SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE
PART OF VOLUME XXXV

THE APODOUS HOLOTHURIANS

A MONOGRAPH

OF THE

SYNAPTIDÆ AND MOLPADIIDÆ

Including a Report on the Representatives of these Families in the Collections of the United States National Museum

BY

HUBERT LYMAN CLARK

(No. 1723)

CITY OF WASHINGTON
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Commission to whom this memoir has been referred:

ADDISON EMORY VERRILL
WILLIAM KEITH BROOKS

WASHINGTON, D. C.
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1907

ADVERTISEMENT.

The present memoir by Dr. Hubert Lyman Clark, of the Museum of Comparative Zoölogy, in Cambridge, Massachusetts, on "The Apodous Holothurians," sea-cucumbers or trepangs, forms part of Volume XXXV of the Smithsonian Contributions to Knowledge.

In this memoir the attempt has been made to give a complete summary of our present knowledge of the two families of sea-cucumbers which lack tube-feet. As a system of classification is the essential foundation upon which any discussion of structure, habits or relationships must be built, the first section is devoted to a discussion of the history of the classification of the two families (Synaptidæ and Molpadiidæ), with comments on the principles involved and a final summary of the system adopted. Most of the original investigations having been based on material in the collections of the United States National Museum, the second section is an annotated catalogue of the Apodous Holothurians of that institution. The third section deals with the family Synaptidæ, and takes up in regular sequence, so far as our present knowledge permits, the structure, physiology, development, habits and classification of these animals. In the last subdivision of this section, each species, recognized as valid, is treated separately in some detail. In the fourth section, the family Molpadiidæ is treated in the same way.

The most important feature of the work is the recognition of the changes taking place in the maturing and senescence of individual holothurians, particularly in the family Molpadiidæ. As a result of this, radical changes in nomenclature have been necessary, but every effort has been made to have the system adopted accord with the most widely accepted codes, and thus be as stable as possible. Special attention has been given to geographical distribution, but the work in this line is chiefly of value as a summary of our present very inadequate knowledge. Artificial keys to genera and species have been freely used with the intention of making the work as useful as possible to all subsequent investigators, and the numerous figures, most of which are copied from other writers, are given with the same end in view.

In accordance with the rule adopted by the Institution, the work has been submitted to a commission consisting of Prof. A. E. Verrill, of Yale University, and Prof. W. K. Brooks, of the Johns Hopkins University, who recommended its publication in the present series.

Chas. D. Walcott,
Secretary.

Smithsonian Institution,
Washington, *June*, 1907.

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INTRODUCTION.

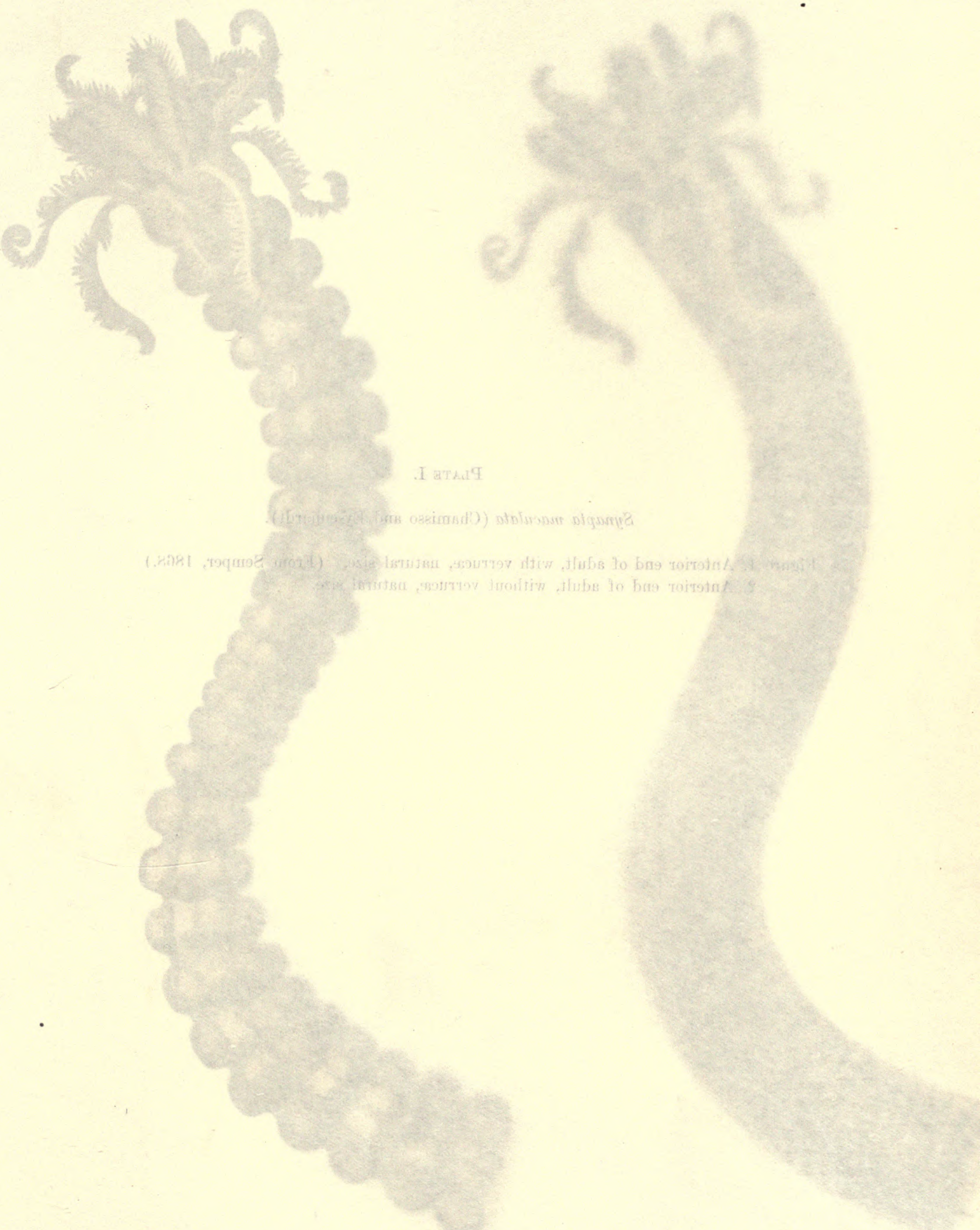
Early in the spring of 1900 the collection of apodous holothurians of the United States National Museum was placed in my hands for identification. This collection consisted of nearly 1,000 specimens from various localities along the American coast, both east and west, from the Banks of Newfoundland and the Aleutian Islands to the Strait of Magellan. It was rich in Molpadiidæ, and furnished an excellent basis for the revision of that family, but it was poor in Synaptidæ, though many of the American species were represented by numerous specimens. Owing, however, to the great need of a revision of the Synaptids, it was thought best to take the opportunity of making it, and the present paper was intended to be a complete account of all the footless holothurians known to science. After the manuscript was completed, in 1906, a supplementary collection from the National Museum, containing over 1,200 specimens, was placed in my hands, and the examination of this additional material has proved of great value, not only by enabling me to test and correct the artificial keys, but by throwing much additional light on the validity of a number of doubtful forms. This report, as it now stands, is intended to include all species described prior to January 1, 1907, and to furnish a means for their ready identification. The synonymy of each species has received careful attention, but no attempt has been made to include every writer who has mentioned the form, unless he has in some way modified or qualified the name in use. The bibliography is thought to include every paper which contains any matter of importance relating to the two families, but a number of papers are omitted which simply contain casual references to, or familiar facts concerning, some of the well-known species.

As a matter of convenience, the classification of the two families is discussed first, and this is followed by an annotated list of the species in the collections of the National Museum, including descriptions of new genera and species. The remaining space is occupied by an account of the morphology, embryology, physiology, ecology, and taxology of the two families, with artificial keys and an account of each species, especial attention being given to the geographical distribution. The figures are intended to illustrate not only the new forms described, but also previously known species that have not been figured, and some others, figures of which will be of service to the student of these animals. A synonymic index is also given, to aid in finding any species referred to by previous writers. A sincere effort has been made to place the nomenclature on as firm a basis as possible, by the use of the now very generally accepted principles laid down in the International Code. This has involved a number of changes which, however unwelcome, were bound to be made sooner or later. The author lays no claim to infallibility, however, and does not expect that no errors will be found in his results. Lack of knowledge or poor judgment on his part, coupled with the inadequate descriptions of early writers, afford many loopholes for mistakes.

In conclusion, I desire to express the great obligation I am under to Mr. Richard Rathbun, the Assistant Secretary of the Smithsonian Institution, for his unfailing courtesy and many helpful suggestions, and to Miss Mary J. Rathbun, for much kind assistance in connection with nomenclature and illustrations. My friend, Professor L. T. Larsen, of Olivet College, has afforded me invaluable assistance in my effort to have philologically correct the new names I have been obliged to coin. I am also greatly indebted to Dr. Hjalmar Östergren, of Upsala, who by his letters and kindness in sending me specimens, as well as by his publications on the Synaptidæ, has proved an invaluable aid.

Finally, Dr. W. K. Fisher has very kindly permitted me to have advance sheets of his valuable memoir on Hawaiian Holothurians, and these have enabled me to include his work herein.

CAMBRIDGE, MASS., *April* 1, 1907.



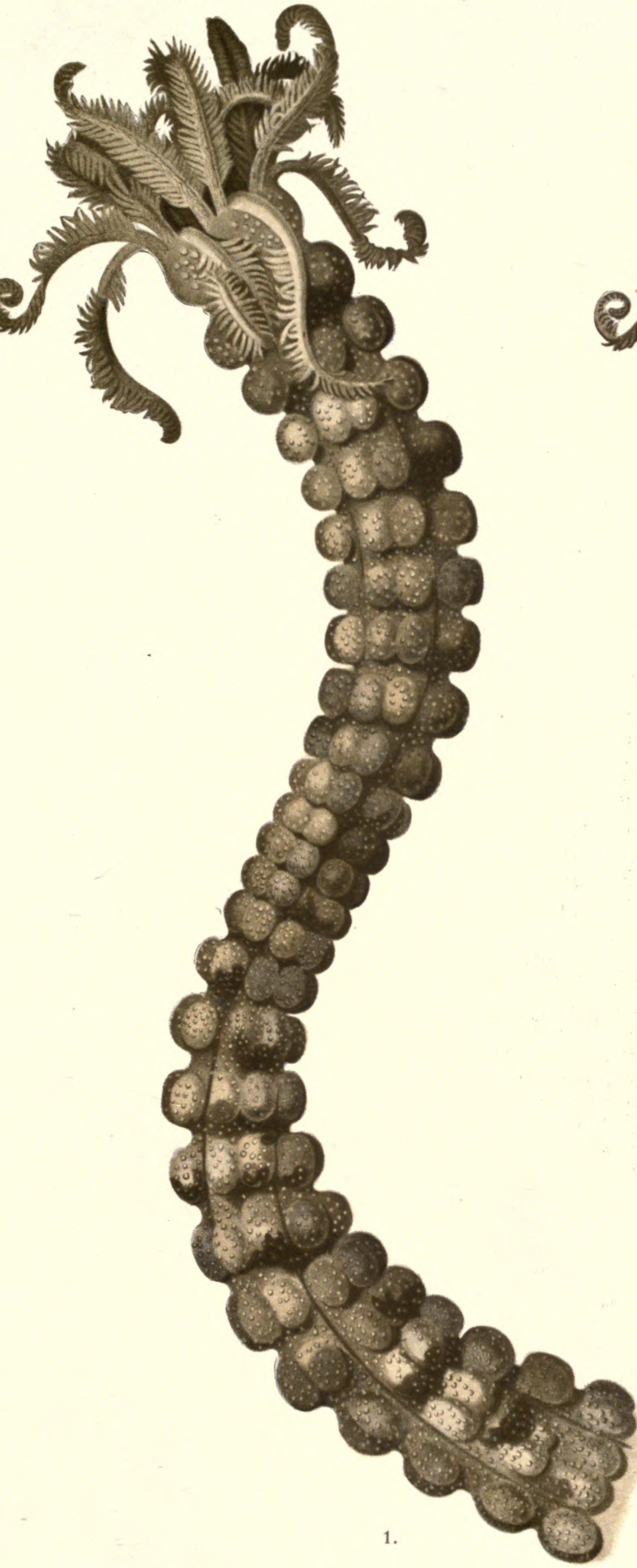
Synapta maculata (Chamisso and Eysenhardt).

PLATE I.

Synapta maculata (Chamisso and Eysenhardt).

Figure 1. Anterior end of adult, with verrucæ, natural size. (From Semper, 1868.)

2. Anterior end of adult, without verrucæ, natural size.



1.

2.

Synapta maculata Chamisso and Eysenhardt.

PART I.

THE CLASSIFICATION OF THE APODOUS HOLOTHURIANS.

