anterior end of the mid-gut, and present a denser appearance owing to a finely granular secretion they enclose. Diatoms and other substances, organic and inorganic, are present in abundance.

The circulatory system is typical in all essential particulars. The heart (Plate **10**, fig. 14) is distinctly more muscular than the average, and the dorsal aorta is not only larger than usual but it is lined with an endothelium uncommonly distinct especially in the anterior end of the body. Beyond this point no other distinctive features have been recognized.

The openings of the coelomoducts into the pericardium occur slightly behind the level of the posterior dorsal commissure. From this point the dorsal section of each of the ducts extends anteriorly and unites with the mid section of the main portion of the organ. This main, glandular or ventral section is characterized by great simplicity. Faint lobes occur in its walls accentuated by a very few internal septa.

The nervous system is normal in all of its essential features.

Chaetoderma squamosum, sp. nov.

A single specimen (Plate **11**, fig. 5) of this species was dredged at a depth of 1,234 fathoms (Sta. 2534A) about 200 miles southeast of Cape Cod, Massachusetts. The total length of the body was 25.7 mm. with a width of 1.3 mm. in the prothorax and of 1.2 mm. and 1.7 mm. through the metathorax and abdomen respectively. The color is grayish white due in part to a grayish colored incrustation particularly over the pro- and metathorax and to the lead colored liver partially visible through the translucent body wall and over lying spicules. The buccal sensory plate, roughly elliptical in outline, is somewhat concealed in the semicircular groove; it is apparent, however, that the mouth opening is comparatively small and is entirely surrounded by the plate.

In the neighborhood of the junction of the pro- and metathorax the spines (Plate **11**, fig. 9) measure from 0.11 to 0.19 mm., and are further characterized by unusual thinness and the absence of a sharply defined keel. The hypodermis (Plate **13**, fig. 7) lacks any distinguishing features. In many places, especially in the anterior end of the body, the nuclei are arranged in two or three layers although the cells to which they belong may actually constitute a single layer. Occasionally the more external nuclei are spindle-shaped, but it is not certain that this characteristic is correlated with any especial function. The nuclei of the spicule-matrix cells are conspicuous objects, nearly twice the size of the ordinary hypodermal nuclei, and are further distinguished by staining a lighter shade.

The buccal plate comprises a thick, external cuticular plate secreted by the underlying hypodermis whose cell boundaries are very difficult to determine. For this reason it is impossible in the present instance to accurately relate these elements to the numerous nerve and muscle fibres and to the ductules of deep seated gland cells. Generally speaking the hypodermal cells are relatively slender, often unusually high in the vicinity of the mouth and at various places muscle cells appear to pass between them to attach to the cuticular plate, while nerve fibres have been undoubtedly seen to attach to the bases of a few cells with spindle-shaped subcentral nuclei. The ductules perforating the plate, or opening adjacent to it, are usually closely associated with nerve fibres originating in the precerebral ganglia attached to the brain; but they have not been definitely traced to any special set of cells. Several groups of gland cells, of shrunken appearance probably owing to reagents, are imbedded in the wall of the digestive tube in the neighborhood of the mouth. These may be connected with the ductules in question, but on the other hand there are signs that they are in reality buccal glands opening by ill-defined passages into the digestive tract.

In common with other members of the genus, this species possesses a digestive tract comparatively simple in its structural details. The mouth opens into a well-defined buccal tube of average size and with slightly folded walls in which the lining epithelium consists of slender cells possibly ciliated and without very distinct cell boundaries. Immediately anterior to the peg-like tooth the ventral wall becomes modified to form a well-defined patch of slender, ciliated cells — the subradular organ, judging by position and innervation. Here and there, especially in the ventral half of the tract, gland cells are imbedded in the muscular walls, and in some instances at least open into the digestive tract by intercellular ductules. These glands become relatively abundant in the neighborhood of the radula where they chiefly open on prominent folds of the lateral walls of the gut.

The radula (Plate 11, fig. 10) is, as usual, a slender conical structure 0.4 mm. in length, and in its relations, muscular attachments, and matrix cells conforms closely to other species of the genus.

A very short distance posterior to the radula the digestive canal narrows rapidly, becoming elliptical in cross section, whereupon it almost immediately unites with a dilated portion whose walls have been largely stripped of their lining epithelium due apparently to the reduction of pressure upon being brought to the surface. Where it remains the cells agree in being relatively large columnar elements in which the centrally placed nuclei are unusually conspicuous. A darkly staining secretion covers their free surface, but its origin is uncertain, though it may have been elaborated by these cells as they generally show traces of glandular activity. This dilated section of the canal narrows considerably in the posterior end of the prothorax (Plate 11, fig. 8), and as an almost perfectly circular tube extends into the metathorax where it unites in characteristic fashion with the stomach and liver. In the abdomen a mass of diatoms, sponge spicules, and inorganic debris prevented sectioning; in the cloacal regions the position of the gut was typical.

The coelomoducts are comparatively simple structures, holding the usual position and presenting the customary appearance. Beyond this statement there is little to be added that will aid in diagnosing the species. From its opening into the pericardial cavity each duct, slender in outline pursues a course anteriorly and at the same time assumes a position dorsal to the main or ventral portion of the duct. In this situation, considerably enlarged and with three or four slight folds springing from its inner surface, it extends anteriorly for a considerable distance and becomes continuous with the ventral section. This last named division, relatively large in diameter and likewise supplied with a few folds, extends posteriorly until it has traversed approximately one third the length of the cloacal chamber into which it then opens by a conspicuous pore.

As in several other species of this genus the walls of the cloacal cavity are modified to form a well-defined area surrounding the external openings of the coelomoducts. The component cells comprise slender supporting cells and elongated gland cells sharply defined from the cubical elements that at other points line the chamber.

The nervous and circulatory systems were studied in detail, but no especially noteworthy features were encountered.

Neomenia verrilli, sp. nov.

A single specimen of this species occurs in the present collection, bearing the label "Gulf of St. Lawrence, 313 f'ms. J. F. Whiteaves, 1872." The animal has been decalcified and cut open along the mid dorsal line, an operation that has destroyed some of the organs though their general plan is still discernible. The body is thick-set (Plate **3**, fig. 6), bean-like in form and measures approximately 25 mm. in length by 8 mm. greatest diameter. The color in a preserved state is light yellow.

The work of decalcification is complete, not a sign of a spicule being evident, yet it is certain that, as in other species of Neomeniidae, one layer of spines was present originally. While the papillae differ in detail among themselves, these variations appear to be due to growth and possibly to some extent to fixation. Little if any pigment is present in the component cells, and no clearly defined nerve supply has been traced to them. It may be added that these organs are comparatively numerous (Plate **3**, fig. 8). The remaining hypodermal cells are comparatively small, without clearly defined boundaries and are devoid of features of special interest. No dorsal keel exists.

A well-defined spiculose, cuticular bridge separates the atrial cavity from the external opening of the anterior pedal gland. Anteriorly this last named space appears as a narrow slit, when viewed from the mid line, but in cross section it is seen to extend far outward on each side and to possess plain though highly glandular walls. About midway its dorsal wall loses its glandular character and develops numerous folds, large and small, which more posteriorly decrease to seven or eight. In the middle of the body the foot has been cut away, but in the posterior third it reappears with this reduced number of folds. Whether this condition continues to the cloacal chamber cannot be determined owing to slight mutilations.

As noted previously the anterior, plain-walled section of the anterior pedal gland outlet is composed of highly glandular cells whose secretion, after treatment with Delafield's haematoxylin, stains a uniform lavendar tint. With the appearance of the folds on its dorsal surface the component cells lose their glandular character, and the deeper seated cells, pyriform in shape and opening by delicate ductules through the folds, stain intensely and probably represent the anterior pedal gland of other neomenians. Posterior to the anterior pedal gland outlet these last named glandular elements decrease in size and number and shade into the posterior pedal gland.

The extremities of the body presented almost identically the same appearance, and it was only from the study of sections that the atrial opening was definitely located. The cirrose cavity into which it leads is relatively small, and is almost completely separated into two subdivisions crowded on each side of the body against the body wall (Plate **4**, fig. 7). While there are no clearly differentiated sensory ridges bounding the cirrose area, the entire atrial cavity, with the exception of the cirri themselves, is lined with an epithelium composed of high and slender cells similar to those composing the ridges in other species. Appearances indicate that these cells are sensory in character, but the absence of undoubted nerves renders the identification uncertain. Along the inner boundary of the cirrose area is an unusually high fold that like a curtain shuts off to a large extent these lateral cavities from the median space, which may represent the buccal cavity. If this fold represents the inner atrial ridge of other Solenogastres its cells, low in form and non-ciliated, give no indication of possessing any sensory function.

At the commencement of the buccal or pharyngeal cavity, a great fold, seamed with numerous minor corrugations, springs from the dorsal side, and in the first part of its course almost fills the cavity. More posteriorly it becomes subdivided into three or four lesser folds, that, with others which have arisen on the lateral and ventral surfaces of the pharynx, extend longitudinally to a point probably corresponding to the posterior end of the pharyngeal tube where they terminate as abruptly as they began (Plate **3**, fig. 4). All of these folds are deeply furrowed with secondary ridges, and are supported by an abundance of muscle and connective tissue, which likewise give support to a large number of gland cells. These last named elements appear to be grouped in the form of slender lobules, but the protoplasm of which they are composed stains but faintly, and their relations with the overlying epithelium are obscure. At several points what appear to be ductules are evident, and a darkly staining secretion on the exposed surface of the pharyngeal epithelium indicates that the products from these cells escape as usual by intercellular channels.

As noted in the foregoing paragraph the large pharyngeal folds end abruptly posteriorly; and immediately behind them a large circular fold arises composed of muscle and connective tissue penetrated by blood sinuses. This fold appears to be capable of a certain amount of protrusion, but owing to the lack of well-defined protractors and retractors its movement is probably limited. The lining epithelium is composed of high, slender cells charged distally with a granular secretion not encountered elsewhere in the digestive tract. Distinct ventral salivary glands are absent, and it is possible that these cells are homologous or at all events that they perform a similar function.

No radula is present.

Beyond this circular fold the stomach-intestine appears with walls fashioned into numerous longitudinal folds lined internally with digestive cells without distinct boundaries and densely packed with innumerable granules. Along the mid-ventral line the cells of this character blend insensibly with others, almost cubical in form, and non-glandular, that anteriorly form a narrow trough-like tract which nearer the middle of the body develops folds and in this condition extends to the region of the seminal receptacles. Here the intestine narrows to pass between the limbs of the coelomoducts, and this non-glandular portion of the gut gradually extends toward the dorsal side until at the anal opening it comprises fully half of the digestive tube. The mutilation of the specimen renders it impossible to state with certainty, but it appears that the dorsal glandular tract does not disappear until the cloacal chamber is reached.

The cloacal cavity is a spacious chamber, and as in other species of the genus its walls are provided with extensive branchial folds (Plate **4**, fig. 5), numbering apparently between fifteen and twenty pairs. These in turn are often supplied with many secondary folds, the appearance in cross section reminding one strongly of ctenidia.

Between the bases of these folds and the somatic musculature are large numbers of gland cells separated into small lobules by connective-tissue septa between which blood sinuses make their way. No traces of ductules are apparent though there are evidences here and there, possibly a *post mortem* effect, that some of the cells have released their hold and are free in the blood stream, while others, attached by very slender stalks, appear to be in process of liberation. In a general way these elements remind one of the concrement cells as described by Brock (1883), but there is no definite evidence that they are homologous or that they function similarly.

The circulatory system has suffered to a greater extent from the mutilation of the specimen than any other set of organs, but so far as determined it conforms closely to the neomenian type. The pericardial cavity is of moderate size only, and the ventral displacement indicated in the reconstruction (Plate 3, fig. 1), may be an abnormal state of affairs. As indicated there is a shallow pouch-like expansion of the forward wall in the neighborhood of the renopericardial openings, but with the exception of a somewhat thicker, slightly corrugated wall there are no indications that it may play any especial function.

The heart is a two-chambered organ, the blood from the branchiae and the dorsal part of the posterior end of the body entering the hindmost section. There are indications of a valve guarding the union of the two divisions. The clearly defined dorsal aorta, holding the usual position and supplying the customary organs, makes its way to the head cavity, and there communicates with an extensive system of spaces which in turn soon combine to form the median ventral sinus and that of the general visceral cavity. In the posterior end of the body, about the level of the anterior end of the shell gland, the first named of these canals rapidly diminishes in size, while the other communicates with spaces leading into the branchiae and beyond them into the heart.

The nervous system is more than usually well-defined, and for this reason more than ordinary care has been taken to determine the position of the various ganglia and their more important branches. The brain occupies the usual position above the atrial cavity, and with the exception of its comparatively small size presents no especially noteworthy features. As usual it originates on its anterior face several nerves that are distributed to the atrium and the adjacent body wall; and laterally it gives rise to the connectives passing to the labiobuccal, lateral, and ventral ganglia. The last named connectives like the brain, are of exceptionally small calibre, and lying loosely in the visceral cavity may be traced to the region of the outlet of the anterior pedal gland where they unite with the ventral ganglia. Close to the point of union the ganglia are strongly enlarged, and are united by two commissures of considerably larger size than those in a more posterior position.

With the exception of the most anterior, the connectives uniting the lateral and ventral ganglia are spaced at fairly definite intervals. The exception arises on each side from what appears to be the connective to the ventral ganglion since no nerve cells occur in its vicinity, and on the other hand it unites with the anterior swollen extremity of the lateral cords. The last named enlargement gives rise to two strong branches of which the smaller, directed anteriorly, makes its way into the vicinity of the bases of the cirri. The other makes its way ventrally and is distributed in part to the somatic muscles, while a comparatively large nerve extends between the lobules of the anterior pedal gland where it becomes lost to view. Another nerve destined to the same organ arises from the lateral cords about midway between the first and second latero-ventral connectives.

As usual nerves spring from the dorsal side of the lateral ganglia, and though clearly defined and of relatively large size none have been traced as far as the mid-dorsal line. They branch repeatedly over the internal face of the somatic muscles which they probably innervate together with the overlying hypodermis.

The labiobuccal connectives are so closely associated with the lateral for a short distance beyond the brain that though they are fairly distinct they nevertheless occupy the same sheath. Beyond this point they may be followed with unusual clearness, and owing to this fact more than ordinary care has been exercised in determining the relation of the principal elements. Loosely attached to the muscular coat of the digestive tract each connective extends posteriorly to the labiobuccal ganglion placed about opposite the posterior end of the outlet of the anterior pedal gland. At approximately two thirds of its length from the brain two or three branches are developed of which the largest, crossing the dorsal surface of the pharynx, forms a commissure. The others, imbedded in the muscular pharyngeal walls, have been followed to a greater or less extent until their subdivisions become so small in cross sections that they disappear from view. At many points minute nerves appear in the pharyngeal wall, and give the impression that they are parts of an extensive plexus such as is known to ensheath the digestive tract in several other molluscs. Other nerves of this same character occur at a short distance anterior to the labiobuccal ganglia.

Immediately in front of the ganglia a simple, ventral commissure occurs.

A few small nerves arise from it, but soon become lost to sight in the ventral pharyngeal musculature. The labiobuccal ganglia are sharply defined spherical structures, and each is connected by a dorsal and ventral commissure. There are thus two dorsal and two ventral commissures, but no signs whatever of a subradular complex. This is not surprising as a radula is lacking completely, and a subradular organ, if such exists, is far from being a sharply differentiated structure.

The nervous system in the posterior end of the animal has been partially destroyed so that only the broader features have been worked out. Its general configuration, however, is essentially the same as in *Drepanomenia vampyrella.* The pedal cords continue to a point about opposite the middle of the cloacal coecum or vagina (Wiren) where they bend abruptly, and coursing dorsally and posteriorly unite with the lateral cords slightly ventral to the openings of the coelomoducts into the pericardium. From this point of union, on one side, a heavy nerve, doubtless the dorsal commissure, extends for a considerable distance toward the mid line. The commissures uniting the pedal cords appear to be more numerous than the latero-pedal connectives, but beyond this fact no especially interesting features have been observed.

As usual the animal is monoecious, and in this instance is sexually mature, the swollen gland extending from the pharyngeal region to the pericardium being distended with sex products in all stages of development. Anteriorly the ovo-testis contains sperms only, but a very short distance behind the forward tip of the organ ova appear attached as usual to the inner faces of the tubes. The canals leading into the pericardium are comparatively short, though of more than average diameter, and are richly ciliated throughout. As is more fully described in the section on the circulation, the pericardium is provided on each side of the body with two relatively wide diverticula with which the coelomoducts connect. The reno-pericardial openings are unusually wide and conspicuous, and are further distinguished by being surrounded by cells of greater height than is encountered elsewhere in the pericardial wall and by bearing a ciliated coat.

The upper section of each coelomoduct, pursuing its way anteriorly to the region of the seminal receptacle, is of more than ordinary length and is fashioned into a number of short turns (Plate 3, fig. 4) that give it a somewhat complicated appearance in cross section. Throughout its entire extent each canal is provided with a dozen or more high, longitudinal ridges supported by muscle and connective-tissue fibres penetrated in many instances by blood sinuses. The component epithelial cells are relatively slender, of moderate height and in addition to containing small amounts of some finely granular substance support a well-defined ciliated coat.

At the junction of the dorsal and ventral divisions of the coelomoducts on each side is a large vesicular appendage (re) that probably functions as a seminal receptacle since each contains a very few spermatozoa together with a small amount of some glandular secretion. The walls of the neck-like duct are similar to those of the dorsal limb of the coelomoduct, and are heavily ciliated, as are the cells of the receptacle adjacent to it. On the other hand the walls of the expanded portion comprise cells of two types, goblet-shaped glandular elements with basal or subcentral nuclei, and exceedingly slender supporting cells. The secretion of the first named class is restricted to the distal half of the cell, and from its homogeneous appearance and seemingly viscous character probably exists in the form of a fluid in living material.