The first writer on Holothurians who recognized the presence or absence of feet (pedicels) as an important character in the classification of the group was J. F. Brandt ('35), in his account of the animals observed by H. Mertens. He divided the group Holothuriæ, which he ranked as a family, into two great subdivisions, the PEDATÆ and the APODES. Unfortunately, however, he failed to distinguish accurately the apodous from the pedate forms, and consequently, as Ludwig ('81*b*) has shown, many really apodous forms occur in the Pedatæ. He divided the Apodes into the PNEUMONOPHORÆ and the APNEUMONES, according to the presence or absence of respiratory trees. But here again his observations were not exact, and some forms without respiratory trees are placed in his Pneumonophoræ. Burmeister ('37) ranked the holothurians as an order including several families, one of which, called by him SYNAPTIDÆ, was equivalent to Brandt's Apodes. Grube ('40) called the same group CHIRIDOTÆ, Forbes ('41) called them SYNAPTÆ, Gray ('48) SYNAPTIDÆ, and Siebold ('48) SYNAPTINÆ. Johannes Müller ('50) considered the possession of respiratory trees as the important point in holothurian anatomy, and accordingly he divided the order into "lungenlose" and "lungentragende" groups; the latter were divided into the "fusslose" and "fussige," and the "fusslose" were christened MOLPADIIDÆ. Bronn ('60) recognized the position of the holothurians as a class, and divided it into two orders, the first of which contained only the extraordinary Rhopalodina, while the second was divided into two suborders, APODIA and EUPODIA, the Apodia equivalent to Brandt's Apodes. Under the APODIA were placed two families, the Synaptidæ (without respiratory trees; four genera, Synapta, Synaptula, Chiridota, Myriotrochus) and the LIODERMATIDÆ (with respiratory trees; three genera, Lioderma, Haplodactyla, Molpadia), Müller's Molpadiidæ.

With the publication of Selenka's monograph ('67) the study of the holothurians really began, from a modern systematist's point of view. He divided the class HOLOTHURIOIDEA into two orders, the PNEUMONOPHORA and the APNEUMONA, the former with three families, the last of which, the LIOSOMATIDÆ, was equivalent to Müller's Molpadiidæ. Selenka's classification of the footless forms may be tabulated thus:

Orders.	Families.	Genera.
PNEUMONOPHORA . .	Liosomatidæ . .	Molpadia, Liosoma, Haplodactyla, Caudina, Embolus.
APNEUMONA	Synaptidæ . . .	Synapta, Synaptula, Chirodota, Myriotrochus, Eupyrgus, Rhabdomolgus.

In the Liosomatidæ, Selenka included nine species, of which one was described for the first time. In the Synaptidæ were included 44 species, of which 29 were placed in the genus Synapta and 10 in Chirodota.

The notable monograph of Semper ('68) used essentially the same classification, but he called the family of footless Pneumonophora, Molpadiidæ, and in it he placed a new genus Echinosoma. He also described a new Haplodactyla, *H. molpadioides,* with two varieties, *pellucida* and *sinensis*. Under the Apneumona he placed two new families, the EUPYRGIDÆ and ONCINOLABIDÆ, each with one genus, but he expressed strong doubts as to the validity of these families, and regarded the genus Eupyrgus as probably belonging to the Molpadiidæ, and Oncinolabes as synonymous with Synapta. Under the Synaptidæ he placed a new genus, Anapta, containing one species. He also added 10 new species of Synapta and admitted 23 others; five new Chirodotas, and admitted 12 others; and he recognized three other genera each with one species. Semper therefore listed 68 species of apodous holothurians as against Selenka's 53.

Seventeen years later, Lampert ('85) returned to the classification of Brandt and recognized the order Apoda, with its two suborders each with a single family. His arrangement was as follows:

Suborders.	Families.	Genera.	No.	No. of valid species.	New species.	Doubtful.	Total.
Apneumona	Synaptidæ . .	Synapta, Anapta, Chirodota, Myriotrochus, Trochoderma, Acanthotrochus, Rhabdomolgus.	7	78	0	4	82
Pneumonophora . .	Molpadiidæ .	Haplodactyla, Molpadia, Liosoma, Caudina, Trochostoma, Ankyroderma, Eupyrgus.	7	24	0	1	25
			14	102	0	5	107

The next great monograph on holothurians, that by Théel ('86 *a*) adopts the same classification, except that Embolus is admitted among the Molpadiidæ and Liosoma is not. Owing to the description of 11 new species, the total number treated is 118, of which 26 are regarded as of doubtful standing. The classic work of Ludwig ('92*b*) in Bronn's Thierreich introduces an entirely new basis of classification and breaks up the suborder Apoda. Ludwig shows that the embryology of the Synaptidæ sets them apart as a distinct group from the other holothurians, and he therefore divides the class HOLOTHURIOIDEA into two orders, the ACTINOPODA and the PARACTINOPODA, distinguished by the place of origin of the circumoral tentacles. The Actinopoda include four families, of which the last is the Molpadiidæ, containing the footless species. The Paractinopoda includes the single family Synaptidæ. Ludwig's arrangement of genera is as follows:

Molpadiidæ = Molpadia (2 species), Eupyrgus (1), Haplodactyla (5), Caudina (4), Trochostoma (12), Ankyroderma (8).
6 genera, 32 species.
Synaptidæ = Synapta (51 species), Anapta (5), Chiridota (20), Trochodota (2), Trochoderma (1), Myriotrochus (1), Acanthotrochus (1).
7 genera, 81 species.
Total, 13 genera, 113 species.

The last important paper of the nineteenth century dealing with the classification of the footless holothurians is Östergren's ('98*b*) admirable revision of the Synaptidæ. He proposes to divide the family into three subfamilies, chiefly because of differences in the calcareous deposits: Synaptinæ with anchors and plates, or occasionally (Anapta) only miliary granules; Chiridotinæ with 6-spoked wheels, or sigmoid or bracket-shaped particles, never anchors; Myriotrochinæ with wheels having 8 or more spokes, never collected in papillæ. Under the Synaptinæ, he places Anapta and five other genera, made from the old genus Synapta, as follows: Euapta, Chondroclœa, Synapta, Labidoplax, Protankyra. These genera are distinguished from each other mainly by the shape of the tentacles and anchors and anchor-plates. Under the Chiridotinæ are placed two genera, Sigmodota and Chiridota, while Myriotrochus, Trochoderma, and Acanthotrochus make up the third subfamily. Altogether Östergren recognizes 81 species of Synaptidæ, the same number listed by Ludwig six years before.

The report on the holothurians of the "Travailleur" and "Talisman," by Rémy Perrier (:03), returns to the old arrangement of Brandt again, but is notable for the relative rank given previously recognized groups. He considers the apodous holothurians a natural assemblage, and ranks them as a subclass, the Apodes. This subclass includes two orders, the ANACTINOPODA[1] with one family, the Molpadiidæ, and the PARACTINOPODA with three families, the Synaptidæ, Chirodotidæ, and Myriotrochidæ. Thus Östergren's subfamilies are here raised to full family rank. Delage and Herouard (:04) recognize two orders, ACTINOPODIDA and PARACTINOPODIDA, under the first of which they place

[1] Spelled Anactipoda on page 261, where first introduced; elsewhere spelled as above given.

the Molpadiidæ as a distinct suborder, with the usual single family and six genera. Their classification of the Paractinopodida is most confusing, for no subordinate groups are given save genera, of which 14 are recognized, two being known only from fossil remains. Moreover, although several references are made to Östergren's work, these only add to the confusion, for blunders are made in attempting to indicate the subfamilies proposed by him, and an obvious slip of the pen concerning the Chiridotinæ makes matters still worse. MacBride (:06), ignoring Ludwig's important embryological work, divides the holothurians into six orders, of which the last two are the MOLPADIIDA and SYNAPTIDA, each containing a single family and six genera. Such a classification is certainly no contribution to our knowledge of the group! Fisher (:07) recognizes the classifications used by Ludwig and by Östergren, at the same time calling attention to some points of nomenclature in which the latter seems to be in error. He adds a new genus (Opheodesoma) which is practically section B of Östergren's Euapta, and gives a very full account of the type species. He also describes four other new forms of Synaptidæ.

In arranging any scheme of classification, the first point to be determined is the relative value of characters upon which to base specific, generic, and family differences. In the holothurians, the characters which best determine family limits are the presence or absence of true retractor muscles and respiratory trees, the number and form of the tentacles, and the presence or absence of other ambulacral appendages. Since the ambulacral appendages, except tentacles, vary greatly in number, size, and arrangement, even in a single species, the characteristic features of the internal anatomy carry more weight. The group of apodous holothurians therefore cannot be accepted as a natural group, especially since the genera Himasthlephora and Gephyrothuria form an obvious connecting link with the pedate forms. The absence of respiratory trees is, however, a constant and remarkable character, and, combined as it is with the absence of pedicels and papillæ and the presence of unbroken circular muscles, marks out the Synaptidæ as a well-defined family, aside from its ordinal characters. The other apodous holothurians are less susceptible of satisfactory definition, aside from the lack of pedicels, but the shape of the body usually terminating in a more or less evident caudal portion, the peculiar, short tentacles, combined with the presence of respiratory trees, are really quite characteristic for the Molpadiidæ. These two families may therefore be accepted as including all known apodous holothurians (except the remarkable and unique Pelagothuriidæ), but there is no intention of implying any necessarily close connection between them. Perrier's (:03) reëstablishment of the group Apodes seems to be an attempt to base the classification on an obvious, external character, because it is convenient and easy to note, rather than an effort to reach a natural arrangement. No new arguments are advanced in favor of the Apodes, and the evidence is certainly against their standing as a subclass.

In discussing the classification of the Synaptidæ, the question naturally arises whether the subfamilies suggested by Östergren ('98*b*) are worthy of recognition. Subfamilies may be quite as natural groups as families, but if they are simply artificial assemblages they needlessly complicate the classification, unless the number of genera is unusually large, which is certainly not the case with the Synaptidæ. That Östergren's subfamily Synaptinæ is a natural group seems very probable, the genera contained in it being evidently related to each other. There is more room for question whether the Chiridotinæ and Myriotrochinæ can be properly separated from each other, but the calcareous particles are certainly strikingly different in the two groups, and it is at least probable that no violence is done in separating them. But Perrier's (:03) proposition to make full families of these subdivisions of the Synaptidæ cannot be approved without exaggerating their differences.

In attempting to define genera or species in the Synaptinæ, we are met with the difficulty that many are known from a single specimen or at most a few, and nothing is recorded of their life histories. Especially is this true of the various East Indian species, and since, in those species whose life history has been studied, it is known that the number of tentacles gradually increases as the animal approaches maturity, it is very probable that some of the 10- and 13-tentacled species will prove to be the young of other 12- or 15-tentacled forms. Moreover, many species have been described from fragments, the anterior end of the body being missing, and consequently the species are based wholly on the calcareous particles, which is of course unfortunate; for it ought to be clearly understood that the calcareous particles in the skin of Synaptids (as in all holothurians) are more or less variable, and while each species usually has its own distinct sort, yet there is a very wide range of diversity, even in one individual, and exact conformity to a given type must not be expected or looked for. The six genera proposed by Östergren appear in the main to be natural groups, and will doubtless be quite generally accepted. But unfortunately in selecting his names, Östergren overlooked or ignored some of his predecessors. The name Synapta was proposed by Eschscholtz ('29) for a species which he called *mammillosa,* and he also states that *Holothuria maculata* Chamisso and Eysenhardt is congeneric. There can be little question that these two species are the same, in spite of the extraordinary difference in the colored figures given (see page 79), and it is further reasonably sure that they are no other than the species well known as *beselii* Jäger. The name Synapta must therefore be retained for this species, which Östergren puts in his genus Chondroclœa. Owing to its unique anchor-plates, and some other peculiarities, it is better to regard it as *sui generis,* and let the other members of "Chondroclœa" stand apart. They cannot, however, be called by Östergren's name, for among them is "*vivipara*" (=*hydriformis* Lesueur), which was made the type of the genus Synaptula by Oersted in 1849, and they must therefore be called by the earlier name, of which Chondroclœa is obviously a synonym. One species of this group, however (*kefersteinii*), is so distinct from the others in its large number of tentacles that it may well be considered as the representative of another genus, for which I would suggest the name Polyplectana (see page 76). Östergren's other genera Anapta, Euapta, Labidoplax, and Protankyra are all valid and may be accepted without further discussion. His genus Synapta, however, must bear the name Leptosynapta, proposed for it by Verrill in 1867.[1] To these genera it is now necessary to add the recently rediscovered Rhabdomolgus Keferstein. It is also necessary to recognize a new genus, Dactylapta (see page 111), for a remarkable species from the Indian Ocean. Fisher's (:07) division of Euapta into two genera seems to me of doubtful value, but the two groups are as easy to distinguish from each other as they are from Synaptula, and we may therefore recognize Ophcodesoma, for the present at least, without doing violence to any natural relationships. We thus recognize 11 genera of Synaptinæ.

When we come to the Chiridotinæ we must first of all determine to what characters we will give the most weight. The number of tentacles offers an obvious and tempting character, but one which must be used guardedly; it does not seem to be natural or justifiable to separate forms with 10 tentacles from those with 12, solely on that ground. Of course, where the difference in number is greater, the character has more weight. It is probable that Ludwig is right in putting the emphasis on the distribution of the calcareous wheels, while the presence or absence of the sigmoid bodies may be regarded as the feature of second importance. With these principles in mind, we find the classification of this subfamily quite simple. Östergren divides it into two genera, Sigmodota and Chiridota. The former genus was suggested by Studer ('76) for species having calcareous particles in the form of sigmoid bodies. Östergren proposes to include in Sigmodota all the species with sigmoid bodies, whether they have wheels or not, restricting Chiridota to species having no sigmoid bodies, and with the wheels in papillæ. The genera Toxodora Verrill ('82) and Trochodota Ludwig ('92*b*) are thus included in Sigmodota by Östergren, though he recognizes three distinct groups in the genus. Ludwig (92*b*) puts Toxodora under Anapta and bases Trochodota on the species with 10 tentacles, the wheels scattered (*i. e.*, not in papillæ), and sigmoid bodies present. The tentacles of Toxodora, however, are peltato-digitate, whereas those of Anapta are pinnate; the calcareous particles are also of essentially different types; it is hardly legitimate, therefore, to unite the two groups, for there is no reason to believe that they have a common ancestry or any close genetic connection. Verrill's genus appears to be valid and may be defined as

[1] Fisher (:07) has already called attention to these necessary modifications of Östergren's names.