The ventral limbs of the coelomoducts hold the customary relation to the other organs in the posterior end of the body, and are not only of relatively small diameter but the walls are comparatively thin. From the quantities of secretion imbedded in the walls it appears probable that this is the usual state of affairs. The epithelial lining is thrown into folds of varying sizes each supported usually by fibres sent in from the sheath surrounding the organ. The cells are high, slender elements with the distal portion containing groups of small granules staining moderately with Delafield's haematoxylin. This state of affairs continues to the median, undivided section where the cells become more nearly cubical especially in the neighborhood of the opening into the cloacal chamber. The external reproductive pore does not communicate directly with the general cloacal cavity, but with a compartment of it that in turn gives rise to the diverticula responsible for the development of the penial spines. Ventrally this same space leads into a heavy tubular outgrowth termed by Wiren (1892) the vagina or copulation organ.

The so-called vagina (co) is a diverticulum of the anterior cloacal wall reinforced with a heavy muscular sheath. The muscular elements comprise three classes, an innermost, heavy circular layer external to which is a thin covering of longitudinal fibres, while here and there small, radiating bundles extend through these layers from the neighborhood of the inner epithelial lining. The internal bounding membrane consists of slender, ciliated cells, apparently slightly glandular, produced into numerous small folds. Along the mid-ventral line the muscular sheaths are pushed inward, thus producing a species of typhlosole that continues throughout the greater part of the organ.

Distally the vagina opens into a pair of relatively large sac-like organs symmetrically placed on each side of the mid line. From sections, which pass longitudinally through these structures, it is very difficult to gain a clear idea of their character, and, as will be seen, it is equally trying to ascribe to them a definite function. The epithelial lining appears to be fashioned into a large number of heavy folds (Plate 3, fig. 3), and occasionally where the walls are bare they appear golden yellow in color after treatment with haematoxylin. This seemingly is due to large quantities of secretion, though even with high magnification cell boundaries and nuclei are invisible. Generally speaking the lining epithelium affords attachment for myriads of spermatozoa, which, with great regularity of arrangement, seem to be imbedded in the cells themselves, while the tails extend outwardly and together with the above mentioned secretion practically fill the lumen of the organ. Even in portions of the vagina and the expansions of the cloacal wall, into which the penial spines emerge, sperms find attachment to the lining epithelium though their numbers per unit area are considerably less than in the vesicles themselves. It may be mentioned that the golden yellow secretion occurs at intervals throughout the vagina and lateral to it, having apparently passed into these locations from the sac-like expansions or vesicles.

Regularity of arrangement of spermatozoa within a vesicle is usually considered to be an indication that the organ in question functions as a seminal receptacle, while the reverse condition indicates that the structure plays the rôle of a seminal vesicle. If such a line of argument be followed in the present instance then these pouches are seminal receptacles. It is a very unusual thing, unique in fact, to find organs such as these in such a situation, and it is the more difficult to look upon them as receptacles since a pair of these last named organs occurs in the usual position at the junction of the dorsal and ventral limbs of the coelomoducts. It is possible that they function as such temporarily, and that the sperms take up their final position in the usual receptacles, but nothing short of a series of specimens in different stages of sexual maturity will indicate the true solution of the problem.

Wiren (1892) has described a vesicular attachment, filled with sperms, of the dorsal limbs of the coelomoducts in the neighborhood of the pericardial openings in *Neomenia carinata*. In sections they hold the same general position that the sperm sacs do in the present species, but in our specimen the dorsal limbs are unmutilated, and a careful examination of them throughout their entire length fails to disclose any spermatozoa, much less any noticeable enlargement.

Each penial spicule sheath and the included spine are of unusual length and girth, and with the accompanying muscles form a very conspicuous element of the accessory reproductive apparatus. In addition to these elements there exists a trough-like guide or groove (Plate 4, fig. 8) in which the spicule rests. As in the case of the spine this guide appears to be cuticular in character, but whether in life this serves as a matrix for calcium salts it is impossible to state at present. Both of the structures are secreted by numerous slender cells, clear and well-defined at the distal extremity of the sheath, but growing indistinguishable near the free opposite end.

The external sheath is composed largely of connective tissue to which the retractor and protractor muscles are attached. The first named are of larger size and are united with the sheath in the neighborhood of its distal extremity. On the other hand they become inserted chiefly in the cuticular trough though small slips extend to the spine that thus is possessed of a certain amount of independent action. The protractors attaching to the spine are comparatively thin and delicate, and, so far as may be judged from sections, are attached both to the grooved guide and to the sheath. Another protractor, of much larger size, is inserted in the grooved plate near its outer end, and extending in a postero-ventral direction fuses with the somatic musculature lateral to the posterior termination of the foot.

In addition to these elements the spicular apparatus comprises a pair of highly developed glands (pgl) that in the present instance are fully as large as the shell gland. Each of these is placed somewhat above and to the inside of the ventral limbs of the coelomoducts or shell gland (Plate 4, fig. 1), and presents the appearance of an inflated sac ellipsoid in form. Internally well-defined septa spring from the walls, and in the anterior end of the organ these become so united that they form a number of diverticula communicating with the main cavity of the gland. The cells of the epithelial lining are more or less goblet-like in shape, and distally contain vacuoles in which are occasional globules of some secretion.

In the neighborhood of the free extremity of the retracted spine a duct opens into the surrounding space, and on the other hand passes laterally then dorsally and toward the mid line to enter the mass of connective tissue ventral to the shell gland. In this position, close to the gland just described, it becomes lost to view owing to the mutilation of the specimen. Two possibilities present themselves; either it opens into the shell gland or into this large, overlying gland. The former course appears unlikely, especially in view of the fact that in *Neomenia carinata* Wiren (1892) has described a large accessory penial gland whose relations bear a close resemblance to the state of affairs in the present case.

In conclusion it may be added that the members of the genus Neomenia can scarcely be considered primitive. The complexity of the reproductive system especially, with its penial spines and glands, seminal vesicles, and receptacles, appears to indicate that the genus stands in about the same relation to the primitive mollusc that the pulmonates do to the prosobranchs.

Proneomenia acuminata Wiren.

One specimen of this species was dredged in the Straits of Florida (Sta. 5 Be) at a depth of 152–229 fathoms; a second was taken south of Martha's Vineyard, Mass. (St. 893 Fk) at a depth of 372 fathoms; while a third came from practically the same location (Sta. 2547 A) at a depth of 390 fathoms. The first is somewhat distorted, and in a normal state probably measured not far from 20 mm. in length by 1.7 mm. in thickness: the second is 23 mm. long by 1.8 mm. thick; the third measures 30 mm. in length by 1.7 mm. in diameter. The anterior end is bluntly rounded (Plate 5, fig. 3), while the posterior extremity terminates in a rounded point, and owing to the large size of the cloacal opening it is probable that in life its borders can be widely expanded as in the case of *Ichthyomenia ichthyodes*.

The atrial opening, surrounded by rounded, prominent lips, is distinctly separated from the ventral groove whose anterior excavation, the outlet of the anterior pedal gland, is invisible externally though in decalcified material it shows faintly through the translucent cuticle. While the outline of the outlet is somewhat irregular in form it consists, generally speaking, of hemispherical diverticula extending laterally a short distance from the ventral groove.

The anterior pedal gland is a voluminous organ occupying most of the visceral cavity between the region of the radula and the outlet of the dorsal salivary gland. Although the cells are of varying size, owing to age or the amount of secretion they contain, all agree in being more or less pyriform with an irregular somewhat varicose ductule leading to the exterior of the body. The secretion itself is invariably finely granular, staining intensely in Delafield's haematoxylin, and usually fills the cell. As is the case generally with the Neomeniidae the ductules open by intercellular channels into the anterior end of the ventral furrow.

The posterior pedal gland is directly continuous with the anterior from which it differs in no essential particular, save in the smaller size of the cells and their lesser number. The ductules lead to the median fold, or rudimentary foot, and in addition are distributed to the epithelium of the ventral groove generally as far as the spiculose cuticle. With the posterior termination of the foot in the neighborhood of the external reproductive pore, these cells disappear, but close behind the gonoduct exit the wall of the cloaca is supplied with a scattering band of cells of the same character opening along the border of the spiculose cuticle.

The cuticle is of moderate thickness only and the hypodermis is exceptionally thin and its cells difficult to interpret. The spicules, with which the cuticle is crowded, are of the customary proneomenian type, slender, slightly curved needle-shaped structures (Plate 5, fig. 4) arranged in approximately seven layers. Radially directed spines appear to be lacking excepting in the region of the ventral groove.

The papillae (Plate 5, fig. 6) appear in life to have been filled with a highly fluid substance that after treatment with reagents largely disappears, leaving the few component cells in a much shriveled condition. In the expanded portion five to seven nuclei are usually visible; none appear in the stalk.

As noted previously the hypodermis is a very thin sheet, and the component cells are very inconspicuous. The spicule-matrix elements on the other hand are relatively distinct, and maintain essentially the same relations as in *Proneomenia hawaiiensis* for example. The cells retain their attachment to the spine until the latter has travelled halfway to the surface of the body, and in some cases they retain their connection for a longer period.

The position of the dorso-terminal sense organ was discernible in surface view, owing to the presence of numerous, small overarching spines though the cavity itself was not visible. In sections it presents the appearance of a hemispherical depression composed of very slender cells resting upon the somatic musculature. A unique feature appears in the form of a comparatively large number of gland cells filled with a darkly staining secretion, located about the rim of the pit adjoining the spiculose cuticle. In some instances the cells are in the general hypodermal layer; in other cases they are in the underlying tissue, but in any case they open through intercellular spaces about the margin of the depression.

There are strong reasons for the belief, first expressed by Thiele, that the anterior enlargement of the digestive tract, with its ciliated ridges and finger-shaped cirri, is in reality a modified snout homologous with that in the Chitons, and perhaps with the sensory shield in the Chaetodermatidae. On such an assumption the true mouth is deeply seated, and in the present case is in the neighborhood of the outlet of the dorsal salivary gland.

In the specimen in hand the atrial opening, subterminal in position is a relatively long narrow slit leading into a spacious chamber, the atrial cavity, whose limits are fairly well-defined by two prominent horseshoe-shaped ridges, which fuse posteriorly (Plate 5, fig. 1). The first of these, the outermost and continuous across the mid line, courses parallel to the borders of the outer opening, and is bounded externally by slender cells bearing a well-defined coat of cilia. Internally it is supported by an abundance of connective tissue and is penetrated by a blood sinus distended by blood corpuscles. It thus appears, as has been suggested, that these organs may play a part in the process of respiration, but the nature of the overlying epithelium and the presence of nerve fibres beneath it indicates also that it is a sense organ though its office is unknown.

As in *Proneomenia hawaiiensis* and some other neomenians, this external atrial ridge is bounded on its outer side by a lower prominence (Plate 5, fig. 1) whose slender cells are fully twice as high and are evidently sensory. In this species fibres may be traced into its neighborhood, but it is not so evident that they are sensory as in a few other species. In *P. hawaiiensis* a cord-like group of ganglion cells is situated in close proximity to the overlying ridge, which it supplies with numerous delicate fibres, and in the opposite direction is united at fairly frequent intervals with some of the ganglia located about the bases of the cirri. There thus appears to be little doubt that in such cases we are dealing with a definite sense organ, and it is probable that in *Proneomenia acuminata* the same is true.

Throughout its entire extent this external sensory ridge contains a small number of gland cells, whose slightly vacuolated secretion stains intensely in haematoxylin. In the posterior third of its course additional cells of the same character appear in the outlying hypodermis beneath the spiculose investment, and in this position they continue to the posterior border of the atrial cavity.

The inner atrial ridge, in form and structure and perhaps in function, is the counterpart of the external one (Plate 5, fig. 1).

In the area circumscribed by these prominences the cirrose area is located, and is characterized in the present instance by numerous slender diverticula of the atrial wall. These arise singly, and are further distinguished by multitudes of slender, lightly staining cells containing small quantities of yellowish pigment. The contained cavity is extremely slender, preventing the entrance of blood corpuscles but allowing the entrance of slender fibres from the underlying tissue. In certain species these fibres appear to be in part branches of nerves and such may be the case here, but the contorted appearance of these organs leads to the belief that contained muscle fibres are, at least in part, responsible for their condition.

Immediately behind the union of the atrial ridges the wall of the digestive tract is smooth, but rapidly develops folds, as the pharynx is approached, of irregular appearance and bounded by the cubical cells characteristic of the pharyngeal epithelium generally. The accompanying figure (Plate 5, fig. 1) represents approximately the existing state of affairs, but the folds though generally longitudinal are somewhat diagrammatically shown.

In this species the dorsal salivary gland (Plate 4, fig. 11, Plate 5, fig. 1) is a marked feature, owing to its size and compactness. It comprises numerous globular or pear-shaped lobules of various sizes bounded by a connective-tissue sheath, and in every instance these are without central cavities. The component cells are pyriform, and their ductules open by intercellular channels in the epithelium of the prominent diverticulum on the dorsal wall of the pharynx. Vacuoles are abundant in their cytoplasm, and in life they are doubtless filled with a secretion that in preserved material stains very faintly in haematoxylin.

From the outlet of the dorsal salivary gland to the forward end of the radula the pharynx is approximately circular in outline, and is reinforced by a layer of circular muscles and more externally by a longitudinal set. Radiating bundles, acting as dilators, pass from this muscle sheath to the body wall.

The ventral salivary glands are tubular, paired organs about 3 mm. in length, situated throughout the greater part of their course on the ventral side of the body between the stomach-intestine and the body wall. The component cells, all bordering on the narrow centrally placed lumen (Plate 5, fig. 2), are without definite cell boundaries, and the secretion they elaborate occupies numerous vacuoles in the cytoplasm except in the immediate vicinity of the basal or subcentral nuclei. In close proximity to its outlet into the pharynx this glandular portion passes abruptly into a much more slender, non-glandular duct leading to the opening at the side of the exposed portion of the radula. In this non-glandular section the lumen is eccentrically placed, the ventral cells being three or four times longer than those of the dorsal side.

The radula is a well-defined structure, normally placed, and is of the polystichous type. The teeth (Plate 4, fig. 9) are comparatively small and delicate, and as far as may be judged from cross sections number approximately twenty-eight in each transverse row of which there appear to be about forty-five, though this last estimate is difficult to prove definitely. The radular supports lack the vesicular structures found in several other species of neomenians, and consist entirely of a compact mass of muscle and connective-tissue fibres far too intricate to define accurately from the study of sections alone. It may be said, however, that close to the posterior end of the radula fibres pass to the overlying pharynx or oesophagus, and others, much more powerful, extend from the extreme posterior tip to the overlying radula sheath. In addition to these, numbers of others extend from the radula sheath to the walls of the pharynx. It thus appears that the radula, by reason of its intrinsic muscles, is capable of considerable movement but probably, during the feeding process, the greatest motion is produced by the protrusion and retraction of the pharynx which carries the radula forward and backward.

In *Proneomenia hawaiiensis* two well-defined subradular organs exist innervated by fibres from ganglia, connectives, and commissure essentially the same as in the Chitons for example. In the present specimen two patches of modified cells, of the same character, exist and as they are in close proximity to a pair of small ganglia it is reasonable to believe that here likewise we are dealing with a definite sense organ. The component cells (Plate 4, fig. 10) form knob-like elevations, surrounded by a shallow groove, on each side of the forward border of the radula. Posteriorly they become continuous with the ventral wall of the short, non-glandular ducts from the ventral salivary glands so that the secretion from these organs pours over them in escaping into the pharynx.

In addition to these two modified areas the epithelium, continuous with them across the mid line, is also of unusual height, being fully three times thicker than that bounding the pharynx elsewhere (Plate 4, fig. 10). Its cells appear, though not clearly, to contain small amounts of some faintly staining secretion, but whether this is associated with a special sensory function has not been determined since no definite nerve supply has been detected.

Immediately behind the radula the pharynx unites with the stomach-intestine without any material change in the character of the epithelial lining or the nature of its longitudinal folds. And furthermore the stomach-intestine itself with its glandular lining and regular outpouchings does not differ from the usual neomenian type, though certain features demand a brief description.

The first of these concerns the anterior dorsal coecum, which extends as far forward as the brain. Throughout its entire course it is dorsoventrally compressed, and is totally devoid of pouches though its lining epithelium resembles that of the stomach-intestine. Ventral to its base (Plate 5, figs. 1, 2) is a much smaller, anteriorly directed coecum similar, in the character of its lining cells, muscular sheath and folds, to the pharynx with which it is directly continuous. Finally the pharyngeal epithelium extends along the ventral side of the digestive tract as far as a dorsoventrally compressed ventral coecum whose cells are identical with those of the stomach-intestine. It is thus apparent that the pharynx or oesophagus dilates posteriorly into a funnel-shaped structure and in this form unites with the stomach-intestine.

The stomach-intestine, with its lateral sacculations, dorsal ciliated tract, and lining of digestive cells, presents no especially noteworthy features. As it passes between the limbs of the gonoducts it becomes triangular, then more or less elliptical as it crosses the undivided section and finally as an almost circular canal it opens into the cloaca.

The cloacal chamber is of moderate size only (Plate 5, fig. 5), and its plain or only slightly folded walls exhibit no especial peculiarities though it may be said that the cells forming the lateral walls are heavily ciliated. Undigested material, associated with some darkly staining secretion, fills the cavity with the exception of that held by a parasitic or commensal worm, apparently a rhabdocele.

The condition of the present specimen indicates that the breeding season was close at hand, as the gonad is greatly distended with sex products and the gonoducts are in a condition of great glandular activity. The reproductive gland, distinctly paired throughout, extends anteriorly as far as the level of the radula, and on the other hand unites, as usual, with the front end of the pericardial cavity. With the extreme forward tip of each division of the gonad the organ is filled laterally with male products, in all stages of development while large numbers of what appear to be nearly mature ova attach to the wall along the mid line.

Posteriorly the conditions are peculiar. The halves of the gland diverge widely until in the region of the pericardium they are separated by a space nearly equal to one third the diameter of the body. This intervening space is spanned dorsoventrally by muscle fibres, and is filled with blood corpuscles and furthermore is directly continuous with the heart so that it is doubtless a greatly expanded aorta. Close to the posterior end of each half of the ovo-testis a small duct arises from the dorsal side and coursing ventrally to a slight degree it then pursues a direct path (about once again as long as is represented in Plate 5, fig. 5) to the forward end of the pericardium. The lateral walls of these small canals are folded to a slight degree, and the slender cells support a ciliated coat. Toward the mid line the walls are relatively smooth and serve for the attachment of small numbers of spermatozoa that have also made their way into the front end of the pericardium.