Chiridotinæ without wheels, but with small C- or bracket-shaped bodies. It is thus very closely allied to Chiridota. The genus Trochodota is a natural group, well characterized by several morphological features. At first sight it might seem that Ludwig's name is antedated by Studer's Sigmodota, but although Studer states that his type species is Lesson's *purpurea,* a perfectly recognizable species which Ludwig makes the type of Trochodota, he incorrectly identified the Chiridotinæ before him and in spite of their having 12 tentacles, called them *purpurea;* consequently he states that Sigmodota has 12 tentacles. (It has been generally assumed that he says further there are no wheels in Sigmodota; as a matter of fact, he says nothing whatever on that point.) Ludwig ('98*b*) has shown that the species Studer had in hand was undoubtedly *Chiridota contorta* Ludw., and as his generic diagnosis fits that species, *contorta* becomes the type of Sigmodota. But even though it is thus clear that Sigmodota and Trochodota are not synonyms, the former name cannot be used; for in 1868 Semper suggested that the peculiarities of *Chiridota australiana* Stimpson warranted its being made the type of a new genus to which he gave the name Tæniogyrus. This seems to be a natural and acceptable course to follow; but the genus, which is characterized by the presence of wheels collected in papillæ and numerous scattered sigmoid bodies, includes besides the type-species, *C. contorta* Ludwig and consequently Sigmodota Studer is a synonym of Tæniogyrus Semper. The interesting species, *C. japonica* v. Marenzeller, bears the same relation to Tæniogyrus that Toxodora does to Chiridota, and therefore is best treated as the type of a new genus, Scoliodota (see page 125). There are still left about a dozen species to make up the genus Chiridota, but one of these, the widespread *C. rufescens* Brandt, is so distinct from the others that it is entitled to generic rank, and we may call the genus Polycheira (see page 120). It is clear, I think, that *Anapta inermis* Fisher is one of the Chiridotinæ, and must, therefore, be made the type of a new genus which may well be called Achiridota (see page 126). There are thus seven genera of Chiridotinæ which it seems proper to recognize, instead of the two given by Östergren. However much multiplicity of genera is to be deplored, it cannot be avoided in this subfamily if our classification is to show natural relationships. In the Myriotrochinæ there are three well-marked genera, universally recognized, based on the form of the calcareous wheels; Myriotrochus, with wheels having 10-25 spokes and 17-35 large teeth extending horizontally inward from the rim; Trochoderma, with wheels having 10-16 spokes, and the rim with large, scattered, sharp knobs, but no horizontal teeth; Acanthotrochus, with two distinct kinds of wheels.

Turning now to the Molpadiidæ, we are confronted by only about half as many species as in the Synaptidæ, but with even more difficulty in arranging them in genera. No suggestion of subfamilies needs consideration in this group, the genera are so closely allied. Of the 10 genera which have been proposed, six are universally accepted: Ankyroderma, Caudina, Eupyrgus, Haplodactyla, Molpadia, and Trochostoma. Embolus Selenka is now regarded only as a synonym of Trochostoma; Echinosoma Semper corresponds to Eupyrgus; Microdactyla Sluiter is best treated as a synonym of Caudina; and Liosoma Brandt (Lioderma, Bronn), used by Stimpson for a Trochostoma, is really a synonym of Chiridota. But generic limits in this family are not sharply drawn and the evidence now to be presented breaks down all possible distinction between Ankyroderma and Trochostoma. As generally defined, the former is distinguished from the latter by the presence of rosettes of racquet-shaped rods, from the center of which there extends outward a conspicuous anchor. These anchors have a long shaft and serrate flukes, so that if they are numerous, the body surface is very rough, and it is not remarkable that Ankyroderma has been considered a clearly defined genus. I have had the opportunity of studying more than 350 specimens of these two genera, and a careful, long-continued examination has convinced me that the presence of the anchors and rosettes of racquet-shaped rods cannot be regarded as even a constant specific character. The first intimation I received of this fact came when comparing some specimens of "*Ankyroderma danielsseni* Théel" with others which I had identified as "*Trochostoma violaceum* (Studer)." I was struck by the similarity in general appearance and in the calcareous deposits of the body-wall, and my faith in the distinction between the two genera was shaken when I found some of the racquet-shaped rods in a specimen of what I had called Trochostoma. This led me to make numerous preparations from nearly all the specimens, and the longer I compared them, the more I became convinced that they all belong to a single species. Some are perfectly distinct specimens of *T. violaceum,* and show not a trace of anchors or racquet-shaped rods, and others agree perfectly with Théel's ('86*a*) description and figures of *A. danielsseni.* Between these two extremes, however, there are several specimens which at first sight would pass for *T. violaceum,* but of which a careful examination shows that here and there are scattered more or less imperfect groups of racquet-shaped rods, and occasionally there is evidence of an anchor having been present. My suspicion that Ankyroderma was untenable was thus confirmed, but it was made a certainty when I came to study the 150 or more specimens of Ludwig's *T. intermedium.* These varied in length from 17 to 180 mm. and showed all sorts of intermediate stages in the condition of the racquet-shaped-rod rosettes. The smaller specimens (those under 60 mm.) all have a very thin skin in which the colored bodies are light yellowish brown and the rosettes with anchors are numerous. They are clearly Ankyrodermas and I at first supposed they represented a new species of that genus. The largest specimens (those from 100 mm. up) have the body-wall rather thick and firm, the colored bodies in the skin very numerous and deep red or brown, and, with one exception, no anchors or rosettes. The specimens intermediate in size differ greatly in the texture of the skin, in the quantity and shade of the colored bodies, and in the presence, number, and condition of the rosettes. As a rule, it is undoubtedly true that the larger the specimen, the thicker the skin, the fewer and more imperfect the rosettes, and the darker and more numerous the colored bodies. But there are many exceptions: some rather small specimens show no trace of the rosettes, while some large specimens have the rosettes quite common and occasionally nearly complete. It is noticeable that as the rosettes begin to disappear, the number of rods become reduced and they begin to be transformed into colored bodies. Théel ('86*a*), Ludwig ('94), and others have referred to this transformation of calcareous particles into colored bodies, but in the specimens of *intermedium* before me, it is unusually well shown by the racquet-shaped rods. The gradual disintegration of a complete rosette with anchor into a heap of rounded colored bodies can be easily traced, and is well shown in figures 5 to 12, Plate XII. Ludwig ('94) in his account of *T. intermedium* refers to the occasional presence of peculiar, scattered, racquet-shaped rods, and figures one; so that it is clear his experience was not greatly different from mine. Moreover, in speaking of *Ankyroderma danielsseni,* Ludwig ('94, pp. 164-170) refers to the difficulty of deciding without very careful examination whether a given specimen is an Ankyroderma or a Trochostoma, so rare are the rosettes and anchors in some cases. As to the significance of these facts, our knowledge is as yet too imperfect to draw any clear conclusions. Chemical analysis of the deposits (see page 143) shows that the colored bodies are radically different from the ordinary deposits in the skin. Both are possibly connected with the process of excretion; but why one should replace the other, it is certainly hard to say. That the change is closely connected with the age of the individual seems to me almost certain, though it must be remembered that size in Echinoderms is not a sure criterion of age. It is interesting to note that most of the species of Ankyroderma described have been less than 60 mm. long, while many of the Trochostomas range over 75. The discovery that the presence of anchors and rosettes is not a constant feature of even a given species, combined with the fact that in Trochostoma the calcareous plates and tables are more variable and show greater individual diversity than in any other genus of holothurians, makes the proper classification of the genus at the present time almost hopeless. There may be some species in which the anchors are present throughout life and there may be species in which they are never present. In determining species, therefore, the presence or absence of anchors and rosettes can only be considered as a secondary character, even if it can wisely be taken into account at all. The name Trochostoma antedates Ankyroderma by two years and must therefore have the preference if either be used, but as a matter of fact both are synonyms of Cuvier's Molpadia. Although Cuvier's diagnosis is very brief and is also erroneous, there can be no doubt that the animal he had in hand was a specimen of what has since been called Trochostoma; for he says it was from the Atlantic Ocean, and none of the other genera to which his description might apply occur there. If we do not use Molpadia in this sense, it cannot be used at all, and the name of the family would consequently have to be changed. Since I have no doubt as to the group of holothurians to which Cuvier intended to apply Molpadia, I should not consider myself justified in rejecting his name.

As regards the remaining genera we are in difficulty, because of the very incomplete characterization given them by their original describers and the subsequent extensive emendations of later writers. The loss of the type specimens increases the trouble. The small genus Eupyrgus is the best characterized of all and seems to be a natural group. In 1840, Grube described Haplodactyla, a genus which he characterized as having simple tentacles without digits. Curiously enough, as Ludwig has shown, his type seems to have been a specimen of *M. musculus* Risso, and consequently Haplodactyla is a synonym of Molpadia. In 1868, Semper described a holothurian to which he very naturally applied the name Haplodactyla, but unfortunately Grube's name cannot be so used, if we are to observe the modern rules of zoölogical nomenclature, and consequently Semper's species and its allies are without a generic name. As the tentacles lack digits, we may call the group Aphelodactyla. In 1841, Gould described, under the name *Chirodota arenata,* a remarkable holothurian from the coast of Massachusetts, which Stimpson ('53) later made the type of a new genus Caudina. Unfortunately, Stimpson makes no attempt to define this genus or to show how it differs from Molpadia, referring simply to Ayres' ('52*a*) description, which contains some glaring errors. However, owing to the type species being well known, Caudina has been very generally accepted, and several other species have been added to the genus. In 1850, Müller described an interesting holothurian which he called *Molpadia chilensis,* and in 1868 Semper added *M. australis.* The latter gave a revised diagnosis of the genus, based on his own and Müller's work, and widely different from the original one of Cuvier. As defined by Semper, Molpadia was distinguished from Caudina chiefly by the presence of "retractor" muscles. As that character is one of very doubtful importance among the apodous holothurians (see pages 52 and 144), the species included by Semper and later writers in Molpadia belong rather in Caudina. One important exception to this statement must be made, however, for Sluiter's (:01) species, *M. demissa,* is evidently quite unlike the others, and must be made the type of a new genus, which may well be called Acaudina, from the absence of a caudal appendage.

Although many new species of apodous holothurians have been described in the past 20 years, no new genera ascribed to either family have been named, except in the rearrangement of the Synaptidæ referred to above. It is remarkable, therefore, that the collection from the National Museum should afford examples of two holothurians so extraordinary that they cannot be placed in any known genus, and the definition of the Molpadiidæ will have to be altered to make it possible to enter them in that family. In order to lay out clearly the plan of classification adopted in the present paper, it is necessary to introduce these new genera at this point. The descriptions will be found later on (see pages 39 and 40). One of these genera is based on four specimens from the Western Atlantic Ocean, of which the largest is only 28 mm. long. Owing to some curious lash-like dorsal papillæ, I have given the name Himasthlephora to this remarkable holothurian. It bears a striking resemblance to Gephyrothuria Koehler and Vaney (:05), which is regarded by its describers as representing a new family (Gephyrothuridæ) of Aspidochirotæ. A careful comparison of Himasthlephora with the descriptions and figures of Gephyrothuria convinces me that the two genera are very closely allied, if not identical. But it seems clear to me that they are Molpadiidæ and that the new family is quite uncalled for. On account of the differences in the tentacles and the caudal appendage, it seems best to keep the two genera separate for the present. The other genus to be described is based on three specimens from Bering Sea, the general appearance of which is not unlike "Trochostoma;" but the tentacles are extraordinarily different, and the name of the genus (Ceraplectana) is based on this character. There are, therefore, eight genera of Molpadiidæ recognized in the present report.

The following table shows in outline the classification herein adopted and the number of species recognized in each genus:

Families.	Subfamilies.	Genera.	Type species.	No. of species herein recognized.
Synaptidæ Burmeister. 21 genera, 88 species.	Synaptinæ Östergren. 11 genera, 60 species.	*Synapta* Eschscholtz.	*maculata* Chamisso & Eysenhardt.	1
		Euapta Östergren.	*godeffroyi* Semper.	2
		Opheodesoma Fisher.	*spectabilis* Fisher.	4
		Polyplectana, gen. nov.	*kefersteinii* Selenka.	1
		Synaptula Oersted.	*hydriformis* Lesueur.	8
		Leptosynapta Verrill.	*inhærens* O. F. Müller.	9
		Labidoplax Östergren.	*buskii* McIntosh.	5
		Protankyra Östergren.	*abyssicola* Théel.	25
		Anapta Semper.	*gracilis* Semper.	3
		Dactylapta, gen. nov.	*dubiosa* Koehler & Vaney.	1
		Rhabdomolgus Keferstein.	*ruber* Keferstein.	1
	Chiridotinæ Östergren. 7 genera, 22 species.	*Chiridota* Eschscholtz.	*discolor* Eschscholtz.	13
		Polycheira, gen. nov.	*rufescens* Brandt.	1
		Tæniogyrus Semper.	*australianus* Stimpson.	2
		Trochodota Ludwig.	*purpurea* Lesson.	3
		Scoliodota, gen. nov.	*japonica* v. Marenzeller.	1
		Toxodora Verrill.	*ferruginea* Verrill.	1
		Achiridota, gen. nov.	*inermis* Fisher.	1
	Myriotrochinæ Östergren. 3 genera, 6 species.	*Myriotrochus* Steenstrup.	*rinkii* Steenstrup.	4
		Trochoderma Théel.	*elegans* Théel.	1
		Acanthotrochus Danielssen & Koren.	*mirabilis* Danielssen & Koren.	1
Molpadiidæ J. Müller. 8 genera, 46 species.	....	*Molpadia* Cuvier.	*holothurioides* Cuvier.	27
		Caudina Stimpson.	*arenata* Gould.	8
		Acaudina, gen. nov.	*demissa* Sluiter.	1
		Aphelodactyla, nom. nov.	*molpadioides* Semper.	5
		Eupyrgus Lütken.	*scaber* Lütken.	2
		Ceraplectana, gen. nov.	*trachyderma*, sp. nov.	1
		Himasthlephora, gen. nov.	*glauca*, sp. nov.	1
		Gephyrothuria Koehler & Vaney.	*alcocki* Koehler & Vaney.	1

Finally, in conclusion of this section, it may be stated that no subspecies or varieties are accepted. In some cases proposed subspecies, when well characterized, have been raised to full specific rank, while more commonly no attempt is made to distinguish them at all. The wide-ranging species are so variable and our knowledge is at present so incomplete, genuine subspecies cannot be positively determined. Until our collections are far more extensive and have been studied with great care, we cannot profitably make use of subspecific or varietal names.