Posteriorly the walls of the pericardium are continuous with the coelomoducts that arise as slender tubes with plain walls consisting of cubical, ciliated cells. During the first part of their course each is crowded between the shell gland and the somatic musculature, but after extending upwards of one third the distance to their anterior attachment they shift into the angle between the shell gland and the seminal receptacle and become considerably enlarged. The walls show slight signs of glandular activity and here and there the cells form slight folds. The opening into the shell gland is borne on the summit of a hemispherical papilla, and is further marked by a yellowish secretion (unstained in haematoxylin) that has escaped from the dorsal section and may be traced some distance posteriorly in the lumen of the shell gland.

Each seminal receptacle is an elongated sac, of sinuous outline when viewed dorsally, resting upon the anterior horn of the shell gland. The walls are relatively thick with slight folds here and there and present a dense appearance due apparently to the presence of a finely granular secretion. A very few spermatozoa find attachment to the walls. The union with the shell gland is made by means of a very slender, short tube placed slightly in front of the union of the dorsal and ventral sections of the coelomoduct.

The shell gland, or ventral division of the coelomoduct, is of the usual horseshoe-shape, and as may be seen in the figures is a massive affair. For a distance equal to half the length of the seminal receptacle its epithelial lining is charged with a darkly staining granular secretion that in many places has escaped into the adjacent relatively large lumen. Posterior to this point the nature of the cells changes abruptly for not only do they become of greater height but the secretion, practically unaffected by haematoxylin, acts as though in life it had been of a highly viscous character. This is especially true of the elements of the ventral half of the organ which continue to present this appearance throughout the median, undivided section of the shell gland as far as the point where it narrows to form the small, non-glandular tube communicating with the cloacal chamber. On the other hand the dorsal cells of the median division of shell gland become charged with a darkly staining, partially granular, secretion which likewise extends to the narrow canal communicating with the cloaca. The terminal section of the coelomoducts is a tube of comparatively small diameter (Plate 5, figs. 5, 8) composed of slender cells fashioned into several inconspicuous folds. Circular muscles form a sheath about it, and radiating bands, probably functioning as dilators, pass from it to the body wall.

In sections it may be seen that the spiculose investment of the animal extends within the body as far as the external reproductive aperture (Plate 5, fig. 5). What probably function as copulatory spicules occur at the sides of the ventral furrow (openings shown in Plate 5, fig. 8) a short distance in front of the posterior end of the foot. These organs present the form of needle-like bodies, so far as can be judged from decalcified specimens, are probably derived from the usual type of spine occurring everywhere in the region of the ventral furrow, and form two groups of from 12–14 on each side of the mid line. Each spine occupies its individual sheath, which extends anteriorly and laterally from the outer opening, and ends blindly where a single matrix cell is located. While no definite muscles appear to attach to these bodies, the region in which they occur, and in fact the entire border of the cloacal chamber, is highly muscular and doubtless can be opened widely, thus bringing these penial spines into an exposed position.

The type-specimens of this species was taken in the "West Indies" at a depth of 540 meters, practically the same as the habitat of the present specimens. Some of Wiren's reconstructions and drawings of various organs appear to be somewhat diagrammatic and do not entirely accord with what exists in the specimens in hand. Accordingly the foregoing detailed description has been arranged with the hope that it may be compared with Wiren's account and the type-specimen.

Dorymenia peroneopsis, sp. nov.

A single, unattached specimen of this species was dredged south of Martha's Vineyard, Massachusetts (Sta. 2715A) at a depth of 1,753 fathoms. The body measuring approximately 25 mm. in length by 2 mm. in greatest thickness, is broadly elliptical in cross section with a slight flattening of the ventral surface. The anterior end is bluntly rounded while the posterior extremity tapers abruptly to a point. From external view no line of separation exists between the atrial opening and the ventral furrow, and sections show that the usual spiculose bridge is lacking. The outlet of the anterior pedal gland is accordingly located immediately behind the external opening of the atrium, although otherwise it is not especially modified externally. The ventral furrow is continuous with the cloacal chamber. The cloacal opening is relatively large, ventrally placed and is overarched by the posterior pointed end of the body, whose lateral margins may perhaps be separated in life to expose the genital spicula, the appearance of the hinder end of the animal at such times resembling *Ichthyomenia ichthyodes.*

A well-developed dorso-terminal sense organ (Plate 7, fig. 7), visible in sections only, is present about the level of the anterior margin of the cloacal opening. It presents the usual cup-shaped appearance, is adjacent to the median dorsal sinus entering the posterior end of the heart, and is innervated by two nerves springing from the mid section of the suprarectal commissure lying immediately posterior to the pericardium.

The cuticle investing the body is of more than average thickness (0.1 mm.) and is developed by a hypodermal layer whose component cells are not clearly defined and therefore are unfavorable for study. So far as could be determined they comprise three types, columnar elements seemingly responsible for the development of the cuticle, spicule-matrix cells which in early stages are indistinguishable from the foregoing, and those forming the papillae. These last named structures are stubby bodies (Plate 8, fig. 9), resembling an inverted cone composed of highly vacuolated protoplasm in which nuclei are usually visible throughout the entire organ.

The spicules are hollow, needle-like bodies (Plate 8, fig. 2) those of alternate layers crossing the others almost at right angles. In their formation no points of especial interest have appeared. As usual several cells take part in the process, and after functioning appear to shrink back into the hypodermal layer without retaining any visible connection with the spicule. The average length of fully developed spines from the sides of the body about the middle of the animal measure from 0.4 to 0.48 mm.

The anterior pedal gland is an organ of moderate size occupying the major portion of the visceral cavity between the level of the mid section of the atrial cavity and the posterior border of the brain. The component pyriform cells, measuring from 0.017 to 0.0216 mm. in greatest length, are early filled with a stringy, violet colored secretion, after treatment with Delafield's haematoxylin, which becomes finely granular in the later stages of its development. Each cell is continuous, as usual, with a delicate ductule which opens by an intercellular channel to the exterior.

The outlet of the anterior pedal gland, when viewed laterally from the mid line, presents the appearance of a fairly long, narrow slit (Plate 7, fig. 5). In cross sections this slit is seen to expand laterally into a well-developed chamber with corrugated walls composed of columnar cells furnished with a heavy coat of cilia. The folds of the dorsal wall merge into a single median fold which more posteriorly becomes continuous with the foot. Everywhere throughout this fold, and over the entire surface of each crypt, the secretion of the anterior pedal gland makes its exit in the form of a finely granular, almost homogeneous substance with a strong affinity for haematoxylin dyes.

The posterior pedal gland is moderately developed, and in the form of a slender rod of cells on each side of the mid line continues from the anterior pedal gland to the cloacal opening. The foot itself presents the usual wedge-shaped form, accompanied on each side by a non-spiculose hypodermal layer, both structures serving as the outlet for the secretion of the gland.

The atrial opening, holding the customary subterminal position, leads into a cavity possessing essentially the same relations as in various other species of neomenians. Two horseshoe-shaped ridges, an internal and external, surround the cirrose area and after uniting posteriorly gradually shade into the folds of the pharynx. The component cells are slender, columnar elements moderately ciliated and are supported by a framework of muscle and connective-tissue fibres penetrated by slender blood sinuses and a few nerve bundles from the adjacent ganglionic mass. The cirri are prominent, finger-shaped structures, arising from separate bases or united into groups of from two to four, and are composed of low columnar or cubical cells ranged about a slender cavity too small to admit of the entrance of blood corpuscles though containing delicate fibres of unknown character.

A short distance posterior to the cirrose area the pharynx arises as a circular tube of somewhat smaller diameter than that of the atrial cavity. At the outset its walls are fashioned into numerous longitudinal folds, especially along its lateral and dorsal surfaces. Approximately halfway back to the radula a heavy fold develops in the dorsal wall, and sections show it to be packed with innumerable lobules of what probably is the dorsal salivary gland. These lobules are cirrus-like masses composed of relatively small cells whose secretion stains a light pink after treatment with haematoxylin. Slender ductules from the component cells make their way through the adjacent muscle fibres and open by intercellular pores throughout the entire surface of the dorsal fold.

The pharynx beneath the outlet of the dorsal fold is ventrally produced into a deep pocket, which posteriorly develops a slit-like cavity functioning as the outlet of the ventral salivary glands. In the mid line between the salivary ducts the epithelium becomes more columnar and may function as a subradular organ, as in *Proneomenia hawaiiensis* for example. A commissure from the labiobuccal system passes in close proximity to it, but beyond this fact there is nothing to indicate its function. The ventral salivary glands are long, tubular organs, about one eighth the diameter of the body in thickness, and contain a lumen of unusually large size. The component cells, on the other hand, are relatively small and are densely packed with granules staining a dull pink after treatment with haematoxylin.

The mid section of that portion of the pharynx posterior to the outlet of the dorsal salivary gland is the seat of the radula whose musculature and relations to other organs are unique in this genus. In common with other Glossophora the teeth are developed by clearly differentiated odontoblasts on a well-defined basement membrane, and as far as can be judged from a careful examination of cross sections number nine in each row. There are probably not less than twenty-five rows. The median tooth is triangular with a base whose length is approximately twice the height. Each admedian tooth is likewise triangular with the base not over half that of the foregoing but with a height fully as great. The lateral teeth are more spike-like, and like the admedian are slightly twisted. These data, however, are largely derived from the study of fragments and are doubtless incomplete.

Beyond the narrow section where the fully developed teeth are fully exposed in the pharynx the remaining portion, comprising fully half the total length of the lingual ribbon, is bent backward and occupies the cavity of a large diverticulum of the pharynx ventral to the radula proper (Plate 7, fig. 5). As noted presently this ventral sac is operated by several heavy muscles, whose relations have been determined with a fair degree of accuracy, though their mode of operation is not wholly clear. The position of this entire radular system in the present specimen indicates that it is in a contracted state, and it is probable that in the act of feeding the pharyngeal tube is not only widened considerably, but that the radula is projected anteriorly borne on the summit of the ventral diverticulum. This will become more intelligible after the muscles concerned have been described.

The entire outer surface of the ventral diverticulum is in contact with a sheath of circular muscles of great thickness especially in the mid section (Plate 7, fig. 4, 6). This sheath is pierced at the blind end of the diverticulum by two well-defined muscle bundles (Plate **7**, fig. 6) which are attached to its wall and on the other hand are fastened to the two pairs of globular radular supports located beneath the posterior end of the radular sac. The blind extremities of the radula and the ventral diverticulum are thus closely bound together. It is probable therefore that the contraction of the circular muscle sheath results in a lessened diameter and an increased length of the diverticulum whose free extremity is thus pushed forward into the anterior section of the pharynx. This process is doubtless aided by the action of two pairs of muscles that appear to act as protractors. The more conspicuous of these is attached to the globular radular supports and extends forward, expanding in a fan-like fashion, before becoming inserted in the radular sac (close to the exposed teeth), the adjacent wall of the pharynx and to a greater extent in the anterior end of the ventral diverticulum. The second pair of protractors is relatively small, and from their insertion in the circular coat of the mid section of the diverticulum extend forward and downward to become attached to the ventral wall of the small *cul-de-sac* into which the ducts of the ventral salivary glands open. The retractors are likewise four in number. The first and most posterior pair is attached to the median radular supports and extending posteriorly and ventrally unites with the body wall. The more ventral pair is attached to the ventral diverticulum, close to the insertion of the ventral protractors, and after pursuing a ventral and backward course also fuses with the somatic musculature.

The stomach-intestine presents no especial features of interest beyond what is sufficiently illustrated in the reconstructions of the anterior and posterior ends of the body (Plate **7**, fig. 5, 7). A well-developed, non-sacculated anterior coecum extends from the termination of the pharynx to the brain region. The main gut is provided with the customary ciliated tract adjacent to the gonad, and elsewhere is furnished with high columnar cells charged with a granular secretion which is periodically discharged by constricting off the distal extremities of the cells. In the region of the pericardial cavity the sacculations disappear, the gut becomes approximately circular in outline and as a relatively wide canal opens into the cloacal chamber.

The pericardial cavity is a comparatively large space typically located in the posterior end of the body. The heart likewise is well developed (Plate **7**, fig. 7), and is fashioned into two chambers communicating by a narrow pore apparently guarded by a valve. The posterior division, presumably the auricle, is comparatively thin-walled, distinctly less so than the anterior division, and both are spanned by delicate trabecular muscles.

The vessels to the gonad, and the communication of the dorsal vessel or aorta with the channels in the head region are of the usual type. These last named sinuses are relatively small yet can readily be followed past the anterior pedal gland and about the buccal wall to a small ventral median sinus originating immediately posterior to the outlet of the anterior pedal gland. Above the forward end of the foot this median sinus is of more than usual width, but throughout its entire extent to the posterior end of the body it communicates here and there with the overlying visceral sinus. As the hinder end of the animal is approached these two blood spaces unite at more frequent intervals and finally fuse completely. The single channel thus formed communicates with the posterior end of the heart.

No distinct branchial apparatus exists in this species. The walls of the cloacal chamber are smooth and ciliated, and as they are in intimate contact with the visceral sinus they may function in the respiratory process.

The present specimen, although of considerable size, is sexually immature, and it is altogether possible that during the breeding season the general appearance of the accessory reproductive apparatus may be considerably altered, though the configuration of the component organs will probably remain about as that shown in the reconstruction (Plate **7**, fig. 7). The gonad exists in the form of two slender tubes ending blindly anteriorly and separated widely by the dorsal aorta. Posteriorly they enter the pericardium, whose size and general appearance in sections are similar to what has been found to exist in Strophomenia. The gonoducts, in the form of slender tubes, arise from the posterior border of the pericardial cavity and extending downward and forward join the shell gland or ventral section.

The dorsal section of each coelomoduct is a tube of approximately even calibre throughout (Plate **8**, fig. 6), and is composed of cubical cells, possibly ciliated and certainly without any signs of glandular activity. The ventral section is of somewhat larger size, and is likewise formed of cubical cells in which there are very small quantities of a darkly staining secretion. At the junction of the dorsal and ventral sections a small sacculation may represent the characteristic seminal receptacle though it contains no spermatozoa.

Ventral to the coelomoducts are two diverticula each of which communicates with the cloacal cavity and probably contains a spicule though the process of decalcification has wiped away all traces. Retractor muscles attach to the outer surface of the blind end and on the other hand extend anteriorly to become inserted in the body wall. Protractors likewise attach themselves to the sheath, though more posteriorly, and following along the walls of the sheath are inserted in the forward border of the cloacal chamber wall.

Owing to the fact that the sheath surrounding the larger nerve bundles stains with unusual clearness, considerable care has been taken to trace out the more important trunks. The brain, holding the usual position dorsal to the pharynx, is more than usually globular and lacks the customary groove in the region of the commissure connecting the nerve cells of the two sides. From its anterior face the usual three pairs of nerves take their origin, and after connecting immediately with small, spherical ganglia are distributed to other ganglionic masses attached to the external surface of the atrial wall.

From the sides of the brain the lateral, pedal, and labiobuccal connectives originate as separate, distinct roots. At the point of union of each lateral connective with the ganglion there is a well-defined enlargement which anteriorly gives rise to a strong fibre passing forward and closely applied to the somatic musculature. In the neighborhood of the atrium and atrial ridges it branches repeatedly and the resulting subdivisions give evidence, in some instances at least, of uniting with ganglia in the neighborhood of the cirri. From this same anterior enlargement a small nerve arises and passing ventrally becomes lost in the region of the outlet of the anterior pedal gland. The anterior end of each pedal ganglion is likewise developed into a globular enlargement from which one or two nerves arise that soon become lost in the surrounding muscle tissue. It may be mentioned that the lateral and pedal connectives are each united by a small connective in close proximity to the brain.

The labiobuccal ganglia are ellipsoidal bodies occupying a space between the muscles of the radula and the lateral portions of the overhanging stomach-intestine. There is developed, from the anterior surface of each, a strong nerve, the labiobuccal connective, which in the contracted state of the present specimen is considerably twisted throughout its course to the brain. About one fourth of the distance from the ganglion to the brain each of these connectives enlarges considerably, though apparently without the presence of ganglion cells, and gives rise to three distinct nerves. One of these pursues a course anteriorly, and imbedded in the muscles of the gut unites with a corresponding branch from the opposite side, thus forming a commissure. Throughout its course at least three pairs of small nerves are developed which often branch repeatedly before being lost to view in the surrounding muscles. The other two nerves springing from the labiobuccal connective pass ventrally where one becomes lost when lateral to the outlet of the ventral salivary gland. The other passes beneath the duct and forms a commissure. No signs of ganglia exist along this ventral commissure, and accordingly there are no indications that it forms a subradular system as might be suspected from its position. The labiobuccal ganglia are also united by the usual commissure crossing over the dorsal surface of the radula.

In the posterior end of the body both the lateral and pedal ganglia terminate in well-defined enlargements which are united in typical fashion by connectives. A few small nerves from the pedal enlargements extend posteriorly and become lost in the somatic musculature. In addition to the suprarectal commissure the posterior end of each lateral ganglion gives rise to two main nerve bundles whose ultimate ramifications form a plexus over a considerable portion of the posterior end of the animal. Only a small portion of this network has been followed in detail, but there are indications that it exists beneath the somatic musculature, behind the level of the posterior end of the pericardium. Small ganglionic masses occur at the nodal points. It may be added that this net extends across the mid-dorsal line, at least in the neighborhood of the dorso-terminal sense organ, thus forming a species of suprarectal commissure though of a diffuse type. A careful examination of the nerves innervating the dorso-terminal sense organ shows that they have their origin in the more anterior of the dorsal commissures, which accordingly corresponds to the usual one in neomenians generally. Simroth mentions two dorsal commissures in Proneomenia but as no figure is given a further comparison is not possible.

Strophomenia agassizi, sp. nov.