PART II.

THE APODOUS HOLOTHURIANS OF THE UNITED STATES NATIONAL MUSEUM.

The collection contains about 2,200 specimens, representing 43 species, of which 23 are Synaptidæ and 20 are Molpadiidæ. There seem to be eight species which have never been described, two of these representing new genera. The collection is almost wholly from the American coast, and chiefly from the Pacific coast of North America. Most of the specimens are in good condition, but many of the Chiridotas, especially those from deep water, are almost worthless. The large series of specimens of *Chiridota lævis* and *discolor,* and of *Molpadia musculus* and *intermedia* have been of the greatest value in attempting to solve the problems connected with those perplexing genera. The following are the species represented in the collection:

SYNAPTIDÆ.

Synapta maculata (Chamisso and Eysenhardt).

There is a single specimen in excellent condition, collected at Cebu, Philippines, by the "Challenger."

Euapta lappa (Müller).

There are two large specimens from Great Sound, Bermudas, which are of interest as the only specimens yet recorded from those islands.

Synaptula hydriformis (Lesueur).

There is a single small specimen of this species from Watling's Island, W. I.

Leptosynapta dolabrifera (Stimpson).

There are six good specimens of this interesting species, from Port Jackson, New South Wales, the locality where Stimpson's type was taken. There have been no records of, or notes on, this species published since Stimpson's original description; consequently these specimens are of the greatest value in determining the relationships of the species.

Leptosynapta inhærens (O. F. Müller).

There are some 130 specimens from Woods Hole, Mass., and vicinity, 10 from New Haven, Conn., 155 from Newport, R. I., and 8 from Provincetown, Mass. There are four specimens from Point Loma, California, which show no characters by which they can be distinguished from specimens from the

Atlantic coast. There are also two fragments of a Synapta from Sitka, Alaska (Eastern harbor, 16 meters, green mud), which is probably a young individual of this species. These fragments are about 2 mm. in diameter, yellowish, with scattered minute red spots. One is an anterior end and has 10 pinnate tentacles, each with 7, 9, or 11 digits and 2 or 3 sense-cups. The calcareous ring and particles in skin are like those of *inhærens*, except that the anchor arms are smooth. All of these peculiarities seem to me to indicate immaturity, but the specimen is strikingly suggestive of Östergren's *Synapta decaria* (*q. v.*). An anterior end of a similar small synaptid with 11 tentacles is in the collection labeled simply "Alaska," and confirms the opinion that the one from Sitka is a young *inhærens*. There is also a nicely preserved specimen from Bergen, Norway. I am unable to distinguish satisfactorily between the specimens from Alaska, California, Massachusetts, and Norway.

Leptosynapta ooplax (v. Marenzeller).

There are 18 specimens from Funafuti, of which the largest is about 200 cms. long. The calcareous particles are like those of Bedford's variety *lævis* from the Loyalty Islands, but there is no little diversity even in a single individual.

Labidoplax digitata (Montague).

There are two specimens from Trieste, Austria, of small size, but notable for the large size of the anchors and plates near the posterior end of the body. Many of the anchors are half a millimeter or more in length, but they do not resemble the so-called "giant" anchors of this species. Sense-cups are present on the tentacles, but I failed to detect a "giant" anchor anywhere.

Labidoplax dubia (Semper).

There are five specimens of this species taken off the coast of Japan by the "Albatross" (Stations 3723, 3724, and 3770) in 23-81 m. They agree perfectly with the specimens called "*incerta* var. *variabilis*," by Théel ('86*a*) collected near Japan by the "Challenger." I fail to distinguish them from *dubia* Semper in any other way than by the presence of sense-cups on the tentacles, which Semper says were lacking in *dubia*. As he only had a single, mutilated specimen, however, I cannot consider this difference of great importance. The specimens before me are 60-70 mm. long and about 4 mm. in diameter, and are of a dirty whitish color, though one specimen shows an evident reddish tint dorsally. There are 5 or 6 sense-cups on each of the 12 tentacles, and 4 digits. The anchors and plates are abundant; the former are 200-265 μ long; the latter, 180-235 μ. The miliary granules are very scarce and usually have the ends little, if at all, bent.

Labidoplax thomsonii (Herapath).

A decalcified synaptid from Naples lacks sense-cups on the tentacles and seems to be referable to this species.

Protankyra abyssicola (Théel).

Plate IV, Figs. 8-11.

A single strongly contracted individual of this species is in the collection, dredged by the "Albatross" in 2,260 m. (St. 2382) in the Gulf of Mexico, lat. 28° 19′ 45″ N., long. 88° 01′ 30″ W. Fortunately the anterior end is uninjured, and it is possible, therefore, to figure one of the tentacles and the calcareous deposits. These agree essentially with those described by Ludwig ('94) for the closely allied species *pacifica*. The specimen is 65 mm. long and 5 mm. in diameter, and the color is dark yellowish, with considerable reddish pigment at base of tentacles, on the inner side. Anchors and plates are numerous on the bivium, but are almost wanting on the trivium near the middle of the body, though somewhat more common posteriorly. There are 7 polian vessels, slender and nearly equal. The stone canal was not found. The genital glands are small and somewhat branched. The anchors (700 μ long) have the teeth on the flukes sharp, and not blunt, as figured by Théel. The plates (550 μ) have the holes rather smooth or with several teeth. No miliary granules were found.

Protankyra pacifica (Ludwig).

The type and co-type of Ludwig's *Synapta abyssicola* var. *pacifica* from "Albatross" Stations 3360 and 3381, off Panama, 3,009-3,189 m., are in the collection. They are quite different from *abyssicola* and are entitled to full specific rank.

Protankyra brychia (Verrill).

Plate IV, Figs. 12-14.

There is a single headless fragment of this species, from 1,688 m. off Cape Hatteras ("Albatross" Station 2111), lat. 35° 9′ 50″ N., long. 74° 57′ 40″ W. Although not labeled, I suspect this is Verrill's type, as it is from the same locality and answers his description exactly. It is gray, 100 mm. long and about 9 mm. in diameter. There are two polian vessels and long branched genital glands. The anchors and plates are similar to those in the preceding species, but are much larger, a full mm. or more in length, and the flukes of the anchors are more slender. Miliary granules in the shape of simple elongated discs or oval rods occur along the radii. The anchors and plates are in approximately three longitudinal rows in each interradius.

PROTANKYRA DUODACTYLA, sp. nov.

(δύω, two + δάκτυλα (poetic plural), fingers; in reference to the number of digits.)

PLATE IV, FIGS. 1-7.

Tentacles 12, well expanded, each with only 2 digits. Calcareous ring narrow, 1 mm. high, the radial pieces slightly higher and perforated for passage of the nerve. Cartilaginous ring wanting. Polian vessels only 2. Stone-canal single, of moderate size. Genital glands long and branched. Body rather stout, cylindrical. Anchors 360 μ long, similar to those of *inhærens,* though the base is somewhat wider. Plates 300 μ long, unlike those of any known synapta, perfectly flat, usually with no bow, and with smooth holes. Two holes are much larger and more elongated than the others, and lie side by side, with the smaller holes more or less symmetrically arranged at the two ends of the plate. One end usually has many more holes than the other, and no two of the plates are exactly alike; many seem to be only partly developed. Miliary granules wanting, but there are numerous branched rods and perforated plates in the tentacles. Color, uniform gray. Length, 60 mm. Diameter, 8 mm.

The specimen just described (type, Cat. No. 19,829, U. S. N. M.) was taken at "Albatross" Station 2871, in 1,006 m., lat. 46° 55′ N., long. 125° 11′ W., about 60 miles off Gray's Harbor, Washington. A second specimen, in very poor condition, is in the collection, from lat. 54° 11′ 30″ N., long. 167° 25′ W., 1,777 m. In this specimen the plates are only 250 μ long, and many of them have a more or less incomplete bow on that end of the plate which has the more numerous holes (fig. 5). The presence of only 2 digits allies this species to *P. bicornis* (p. 101), but the plates are very different from those of that or any other species.

ANAPTA FALLAX Lampert.

There are 2 incomplete specimens from off the southern coast of Chile, "Albatross" Station 2784, lat. 48° 41′ S., long. 74° 24′ W., 350 m. Both are anterior ends of small individuals, the oral discs being only 3 mm. in diameter. Each has 12 tentacles with 7 or 9 digits. The minute elliptical rods are most numerous along the radii, and the tentacles are richly supplied with slightly curved rods, which are either smooth or rough. The color of these specimens is pale yellowish brown.

CHIRIDOTA DISCOLOR Eschscholtz.

There are considerably more than 600 Chiridotas in the collection, which almost defy classification, for though the largest specimens are easily separated from the smallest, not only by size, but by color and general appearance, there are almost all possible intergradations between the extremes. The largest specimens are all from Alaska or Siberia, and are distinctly gray or creamy whitish in color. In life, the largest must have been over 30 cm. long and about 15 mm. in diameter, but most of the specimens of approximately the same color and general appearance are much smaller, 10-15 cm. in length. The wheel-papillæ are usually in a single row, and that is apparently in the mid-dorsal interambulacrum. These specimens, I believe, represent Eschscholtz's species *discolor,* as shown by the habits as well as the habitat, for they are said to be "common in mud, under rocks." Eschscholtz, however, says that *discolor* has 15 tentacles, 12 large and 3 small, while all the specimens I have examined (save 1 with 9) have 12 tentacles. Moreover, he says that there is on each of 3 interradii a single row of large white spots (the wheel-papillæ, doubtless); while most of the specimens before me have only one, many have none, a few have 2, several 3, and one 5. In spite of these differences, the fact that this seems to be the abundant littoral chiridota of Alaska makes it very probable that it is the species Eschscholtz was describing. I have accordingly referred the following 207 specimens to *discolor:*

1	specimen from	Arctic Ocean.
11	specimens from	Alaska.
16	" "	Nazan Bay, Atka, Alaska.
20	" "	Atka Island, Alaska.
3	" "	Port Etches, Alaska.
4	" "	Robben Island, Siberia, 50 m.
1	specimen from	Bering Island.
7	specimens from	lat. 65° 25′ 28″ N., long. 171° 11′ 26″ W.
18	" "	"Albatross" Station 2852, lat. 55° 15′ N., long. 170° 33′ W., 74 m.
1	specimen "	" " 2853, lat. 56° N., long. 154° 20′ W., 286 m.
2	specimens "	" " 2871, lat. 46° 55′ N., long. 125° 11′ W., 1,006 m.
2	" "	" " 2928, lat. 32° 47′ 30″ N., long. 118° 10′ W., 750 m.
4	" "	" " 3077, lat. 55° 46′ N., long. 132° 24′ W., 580 m.
30	" "	" " 3227, lat. 54° 36′ 30″ N., long. 166° 54′ W., 405 m.
11	" "	" " 3310, lat. 53° 56′ 51″ N., long. 166° 28′ 53″ W., 104 m.
5	" "	" " 3324, lat. 53° 33′ 50″ N., long. 167° 46′ 50″ W., 196 m.
2	" "	" " 3326, lat. 53° 40′ 25″ N., long. 167° 41′ 40″ W., 1,037 m.
2	" "	" " 3329, lat. 53° 56′ 50″ N., long. 167° 8′ 15″ W., 720 m.
20	" "	" " 3439, lat. 57° 06′ N., long. 170° 33′ W., 74 m.
2	" "	" " 4227, near Naha Bay, Alaska, 111-117 m.
45	"	with no label.
207	"	from 21 stations.

Many of these specimens are in poor condition, some so very poor as to make positive identification impossible. It is not unreasonable to suppose that if this great mass of material could have been carefully studied when living, it would have been possible to distinguish at least two species, but at present such division would be hazardous and of no advantage.

CHIRIDOTA REGALIS, sp. nov.

(*regalis,* royal; in reference to the color.)

Similar in general appearance to *discolor,* but distinguishable at once by the purple color. In some specimens the color is pale, but in most it is quite deep, and in some it is a rich royal purple. The wheel-papillæ are rather numerous, but are confined almost wholly to the mid-dorsal interambulacrum, although anteriorly a very few may occur in the lateral interambulacra. Aside from the color, this handsome species differs from *discolor* and *lævis* in the presence of C-shaped deposits along the ambulacra. These deposits are similar to those shown in figure 27, plate VII, and seem to be constantly present, although not always abundant. They are not confined to the area of the longitudinal muscles, but occur in the skin along each side of that region. The largest of the specimens in the collection is upward of 200 mm. long.

26 specimens from "Albatross" Station 3695, south coast of Honshu Island, Japan, 198-428 m.
3 " " " " 3737, Suruga Gulf, Honshu Island, Japan, 290-300 m.
—
26 " " 2 stations.

CHIRIDOTA LÆVIS (Fabricius).

Of the more than 400 Chiridotas remaining, there are some which are very clearly representatives of Fabricius's species, but there are others which are quite different, although there are numerous connecting examples. The condition of the specimens makes a careful separation of species out of the question. There are, however, 4 sorts of individuals which are fairly recognizable, though not always so. The typical form is small, soft, pinkish, more or less translucent, and has the wheel-papillæ in 3 rows dorsally, with some scattered ones anteriorly on the ventral interambulacra. These are from water 5 or 7 m. deep, between Nantucket Island and High Duck (Grand Manan), off the Atlantic coast of America. Others resemble these in the arrangement of the wheel-papillæ, but are much larger and are cream-colored or light gray; they are from the Bay of Fundy, Labrador, and Anticosti. Still others have the body-wall generally stiffer, and the color is more or less dirty brownish. These are all from the Pacific coast of America, and may prove to be a distinct species from those of the North Atlantic. The fourth sort are similar to the latter, but have the wheel-papillæ in a single row. They are also all from the North Pacific. Since the Atlantic forms answer well to Duncan's and Sladen's description of Fabricius's species, I feel justified in calling them *lævis,* and as I am not able to find any constant distinguishing characters, I have referred all of the following specimens to that species:

1	specimen	from	Anticosti.		
3	specimens	from	Labrador.		
40	"	"	the Bay of Fundy.		
26	"	"	between Nantucket (N. B.) and High Duck, in 5-7 m.		
1	specimen	from	"Albatross"	Station	2866, lat. 48° 09′ N., long. 125° 3′ W., 308 m.
1	"	"	"	"	2922, lat. 32° 27′ 15″ N., long. 119° 5′ 15″ W., 85 m.
3	specimens	"	"	"	3070, lat. 47° 29′ 30″ N., long. 125° 43′ W., 1,145 m.
50	"	"	"	"	3193, lat. 35° 25′ 50″ N., long. 121° 9′ 10″ W., 288 m.
250	"	"	"	"	3196, lat. 35° 2′ 55″ N., long. 120° 59′ 40″ W., 360 m.
2	"	"	"	"	3210, lat. 54° N., long. 162° 40′ 30″ W., 869 m.
3	"	"	"	"	3326, lat. 53° 40′ 25″ N., long. 167° 41′ 40″ W., 1,037 m.
10	"	"	"	"	3329, lat. 53° 56′ 50″ N., long. 167° 08′ 15″ W., 720 m.
10	"	"	"	"	3330, lat. 54° 0′ 45″ N., long. 166° 53′ 50″ W., 632 m.
2	"	"	"	"	3340, lat. 55° 26′ N., long. 155° 56′ W., 250 m.
4	"	"	"	"	3343, lat. 47° 40′ 40″ N., long. 125° 20′ W., 929 m.
9	"	"	"	"	3603, lat. 55° 23′ N., 170° 31′ W., 3,188 m.
4	"	"	"	"	3607, lat. 54° 11′ 30″ N., long. 167° 25′ W., 1,776 m.
419	"	"	17 different stations, mostly collected by the "Albatross."		

Many of these specimens are in very poor condition, a large majority having the calcareous deposits dissolved. It is practically out of the question to separate them and make more than a single species from the lot, although it seems almost certain that there are at least three species included in this mass of material.

Chiridota pisanii Ludwig.

There are three specimens from Gregory Bay, Strait of Magellan. The wheel-papillæ are very few, but there are many miliary granules along the radii.

Chiridota rotifera (Pourtales).

From Key West there are 9 small specimens of this common tropical species.

Tæniogyrus australianus (Stimpson).

There are five excellent specimens of this very interesting species in the collection from Port Jackson, New South Wales. They show that Stimpson's description is correct as far as it goes, and that the species is entirely distinct from either *contortus* Ludwig or *dunedinensis* Parker. The specimens are yellowish, 30-50 mm. long and each has 10 tentacles, with 5-6 pairs of digits. The genital glands are distinctly branched, and there is a single polian vessel.

The calcareous ring is very narrow, much as Dendy ('97) figures it for *dunedinensis*. The wheel-papillæ are conspicuous in the three dorsal interradii, especially anteriorly. The sigmoid bodies are also collected, on the dorsal side, into little groups which appear to the naked eye as numerous small whitish papillæ.

TÆNIOGYRUS CONTORTUS (Ludwig).

There are 3 specimens of this species from the Strait of Magellan, "Albatross" Station 2771, lat. 51° 34′ S., long. 68° W. They were dredged in 91 m., and measure 40-45 mm. long.

SCOLIODOTA JAPONICA (v. Marenzeller).

There is a single specimen in the collection, one of those taken by the "Challenger" at Port Jackson, New South Wales, and already described by Théel. There can be no doubt that wheels are entirely wanting.

MYRIOTROCHUS RINKII Steenstrup.

There are rather more than 600 specimens of this little holothurian in the collection, from 10 widely separated points: Point Belcher, Arctic Ocean, 16 m., sand; off the banks of Newfoundland, lat. 45° 35′ N., long. 55° 01′ W., 121 m.; Barden Bay, Inglefield Gulf, 18-72 m.; Norway; Cape Smyth, Alaska; Aberdore Channel, east of Alger Island; Point Barrow, Alaska; Greenland; Kara Sea; and "Albatross" Station 3440, Bering Sea, lat. 57° 05′ N., long. 170° 41′ W., 86 m. The abundance of material from Bering Sea and the banks of Newfoundland led me to make a comparison of the calcareous wheels of the specimens from those points. These measure 164 to 328 μ in diameter, but average about 245 μ, and the very great majority are near that figure. The wheels of specimens from the banks average 16.5 spokes and 26.5 teeth on the rim; the number of spokes, therefore, is about 0.62 that of the teeth. In specimens from Bering Sea the average was 17 spokes and only 23.7 teeth, or about 0.71. This difference was found in counting 10 wheels chosen at random in each of 10 specimens from each locality. It is not probable, however, that it really has any significance, as the number of spokes and teeth shows such great diversity, and there is apparently no correlation between the two; for although the wheel with the smallest number of spokes (12) had the smallest number of teeth (16) and the wheel with the largest number of spokes (22) had the largest number of teeth (30), wheels with only 15 spokes had as many as 29 teeth—that is, a ratio of only 0.51—while others with 17 spokes had only 18 teeth, or a ration of 0.94. In every case, however, there were more teeth than spokes. It is interesting to compare these figures with those given by Östergen (:03). He says the wheels of specimens from eastern Siberia average from 240 to 260 μ, while those of Norwegian specimens averaged 208-

220; the American material is thus seen to be very similar in this particular to the Siberian. The Siberian specimens, however, averaged about 20 spokes to the wheel, while those from Norway had about 16; so, in this particular, American specimens are more like the Norwegian. The average number of teeth, as given by Östergren, is 26.5–29.3, which is decidedly more than in the American material. The number of spokes is about 57 per cent of the number of teeth in Norwegian specimens, about 62 per cent in Newfoundland specimens, about 71 per cent in Bering Sea material, and about 76 per cent in high Arctic specimens. It seems quite possible, judging from these figures, to draw the conclusion that the number of spokes tends to decrease toward the southern limit of the range of *Myriotrochus rinkii.*

MOLPADIIDÆ.

Molpadia affinis (Danielssen and Koren).

In the same bottle with the two specimens of *arctica* from the Kara Sea, labeled *"boreale"* (see page 32), was a third specimen, 75 mm. long, with a few scattered colored bodies and numerous calcareous tables exactly like those figured by Danielssen and Koren ('82) for *affinis;* there are, however, no anchors or rosettes. Although the status of *affinis* is not beyond question, this specimen must for the present be referred to that species.

Molpadia amorpha, sp. nov.

(ἄμορφος, misshapen; in reference to the imperfectly formed calcareous tables.)

Plate XIII, Figs. 14-22.

Body rather stout, the caudal region short; skin thin, but not delicate. Ground color, gray, more or less spotted, flecked or blotched with dark purplish; in some specimens the purplish predominates, especially toward the anterior end, which may become almost uniformly dark; the oral disc and tail are, however, always gray. Tentacles 15 (in two specimens there were only 14), each with 3 terminal digits. Calcareous ring as usual. Deposits of two kinds, elliptical phosphatic bodies, and calcareous tables; elliptical bodies small and dark purplish red, though some very small, yellowish-brown ones also occur; tables small and irregular, widely scattered in body-wall, but common though not crowded, in the caudal region. They are very abortive, twisted and incomplete, and it is upon this fact that I have based the name.

3	specimens from "Albatross" Station	2779, lat. 56° 6′ S., long. 70° 40′ 30″ W., 138 m.
1	specimen " " "	2783, lat. 51° 2′ 30″ S., long. 74° 8′ 30″ W., 220 m.
20	specimens " " "	2784, lat. 48° 41′ S., long. 74° 24′ W., 349 m. Types and co-types, Cat. No. 19,866, U. S. N. M.
—		
24	" " 3 stations.	

The largest specimen is 140 mm. long (10 mm. is "tail") and 45 mm. in diameter; the smallest is 52 mm. long and 20 mm. in diameter. The specimens from Station 2779 are very large and very deep purplish-red, excepting only the oral disc and tail; they thus bear a striking resemblance to some specimens of *oölitica*.

The general appearance of most of the specimens, in form, color, and texture of skin, distinguish them at once from any other species which I have seen, and the scattered, very imperfect tables are also quite characteristic. The species is probably most nearly related to *Molpadia intermedia* (Ludwig), but the specimens from Stations 2783 and 2784 are easily distinguished from any specimen of that species which has come under my notice, while those from Station 2779 were identifiable by means of the infrequent, scattered misshapen tables of the body-wall.

Molpadia antarctica (Théel).

There are numerous specimens of this species, all but two from the vicinity of Wellington Island, off the coast of Chile. The largest is 92 mm. long, while the smallest is only 14. They all agree in having a very thin and delicate skin, gray in color, but generally somewhat blotched with yellowish-brown, especially dorsally and anteriorly; in some specimens there is a tinge of brown around the caudal region. There are numerous calcareous deposits in the small specimens, but in those over 30 mm. long, they are confined to the caudal region, and in a specimen 35 mm. long they are scarce even there. In the large specimens no trace of calcareous bodies could be found in any part of the skin. The deposits are similar to those in the following species; the disc is in most cases regular, and the spire is longest in the smallest specimens, where it sometimes has as many as 7 cross-bars; in older specimens the spire of the tables is shorter and it may be wanting.

3	specimens	from	"Albatross"	Station	2782, lat. 51° 12′ S., long. 74° 13′ 30″ W., 464 m.
5	"	"	"	"	2783, lat. 51° 02′ 30″ S., long. 74° 08′ 30″ W., 220 m.
18	"	"	"	"	2784, lat. 48° 41′ S., long. 74° 24′ W., 349 m.
2	"	"	"	"	2791, lat. 38° 8′ S., long. 75° 53′ W., 1,218 m.
28	"	"	4 stations.		

Molpadia arctica (v. Marenzeller).

Of this species there are three specimens before me, two of which are labeled "*Trochostoma boreale*, Kara Sea," while the third is labeled "*Trochostoma arcticum*, Norway." These specimens all agree in the entire absence of colored bodies in the skin, and although the tables are simpler and less crowded in the specimen from Norway than in the others, I am not able to separate them satisfactorily. They have the thin skin characteristic of *arctica*, and I have no hesitation in referring them all to that species. Whether *arctica* is really distinct from *borealis* (*oölitica*) is still an unsettled point; so far as I know, connecting forms have not been recorded as yet.

Molpadia arenicola (Stimpson).

Plate XII, Figs. 1, 2.

There are 8 specimens of this species in the collection, and they agree perfectly with Stimpson's description, except that the calcareous ring consists of the usual 10 pieces found in the Molpadiidæ. The largest is about 120 mm. long and 35 mm. in diameter, and the caudal portion is not abruptly narrowed, though it is only 5 mm. thick at the extremity; although there are no deposits in the skin of the body, there are numerous small, much-branched rods and perforated plates in the skin of the tail. In the smallest specimens, the calcareous particles are more abundant. The specimens are from San Pedro and San Diego, California, and "Southern California." Some, if not all, were picked up on the beach after storms.

Molpadia blakei (Théel).

There is a single specimen of this very well characterized form, from "Albatross" Station 2383, Gulf of Mexico, lat. 28° 32′ N. and long. 88° 6′ W., 2,126 m. It is of a light grayish-brown color and about 50 mm. long. The caudal appendage is very short, there are no colored bodies, and the remarkable tables are very abundant, though not crowded.

Molpadia granulata (Ludwig).

Ludwig's type and three co-types, from "Albatross" Stations 3361 and 3399, off Panama, 2,648–3,132 m., are in the collection, but there are no other specimens.

Molpadia intermedia (Ludwig).

Plate XII, Figs. 5-15.

This is apparently the common Molpadia of the eastern Pacific, for there are no less than 143 specimens before me, collected at various points from the 28th to the 56th parallel, and at depths ranging from 52 to 2,925 m. They vary in length from 17 to 105 mm., with corresponding variety in form, texture of skin, and color. The smallest specimens are gray, and the yellowish-brown ellipses in the skin are so small and scattered they only become visible under the microscope; the skin is very thin and delicate and abundantly supplied with calcareous bodies, the tables characteristic of the species, and the rosettes and anchors supposedly characteristic of Ankyroderma. The largest specimens have the ground color gray, but this is more or less completely hidden by the reddish-brown color, caused by the very numerous "ellipses"; the skin is moderately thin but firm; the calcareous bodies are in nearly all cases simply the tables, but not infrequently the last browning remnants of a rosette are found, and occasionally more or less complete rosettes and anchors occur. Between the two extremes all possible intergradations occur, and it seems almost beyond question that the small specimens are the young, the large specimens the adults. Ludwig had only 5 specimens before him for his description, and all were over 48 mm. long, but he speaks of the very thin skin of the smallest and of the presence of rare, scattered, perforated rods, like those which make up the rosettes of Ankyroderma, though he did not find any rosettes or anchors.