Five specimens of this species were dredged southeast of Nantucket, Mass. (Sta. 2046A) at a depth of 407 fms., and four additional specimens were taken to the northeast of this point (Sta. 2528A) in water 677 fms. deep. In every case the animal was coiled about the branches of an alcyonarian coral, *Acanthogorgia armata*. Two of the specimens from Sta. 2046A are in the act of copulation, the posterior ends being applied to each other so that the cloacal openings are in communication with each other (Plate 1, fig. 1). In alcohol the color is light brownish yellow. The largest specimen is 37 mm. in length and 1.5 mm. in average diameter, while the smallest is 22 mm. long and 1.1 mm. in thickness. In the only specimen sectioned two dorso-terminal sense organs are present (see section on nervous system).

The cuticle surrounding the body measures, along the sides of the animal, approximately 0.19 mm.; along the dorsal side it is slightly thicker.

Innumerable spicules are buried beneath its surface and form, roughly, seven or eight layers. The greater number of spines, hollow, needle-like, slightly curved structures rounded at both ends (Plate 1, fig. 3) form two series crossing about at right angles. Among these are many radially directed spicules, likewise hollow but with the basal extremity truncated or slightly rounded (Plate 1, fig. 3).

The hypodermal cells are small and their boundaries indistinct, yet there are many examples of spicule formation where several cells may be seen attached to the base of the spine, and again many cases where but one cell has been detected attached to the radially directed spicules. In examples of the first class the matrix cells lose their connection when they become non-functional.

The papillae (Plate 1, fig. 2), each attached to the hypodermis by a relatively thick stalk, are numerous and are crowded together at the surface of the body. In the expanded portion are a number of nuclei, twenty is the average of six examples, and with these there are frequently darkly staining globular masses that appear to be some glandular product.

The anterior pedal gland, while extending from the brain to an even greater distance beyond the outlet posteriorly, is in reality not a voluminous structure as the cells are not compactly arranged nor do they fill to any great extent the visceral cavity. Owing to the fact that the secretion stains an inky hue in haematoxylin nothing has been determined regarding the finer structure of this organ, which otherwise presents no especially noteworthy features.

The outlet of the anterior pedal gland (Plate 1, fig. 4), though not especially voluminous, is of considerable length. Its walls, as usual, are ciliated but otherwise are unmodified save that they are produced into a fold, on each side of the cavity, that becomes gradually lower and finally disappears posteriorly. Halfway back the foot appears as a low ridge in the mid line, that soon reaches its average size, and posteriorly is continuous with the cloacal chamber.

The posterior pedal gland differs from the anterior merely in size, and otherwise requires no further description beyond the statement that it disappears an unusually long distance from the posterior end of the foot (in the specimen studied, opposite the posterior end of the pericardium).

The atrial opening, subterminal in position, leads into a relatively large cavity provided, in typical fashion, with ridges and cirri. Of the former the innermost is considerably larger though the cells composing it are on the average of less height than those of the inner ridge. As may be seen (Plate 1, fig. 4) these folds unite posteriorly and bound the cirri, relatively thick, finger-shaped processes that appear, with very few exceptions, to be attached separately to the atrial wall.

What is probably the true mouth opening occurs in the postero-lateral atrial wall and leads into the long pharynx characteristic of Strophomenia. At the outset the walls of the pharyngeal tube are relatively thin, numerous radial muscles attach it to the body wall, its epithelial lining is developed into many low folds and a very few gland cells are scattered over its surface. Passing backward one third of its length it will be found that the radial muscles disappear, the circular and longitudinal muscles become more abundant, the tube grows more circular and multitudes of pyriform gland cells, arranged in lobules, appear upon its outer surface. This state of affairs continues to the stomach-intestine.

A radula is present, but it is of small size and stains so faintly that even under high magnification it is difficult to interpret its true form. It contains a small number of transverse rows, appears to belong to the distichous type, and in one section there are evidences that each tooth is comb-like with five sharply pointed cusps.

As in other members of the genus there are two, long tubular ventral salivary glands opening on each side of the radula into a shallow depression in the pharyngeal wall. Each of these organs consists of two divisions (a) a slender duct leading from the pharynx to the distal end of the gland where it ends blindly, and with the exception of a small division in close proximity to its outlet this canal is covered by (b) a sheath of gland cells which probably pour their secretion through intercellular channels into the central canal.

While the transition from the pharyngeal epithelium to that of the stomach-intestine is abrupt the muscular coat about the pharynx passes for a considerable distance over the ventral surface of the stomach-intestine proper and the anterior intestinal coecum. This last named organ is highly developed, possesses digestive cells and lateral pouches like those of the succeeding sections of the gut and extends anteriorly as far as the forward border of the atrium. Throughout the body the character of the mid-gut is constant, the pouches especially being remarkably regular. Ventral to the gonad the digestive cells are replaced by low, cubical ciliated elements that beneath the pericardium form an extensive tract. As the gut narrows this tract grows circular as it forces its way between the halves of the shell gland and the ciliated elements approach the mid-ventral line of the gut to become the only lining of the rectum. Near its outer opening the intestine becomes almost square in cross section (Plate 2, fig. 7) and opens with the shell gland into the cloacal chamber.

The heart is a long tubular organ that near its posterior end falls into two divisions as in a few other species of this genus. The aorta, as it springs from the forward end of the heart, is of large size but as it courses anteriorly it assumes normal proportions, and the route it follows and that of the blood after leaving the head region, are typical in all essential particulars, save that the visceral cavity is of more than usual proportions owing to the absence of the usual amount of connective tissue.

In the midst of connective tissue and muscle fibres tracing out the distribution of the smaller nerves is an arduous and time consuming task but when these last named elements are free in the visceral cavity they may be followed with exceptional facility and their study has yielded some interesting results. The brain (Plate 1, fig. 4) not only holds the usual position but gives rise to the customary three pairs of nerves leading to ganglia about the bases of the cirri and in addition originates the lateral, pedal, and labiobuccal connectives. Those passing to the cirri are in nowise peculiar and the same is true for the connectives save that they are more than usually separated as they pass out from the brain, the lateral and pedal laterally and the labiobuccal close to the mid line near the posterior border of the brain.

The lateral ganglia are of approximately even calibre, showing no especial enlargement where they unite with the connective from the brain. In the case of the ventral cords, on the other hand, such a swelling occurs and marks the point from which the first latero-pedal connective takes its rise. Beyond this point connectives and ventral commissures occur with considerable regularity, the latter being usually of slightly larger diameter. In practically every case in the anterior and posterior ends of the body (the middle portion of the body was not sectioned) delicate branches pass from the connectives to the body wall where they disappear from view among the somatic muscles. Other nerves, usually of larger size, originate from the lateral cords and may pass dorsally or ventrally, but in every case they become lost in the body wall without being continuous across the mid line.

The labiobuccal connectives, lightly resting against the sides of the pharynx, pursue their course to the neighborhood of the radula where they join the labiobuccal ganglia united by the usual heavy commissure passing ventral to the pharynx and dorsal to the radula. Anterior to these ganglia an enlargement occurs in each connective and from them two connectives arise, one situated beneath the pharynx the other imbedded in the diffuse salivary glands passes dorsal to the gut. At one or two points between this region and the brain nerves arise from the connectives and form seemingly either dorsal commissures or a very delicate network which it is impossible to trace from sections.

In the posterior end of the body the lateral and ventral ganglia continue to hold the usual positions and to be united by connectives and commissures at fairly regular intervals. A short distance behind the level of the posterior end of the pericardium both of these ganglionic cords enlarge considerably and are united by one especially heavy pair of connectives as may be seen (Plate **1**, fig. 5). Slightly in front of this another pair occurs of about half the diameter of the one behind. The remainder in this region present the usual slender appearance and are sometimes difficult to follow. In many cases they give off delicate fibres that pass to the body wall where they probably supply sense organs or are distributed to the somatic muscles.

The suprarectal commissure is long (Plate **2**, fig. 6), not especially heavy and gives rise to a few very small nerves that pass at once to the rectal wall where they spread out fan-like and disappear from view among the muscle fibres. Here and there are indications of a nervous network over the surface of the rectum but from sections neither its origin nor its configuration has been determined.

The ventral commissures in the posterior end of the body are without exception of large size and are readily followed. In a few cases fibres have been seen to leave them and pass into the ventral body wall, especially lateral to the ventral furrow; and in one specimen (Plate **1**, fig. 5), one such nerve unites with the ventral ganglion and originates a fibre, in the nature of a connective that follows the body wall and resting upon the accessory reproductive organs, passes dorsally and unites with the lateral cord.

The pedal cords, behind the last connective, give rise to a very few nerves that disappear at once in the mass of muscle surrounding the cloacal wall at this point. The lateral ganglia likewise are continued behind the last connective as a heavy cord apparently distributed in large measure to the cloacal wall though some branches may pass to the neighboring body wall.

As in the case of *Proneomenia vagans* this species is in possession of two dorso-terminal sense organs (Plate **1**, fig. 5). Both present the same as well as the customary appearance, but their innervation is unique. In *Proneomenia hawaiiensis* a nerve leaves the exact centre of the suprarectal commissure and pursuing its course along the mid line passes into the base of the single terminal sense organ. In the present case a nerve arises from the suprarectal commissure. on each side of the body near each lateral ganglion. These two nerves extend dorsally then posteriorly and a short distance in front of the more anterior sense organ they unite to form a single fibre that may be traced, without especial difficulty to the base of the organ. The nerve to the posterior organ arises from the lateral cord, on the left side only, behind the suprarectal commissure and making its way across the visceral cavity it finally comes into close contact with the body wall yet may be distinctly followed to the organ in question.

Whether innervation from one nerve or two is the more primitive, it is impossible to say at present, but it certainly appears to be a fact that such an asymmetrical innervation, as in the case of the posterior organ, indicates that it is either an abnormality or is from a phylogenetic standpoint a late formation.

While the presence of copulatory spines and seminal receptacles, filled with sperms, have led to the conviction that copulation takes place among the neomenians no actual example has been noted up to the present time. Definite proof, however, is now at hand, for two individuals from Sta. 2046 were in the act of copulating (Plate 1, fig. 1). Their posterior extremities were in contact so that the cloacal openings were opposite each other, thus placing the two chambers in direct communication with each other, and a whitish secretion appears to have aided the attachment in life, or at all events to have prevented the loss of sperms during the copulatory process. It was thought best not to destroy these specimens so that nothing is known regarding the course pursued by the sperms on their way to the seminal receptacles nor of the appearance of the organs most intimately concerned in the process.

In the sectioned specimen several eggs are present in the pericardial cavity and other indications suggest that the egg-laying season was at its height. Fully formed ova are in the gonad along with multitudes of sperms in all stages of development, and the canals leading from the pericardial cavity are of very large size. In common with the other species of the genus the pericardium is spacious and the coelomoducts, leaving its postero-lateral borders, are of unusually large calibre. As may be seen (Plate 1, fig. 5) the dorsal limb of each canal is externally a simple unmodified tube uniting with the shell gland close to its anterior extremity.

In close proximity to the pericardial opening there is a small, short ridge of cells of larger size than those adjoining and the nuclei are correspondingly large and the cilia longer. This soon disappears and the cells throughout the dorsal limb are lightly staining, cubical, or low columnar, ciliated, and possess indistinct cell boundaries. The ventral section, on the other hand consists of high, ciliated elements filled with a darkly staining, granular secretion. Close to the outlet and extending a short distance along the mid-ventral line of the rectum the cells become lower and the secretion changes, in a fully developed condition, to a granular, highly refractive, yellowish product not effected by haematoxylin. The cells of the seminal receptacles are columnar, and the secretion, consisting of droplets of varying size, is of a lavendar tint. Multitudes of sperms are crowded against their free surfaces and in many cases have produced a vacuolation and even disintegration so that spermatozoa may enter such cells.

Nierstrassia fragile, sp. nov.

Eleven specimens of this species, all unattached, were dredged off the coast of New Jersey (Sta. 2588A) at a depth of 479 fms. where the bottom consisted of green mud. The smallest measures 2.5 mm. by 0.75 mm., while the largest is 5 mm. long by 1 mm., the greatest thickness. This material, very well preserved, was taken in 1885, and for over twenty years remained in an ordinary cork stoppered bottle so that its yellowish brown tint is probably due to tannin. A silky layer of delicate spicules, rather easily dislodged, gives the animal a light frosted appearance. While the spines adjacent to the ventral furrow overarch it the greater number are directed diagonally away from the furrow in a postero-dorsal direction, those along the mid-dorsal line meeting each other without, however, forming any marked keel. While a dorso-terminal sense organ appears to be present the obliquity of the sections (the posterior end of the longitudinally sectioned specimen was lacking) and a number of small folds in the hypodermis renders it difficult to definitely decide this point.

In some respects the hypodermis, cuticle, and single layer of spines show a striking resemblance to the same elements in species belonging to Chaetoderma. The spicules show this most clearly, having the characteristic leaf-like form with a longitudinal keel. By far the greater number of hypodermal cells (Plate 6, fig. 2) are unmodified more or less cubical elements. In some instances a small, compact mass, attached to the base of some of the spines, may represent a degenerate spicule-matrix cell, but in most instances these have disappeared. At rare intervals slender cells, possibly sensory, occur among the larger hypodermal elements but no especial nerve supply has been detected. No structures corresponding to papillae are present, the general appearance of hypodermis and cuticle over the body being represented in the drawing (Plate 6, fig. 2).

The outlet of the anterior pedal gland consists of a simple, hemispherical depression provided with long cilia (Plate 6, fig. 8), lying behind the mouth or atrial opening from which it appears in surface views to be separated by a very narrow cuticular bridge continuous with the general investment of the body. The gland itself, occupying the visceral cavity halfway up the sides of the body, extends from the anterior end of the animal to a point about level with the posterior end of the radula. The cells composing it are pyriform, filled with a darkly staining secretion, among which are larger, lavendar colored masses, apparently consisting of more than one cell. This may be one stage of glandular activity though it appears to be a different secretion.

The foot (Plate 7, fig. 1) arises immediately behind the outlet of the anterior gland in the form of a single fold that, accompanied by the usual pyriform gland cells, extends to a point a short distance in front of the cloacal opening.

The mouth opening is, as usual, subterminal in position (Plate 6, fig. 3), and in some specimens is reduced to a very small pore scarcely larger than in some species of Chaetoderma, while in other cases it is more or less open. In any event it leads into a small chamber holding the position usually occupied by the atrium, but it is somewhat doubtful if it should be interpreted as such. So far as can be detected after careful examination there is no trace whatever of any cirri or atrial ridges, and as the cells lining this space are in large measure at least clearly modifications of those present in the undoubted oesophagus or pharynx it would appear that the atrial chamber is wholly wanting. On the other hand it is important to note that the usual nerves passing out from the forward surface of the brain connect with masses of ganglion cells, probably the homologue of those about the bases of the cirri in other species, and from these masses fibres may be distinctly followed to the bases of some of the cells lining the cavity in question. According to the nerve supply the atrium exists, but judging from cell characters alone it is absent. On which of these criteria dependence is to be placed it is difficult to say though personally I am inclined to take the first named position.

As may be seen (Plate 6, fig. 9) the cells of this first section of the canal are of two, possibly three distinct varieties, club-shaped elements, usually long and slender especially on the dorsal surface, and thread-like supporting or sense cells. In the first type the distal portion is almost wholly occupied in preserved material by a vacuole, the nucleus occupying the basal section. The supporting or sensory cells likewise usually possess basal nuclei, but especially near the antero-dorsal boundary of the cavity some are more distally situated. Often the free surfaces of all of these cells are covered with a yellowish brown, homogeneous substance which extends between the cells far down toward their bases. The origin of this substance could not be determined. Neglecting differences in size these types of cells form the epithelial lining as far as the opening into the stomach-intestine.

As far back as the stomach-intestine, the digestive tract is surrounded by a layer of circular muscles among which numerous radial strands occur, extending to the body wall. Among these elements, from the anterior end of the animal to a point a short distance behind the brain, numerous solitary, pyriform gland cells occur and open by intercellular pores into the digestive tract. In some instances the secretion is abundant, the small spherical granules staining intensely, but especially behind the brain the granules become relatively smaller in size and amount, vacuoles occupying a considerable portion of the cell.

A radula, of the distichous type, is present, and so far as may be determined from sections comprises 15 rows. The form of each tooth is represented in Plate 2, fig. 10, while the radula sac and odontoblasts are faintly shown in Plate 6, fig. 3. In this last figure a small ridge, composed of slender cells, occupies the position of the subradular organ, but while it presents the appearance of a sensory area no definite ganglia have been found in connection with it.

Paired ventral salivary glands are present in the form of small, globular sacs (Plate 6, fig. 3) that on one side at least develop small lobes. One of these is unusually swollen in the longitudinal section and appears to contain a few parasites. The cells are relatively small, vacuolated and in some instances contain a finely granular secretion.

The stomach-intestine exhibits the usual sacculated form and relations to other organs; and the glandular epithelium is not essentially different from that of other neomenians. In the longitudinal sections large numbers of some parasitic protozoan are present in various stages of development and may be responsible for the unusual size of some of the epithelial cells. Posteriorly the canal narrows, becomes laterally compressed as it passes between the limbs of the shell gland and then in the form of a very slender canal makes its exit into the cloacal chamber. As these animals came in unattached with no food in the digestive tract there is nothing to indicate the nature of their habitat.

Owing to the abundance of connective tissue in the visceral cavity it is very difficult to accurately trace the course of the blood, but in its main features the circulatory system is typical. The heart, much contracted, is a tubular structure (Plate 6, fig. 5) in two divisions possibly separated by a valve though this was not clearly demonstrated, and throughout much of its extent it is free from the pericardial wall. In the first part of its course the aorta is of relatively large size, but later becomes greatly compressed and difficult to follow between the halves of the gonad. In the head region it loses its walls, the blood entering sinuses that apparently have the usual relations.

As in the case of the circulatory system the abundance of connective tissue masks the course of the smaller trunks of the nervous system so that the broader features only have been worked out. The brain presents the usual characters, giving off laterally the pedal, lateral, and labiobuccal connectives, and anteriorly, nerves which at once attach to groups of ganglion cells. As noted in connection with the digestive tract these last named ganglia probably correspond to those located about the bases of the cirri in other neomenians, and in the present species they send off fibres that pass to the anterior section of the alimentary canal whether it be an atrium or not. The pedal, lateral, and labiobuccal ganglia and their connectives are normally placed, and as many points throughout the body the first two are united by the usual commissures and connectives. In the case of the labiobuccal ganglia the commissure was followed posterior to the radula, but the abundance of muscle and connective-tissue fibres makes it impossible to determine if there be other commissures or a subradular system.