13 specimens	from	"Albatross"	Station	2838,	lat. 28° 12′ N., long. 115° 09′ W., 79 m.
8 "	"	"	"	2902,	lat. 34° 06′ N., long. 120° 02′ W., 95 m.
1 specimen	"	"	"	2971,	lat. 34° 20′ 30″ N., long. 119° 37′ 50″ W., 48 m.
12 specimens	"	"	"	2972,	lat. 34° 18′ 30″ N., long. 119° 41′ W., 110 m.
10 "	"	"	"	2973,	lat. 34° 19′ 30″ N., long. 119° 44′ 15″ W., 122 m.
50 "	"	"	"	3068,	lat. 47° 55′ 30″ N., long. 122° 27′ W., 243 m.
1 specimen	"	"	"	3193,	lat. 35° 25′ 50″ N., long. 121° 09′ 10″ W., 288 m.
5 specimens	"	"	"	3195,	lat. 35° 14′ N., long. 127° 07′ W., 454 m.
2 "	"	"	"	3196,	lat. 35° 02′ 55″ N., long. 120° 59′ 40″ W., 48 m.
6 "	"	"	"	3307,	lat. 53° 55′ N., long. 170° 50′ W., 1,859 m.
11 "	"	"	"	3308,	lat. 56° 12′ N., long. 172° 07′ W., 2,925 m.
1 specimen	"	"	"	3331,	lat. 54° 1′ 40″ N., long. 166° 48′ 50″ W., 630 m.
2 specimens	"	"	"	3395,	lat. 7° 30′ 36″ N., long. 78° 39′ W., 1,314 m.
2 "	"	"	"	3431,	lat. 23° 59′ N., long. 108° 40′ W., 1,791 m.
2 "	"	"	"	3478,	lat. 36° 44′ 45″ N., long. 120° 57′ W., 122 m.
3 "	"	"	"	3604,	lat. 54° 54′ N., long. 168° 59′ W., 2,522 m.
1 specimen	"	"	"	3666,	lat. 36° 45′ N., long. 121° 53′, 122 m.
1 "	"	"	"	3667,	lat. 36° 45′ N., long. 121° 52′, 162 m.
1 "	"	"	"	3676;	no record.
4 specimens	"	"	"	3737,	off Honshu Island, Japan, 295 m.
1 specimen	"	"	"	3738,	off Honshu Island, Japan, 300 m.
2 specimens	"	"	"	3775,	off Honshu Island, Japan, 103 m.
4 "		No locality.			
143 "	"	23 stations.			

Molpadia musculus Risso.

Plate XI.

Besides Ludwig's type and two co-types, from Stations 3382, 3392, and 3432, off Panama and in the Gulf of California, 2,286–3,230 m., there are three small specimens (27, 43, and 65 mm. in length) of a Molpadia from "Albatross" Station 2393, lat. 28° 43′ N., long. 87° 14′ 30″ W., 945 m., which answer well to his description of *Ankyroderma spinosum,* except for color. All these specimens are very spiny, and the anchors and rosettes are numerous. The color is pale brown, but under the microscope a considerable number of the small reddish-brown ellipses are to be seen. A fourth specimen from "Albatross'' Station 2925, lat. 32° 32′ 30″ N., long. 117° 24′ W., 610 m., is only 18 mm. long, but, unlike Ludwig's specimen of the same size, it is well supplied with anchors. Koehler and Vaney (:05) are convinced that Ludwig's *spinosum* is only a form of the widespread *musculus,* and although I think there is room for doubt on the point, I defer to their opinion, as they have had more material for study.

The form of *musculus* known as *violacea* Studer seems to occupy in the Southern Pacific the place that *M. intermedia* does in the northern, but has an even more extended range, as there are specimens before me from lat. 32° 44′ N. and nearly 52° S., and not less than 16 intermediate stations, at depths of 220–3,229 m. These specimens vary in size from 20 x 8 mm. to 100 x 20, and in color from pale gray, with a few small scattered reddish or purplish spots, to deep wine red, though all the specimens have the oral disc and tail pale gray. There is also great diversity in the shape, abundance, and arrangement of the calcareous bodies; they are most irregular and scattered in the smallest specimen and most regular and transversely arranged in the largest. A few of the specimens seem to have no rosettes and anchors and correspond exactly to the descriptions of *violacea;* others have the browned remains of rosettes, and many others have more or less complete rosettes and anchors present and correspond admirably to Théel's description of *Ankyroderma danielsseni.* I am therefore led to the conclusion that the ankyroderma individuals are probably the young, losing their calcareous particles as they grow older; but the evidence is not indubitably convincing.

6 specimens	from "Albatross"	Station	2781,	lat. 51° 52′ S., long. 73° 41′ W., 626 m.
1 specimen	" "	"	2782,	lat. 51° 12′ S., long. 74° 13′ 30″ W., 464 m.
7 specimens	" "	"	2783,	lat. 51° 02′ 30″ S., long. 74° 08′ 30″ W., 220 m.
39 "	" "	"	2784,	lat. 48° 41′ S., long. 74° 24′ W., 349 m.
1 specimen	" "	"	2923,	lat. 32° 40′ 30″ N., long. 117° 31′ 30″ W., 1,480 m.
1 "	" "	"	2925,	lat. 32° 32′ 30″ N., long. 117° 24′ W., 610 m.
6 specimens	" "	"	3361,	lat. 6° 10′ N., long. 83° 6′ W., 2,648 m.
1 specimen	" "	"	3362,	lat. 5° 56′ N., long. 85° 10′ 30″ W., 2,115 m.
1 "	" "	"	3366,	lat. 5° 30′ N., long. 86° 45′ W., 1,921 m.
4 specimens	" "	"	3381,	lat. 4° 56′ N., long. 80° 52′ 30″ W., 3,190 m.
1 specimen	" "	"	3382,	lat. 6° 21′ N., long. 80° 41′ W., 3,229 m.
2 specimens	" "	"	3392,	lat. 7° 5′ 30″ N., long. 79° 40′ W., 2,286 m.
8 "	" "	"	3398,	lat. 1° 7′ N., long. 80° 21′ W., 2,831 m.
5 "	" "	"	3399,	lat. 1° 7′ N., long. 81° 4′ W., 3,132 m.
1 specimen	" "	"	3407,	lat. 0° 4′ S., long. 90° 24′ 30″ W., 1,593 m.
1 "	" "	"	3418,	lat. 16° 33′ N., long. 99° 52′ 30″ W., 1,188 m.
1 "	" "	"	3429,	lat. 22° 30′ 30″ N., long. 107° 1′ W., 1,654 m.
1 "	" "	"	3627,	lat. 32° 44′ N., long. 119° 32′ W., 1,397 m.

87 specimens from 18 stations.

Molpadia oölitica Pourtales.

There are three specimens of a Molpadia in the collection, which answer admirably to Pourtales' description of *oölitica,* of which *borealis* Sars is almost certainly a synonym. It is probably true in this species, as in others, that the older the specimen, the more elliptical bodies and the fewer tables it will have. The specimens before me are all large, 100, 110, and 122 mm. in length, and dark-colored; one is reddish with small gray patches; another is very dark reddish, with very little gray, and the third is so dark a red it is almost black. In all, the oral disc and the tail are almost white, as they are free from the elliptical bodies which give the color to the body. There are apparently no tables present. The three specimens were all taken by fishermen from Gloucester, on the banks of Newfoundland. There is also in the collection a small molpadid, labeled "*Ankyroderma jeffreysii.* Norway," which has at some time been completely desiccated. It is impossible now to determine its identity, but if it is correctly labeled it may be included here, as *jeffreysii* is very probably the young of *oölitica.*

Molpadia parva (Théel).

The thin-skinned molpadids from the Caribbean Sea, referred by Théel to *antarctica,* and two varieties of *arctica,* are represented in the National Museum collection by nine specimens. While their relationship to *arctica* is obvious, they seem to be clearly and constantly different, and I therefore adopt for them the first of the varietal names suggested by Théel. I do not think, however, that the variety *cærulea* is sufficiently well marked or constant to warrant its separation.

1 specimen from "Albatross" Station 2106, lat. 37° 41′ 20″ N., long. 73° 3′ 20″ W., 2,695 m.
8 specimens " " " 2144, lat. 9° 49′ N., long. 79° 31′ 30″ W., 1,613 m.

Caudina arenata (Gould).

There are 3 specimens of this well-known species from off Cuttyhunk Island (Mass.), in 33 m., the largest 50 mm. long. There are 173 specimens of all sizes, labeled simply "Massachusetts Bay," and a single greatly contracted specimen from "Fish Hawk" Station 1617. From "Albatross" Station 3767, off the coast of Japan, 25-32 m., there is a completely desiccated molpadid, the calcareous particles of which are exactly like those of *arenata.* I am unable to avoid the suspicion that there is some mistake about the label. If not, *arenata* or a very closely allied species occurs in Japanese waters.

Caudina albicans (Théel).

There are 3 specimens from "Albatross" Station 2111, 35° 9′ 50″ N. and 74° 57′ 40″ W., 1,678 m.; 1 from Station 2677, 32° 39′ N. and 76° 50′ 30″ W., 860 m.; and 1 from Station 2682, 39° 38′ N. and 70° 22′ W., 1,807 m. As no connecting links between this well-marked form and the preceding are known, it is hard to see why *albicans* should not rank as a distinct species, instead of a variety (*armata*) of *arenata,* as Théel ('86*b*) described it. The specimen from Station 2682 is labeled "*Trochostoma albicans,* det. A. E. Verrill." The identification appears to be correct, but I am unable to find any satisfactory ground upon which that species can be distinguished from *Caudina arenata armata;* certainly the calcareous particles are identical. The name *albicans* antedates *armata.*

Caudina californica Ludwig.

Besides the type specimen from "Albatross" Station 3434, Gulf of California, 2,858 m., a larger molpadid, labeled "Southern California probably," is in the collection, which is doubtfully referred to this species; it is in poor condition and the calcareous deposits are mostly dissolved. There is also a much smaller specimen, from Station 2838, off Lower California, 85 m., which seems to be a young *californica.* The numerous plates are smaller, more symmetrical and with fewer perforations than in the type, but they are distinctly knobbed or provided with blunt spines. The differences seem to me such as might be expected between the plates of a young and an old individual.

Caudina planapertura, sp. nov.

(*plana,* even, + *apertura,* openings; in reference to the smooth calcareous plates.)

Plate IX, Figs. 6-8.

Tentacles 15, each with 4 long digits. Calcareous ring not very stout, the posterior prolongations of the radial pieces not very prominent and rather pointed. Polian vessel single, long. Stone-canal single, lying in the dorsal mesentery. Respiratory trees long and delicate. Genital glands branched and containing very large ova. Body elongated, tapering into the slender tail, which is more than one-third of the total length. Calcareous particles in the skin smooth, or slightly knobbed, plates perforated with many smooth holes. Color gray, with minute light brown blotches, which are so numerous on the back as to give a faint brown tinge to the dorsal side. Length, 67 mm., of which the caudal portion is 27; diameter of body, 12 mm.; of tail, 3.

This species resembles *C. arcnata* superficially, but is easily distinguished by the very characteristic plates in the skin. It differs from *C. californica* in having the plates smaller, much less numerous, and nearly or quite smooth.

There are 4 specimens (Cat. No. 19825, U. S. N. M.), collected by the "Albatross" (Station 2784) near the southern part of Wellington Island, Chile, lat. 48° 41′ S., long. 74° 24′ W., 349 m.

Caudina obesacauda, sp. nov.

(*obesa,* fat, + *cauda,* tail; in reference to the stout caudal appendage.)

Plate IX, Figs. 1-5.

Tentacles 15, each with 4 sharply pointed digits. Calcareous ring stout, the posterior prolongations of the radial pieces very prominent. Polian vessel single, long. Stone-canal single, small. Filaments of the genital glands very long and unbranched. Body stout, the tail not abruptly narrow. Calcareous particles, cups closed with a cross, similar to those of *C. coriacea,* but the knobs are not so prominent. The anal papillæ are crowded with modified cups and irregular perforated plates, and do not seem to have any such deposits as those figured by Théel (and called "characteristic") from the anal papillæ of *coriacea.* In the tail, however, the deposits are very much crowded, heavily knobbed, and nearly spherical, and the holes are almost obliterated. Color, pale brown. Length, 115 mm., of which the tail is about one-third; diameter of body at middle, 30 mm.; of tail near base, 20 mm.; near middle, 12 mm., and near tip, 4 mm.

There is a single specimen (Cat. No. 19823, U. S. N. M.) of this large and notable species, bearing only the label "Marco, Florida." It is very obviously different from *arenata,* the common Atlantic species, but it is closely related to *coriacea* of the western Pacific. It differs from that form, however, in the shape of the body and in the calcareous particles of the caudal portion. If the label is correct, it is curious that this new species should find its closest ally in a species of the western Pacific. There is a small Caudina from Galveston Bay, Texas, which seems to be of this same species, but as it has at some time been completely desiccated, it is past accurate determination.

Caudina contractacauda, sp. nov.

(*contracta,* made abruptly smaller, + *cauda,* tail; in reference to the form of the caudal appendage.)

Plate IX, Figs. 9-13.

There is a single remarkable specimen of Caudina from the Aleutian Islands, "Albatross" Station 3600, lat. 55° 06′ N., long. 163° 28′ W., taken in 16 meters of water (Cat. No. 19824, U. S. N. M.). It is 70 mm. long, of which a little more than one-third is "tail," though the terminal portion is broken off. The greatest diameter, 24 mm., is just before the body suddenly contracts to form the caudal portion, which is 10 mm. in diameter at the base and 5 near the tip. The color is very pale brown, the body wall thick and firm, partially due to its being strongly contracted. The tentacles and internal anatomy are not peculiar, but like those of any Caudina. The posterior prolongation of the radial pieces of the calcareous ring are only moderately long. The calcareous particles in the body wall are cups closed by a cross, as in *coriacea* and *obesacauda,* but very few of them are symmetrical and even these are apparently without knobs. In fact, the vast majority of the cups are very irregular and incomplete.

Although this Caudina resembles both *coriacea* and *obesacauda,* the differences in the calcareous deposits, combined with the different shape of the body and the geographical isolation of the species, are sufficient to warrant its recognition.

Eupyrgus scaber Lütken.

There is an excellent specimen of this interesting little species, from off the coast of Alaska, "Albatross" Station 2852, 105 m. It agrees well with typical specimens, and I think there can be no doubt of its specific identity. It is of particular interest because the species has not been recorded hitherto from west of Greenland, and its occurrence near Alaska would seem to indicate a circumpolar range.

CERAPLECTANA, gen. nov.

(κεραός, horny, + πλεκτάναι, feelers; in reference to the extraordinary tentacles.)

Tentacles 10, simple, unbranched, horny, and pointed, provided with normal ampullæ. Body nearly cylindrical, but tapering posteriorly into a well-developed caudal appendage. Radial pieces of calcareous ring with marked, but not deeply forked, posterior prolongations. Calcareous deposits in the form of irregular branched plates or straight rods, perforated near the middle, and usually with a single, sharp, outwardly directed spine. Phosphatic deposits present.

The type species of this genus is the following:

Ceraplectana trachyderma, sp. nov.

(τραχύς, rough, + δέρμα, skin; in reference to the prickly body surface.)

Plate XIII, Figs. 5-13.

Color gray, flecked with numerous patches of red brown. Tentacles 10, almost the shape and color and nearly the size of apple seeds, arranged one pair in each interradius. The ampullæ are reasonably long. The respiratory tree divides some distance from the cloaca, and the left branch is very short. Deposits differ somewhat in different specimens. In the smallest the ellipses are small, pale yellowish brown, and occur singly or in groups of three, while the calcareous particles are fairly crowded, irregularly branched rods, flat and wide, and perforated near the middle by several holes, among which there is usually a single outwardly directed sharp spine. In the large specimen the ellipses are reddish brown and are collected in patches, while the rods are nearly straight, without a spine, and crowded at right angles to the axis of the body. The third specimen has deposits intermediate between the other two. Length of body, 63 mm. x 20 in diameter; tail broken; in another specimen the body is 30 x 10 and the tail is an even 10 more.

Three specimens from "Albatross" Station 3603, lat. 55° 23′ N. and long. 170° 31′ W., 3,188 m. (Cat. No. 19860, U. S. N. M.)

This remarkable species is so easily recognized by its peculiar tentacles that it cannot be confused with any other.

HIMASTHLEPHORA, gen. nov.

(ἱμάσθλη, thong of a whip, + φορός, bearer; in reference to the remarkable dorsal appendages.)

Tentacles 15, each with 4 digits, of which the terminal pair are the larger; without ampullæ. Body nearly cylindrical, rather stout, terminating abruptly in a long, slender, caudal portion. Mid-dorsal interambulacrum with 4–6 whiplash-like papillæ. Rudimentary pedicel-like outgrowths near both the anterior and posterior ends of the body. Genital papillæ prominent, 2 mm. or more in length. Respiratory trees small and delicate. Longitudinal muscles simple, flattened, and unpaired. Calcareous ring of 10 pieces, rather stout and synapta-like, with no posterior prolongations. No calcareous or phosphatic deposits in the skin. Careful examination of two specimens failed to show a stone-canal.

The type species of this genus is the following:

Himasthlephora glauca, sp. nov.

(γλαυκός, gray; in reference to the color.)

Plate XIII, Figs. 1-4.

Color light gray; tentacles and papillæ brownish. Length, 28 mm., of which nearly a third is tail; body 8 mm. thick. Genital glands noticeable as tufts of numerous, thick, unbranched tubes, one on each side of mesentery, 3-4 mm. back of calcareous ring. The papillæ in mid-dorsal interambulacrum are 4-6 in number and 5-6 mm. long. There appear to be 5 clusters of pedicel-like projections at the posterior end of the body, at the base of the caudal appendage, and there are rudimentary pedicel-like processes scattered about the anterior end also. Calcareous particles in the skin are wanting, but were possibly dissolved by impure alcohol, as the specimens were collected in 1886.

There are 4 specimens of this most remarkable and interesting holothurian, which were dredged by the "Albatross," Station 2678, in 1,316 m. off the coast of Georgia, lat. 32° 40′ N., long. 76° 40′ 30″ W. (Cat. No. 14726, U. S. N. M.). The general appearance and the tentacles are exactly like the other Molpadids, and the absence of true pedicels confirms the relationship to those forms, especially since Gerould ('96) has shown the presence of rudimentary subcutaneous pedicels in *Caudina arenata.* The papillæ in Himasthlephora are shown by sections (figs. 3 and 4) to be provided with ampullæ, which are connected with the radial canals, but the rudimentary pedicels do not seem to have any such connection. The radial canals, moreover, apparently terminate at the base of the tail instead of at the tip, as in Caudina, although in neither of the two specimens sectioned was this positively determined. In the form and arrangement of the longitudinal muscles (see the section of one in fig. 4) there is a resemblance to the Synaptidæ; but as a very similar arrangement occurs in Eupyrgus (Plate XII, fig. 27), it is not unique among Molpadids. It is very probably a primitive character, retained by Himasthlephora, which on the whole is apparently nearer the pedate ancestor of the apodous holothurians than any of the genera hitherto known except perhaps Gephyrothuria, its relation to which is discussed on page 184.

PART III.

THE SYNAPTIDÆ.

Order PARACTINOPODA Ludwig.

External appendages of water-vascular system arise from circular canal and appear only as circumoral tentacles. While five of these are radial in position, no true radial canals are present in adults.

Family SYNAPTIDÆ Burmeister.

More or less cylindrical elongated holothurians with terminal mouth, without respiratory trees and with water-vascular system greatly reduced; circumoral tentacles, either simple, pinnate, or digitate, are present but lack ampullæ; there are no pedicels or papillæ; circular muscles of body-wall continuous, *i. e.,* not broken or interrupted at radii; characteristic sense-organs (positional organs) present, situated beside radial nerves, near nerve ring; minute ciliated funnels, apparently having an excretory function, usually present in body-cavity on or near mesenteries; calcareous deposits, in form of anchors and plates, wheels or sigmoid bodies usually present, but no tables or phosphatic deposits (see p. 142) occur.

Morphology.

Form and size.—The body is generally elongated and more or less cylindrical, but the exact shape and proportions differ in different species, and, owing to its remarkable contractility, its form differs greatly in the same individual under varying conditions. The largest species in the family is *Synapta maculata,* which reaches a length of more than 200 cm., though the diameter is not commonly more than 3 cm. The smallest species is *Leptosynapta minuta,* which is only 3 to 5 mm. long. Between these two extremes we find great diversity, but species more than 30 or less than 3 cm. when fully grown, are infrequent.

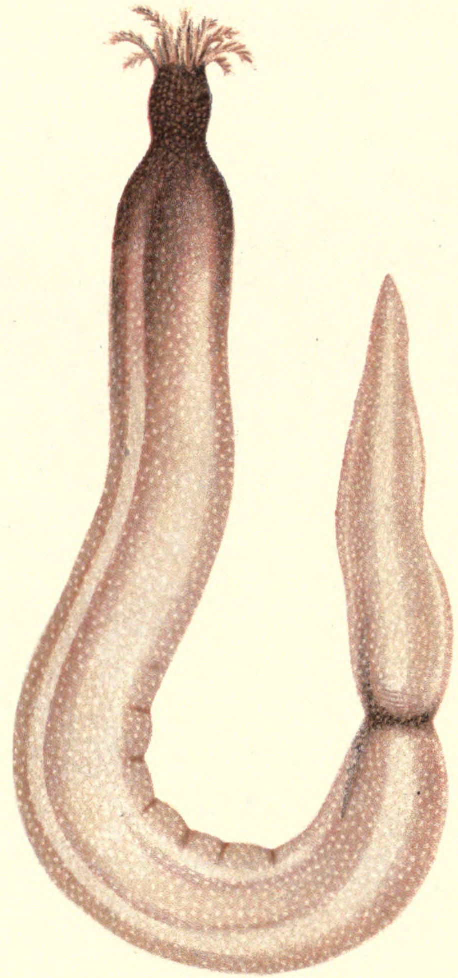
Color.—In color there is some variety, but really bright colors are rare; white, flesh-color, dull yellowish, and gray are the more usual shades, but dull shades of red are common. *Protankyra rodea* is said to be "carmine-red" and *Scoliodota japonica* "blood-red." Green is occasionally found in an olive, or some other dull shade, but the bright shades are rare. Some species are very dark-colored, and have been described as "crimson-black," "dark violet-black," and "brown." The color is seldom uniform, but spots and little papillæ—

PLATE II.

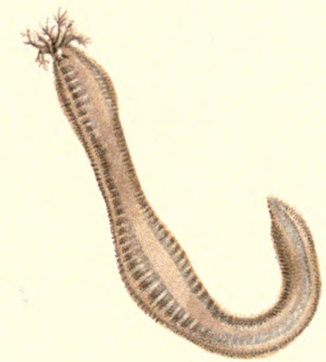
Figure 1. *Anapta gracilis* Semper.
2. *Protankyra similis* (Semper).
3. *Chiridota rigida* Semper.

All natural size and from Semper, 1868.

3.



1.



2.

East Indian Synaptidæ.

white, brown, or red—are often quite thickly scattered over the body. Fine lines of a darker shade often ornament the skins of gray and brown species, and occasionally longitudinal stripes are present. Large irregular blotches of darker or lighter shades often variegate the color. A few species are colored more darkly on one side than on the other, and this is probably due to their manner of life. Subterranean species are usually white or nearly colorless, while species which live about reefs are apt to be gray or brown, and those which live among living corals are generally the bright-colored forms. The color is due, at least in large part, to the presence or absence of pigment cells in the connective tissue of the body-walls. These cells are irregularly radiant in shape, and may be scattered or closely crowded. In *Synaptula hydriformis* the green color is due in some measure to unicellular algæ in the connective tissue. The chemical composition of the pigment varies considerably; in some species pure alcohol does not affect the color, while in others the pigment is dissolved by it; acids and corrosive sublimate dissolve or modify the pigment rapidly. White spots are very frequently due to the aggregations of miliary granules or other calcareous bodies in the skin. Complete absence of pigment tends to make the body-wall transparent, and the longitudinal muscles then stand out as five prominent opaque bands. Even in dark-colored species, the position of these muscles is often indicated by a darker (or lighter) longitudinal stripe.

Body surface.—The surface of the body in the Synaptidæ is almost always more or less rough, and is seldom smooth and slimy, though there are glands in the epidermis. The roughness may be due to the small, usually crowded, and regularly arranged projections of the body-wall itself, known as *verrucæ,* or to the calcareous bodies, single or in heaps. Verrucæ vary greatly in size and prominence, according to the size of the animal and the amount of contraction of the body-wall. In the larger species, they may be very prominent, 5 or 6 mm. high, and 6 or 8 in diameter; in such cases, they generally form regularly transverse and longitudinal rows, the latter usually 10 in number. These large verrucæ are by no means constant in size and form and seem to be dependent on the condition of the animal. They may be large, small, or wholly wanting in individuals of a single species (see Plate I), and, in *Euapta lappa* at least, in a single individual at different times. It is probable that their presence is due to unusual muscular contraction brought on by abnormal external conditions. Their presence or absence is therefore not a character which is of any taxonomic importance. True verrucæ are much smaller and usually much more numerous, sometimes as many as 500 to the square centimeter. They usually contain calcareous deposits and oftentimes pigment. The largest and most noticeable verrucæ occur in the genera Synapta and Euapta, but the smaller ones are found in Leptosynapta, Synaptula, and Tæniogyrus. They are generally wanting in other genera. In most Synaptids the calcareous particles are not of sufficient prominence to affect the appearance of the body surface, but in those species in which the anchors are more than 250 μ in length, or where the calcareous bodies are accumulated in special heaps (as the so-called "wheel-papillæ" of Chiridota), the surface may become rough and even very prickly, not only to touch but to sight. The degree of roughness depends to no little extent on the amount of contraction of the circular muscles of the body-wall, and is almost always more noticeable in preserved than in living specimens. In Trochoderma the body-wall is firm and stiff from the crowded calcareous deposits.