In the posterior end of the body the pedal ganglia gradually diminish in size and finally disappear from view. Almost to the end of their course they continue to be united by connectives with the lateral ganglia, but these show no unusual development and the pedal ganglia lack the posterior enlargements characteristic of some neomenians. The lateral ganglia, on the other hand, terminate in globular masses, in the neighborhood of the pericardial-coelomoduct openings, that are united by a commissure passing dorsal to the rectum where the latter unites with the more expanded section of the gut.

The paired gonad, containing both ova and spermatozoa, extends as usual, from about the level of the anterior end of the foot to the pericardium. In both specimens the ova appear to be somewhat immature while the spermatozoa are in all stages of development and especially in the mid section of the gland are so numerous that they distend its walls to a considerable degree. Posteriorly the halves of the organ gradually narrow, diverge slightly and communicate with the small pericardium.

The opening of each gonoduct is borne on the summit of a small papilla (Plate 6, fig. 5) on the postero-lateral walls of the pericardium, and leads into a tube which passes laterally and then posteriorly to unite with the ventral section, or shell gland. For a distance equal to about one fourth of its length the dorsal half of the gonoduct is a simple, very slender tube but at this point it enlarges somewhat and develops a short pouch-like diverticulum composed of cubical, ciliated cells without any special signs of glandular activity. Continuing its way forward for a short distance another diverticulum, finger-shaped in appearance, arises and on both sides of the body is directed backward and downward. In the usual position for the seminal receptacle a very slender tube appears, on each side of the body, that is directed anteriorly for a short distance and terminates in a slight enlargement. These three pairs of diverticula are empty and accordingly afford no clue as regards their possible function. The cells of this dorsal section of the gonoduct are all more or less cubical, ciliated but without ridges or other modifications.

The shell gland, (Plate 6, fig. 5), composed of the usual long and slender cells, occupies the usual position. Posteriorly the halves unite to form a single median section with folded walls, but the union is unusually near the opening into the cloaca. Lying ventral to this portion of the reproductive system there are two bundles of spicules, five in each group, that are developed and concealed in two diverticula, arising not from the cloaca, as is usual, but from the undivided section of the shell gland. Each of these spicules is rod-shaped, apparently straight with the base rounded and the distal extremity pointed, and during the act of copulation is probably protruded through the reproductive opening into the cloaca. As may be seen (Plate 6, fig. 7), the median section of the shell gland and the adjoining undivided portions together with the bundles of spicules are imbedded in a relatively large diverticulum, rich in muscles, that in life may doubtless be protruded beyond the opening of the cloaca.

In reality the cloacal chamber is comparatively large but usually it is almost completely filled by the great diverticulum bearing at its tip the reproductive opening. In some specimens it is partially closed and in other cases its margins are widely expanded. Throughout the greater part its walls are smooth and unmodified but beyond the reproductive and anal openings five or six low ridges (Plate 6, fig. 4) make their appearance, and while they may be respiratory they certainly possess some additional unknown function since the pyriform cells are highly glandular and their distal extremities are filled with a colorless secretion after treatment with haematoxylin. In the neighborhood of the anal opening additional groups of cells occur, and in some instances appear to open into the cloacal cavity, but the supposed ductules may in reality be delicate strands of connective tissue.

EMBRYOLOGY.

In the report of the Solenogastres of the North Pacific a species of neomenian, *Halomenia gravida*, was described that carried in the spaces between the branchial folds of the cloacal chamber twenty-five embryos in various stages of development. As the single specimen was sectioned before these were discovered it is obvious that the following account of the early growth of this species has been based solely on sections and reconstructions. It may be said, however, that unusual care has been exercised in their study, and while certain details, to be noted later, are doubtless faulty, the broader features are fairly clear and intelligible.

In the earliest stage two distinct nuclei are present (Plate **13**, fig. 5) together with four other bodies that may be nuclei, though appearances (Plate **13**, fig. 10), suggest that more probably they are unusually large yolk granules superficially coated with a dense layer of protoplasm or some glandular secretion. The egg measures at this time 0.32 mm., assuming that a slight elongation is due to the pressure of the neighboring branchial folds. A single polar body (Plate **14**, fig. 10) is attached, and it is a peculiar fact that in every case where these cells have been seen there is never more than one. A delicate membrane, cuticular in appearance, surrounds the egg, and where it has remained undisturbed it is closely adherent to the yolk granules beneath. At other points on the surface it may be thrown into folds, but as these lack regularity and any signs whatever of nuclei, it is probably a vitelline membrane and not a chorion, though this last named structure occurs normally in the Chitons and several Solenogastres. Furthermore in developing ova within the reproductive gland of Halomenia there are no traces, even in early stages, of a chorion though the cuticular membrane just described is well defined. Immediately within the membrane, and adjacent to the polar body, a clearly defined nucleus exists closely surrounded by yolk with the exception of an excentrically placed archiplasm mass. It is probably the female pronucleus, while the remaining one of similar appearance is the sperm nucleus.

In the only other early stage two undoubted nuclei hold the same relative positions, and again there are four bodies that as before may be either nuclei or yolk granules. It is worthy of note that one or two similar bodies may occur in fairly advanced embryos, and on the other hand none of these bodies has ever been detected in mature ova within the gonad. Furthermore in these early stages no cleavage planes have been noted.

In the next stage segmentation has commenced, resulting in twenty-eight cells (Plate **13**, fig. 13). These show no differentiation into micromeres and macromeres, and so far as may be judged from sections the inequality of size noticed among the cells is irregular and not confined to a definite hemisphere. All of the cells are closely crowded together and consequently no sign of a blastocele exists (Plate **14**, fig. 11). These facts together with the absence of polar bodies in this particular embryo and the uniform distribution of yolk renders it impossible to distinguish the principal axes.

In the succeeding stage (Plate **13**, fig. 6) approximately one hundred nuclei are present and an elongation of the larva defines the principal axis. There are, however, no definite signs of blastopore or blastocele, and the size and arrangement of the cells does not certainly define the dorsal and ventral surfaces. Sections (Plate **14**, fig. 8) show that at this stage several cells are wholly enclosed within the partially formed external layer whose component cells are of unequal size and irregular arrangement. In a few cases the position of karyokinetic spindles indicates that the internal cells are formed by tangential divisions, a species of delamination, while other cleavages at right angles to these further increase the number of cells on the exterior.

In advance it may be said that in the larvae of this species test cells partially enclose the body as Pruvot ('90) has shown to be the case in *Myzomenia banyulensis*. While no definite reliance can be placed on reconstructions for determining the exact shape and arrangement of cells it nevertheless appears fairly well established that in the stage under consideration the external cells are not so definitely arranged as in the later stages, and even there they are not so diagrammatically placed as in Pruvot's figures.

In the next stage (Plate **13**, fig. 12) a single polar body remains in place, held by the vitelline membrane, and the animal pole is thus determined, together with the probable point of origin of the cerebral ganglia though these last named structures have not as yet put in an appearance. The differentiation of the test cells has become evident to a certain extent, although their exact limits have not been determined from reconstructions. Granted that the polar body has not shifted from its point of origin, it does not appear to mark the centre of the test cells which may be seen (Plate **14**, fig. 1) to extend over nearly the entire dorsal surface. Furthermore while the test cells may form rows or definite bands about the embryo, reconstructions give no clear evidence of this fact up to the present point in the development.

In sections the cells, exclusive of those forming the test, that is those destined to develop into the fully formed animal, are much more numerous than before, and are as yet without signs of differentiation into the fundaments of the various organs. This statement may perhaps be modified in one particular, for on the ventral side immediately posterior to the large test cells is a group of several elongated cells extending from the surface to a considerable distance into the interior. Their external position is marked by a shallow depression (Plate **14**, fig. 9), and appearances suggest that this is the region of the blastopore, and that the cells are stomodeal elements destined to become much more numerous and prominent in later stages. As may be seen in the figures no definite blastocele is evident.

Later stages are ushered in with the development of the test (Plate **13**, fig. 11), the great increase in the number of the remaining ectoderm cells, and the appearance of a definite stomodaeum, mid-gut, and cerebral ganglia together with the appearance of recognizable mesodermal elements. In other words, differentiation has now advanced to a stage where the three germ layers are clearly defined, and certain systems broadly outlined so that the following account will probably gain in clearness if these various systems are considered individually rather than parts of the whole.

The Test:— As has been noted some of the test cells have been seen to arise at an early stage by tangential divisions of the relatively few cells composing the body of the embryo. Concerning the cleavages of cells left in the interior there is nothing known. The differentiation of the test itself from the remainder of the ectoderm of the trunk region is accomplished by a slower rate of division that is soon brought to a complete standstill. As may be seen in the figures (Plate **13**, fig. 11, Plate **14**, fig. 3), the test extends at the outset farther over the ventral side than on the dorsal, but in the latest stage in the present collection (Plate **14**, fig. 4) a shifting has evidently occurred as the brain is placed at the anterior end of the embryo, and the mouth is well forward on the ventral side. Even yet the organ is asymmetrical in position, but more radially adjusted than at first. Judging from the amount of yolk, contained in the test cells of the oldest embryo it is evident that a very considerable time must elapse before the nutritive material is absorbed and the remnants cast off. While the nuclei present an irregular, somewhat shrunken appearance the cytoplasm is not vacuolated, as are functional test cells of Chitons or Yoldia for example, and it is probable that a much greater diminution in size occurs before these elements become wholly non-functional and worthless.

That a diminution in the size of the test has already ensued in the oldest larva is evident from a comparison with the figures of earlier stages. In the oldest larva the increase in the size of the body is not especially marked, and yet the test does not compose more than half of the external surface. Measurements, somewhat roughly made, indicate that a shrinkage of approximately two fifths of the original superficial extent of the test has taken place. To what extent this progresses is not known; nor is it known what means are employed to increase the area of the remaining ectoderm. In a few cases cells of the trunk ectoderm have been seen, containing karyokinetic spindles thus indicating one source of increase. On the other hand there are certain large, yolk containing cells in the anterior end of the body of the oldest larva (Plate **14**, fig. 4) that do not appear to belong to the mid-gut. From their position it is altogether possible that products of these are added to the external layer as the free border of the test advances toward the apical pole. There is no indication other than this of an ectodermic layer beneath the test, and the indication is that at the time of its dehiscence the test is a comparatively insignificant organ.

Nervous System:— In the earliest recognizable stage the cerebral ganglia appear (Plate **14**, fig. 6) as a set of cells bordering a depression in the test. It is evident that originally one or more cells, indistinguishable in sections from those of the test, underwent cleavages in which the plane of division cut the surface of the body at right angles. The resulting elements migrated some distance into the interior of the embryo, and at a later time other cells were cut off from these parent cells that remained in contact with the depression. By the successive divisions of daughter and parent cells a large accumulation is produced, extending from the exterior to the neighborhood of the stomodaeum. Within a comparatively short time wing-like prolongations are developed which encircle the stomodaeum and still later these are continuous with a rod-like mass resting against the ventral ectoderm and extending to the posterior end of the body (Plate **4**, fig. 3, 4). Unfortunately all of the sections of the later stages are longitudinal, and it is not possible to determine if this ventral band is double, as it ultimately must become if my belief is correct that it forms the ventral cords.

While the evidence goes to show that the cerebral ganglia arise at one point in the outer layer of cells, later stages indicate that the depression undergoes a considerable lateral expansion, and in one case the two accumulations, destined to form the halves of the brain, become almost if not completely separated from each other, there being two external pits in contact with the surface. In another example the nerve masses are at opposite ends of a transverse groove and are thus incompletely separated. In the oldest stage the nerve mass is in contact with the anterior surface at one point only, and its double character does not appear until it divides to surround the stomodaeum.

Apical Sense Organ:— An apical sense organ may exist in this anterior depression from which the cerebral ganglia arise. One is present in *Myzomenia banyulensis* according to Pruvot, but in the present series of embryos there are, with one possible exception, no especially developed apical cells nor tuft of cilia. The exception is the oldest embryo where a small band of cells extends in the mid line from the ganglionic enlargement bordering upon the stomodaeum to the surface where it ends in a slight pit. The material is excellently preserved yet it is not possible to detect apical cells, and cilia have never been seen at this point or anywhere else on the body.

The Terminal Ring:— In Pruvot's figures of Myzomenia there appears a circular group of relatively large cells surrounding the posterior end of the body. This organ, somewhat resembling an annelid telotroch, is ciliated and a diffuse tuft of cilia projects from the enclosed, terminal depression. In some of the oldest embryos of Halomenia the same structure, minus the cilia, holds a corresponding position (Plate **13**, fig. 11). The cells are comparatively large yolk-laden elements (Plate **14**, fig. 1, 2), resembling small test cells, and are arranged about a saucer-shaped depression. At first they form two rows as in Myzomenia, but in the oldest embryo in my possession the ring-like arrangement has become lost, the cell boundaries have seemingly disappeared and I have not been able to detect any nuclei that may with certainty belong to these cells. The depression is likewise lacking and the yolk granules merely form a confused mass (Plate **13**, fig. 9) at the posterior end of the body. In this same section the ectoderm adjacent to the "telotroch" appears to be passing beneath the yolk granules, leaving them upon the exterior, but the absence of definite cell boundaries renders this somewhat uncertain. Appearances suggest that the terminal ring is a larval organ that, like the annelid telotroch, is cast off.

The fate of the cells within the terminal ring is uncertain. In early stages (Plate **14**, fig. 2) the depression is composed of yolk-bearing elements similar to those of the ring itself though of smaller size. At a considerably later stage (Plate **14**, fig. 3) the cells in the corresponding position are relatively small, without yolk granules and with indistinct boundaries, and it is reasonable to conclude that they are the progeny of the cells originally included within the terminal ring. Anteriorly they are continuous with the ganglionic cord extending along the ventral side of the body. In the oldest stage the nerve cord comes in contact with the epithelial layer in the posterior end of the body (Plate **13**, fig. 9), and the only tenable theory that suggests itself is that the terminal cells of the ganglionic cords, those adjacent to the epithelium, have originated from the elements at first surrounded by the terminal ring.

While the cells of the epithelium with which the ganglionic cords come in contact form a fairly distinct group, they are not depressed and otherwise give no indication of constituting a special sense organ, although I am inclined to look upon them as the future dorso-terminal sense organ characteristic of many adult neomenians.

The Foot:— The oblique direction of the sections through the oldest embryo renders it practically impossible to determine the exact arrangement of the cells of the ventral surface. Immediately beneath the ventral rod of ganglion cells, and therefore in the mid line, the cells are clearly defined columnar elements placed approximately at right angles to the surface of the body. A short distance removed on each side the cells of this character become replaced by others of more slender appearance that are inclined toward the posterior end of the body. It thus appears that along the mid-ventral line there is a strip of cells about one sixth of the body diameter in width, that probably becomes the future ventral groove and included fold although there are no indications that these structures exist as yet. At the anterior border of this strip, and consequently immediately posterior to the mouth opening, is the anterior pedal gland, consisting of several cells bordering upon a slight depression (Plate **14**, fig. 4) — the future pit-like outlet prominent in the adult. Five or six cells contain small quantities of a moderately staining secretion, and are relatively conspicuous objects.

Shell (?): As just noted the cells bordering upon the mid-ventral line are inclined posteriorly with reference to the surface of the body, and this appears to be generally true of the whole trunk region. Especially along the mid-dorsal line they are comparatively slender, columnar elements (Plate **14**, figs. 3, 4), containing distinct spherical or ellipsoidal nuclei and one or two yolk granules each. In the oldest larva these have separated at fairly regular intervals, and originally I was inclined to consider the spaces thus formed as the seat of calcareous products. There is, however, a lack of any definite cuticular sheath, and no perforation or elevation of the membrane bounding the body, and accordingly I am now of the opinion that these spaces are due to methods of preparation of the material. In the posterior end of the embryo there is a distinct slit (Plate **13**, fig. 9), extending through three sections or about one fifth the diameter of the trunk, that is bounded by a delicate though none the less definite cuticular sheath. It has the appearance of a developing spine, scale or plate of calcareous material, but with one specimen only it is not possible to form a definite opinion. It is very evident that the oldest larva of Myzomenia as figured by Pruvot with its many scale-like plates is much more highly developed than any embryo in the present collection.

Stomodaeum: — As previously noted a few of the cells on the ventral side of the body, at the posterior border of the test, rest against a shallow depression (Plate **14**, fig. 7, 8) in relatively early stages, and extend for a considerable distance into the interior of the embryo. They thus occupy identically the same position as the future stomodaeum, and it therefore becomes practically certain that the depression is the first indication of the blastopore and that the slender cells are stomodeal elements. In the next stage (Plate **14**, fig. 3) in the present collection the yolk-laden mid-gut, communicating with the exterior, is directly in contact with the test cells anteriorly, but posteriorly it connects with the yolk free stomodeal cells which extend for a considerable distance within the body. The stomodaeum is thus a semitubular structure largely confined to the posterior side of the digestive tract. This same state of affairs continues in the oldest stage (Plate **14**, fig. 4).

Mesoderm:— After the formation of the ectoderm the remaining cells form a confused mass within the interior. Order, that is regularity of arrangement, is not established until relatively late in development (Plate **14**, fig. 3) when the mid gut is distinctly outlined. Between the gut and the ectoderm are several fairly large yolk-laden cells whose exact nature is open to question. Anteriorly, between the test and the gut, several of these appear (Plate **14**, fig. 3), and in the latest stage represented (Plate **14**, fig. 4) these appear in even greater abundance. They ultimately may become incorporated with the mid-gut, or in part at least they may form the ectoderm of the anterior end of the body as the test diminishes in size, or in whole or in part they may be mesoderm. In the posterior end of the body similar cells appear, of somewhat smaller size, that I am inclined to consider true mesoderm. Unfortunately the question cannot now be decided.

Endoderm:— The endoderm, as indicated in the preceding paragraph, does not become clearly differentiated until relatively late in development, judging from the material in hand. At the time that the stomadaeum communicates with the succeeding section of the digestive tract the mid-gut is clearly defined as a blind sac filling practically all of the interior of the body.

The component cells at this time are comparatively large, and as they are filled with yolk granules they are clearly distinguished from the stomodeal elements. In the latest represented stage (Plate **14**, fig. 4) the mid-gut in its central portion appears as a confused mass of cells owing apparently to great irregularities in the position of the component cells. The general outline of the organ, it is believed, is correctly indicated. No trace of a proctodaeum or cloacal chamber has been discovered.

Comparisons.— The only other accounts of the development of a Solenogastre comes from the hand of Pruvot who investigated two species, *Myzomenia banyulensis* and *Proneomenia aglaopheniae.* The two reports are very brief, and in some respects the observations coincide with those of the foregoing paragraphs; on the other hand there are certain statements that are open to question. These agreements and differences will now be considered in brief.

In Myzomenia the eggs as they leave the gonad and enter the coelomoducts are naked. A membrane is present when the eggs leave the body, and it therefore follows that the shell gland forms the envelope. It does not follow, however, that the ducts are not at the same time excretory organs though this may indeed be the case. In Halomenia the ova in the gonad are surrounded by envelopes of the same character as surround the eggs stored in the cloacal chamber. The shell gland is highly developed in this species, but what part it plays in the reproductive process is not clear.

The four-cell stage comprises one large and three small cells; successive divisions of the smaller cells enclose the products of the larger. At a later period the embryo becomes cap-shaped and a large pit in the ventral half of the embryo is believed to represent the blastopore. The test now becomes clearly defined, an apical tuft of cilia arises, the trunk region, button-like in form, protrudes beyond the margin of the test and a ciliated terminal ring encloses a pit-like depression termed the blastopore. Calcareous plates arise at various points upon the surface of the body, whereupon the metamorphosis ensues.

Turning now to the development of Proneomenia it is evident that in several respects it bears a close resemblance to Halomenia. The blastomeres are described as being slightly unequal, surrounding a small blastocele. Invagination occurs and a large blastopore is formed. The larva now elongates and, covered with a ciliated coat borne on five tiers of cells forming three zones or segments, the resemblance to the Myzomenia larva is fairly complete. There are, however, certain details of the process that are difficult to comprehend. A brief summary[1] will make this fact clear.

"The layer forming the primary invagination (? archenteron) does not correspond to the definitive entoderm, but gives rise to *all* the tissues of the trunk. By the tangential division of its cells, it gives rise to a superior entodermic mass resting upon a single layer of cells; the latter increases by the radial division of its cells and becomes infolded, forming three invaginations; of these the middle one, which remains open, becomes the future proctodaeum, while the two lateral ones close and are transformed into the masses of mesoderm, the lateral mesoderm-bands. The lower layer, which now has the form of a vault, represents the ectoderm of the trunk. The lips of the proctodaeum now grow out to form the caudal button which first projects into the cavity of the ectodermal vault, but later, together with the entire vault, becomes evaginated through the depression at the posterior end of the larva. This conical protuberance with the caudal button and the proctodaeum at its extremity represents the trunk of the young Proneomenia. The entoderm still remains as a solid mass with the mesoderm-bands on either side and in contact with the proctodaeum behind. The next important change is the appearance of three ventral invaginations of the larval ectoderm, just behind the circle of large cilia on the middle segment; the median of these invaginations, the larval stomodaeum, is merely transitory, while the two lateral ones are concerned in the formation of the ectoderm and mesoderm of the head. These two unite, forming a transverse band capping the anterior end of the entodermic mass and prolonged posteriorly at two points to meet the mesoderm-bands of the trunk; this portion appears to form the muscles, while the more dorsal elements of the invagination form the cerebral ganglia. The cells of the apical plate seem to take no part in the formation of the nervous system. The ectoderm of the head appears to form entirely from these anterior invaginations, while that of the trunk develops from the primary posterior invagination. The latter is now completely evaginated, and has developed the provisional imbricated spicules. In this way the young Proneomenia is developed under cover of a provisional ectoderm which serves as a locomotory organ and is thrown off at the moment of metamorphosis. The adult does not exhibit a distinct head but, during development, this structure is perfectly distinct and arises quite independently of the trunk."

Upon first thought it appears difficult to correlate some of these observa-

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[1] From a note by M. F. Woodward in the English translation of Korshelt and Heider's Text-book of the embryology of invertebrates. 1900, **4**, p. 19.

tions with those pertaining to the development of any other class of animals, but the difficulty, it appears to me, arises at the outset when the cells included within the test are declared to be wholly endodermic. I shall endeavor to show that they comprise the elements of all three germ layers, and that the Solenogastre development may be derived from that obtaining in the Chitons for example.

In the first place I am in entire accord with those authors, notably Drew (1901), who look upon the test as a highly developed velum. In Ischnochiton it is a relatively insignificant structure forming an equatorial band around the embryo and dividing the animal hemisphere from the vegetative, or, roughly speaking, the head from the trunk. Until the metamorphosis it remains functional when it is cast off. Remodelling such a type of larva into that of Halomenia it is necessary merely to greatly widen the band. This well nigh obliterates the usual head vesicle, leaving only those cells at the animal pole that develop the cerebral ganglia. In the vegetative half of the animal the cells responsible for the development of the trunk ectoderm are likewise greatly reduced though by no means wiped out entirely. In both types the blastopore is situated on the ventral side adjacent to the velum or test, and the ectoderm that forms the future trunk is continuous with the margins of the test.

The absolute proof of this theory rests upon a knowledge of the history of the early blastomeres, and this unfortunately is almost totally lacking. We know that the early cleavages may be nearly equal or highly unequal, but to assume that because one or more cells become partially withdrawn into the interior at an early stage it is therefore endodermal is certainly not justified. Furthermore it is unfortunate that the terms micromere and macromere have been introduced in describing the Solenogastre development since these terms apply to the history of the cells in question rather than to its size. We know that in the majority of the Trochozoa that have been carefully examined, the original four cells divide three times forming three quartettes of micromeres, some of which as a matter of fact may be larger than the remaining parent cells or macromeres which are now endodermal. Whether this is true of the Solenogastres we do not know, but the arrangement and fate of many of the cells suggests strongly that something akin to this has taken place.

Considering now the gastrulation of Myzomenia and Proneomenia it is evident at the outset that the test is of such large size that when viewed from the side it conceals within its borders the entire trunk. The so-called blastopore is accordingly nothing more than a temporary shallow depression bordered on all sides by the test. The same effect may be produced in Halomenia (Plate **13**, fig. 11 for example) by slightly extending the borders of the test. The layer forming this "primary invagination" is therefore no archenteron, and Pruvot is quite correct in claiming that its cells do not correspond to the definitive endoderm and that they give rise to all the tissues of the trunk. By tangential divisions of the cells of this depressed area there is produced a "superior ectodermic mass resting upon a single layer of cells," that is to say the ectoderm of the trunk becomes distinct from the endoderm that later forms the mid-gut (Plate **14**, fig. 5).

In this area circumscribed by the borders of the test are "three invaginations; of these the middle one, which remains open, becomes the proctodaeum, while the two lateral ones close and are transformed into "masses of mesoderm." The proctodaeum is evidently the mid-gut, but that it is open to the exterior or is derived from this species of invagination is certainly an erroneous conclusion resulting from a failure to detect the true blastopore. The mesoderm bands are evidently the ventral cords of ganglion cells as will appear more clearly later on. Concerning the formation of the trunk it may be said that the "lips of the proctodaeum" evidently refers to the rim of the terminal depression in the trunk of comparatively old larvae and the "terminal button which first projects into the cavity of the ectodermal vault" probably refers to the group of cells that in one stage in the development of Halomenia (Plate **14**, fig. 4) lie at the base of this depression. Later the button "together with the entire vault becomes evaginated" beyond the borders of the test, and the presumption is that the button corresponds therefore to the dorso-terminal sense organ.

In the anterior half of the body three invaginations are said to exist in the midst of the test cells. The first, a transitory structure, is said to represent the stomodaeum. If such is actually the case it occupies a very different position from what it does in Halomenia. That it is transitory makes it appear to be a misinterpretation. The two lateral invaginations that ultimately meet to form a transverse band are said to supply material for the ectoderm of the head, the cerebral ganglia and the mesoblastic bands that are "prolonged posteriorly to meet the mesoderm-bands of the trunk." I am not certain regarding the head ectoderm formation but the mesoderm bands are clearly the ganglionic trunks that continue to the posterior end of the body.

GENERAL CONSIDERATIONS.

Since the completion of the report on certain species of Solenogastres from the Pacific Ocean (Heath, 1911) the excellent paper of Nierstrasz (1908) and several objections (*in litt.*) on the part of various investigators open up the discussion of certain questions not fully treated in the earlier paper. It is evident, however, that some of these protests, like many of my own theoretical conclusions, are very largely based on personal opinion. The same material in the hands of these or other students would perhaps be interpreted in various ways from a theoretical standpoint, and accordingly the following paragraphs are very largely a confession of faith with some of the grounds upon which it rests.

The first of these criticisms is directed at the section treating of the formation of the spicules imbedded in the cuticle, which, like the papillae when such are present, is a product of the hypodermis or epidermis as Nierstrasz prefers to term it. At the outset it is important to note that there are two distinct modes of spicule formation, and the confusion that my account appears to have created is largely due to the fact that this has not been kept in mind. In all of the Chaetodermatina, so far as my observations go, each spine is the product of one, and only one, cell, and it may be, indeed it usually is, crowded between adjacent hypodermal (or epidermal) cells. But that these surrounding cells are limited to three, or that they perform a molding function as Wiren maintains (Wiren, '92) is open to serious question. In those sporadic cases where the matrix cell is raised above the general level of the remaining elements of the hypodermal layer the minute spine is clearly seen to rest solely upon this formative cell, and is not in intimate contact with any other cell element. The same method of growth also appears to be characteristic of the families Neomeniidae and Dondersiidae. In those species of the suborder Noemeniina where the spicules form more than one layer a relatively small number of spines are usually directed radially and at the completion of their development project beyond the external surface of the cuticle. So far as I have been able to follow the development of all such radial spicules each is the product of a single cell, which is either attached directly to the base or close to the base at one side.

In the families Proneomeniidae and Pruvotiniidae the development of the tangentially placed spines follows a different course of development, at least in several carefully studied species belonging to the genera Halomenia, Dorymenia, Lophomenia, and Strophomenia. At its first appearance the minute, cone-shaped calcareous product rests upon a relatively large cell that probably may be considered the homologue of the matrix cell in the foregoing types. In this case, however, the matrix cell is surrounded by "seven or eight cells, slender in form, indistinct in outline, with dense nuclei and attenuated bases which are imbedded in the hypodermis proper." The cell membranes of these accessory elements are distally attached to a membrane or sheath enveloping the spine which accordingly is interrupted near the base. The part played by these different cells is obscure. The basal cell doubtless acts as a lime-secreting agent, and the remaining subsidiary cells form the spicule sheath, but whether they likewise supply calcareous material remains undetermined. The important point, however, is clear that all of these cells, eight or nine in number, are attached to the spine, diminish in size as the spine increases, and in many instances retain their attachment permanently. There is therefore nothing to indicate that they are other than matrix cells. Essentially the same mode of development has been described by Plate in his study of the formation of the spines of certain species of Chitons, and it furnishes another line of evidence for the belief that the Solenogastres and Chitons have had a common ancestor.

One point noted in the Pacific report remains obscure. In early stages a minute body rests between the basal matrix cell and the base of the spine. The point in question is whether it is a cuticular product or a cell. In a late stage it undoubtedly is cuticular, and appears to prevent the passage of lime salts from the matrix cell and by its increase and subsequent decrease and final disappearance is responsible for the development of the cavity within the spine.

At the suggestion of Professor Nierstrasz I have made a careful examination of the heart in all of the species of Solenogastres described in the Pacific and in the present report; as a result I cannot feel that much dependence can be placed on this organ as indicating relationships or relative primitiveness considering our scanty knowledge of the group. To me it appears clear that the dorsal blood vessel in the pericardial region has been provided with a highly developed muscular coat, has thus become a pulsatile organ which frequently comprises two divisions, a ventricle and auricle or atrium, as certain authors prefer to term it. In some species this muscular section lies in a dorsal fold of the pericardial wall; in other cases it has severed its connection with the wall and lies freely in the pericardium. In certain species the auricular or atrial division is very short, as in *Chaetoderma argenteum*, or it may be more pronounced as in

Chaetoderma attenatum, and again it may be entered by two vessels but this bipartite condition ends at the pericardial wall. The impression given is that the heart is a relatively simple tube, usually with two divisions, sometimes sacculated, but I have never found more than one auriculo-ventricular opening or any other evidence to show that the heart is a paired organ.

Whether the auricle or atrium is the homologue of the auricles in other species of molluscs is likewise uncertain; there is no clear evidence for or against such a view. And we are, it seems to me, equally in the dark when we approach the subject of the most primitive type of Solenogastre heart. In my opinion the heart which lies in a fold of the pericardial wall as in some of the Proneomeniidae appears to be among the most primitive. On the other hand where it lies freely in the pericardial cavity, as in Chaetoderma or Alexandromenia, it must have arisen from a simpler embryonic condition, and a simpler phylogenetic stage is equally conceivable. Here again the matter rests upon few data and personal opinion and must accordingly remain as an unsettled problem for the present.

The digestive system, like the circulatory and muscular systems, is most susceptible of change, and the wide variations of form and component elements, correlated with differences in habits of life of the different species, renders it difficult to differentiate coenogenetic from palingenetic characters. I believe, however, that in the ancestral Solenogastre the fore gut was provided with both dorsal and ventral salivary glands and a radula, while the mid-gut, as in the modern neomenians, was a relatively simple tube without clearly defined stomach, digestive gland, and intestine. The hind gut appears to me to be a relatively small section of the digestive tract in the Chaetodermatidae, and forms no part of what has been termed the cloacal, anal, or mantle chamber, a point to which I shall return. As Thiele maintains the atrium of the Neomeniina is no part of the fore gut, and it is possible that it is the homologue of the buccal shield in the Chaetodermatina and the snout of the Chitons.

Dorsal and ventral salivary glands clearly appear in several species, such for example as *Proneomenia hawaiiensis* and *Lophomenia spiralis.* On the other hand the ventral set may disappear completely as in Limifossor and several species of Strophomenia. Since dorsal glands exist in Limifossor I am inclined to look upon the diffuse glands attached to the fore gut of Chaetoderma as a modified homologue. Whether this is the case with the equally diffuse glands surrounding the walls of the fore gut in Strophomenia it is impossible to determine. In Alexandromenia there are three distinct groups of salivary glands one of which with paired ducts is doubtless the counterpart of the ventral set of other species. The possible homologue of the dorsal gland here exists as a diffuse band encircling the fore gut in the neighborhood of the brain. The third set is attached to the fore gut between the radula and mid-gut, and in appearance and staining qualities differs from the other two. It is altogether possible that this posterior set is of more recent, independent origin, and it is also possible that the diffuse glands existing in various species of Strophomenia may have had a similar origin. But at the same time it should be kept in mind that these pharyngeal glands in Strophomenia lie in front of the radula and ventral salivary glands and accordingly may represent a diffuse dorsal gland.

Since a radula exists in *Limifossor talpoideus* and *Halomenia gravida*, for example, with odontoblasts and basement membrane typically located, and the entire organ holding essentially the same position with reference to the ventral salivary glands and the pharynx generally as in the Chitons, it is difficult to avoid the belief that it was present before the Solenogastres became an independent group. The radula may indeed have originated as a cuticular product of the fore gut with separate teeth or as minute projections of a more or less extensive buccal lining, but that this has been its history since the Solenogastres branched off from the parent stock is highly improbable. It is true that the radula in present day species is a highly variable structure — distichous, polystichous, with or without a basement membrane, reduced to a conical peg, or absent altogether — but in my opinion the Limifossor and Halomenia types of radulae have preserved their ancestral characters, while the others represent different stages of degeneration. This is wholly aside from the discussion as to which is the more primitive, the polystichous or distichous plan, a matter it appears to me which cannot be settled considering the small amount of comparative anatomical data we now possess.

As to the mid-gut there are wide variations and here again it is difficult to follow the ancestral history. Where the digestive gland is not clearly differentiated or the stomach or intestine sharply defined we certainly have the least complicated state of affairs and it appears to me to be the more primitive. The Chaetodermatina are therefore more highly modified in this respect than are the Neomeniina.

In this connection the so-called anal, cloacal or branchial chamber may be considered to be a development of the anus, as certain authors maintain, and nowise the homologue of the mantle cavity. The lamellae on its walls in the Neomeniina are therefore modified anal folds and according to Thiele and Plate are not homologous to the branchiae of the Chaetodermatidae, which though a coenogenetic development have nevertheless had an independent origin. Nierstrasz likewise considers the neomenian branchiae to be anal folds, but holds that the Chaetoderma type of gill is the most extreme development of such lamellae. In the Pacific report I have argued in favor of the complete lack of homology between the neomenian type of gill and that found in members of the family Chaetodermatidae. Concerning the true significance of the first named I have no evidence to offer. Plate and Nierstrasz have described certain species (*Notomenia clavigera, Archaeomenia prisca, Proneomenia discoveryi*) in which the coelomoducts do not open into the branchial cavity, and for the present at least I am not inclined to argue for or against the theory that the neomenian gill is a derivative of the anal wall. But when it comes to the Chaetoderma type of gill the evidence that it is a development of the anal or proctodael walls is far from being conclusive. If such a type of gill were to be found among the Gastropoda I venture to say it would unhesitatingly be considered as a ctenidium. It has the same macroscopic and microscopic structure, the same blood circulation, musculature, and innervation as the Chiton or Haliotis gill for example, and the space in which it is held contains the outlets of the coelomoducts and digestive tract. So far as appearance and general relations are concerned the gills of the Chaetodermatidae are true ctenidia, and the surrounding space is a mantle cavity. Here again we must have embryological evidence to definitely settle the question.

Regarding the nature of the ventral fold there is little to add to the observations of other authors and the comments made in the Pacific report. A detailed study of the most advanced larvae of *Halomenia gravida,* in which the anterior pedal gland comprises three or four cells, shows no line of demarcation between the cells of the mid-ventral line and those more laterally placed; and even if all stages in the development of this organ were present it is doubtful if it would afford convincing evidence that the ventral fold is a foot with a long ancestral history to those opposed to such a view. Thiele, Plate, and Nierstrasz admit that the fold is an organ concerned in the function of locomotion, but that it, with the anterior and posterior pedal glands, is the homologue of the foot of other molluscs is vigorously denied. To them the organ in question has had an independent origin, and where the furrow stops short of the branchial chamber we have a primitive state of affairs. As a matter of fact the groove passes into the branchial chamber in the larger number of neomenians I have studied, and has led me to suspect that at least a portion of this last named space may be a true mantle cavity, though at present there is no more actual proof for such a view than for the one which considers it to be an anal space. In my opinion this fold, lying in the mid-ventral line and supplied with two glands, holding essentially the same position as the glands and creeping surface in the young Chiton, is a true foot, the homologue of the Chiton foot, and has been derived from a common ancestor. In the Chaetodermatidae there are few traces of its existence; in the Neomeniina it varies from an exceedingly small organ to one relatively wide and comprising several folds, but so far as I can judge these are secondary features having to do solely with modifications within the group.

That the ventral nerve cords cannot be considered pedal ganglia because they innervate the ventral side of the body as well as the ventral fold, and in this respect are unlike other molluscs, appears to me inconclusive evidence. The supraoesophageal ganglia in both molluscs and annelids are probably derived from homologous groups of cells of the head vesicle, and there is a strong probability that the anterior pair of ventral or suboesophageal ganglia in the annelids is the counterpart of the pedal ganglia of molluscs, the repetition of the ventral ganglia in the annelid being correlated with metameric segmentation. The ventral ganglia of annelids innervate the ventral suface, the entire body wall in fact, but with the development of the mantle and its associated complex in the molluscs a new set of ganglia, the pallial, appeared which innervate these typically molluscan organs. Whether this theoretical view is accepted or not it is certainly true that the ventral surface of the body of the molluscan ancestor, before a definite creeping surface became differentiated, was innervated and continues to be innervated whether the foot includes the entire ventral side of the body or not. Where the foot is small, as in the modern Solenogastre, and the body wall continues to form a portion of the under surface both continue to be supplied by this ventral set of nerves. Where the foot constitutes the entire ventral side of the body it alone is so supplied.

The broader features of the nervous system have been described in the Pacific report, and the study of the various species in the present collection merely confirms the general belief that in the Solenogastres it is reducible to one fundamental plan. In every case the brain is attached to three connectives, the lateral, pedal, and labiobuccal, and anteriorly develops nerves which pass into ganglionic masses (precerebral ganglia) in close proximity to the brain (Chaetodermatina) or attached to the bases of the atrial cirri (Noemeniina). The lateral and pedal cords course to the posterior end of the body where they may unite directly or become closely associated by means of unusually heavy connectives. At frequent intervals the pedal cords are united by commissures, while an approximately similar number of connectives unite them with the lateral ganglia. These last named elements are united posteriorly by a heavy suprarectal commissure. The labiobuccal connectives pass to ganglia in the neighborhood of the radula, which are united by a ventral commissure. A dorsal commissure has also been demonstrated in certain species of neomenians (for example, *Dorymenia acuta* and *Strophomenia scandens*) arising from the labiobuccal ganglia or on the labiobuccal connectives. A second ventral commissure may also exist. In a few species of both suborders a subradular system has been demonstrated with ganglia, commissure and connective uniting them with the labiobuccal ganglia.

With these general features in mind the innervation of the various regions of the body will now be described, the description being based solely upon data derived from the study of species I have personally examined. In the Chaetodermatina the nerves from the great precerebral ganglionic masses attached to the anterior surface of the brain innervate the frontal sense organ and the anterior end of the digestive tract. Nerves from the lateral cords, and in some instances from the latero-pedal connectives, attach to the somatic musculature dorsally and laterally, while fibres from the pedal cords pass to the more ventral portions of the body. In the posterior end of the animal the ventral section of the cloacal wall and the adjacent region of the body wall are supplied with nerves originating at the posterior end of the united lateral and pedal cords. The ventral gill retractor and the ventral half of each gill is supplied with a nerve from the ventral side of the suprarectal commissure, while the dorsal half of the gill is penetrated by a nerve arising close to the mid line on the dorsal side of the suprarectal commissure. Another pair of nerves, originating on the dorsal side of this same commissure but more laterally situated, spread over the dorsal cloacal wall and the neighboring portions of the body wall probably including the dorso-terminal groove. In *Chaetoderma hawaiiense* a nerve from the suprarectal commissure, in the mid line, has been followed into the tissue surrounding the rectum. Nerves from the labiobuccal ganglia extend posteriorly along the wall of the fore gut, and in *Chaetoderma eruditum* have been followed as far as the stomach. The subradular organ is supplied with nerves from the subradular ganglia.

In the Neomeniina the six nerves leaving the anterior surface of the brain are in part distributed to ganglia, about the bases of the cirri, from which delicate fibres pass into the cirri themselves. Other branches of these same cerebral nerves, though apparently independent of the atrial ganglia, pass to the anterior end of the body where they doubtless innervate the body wall including the hypodermis. In *Pachymenia abyssorum* and *Dorymenia acuta* the body wall of the anterior end of the body (and possibly the atrial ganglia, cirri, and atrial ridges) is also supplied with nerves from the anterior end of the lateral ganglia. In *Dorymenia acuta* nerves from the anterior end of the pedal cords and from each anterior latero-pedal connective have been followed to the external atrial ridge. The pharynx is supplied, at least in part, with nerves from the labiobuccal ganglia or from some of the labiobuccal connectives, and in *Dorymenia acuta* a pair of small nerves, having an independent origin from the sides of the brain, have been followed a short distance into the pharyngeal musculature. In *Alexandromenia agassizi* and *Pachymenia abyssorum* the walls of the outlet of the anterior pedal gland are furnished with nerves from the anterior end of the pedal ganglia.

The dorsal side of the body is supplied with nerves from the lateral cords, the sides are furnished with branches from the lateral and pedal ganglia and to some extent by delicate offshoots from the latero-pedal connectives, while the ventral surface is innervated by nerves from the pedal cords. In rare instances slender branches from the pedal commissures have been followed into the foot or ventral fold. In the posterior end of the body the terminal section of the shell gland or ventral section of the coelomoducts in *Strophomenia ophidiana* and *Alexandromenia agassizi* are supplied with nerves from the posterior end of the pedal ganglia or from the posterior latero-pedal connective in *Drepanomenia vampyrella*. Nerves to the pericardial wall and heart in *Strophomenia ophidiana* have their origin in the posterior end of each lateral ganglion. Nerves from the same source enter the gill lamellae in *Pachymenia abyssorum* and *Alexandromenia agassizi* which in the first named species at least are also innervated by other nerves from the posterior end of the pedal ganglia. The body and cloacal walls are furnished with nerves from the posterior end of the pedal and lateral cords and in *Drepanomenia vampyrella* an additional supply originates in the most posterior latero-pedal connective. In several species the suprarectal commissure gives off one nerve (two in *Strophomenia regularis*) which enters the dorso-terminal sense organ. In *Alexandromenia agassizi* the nerve to the sense organ is a relatively small offshoot of a branch having the usual attachment to the suprarectal commissure, but more posteriorly it passes into some of the more dorsally placed gill lamellae.

Regarding the fragmentary knowledge we have of the embryonic development of the Solenogastres and the light which this throws on the question of the primitive characters of the group, it must be admitted that very little conclusive evidence has appeared. In an earlier paper (Heath, 1911) it was shown that the Chiton and annelid in their development up to the trochophore stage follow practically the same course. The great test or modified velum in the Solenogastre larva cannot therefore be looked upon as a primitive mark; nor can the posterior invagination which may represent a dorso-terminal sense organ against which the nerve band abuts. Unfortunately we have no conclusive evidence regarding the presence of a true shell nor any data relating to the form and size of the foot. Whether adult characters are to be considered primitive or secondarily modified must accordingly largely rest upon comparative anatomical studies and the personal factor in interpreting such evidence.

As Nierstrasz has maintained the various species of Solenogastres show a truly surprising amount of variation, and while it is possible to find a fundamental plan upon which all are constructed it is most difficult to decide which features are the most primitive. Personally I am strongly of the belief that the ancestral Solenogastre was provided with a mantle cavity containing a pair of ctenidia and the openings of the coelomoducts and digestive tract, and a creeping surface or foot provided with two sets of glands. Whether a shell was present or absent cannot be decided. The digestive tract was provided with a typical radula, dorsal and ventral salivary glands, while the mid-gut lacked a clearly defined digestive gland. The heart, in the posterior end of the body, communicated on one hand with a sinus from the ctenidia and in the other direction connected with the dorsal aorta, which supplied the gonad and opened through a septum limiting the head cavity. This septum was also perforated ventrally to allow the flow of blood into the visceral cavity and probably a ventral sinus from which it passed to the ctenidia. The coelom comprised a genital section opening into the pericardium, which in turn communicated with the exterior by means of two simple, distinct coelomoducts. The nervous system, having essentially the same configuration as it now possesses, was probably more diffuse.

If such indeed does represent the general plan of the ancestral Solenogastre then it follows that the members of the Chaetodermatidae are highly modified in most respects. They have retained their ctenidia, their relatively simple coelomoducts, and in Limifossor there is an anterior septum and a well-developed radula. In the neomenians the foot and glands still persist, and in certain species a typical radula is present together with dorsal and ventral salivary glands and a diffuse digestive gland. In the posterior end of the body great coenogenetic changes have ensued. The coelomoducts are usually united, seminal receptacles have appeared, and a highly glandular epithelium has developed at least in the terminal section. Penial spines and branchial folds are, in my opinion, likewise recent developments. Where the spines imbedded in the cuticle investing the body develop from a single matrix cell it probably represents the most primitive condition, but since certain neomenians develop some of their spicules in the same general fashion as the Chitons do in part it appears probable that both modes prevailed in the ancestral Solenogastre.

As noted above the Solenogastres are a highly variable group, and such genera as Alexandromenia, Pachymenia, and Neomenia appear to me to stand among the most highly modified members of the order Aplacophora. The Chitons on the other hand are a remarkably conservative group, the differences between the most diversified genera, such as Cryptochiton, Chitonellus, and Ischnochiton, being far less than those differentiating Limifossor and Chaetoderma belonging to the same family. When I made the claim that the Chitons represent the most archaic type of modern mollusc I had in mind the highly modified Solenogastres just noted which appear to me to have departed more widely from the ancestral mollusc than any of the Chitons. It doubtless is possible to select a character here and there from the various species of known Solenogastres and produce a list of primitive features of greater length and more importance than in the case of the Chitons. On such a basis of selection the Solenogastres may be considered to be the more primitive group, but where a single species of Solenogastre (especially from one of the genera noted above) is compared with a single species of Chiton it appears to me that more primitive features will be found to exist in the last named. However this is not a matter upon which I would lay great stress since it appears to rest upon much less conclusive evidence than does the theory whereby the Solenogastres are considered to be more closely related to the Chitons than to any other group of molluscs.

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EXPLANATION OF THE PLATES.

a	anus
aor	aorta
ap	anterior pedal gland
b	brain
bc	buccal commissure
bg	labiobuccal ganglion
br	gill
brn	nerve to gill
c	intestinal coecum
cl	cloacal chamber
co	cloacal coecum
cp	coelomoduct
da	dorsal aorta
dsg	dorsal salivary gland
fo	buccal plate
gl	glands of pharynx
gon	gonad
ht	heart
int	intestine
lbc	labiobuccal connective
liv	liver
m	mouth
n	nerve to buccal plate
oe	oesophagus
pe	pedal ganglion
pcg	precerebral ganglion
pcm	pericardium
ph	pharynx
pl	lateral ganglion
ps	pedal sinus
r	radula
rc	seminal receptacle
rs	radular support
s	anterior vertical septum
sc	subradular commissure
sg	ventral salivary gland
sgl	shell gland
sn	subradular ganglion
so	sense organ
sp	spicule
sr	dorsal gill retractor
sro	subradular organ
sto	stomach
sv	seminal vesicle
vr	ventral gill retractor
vs	ventral diaphragm

PLATE 1.

PLATE 1.

Fig. 1. Two individuals of Strophomenia agassizi in the act of copulation; the posterior ends in contact near left side of figure. × 6.

Fig. 2. Hypodermis and papillae in head region. × 135.

Fig. 3. Spicules from middle of body. × 100.

Fig. 4. Reconstruction of anterior end of body.

Fig. 5. Reconstruction of posterior end of body.

Fig. 6. Section across outlet of anterior pedal gland of Neomenia verrilli.

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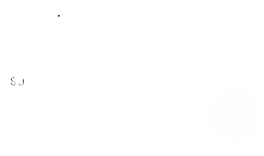
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PLATE 2.

PLATE 2.

Fig. 1. Strophomenia agassizi. Section along line C of fig. 4, pl. 1.
Fig. 2. Same along line B of fig. 4, pl. 1.
Fig. 3. Same along line A of fig. 4, pl. 1.
Fig. 4. Section along line H of fig. 5, pl. 1.
Fig. 5. Section along line D of fig. 4, pl. 1.
Fig. 6. Section along line F of fig. 5, pl. 1. (One third reduced).
Fig. 7. Same along line G of fig. 5, pl. 1.
Fig. 8. Same along line E of fig. 5, pl. 1. × 360.
Fig. 9. Nierstrassia fragile. Ventral fold. × 360.
Fig. 10. Section through radula. × 555.

PLATE 2.

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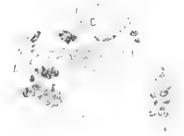

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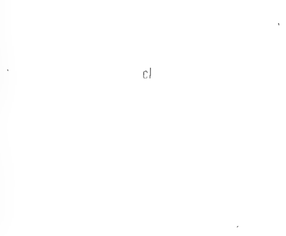

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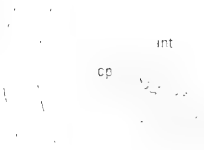

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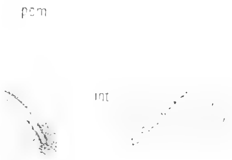

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PLATE 3.

PLATE 3.

Fig. 1. Reconstruction of posterior end of body of Neomenia verrilli. pgl. penial gland.
Fig. 2. Section through posterior end of body along line of D of fig. 1.
Fig. 3. Section through seminal vesicle.
Fig. 4. Reconstruction of anterior end of body.
Fig. 5. Section through accessory penial spines and glands. × 85.
Fig. 6. Lateral view of entire animal. × 2.
Fig. 7. Section through accessory penial spines and glands. × 46.
Fig. 8. Hypodermis and papillae. × 190.

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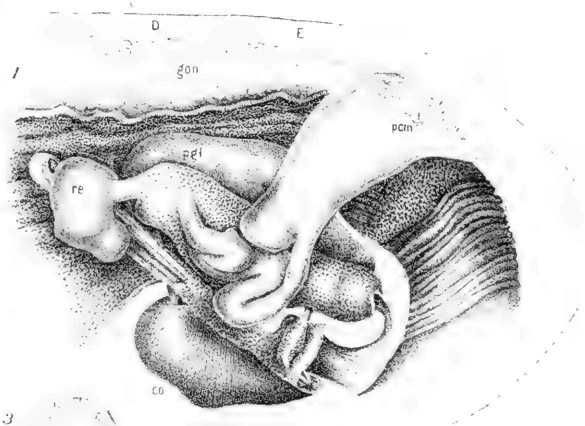

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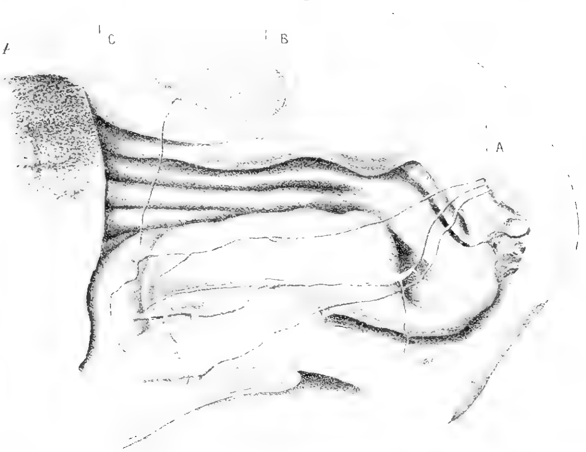

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Meisel Lith. Co. Boston

PLATE 4.

PLATE 4.

Fig. 1. Neomenia verrilli. Section through penial gland and junction of dorsal and ventral limbs of coelomoduct. × 85.

Fig. 2. Section through posterior end of body along line E of fig. 1, pl. 3.

Fig. 3. Section through pharynx along line B of fig. 4, pl. 3.

Fig. 4. Section through pharynx along line C of fig. 4, pl. 3.

Fig. 5. Cloacal folds and attached glands. × 215.

Fig. 7. Section through brain along line A of fig. 4, pl. 3.

Fig. 8. Section through distal end of penial spine, sheath, and attached muscles. × 29.

Fig. 6. Proneomenia acuminata. Section through middle of heart. × 85.

Fig. 9. Teeth to left of mid line.

Fig. 10. Section through pharynx (ph) at level of subradular organ.

Fig. 11. Section along line B of fig. 1, pl. 5.

Fig. 12. Section along line E of fig. 5. pl. 5.

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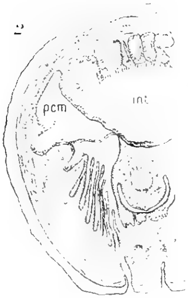

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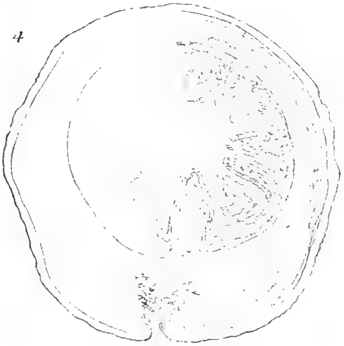

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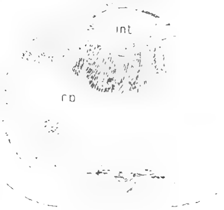

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PLATE 5.

PLATE 5.

Fig. 1. Reconstruction of anterior end of body of Proneomenia acuminata.

Fig. 2. Section through pharynx along line C of fig. 1.

Fig. 3. Entire animal. × 2.

Fig. 4. Spines from sides of body. × 100.

Fig. 5. Reconstruction of posterior end of body. Sg, shell gland.

Fig. 6. Hypodermis and papillae. × 190.

Fig. 7. Section through pharynx (ph) at level of subradular ganglia (srg) above which are ducts of the ventral salivary glands.

Fig. 8. Section along line F of fig. 5 int, intestine.

Fig. 9. Section along line A of fig. 1.

Fig. 10. Section along line D of fig. 5. da, dorsal aorta; ht, heart; sr, seminal receptacle.

Fig. 11. Section through cloacal chamber along line G of fig. 5.

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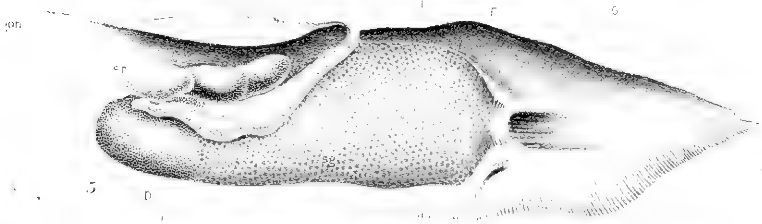

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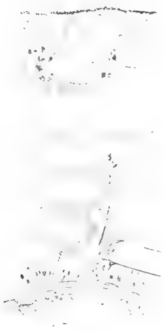

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PLATE 6.

PLATE 6.

Fig. 1. Entire animal of Nierstrassia fragile. × 13.
Fig. 2. Hypodermal layer. × 800.
Fig. 3. Reconstruction of anterior end of body.
Fig. 4. Section through posterior end of body along line F of fig. 5.
Fig. 5. Reconstruction of posterior end of body.
Fig. 6. Section through posterior end of body along line C of fig. 5.
Fig. 7. Same along line D of fig. 5.
Fig. 8. Section through region of brain along line A of fig. 3.
Fig. 9. Longitudinal section through brain and anterior end of alimentary canal. × 180.
Fig. 10. Section through posterior end of body along line E of fig. 5.
Fig. 11. Posterior end of body, ventral view.

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PLATE 7.

PLATE 7.

Fig. 1. Nierstrassia fragile. Cross section at level of B of fig. 3, pl. 6.

Fig. 2. Dorymenia peroneopsis, entire animal. × 3.

Fig. 3. Section through brain at level of line B of fig. 5, pl. 7.

Fig. 4. Section through anterior end of body corresponding to line E of fig. 5, pl. 7. Salivary glands in natural position.

Fig. 5. Reconstruction of anterior end of body. The main portion of the ventral salivary gland has been shifted ventrally to show radular mechanism.

Fig. 6. Reconstruction of radular apparatus.

Fig. 7. Reconstruction of posterior end of body.

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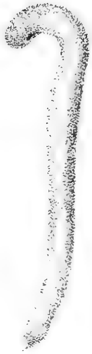

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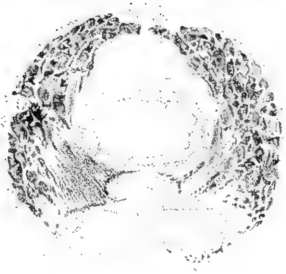

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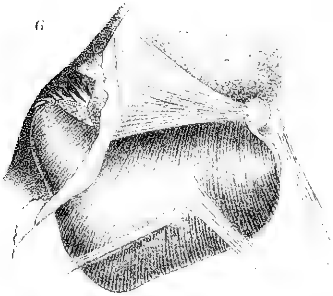

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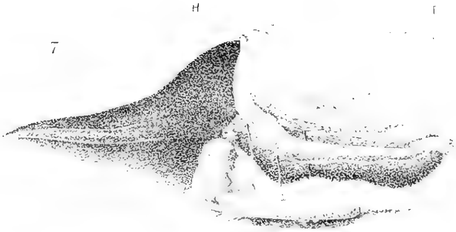

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PLATE 8.

PLATE 8.

Fig. 1. Dorymenia peroneopsis. Section through posterior end of body along line G of fig. 7, pl. 7.
Fig. 2. Spines from side of body. × 190.
Fig. 3. Section along line H of fig. 7, pl. 7.
Fig. 4. Section along line A of fig. 5, pl. 7.
Fig. 5. Section along line C of fig. 5, pl. 7.
Fig. 6. Section along line F of fig. 7, pl. 7.
Fig. 8. Section along line D of fig. 5, pl. 7.
Fig. 9. Papilla and hypodermis, head region. × 255.
Fig. 7. Cross section of pharyngeal (salivary) gland of Chaetoderma caudatum. × 91.
Fig. 10. Section close to junction of pharynx and mid-gut. × 88.
Fig. 11. Section slightly anterior to forward border of pericardium showing alimentary canal, two lateral gonoducts and dorsal aorta.
Fig. 12. Section through mid-gut or stomach.

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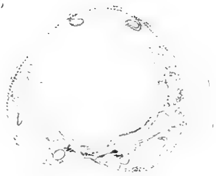

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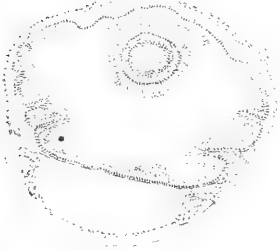

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PLATE 9.

PLATE 9.

Fig. 1. Chaetoderma caudatum, entire animal. × 8.
Fig. 2. Head region of same specimen. × 12.
Fig. 3. Side view of another specimen. × 12.
Fig. 4. Anterior view of same animal as fig. 1. × 12.
Fig. 5. Section at level of radula. × 88.
Fig. 6. Section through pericardium and coelomoducts.
Fig. 7. Section at level of external coelomoduct openings.
Fig. 8. Section at level of brain.
Fig. 9. Hypodermis of prothorax. × 360.
Fig. 10. Junction of stomach and liver.
Fig. 11. Spines from mid section of body. × 190.
Fig. 14. Section through outlets of pericardium into coelomoducts.
Fig. 12. Two specimens of Chaetoderma lucidum. × 4.
Fig. 13. Section through a pharyngeal gland. × 330.
Fig. 15. Spines. × 146.
Fig. 16. Cross section of metathorax. × 46.
Fig. 17. Section through dorso-terminal sensory groove. × 190.
Fig. 18. Cross section at junction of pro- and metathorax.


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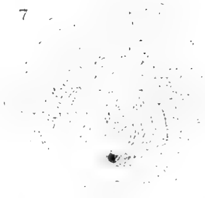
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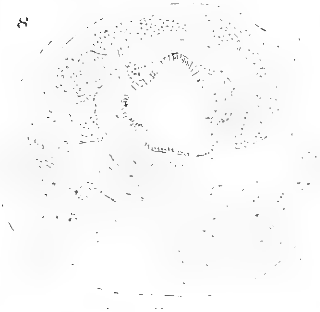
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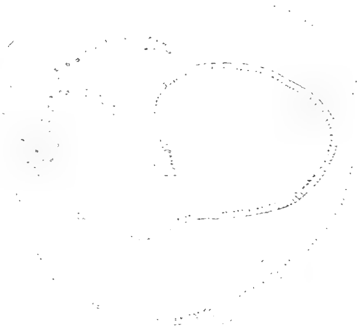
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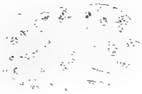
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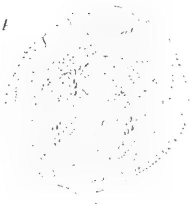
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PLATE 10.

PLATE 10.

Fig. 1. Chaetoderma lucidum. Section through head at level of radula. × 46.
Fig. 2. Cross section through brain.
Fig. 3. Section through posterior end of body at level of coelomoduct outlets.
Fig. 4. Junction of digestive gland and midgut or stomach.
Fig. 5. Junction of pharynx and stomach.
Fig. 6. Section at level of suprarectal commissure.
Fig. 7. Gastric epithelium, showing supposed intercellular bridges.
Fig. 11. Anterior end.
Fig. 8. Chaetoderma bacillum, entire animal. × 7.
Fig. 9. Section through anterior end at level of radula. × 46.
Fig. 10. Section at level of brain.
Fig. 12. Section through junction of pro- and metathorax.
Fig. 13. Portion of hypodermal layer.
Fig. 14. Section at level of posterior end of heart.

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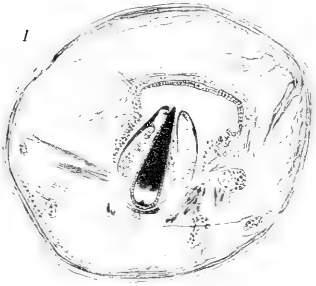

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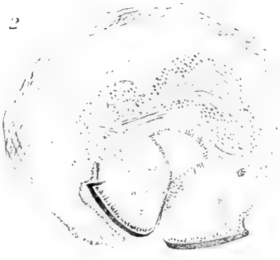

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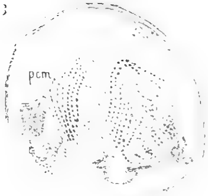

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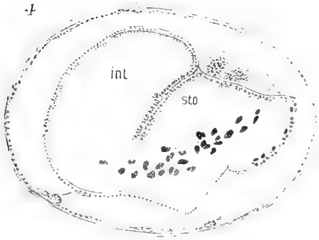

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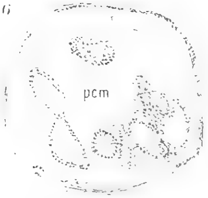

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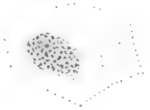

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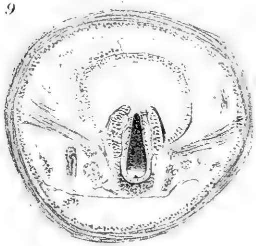

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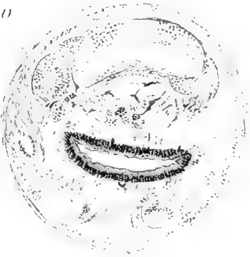

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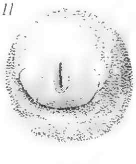

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PLATE 11.

PLATE 11.

Fig. 1. Chaetoderma bacillum. Section near junction of pharynx and stomach.
Fig. 2. Section at level of suprarectal commissure.
Fig. 3. Section at level of coelomoduct openings to exterior.
Fig. 4. Spicules from middle of body. × 146.
Fig. 6. Chaetoderma bacillum. Anterior end.
Fig. 7. Section slightly anterior to opening of gut into cloaca.
Fig. 5. Chaetoderma squamosum, entire animal. × 3.
Fig. 8. Section slightly anterior to junction of pro- and metathorax. × 35.
Fig. 9. Spines from mid section of body. × 91.
Fig. 10. Cross section of body at level of radula.
Fig. 11. Section at level of brain.
Fig. 12. Section about level of middle of pericardium.
Fig. 14. Section near junction of pharynx and stomach.
Fig. 15. Section through anterior end of metathorax.
Fig. 16. Section at level of dorso-terminal groove and coelomoduct outlets.
Fig. 17. Junction of pro- and metathorax.
Fig. 13. Anterior end of young specimen of Chaetoderma vadorum.

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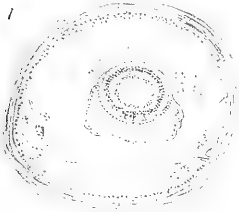

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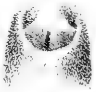

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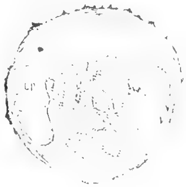

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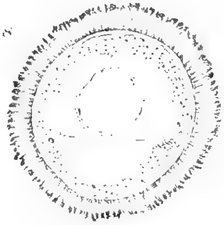

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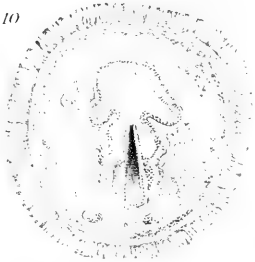

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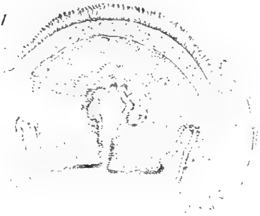

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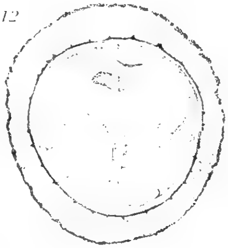

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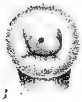

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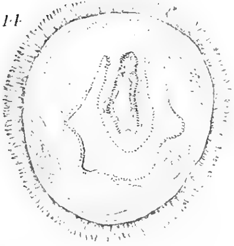

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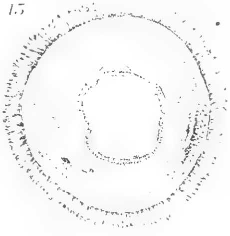

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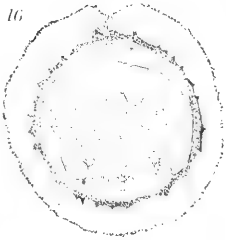

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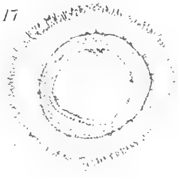

PLATE 12.

PLATE 12.

Fig. 1. Chaetoderma vadorum. Section through anterior end at level of radula.
Fig. 2. Section through one group of pharyngeal glands. × 255.
Fig. 3. Spines from middle of body. × 146.
Fig. 4. Oblique section through metathorax.
Fig. 5. Section through middle of prothorax.
Fig. 6. Section through brain.
Fig. 7. Section at union of pharynx and stomach.
Fig. 8. Section through anterior end of metathorax.
Fig. 9. Section through pharynx slightly behind the radula.
Fig. 10. Section through junction of stomach and liver.
Fig. 11. Section through anterior end of pericardium.
Fig. 12. Same region as fig. 9 in another specimen.
Fig. 13. Section at level of openings of gut and coelomoduct into the cloacal chamber.
Fig. 14. Section through union of pro- and metathorax.
Fig. 15. Section at level of suprarectal commissure.
Fig. 16. Gland cells near mid-ventral line of body in preabdomen. × 255.
Fig. 17. Same region as in fig. 1 of another specimen.


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PLATE 13.

PLATE 13.

Fig. 1. Chaetoderma vadorum.
Fig. 2. Same species, anterior end.
Fig. 3. Section through dorso-terminal groove. × 330.
Fig. 4. Section at level of brain.
Fig. 8. Hypodermis.
Fig. 5. Ovum showing male and female pronucleus of Halomenia gravida.
Fig. 6. Reconstruction of segmentation stage in the development.
Fig. 9. Longitudinal horizontal section through posterior end of larva of about the same stage as in fig. 11.
Fig. 10. Nuclei-like bodies in egg; also shown in fig. 5.
Fig. 11. Reconstruction of an advanced larva.
Fig. 12. Reconstruction of another stage about midway between those represented in figs. 6 and 13.
Fig. 13. Reconstruction of early stage somewhat flattened.
Fig. 7. Hypodermis of Chaetoderma squamosum. × 290.


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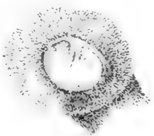
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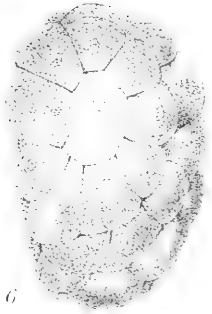
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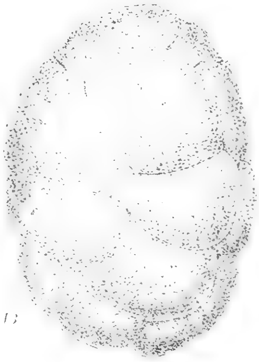
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PLATE 14.

PLATE 14.

Fig. 1. Longitudinal horizontal section through posterior terminal depression in an advanced larva of Halomenia gravida.

Fig. 2. Same; younger than stage represented in fig. 3. × 330. D, v, dorsal and ventral surfaces.

Fig. 3. Longitudinal horizontal section through larva of about the same stage as fig. 11, pl. 13.

Fig. 4. Longitudinal horizontal section through oldest larva.

Fig. 5. Next section to the one represented in fig. 1. The horizontal lines in this and fig. 1 coincide.

Fig. 6. Early stage in the development of the cerebral ganglia. × 360.

Fig. 7. Longitudinal horizontal section of about the same stage as fig. 12, pl. 13. Arrow indicates position of polar body.

Fig. 8. Longitudinal horizontal section of about the same stage as fig. 6, pl. 13. × 91.

Fig. 9. Longitudinal horizontal section of about the same stage as fig. 12, pl. 13. × 91. Arrow indicates position of polar body.

Fig. 10. Polar body and female pronucleus; same stage as fig. 5, pl. 13. × 330.

Fig. 11. Section through larva of about the same stage as fig. 13, pl. 13.

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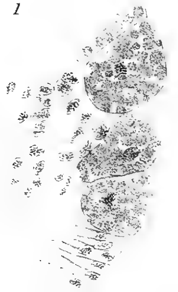

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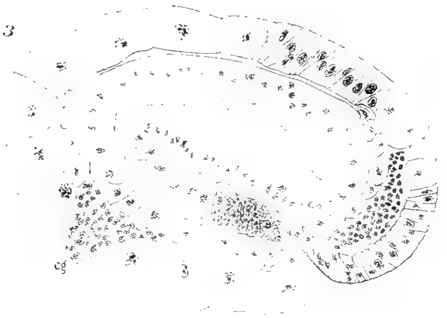

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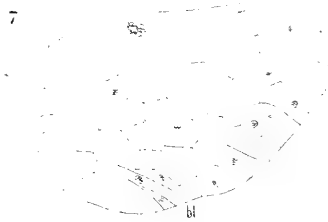

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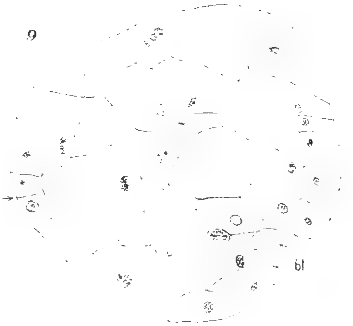

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