Tentacles.—The number of tentacles varies from 10 to 27, but it must be borne in mind that the number in the young is at first five, and that thereafter the number varies with the age of the animal, certainly until sexual maturity is reached, and in some cases possibly thereafter. In some species there is a distinct 7-tentacled stage, while in others the second quintet of tentacles appears simultaneously, and we have a 10-tentacled larva. After that it is probable the tentacles appear singly or in pairs; they certainly do in the 12-tentacled species, whose development is known, but we have no knowledge of the development of any species with more than 12 tentacles. Now these facts have an important bearing on what we are to consider the normal number of tentacles in a given species. Where a large number of mature individuals have been examined, the normal number of tentacles is not difficult to determine, but where only a few individuals, and some or all of those obviously immature, have been available, it is clear that we cannot decide positively on the number for that species. Unfortunately, comparatively few species are sufficiently well known to make our knowledge on this point satisfactory. Although 10 tentacles are characteristic of Rhabdomolgus, Trochoderma, and Trochodota, and of some species of Synaptula, Leptosynapta, Protankyra, Tæniogyrus, and Myriotrochus, few of these latter forms are sufficiently well known to put the matter beyond dispute. One species of Labidoplax (*buskii*) has constantly only 11 tentacles, and since many specimens have been examined, this is probably the normal number. Many Synaptids have the number of tentacles constantly 12, and individual specimens of these species not infrequently have 13. Several species have been described as having 13 tentacles, but all are known from only a few specimens, and it is quite possible that 13 is not the normal number. Many species have 15 tentacles, and individuals of these may have 13, 14, or 16 instead of the normal number. Several species have been described as having 16, 17, 18, or 19 tentacles, but all are East Indian forms, and not one can be said to be satisfactorily known. It is very probable that the normal number for these species will be found to be 20 or possibly 18. It is rather remarkable that not one authentic species is known with 20 tentacles, though one or two have been so described.

The genus Polyplectana has more than 20; the normal number is probably 25, but individuals with as many as 27 are known, and it is common to find specimens with less than the normal number. In regard to the arrangement of the tentacles, when 10 are present there are 2 in each interradius; when 12 are present, the right and left dorsal interradii have 3 each; when 13, the additional tentacle is either in the mid-dorsal or in one of the ventral interradii; when 15, there are 3 in each interradius. We have no information in regard to the arrangement of the tentacles in the species with more than 15 tentacles. The shape of the tentacles differs very markedly, but they are usually provided with finger-like outgrowths called *digits*. Rhabdomolgus is the only genus in which there are no distinct digits whatever. In all other Synaptids there are always at least 2 digits, one on each side, and the number may be as great as 30 on each side. In many cases the tentacles are truly *pinnate* (Plate VI, fig. 19), having a tapering shaft with the digits arranged in a simple row along each side. Those near the middle are the oldest and usually the longest, new digits being formed at both ends of the shaft as the animal grows. In some cases the tentacles are very short, and the few digits (2 or 4) arise at the tip end, from what is nearly a common source; such tentacles are called *digitate*. In the Chiridotinæ we have an arrangement of the digits along the margin of a flattened disc which occupies the upper and outer side of the tentacle. The longest digits are at the top, the youngest and smallest at the lower, outer end. Such tentacles are sometimes called *peltato-digitate*. When contracted, the two sides of the disc fold toward each other outwardly, and, thus folded, the whole disc can be withdrawn more or less completely into the base of the tentacle. The tentacles are sometimes connected with each other at their bases by a more or less evident membranous fold, and in some species the digits are united to each other in a similar manner. So far as known, the tentacles of adult Synaptids are always of equal size. The cases which have been recorded where such was not the case are clearly young individuals, or the observer has been deceived by the unequal contraction of the tentacles. The tentacles are always hollow, containing, as they do, the tentacular canals of the water-vascular system. The wall of the tentacles is made up of a thin cutis overlying a layer of epithelial cells, beneath which is a connective tissue layer—an arrangement essentially the same as in the body-wall. Any calcareous particles present in the tentacles lie in the connective tissue. The cavity of the tentacle is lined with a thin epithelium, and between this and the connective tissue occur the muscles. Longitudinal muscles are always present, so far as synaptid histology is known, but the presence of circular muscles is a disputed point. They are certainly absent in some species, but seem to be present in *Labidoplax digitata* and perhaps in some others. The digits of the tentacles have the same structure as the tentacle itself, but the central cavity which each one contains is, in some species at least, entirely cut off from the tentacular canal (Plate VI, figs. 19 and 20). At the tip of the tentacle the epithelium is much thickened, especially on the outer side, and the thickening probably serves as a special organ of touch. There are no tentacle ampullæ in any of the Synaptidæ. (See p. 147.)

Sense-organs.—The sense-organs of Synaptids are of four very distinct sorts—light-detecting, positional, gustatory, and tactile organs. The *light-detecting organs,* or eyes, are known in only a comparatively few species, and their function has been a matter of some dispute. They are best known in *Synaptula hydriformis,* where at least they are simple eyes (Plate VI, fig. 15). They are situated, a pair at the base of each tentacle, and consist of a distinct, rather horny mesodermal layer, containing scattered nuclei, overlying the swollen end of a large nerve, which arises on each side from the circumoral ring at the base of the tentacle nerve. The ends of these nerves are made up of nerve cells of considerable size with big nuclei, which are somewhat swollen, and are apparently vacuolated at their outer extremities. They are polygonal in outline when seen in cross-section, and the inner ends taper off into fibers which run out into the nerve. The mesodermal covering, which also has the appearance of being vacuolated, is clearly a continuation of the thin mesoderm layer which surrounds all the nerves. The eyes are about 60 μ in diameter, the mesodermal covering being rather more than one-tenth as thick. The pigment, which is contained in the mesodermal covering, is at first bright green, but gradually becomes deep reddish brown, so that the eyes look like small brown spots. In some instances it has been shown that the so-called "eye-spots" are simply clusters of "wandering cells" and are not supplied with special nerves, and are therefore of course not sense-organs at all. The *positional organs* are generally, though incorrectly, called "auditory vesicles," or "otocysts." They are known to occur in a number of species of Leptosynapta, Synaptula, Protankyra, Labidoplax, Chiridota, Myriotrochus, and Acanthotrochus, and no Synaptid is known to lack them. They are spherical sacs situated just outside the calcareous ring, one on each side of each radial nerve, with which they are connected by small nerves. They differ greatly in size, those of *Synaptula hydriformis* (Plate VI, fig. 16) measuring only 60 or 70 μ in diameter, while those of *Labidoplax digitata* are sometimes as much as 210 μ. They are lined with cilia and filled with fluid, and contain one or more little spheres, which are kept in active movement by the action of the cilia. These spheres are heavier than the fluid in which they lie, and constantly tend to sink to the lowest part of the sac, and by contact with the cilia give rise to sensations of changed position. Whether these spheres are made up wholly or in part of inorganic salts is still undetermined, but they appear to be vesicles filled with a denser fluid than that in the sac. The *gustatory organs* (Plate V, fig. 22; Plate VII, figs.

21-22) occur in a number of species of several distinct genera, but many species are known which do not have them. They are small cup-shaped outgrowths on the inner face of the tentacles, near the base, just large enough to be seen with the naked eye, or even smaller. The number on each tentacle varies from 1 to 30 or even more in large animals. Each cup is lined with cilia and is connected by a small branch nerve with the tentacle nerve. There seems to be little doubt that these cups serve as organs of either taste or smell, although the evidence is not conclusive. *Tactile organs,* or "touch-papillæ" (Plate VI, fig. 17), occur in many and perhaps all Synaptids, not only in the tentacles, which are themselves such important organs of touch, but also scattered all over the surface of the body. These "sense-buds" or "touch-papillæ" are small groups of epithelial cells connected at their inner ends with special ganglia situated at the ends of small nerves, which arise as branches of either the radial or tentacle nerves.

Nervous system.—The complete nervous system is known in very few Synaptids, but those species in which it is known agree so well that there is little reason to expect anything strikingly different in other species. At the extreme anterior end of the body lies the *circumoral ring,* a band of nerve tissue surrounding the œsophagus and giving rise to the five *radial nerves* and the *tentacle nerves,* the number of which corresponds to that of the tentacles. The circumoral ring lies above or within the calcareous ring, close upon the outer wall of the circular sinus in which the œsophagus lies, and is a tenth of a millimeter, more or less, in thickness. The outer layers contain most of the ganglion cells, the interior being chiefly fibrous. In those Synaptids which have eyes the optic nerves arise directly from the circumoral ring, and in some species special nerves or nerve bands arise from the inner or lower side of the ring and run to the oral disc and œsophagus. The radial nerves run outward, over or through the radial pieces of the calcareous ring, and then, bending abruptly backward, run with little diminution in size to the extreme posterior end of the body. Each nerve consists of an inner and an outer band, the latter of which contains most of the ganglion cells on its outer side. The two bands lie close together in the connective tissue of the body-wall just outside of the circular muscles. Each radial nerve gives rise to the nerves supplying the positional organs, and to numerous small branches, which supply the muscles and "sense-buds" of the body-wall. In many Synaptids there is an open space or canal, between the radial nerve and the longitudinal muscle, known as the *hyponeural canal;* but it is not always present; it is wanting in *Synaptula hydriformis.* The tentacle nerves arise from the outer, lower side of the circumoral ring and run upward on the inner face of the tentacle, giving off branches to the digits and to such sensory cups or papillæ as may be present.

Body-wall.—The body-wall of the Synaptids is thin and generally translucent, if not actually transparent. In Myriotrochus and some species of Leptosynapta and Chiridota it is so transparent that the inner organs are readily seen through it. It consists of five parts (Plate VI, fig. 21), a cutis and a layer of epithelial cells, which together make up the epidermis; a layer of connective tissue in which lie the calcareous bodies, pigment, etc., a layer of circular muscles—in the radii the longitudinal muscles—and an inner epithelium, which lines the body cavity.

1. *Epidermis.*—The cutis is a thin, transparent, structureless layer, secreted by the epidermal cells, and exhibiting no special peculiarities. The epithelial cells beneath are of three distinct sorts; ordinary, more or less elongated, irregularly polygonal cells, which greatly predominate, but among which are scattered sensory and gland cells, the former in clusters of several dozen, forming the "sense-buds" to which reference has already been made. The sensory cells are much more elongated than the ordinary epithelial cells, and the inner end is drawn out into a fiber which connects directly with the small ganglion lying underneath the sense-bud. Sometimes such sensory cells occur scattered singly among the ordinary epithelial cells. The gland cells are of two kinds, but their number, size, distribution, and activity undoubtedly differ much in different Synaptids, according to the manner of life. The so-called *goblet glands* are the more numerous, and occur in nearly all parts of the epidermis, while the larger *club glands* are much less common and more widely scattered. Both kinds of glands are most numerous and best developed in the epidermis of the tentacles, especially on the outer side near the tip and on the outer side of the digits, the surface of which is quite viscid in most Synaptids. Whether the so-called "contractile rosettes" (see Becher :06) are epidermal structures does not seem to have been determined, but they probably lie deeper. Very possibly they are identical with the larval glandular organs of *Synaptula hydriformis* referred to on page 61.

2. The *connective tissue layer* makes up as a rule more than three-fifths of the body-wall, although the proportion varies with the total thickness. It consists of a mass of fibers, the outgrowing prolongations of spindle- or star-shaped cells, imbedded in a clear, transparent, nearly colorless ground-substance of gelatinous consistency. Besides these connective-tissue cells, so-called *wandering cells* are abundant, which are more or less oval in outline, but often possess pseudopodia as they are capable of amœboid movements. In the connective-tissue layer are found two of the most important structures of the body-wall, the *pigment cells* and the *calcareous bodies*. The *pigment cells* are sometimes more or less oval or spherical bodies, but are often irregular, much-branched particles of coloring matter, most numerous in the outer part of the body-wall just below the epidermis. They are often aggregated in particular

parts of the body and in some species chiefly about the anterior end or on the dorsal side. They often crowd about the calcareous ring and even occur in that structure. The color is generally some shade of red, brown, or black; but purple, green, and yellow pigments also occur, and perhaps other colors. It is possible that the pigment bodies sometimes crowd into the epidermis, but it is doubtful if this is a normal condition. The pigment is generally, if not always, insoluble in water, ether, or pure alcohol, but is rapidly discolored or profoundly changed by acids, alkalies, and corrosive sublimate.

The *calcareous deposits* of the body-wall are rarely entirely wanting. They are formed by special mesenchyme cells in the connective-tissue layer, and their manner of growth is well known. They are almost, if not entirely, pure carbonate of lime. It is most convenient to classify them under four heads: anchors and plates, wheels, curved rods, and miliary granules; all four kinds never occur in any one species, though three often do, and there are usually at least two kinds present.

The *anchors and plates* (Plates IV and V) are more or less symmetrical, and always lie in the body-wall, with the anchor over or outside the plate, and usually their long axes are at right angles to the long axis of the animal. The plate arises as a short rod, parallel to the long axis of the animal, which soon forks at each end. The forks grow and divide dichotomously, with more or less regularity, but the subsequent branches do not grow with equal rapidity. As a consequence, branches of the third and higher degrees meet and fuse, thus inclosing the open spaces which are the perforations in the completed plate. The edges of these holes may remain smooth, or they may become toothed, although the smallest holes are always smooth. In some species the branching, which gives rise to the plate, proceeds so irregularly that the plates become very asymmetrical, this being especially true when the perforations are small and numerous. In species with symmetrical plates the number of large, toothed holes is generally 6 or 7, rarely more, but the number of small, smoooth holes is not limited, though generally less than 10; they are found mostly at the smaller end of the plate. Usually the plates are not flat, but are more or less concave on the outer side, and the posterior end frequently bears an outwardly curved bow, which thus arches the concavity. This bow sometimes bears teeth at the center on the anterior edge. The bow is often imperfect and frequently wanting. Anchor-plates vary in size from 0.1 mm. up to 1 mm. in length, and the breadth is from one-half the length up to nearly equaling it. The plates are always shorter than the anchors which accompany them, though the proportion between the two pieces is very variable. The plates are frequently longest at the posterior end of the body. They are occasionally double and provided with two bows. Two quite different sorts of plates sometimes occur in the same species. The anchor consists of a more or less curved shaft, lying with the convex side against the plate, the posterior end (*stock*) frequently, if not always, connected with the bow or posterior portion of the plate by connective tissue, and the two arms, which are more or less outwardly flaring. The arms are frequently toothed on their outer sides, the teeth, however, pointing, not backward, but forward or outward. When the arms are smooth, there are often several small knobs on the vertex of the anchor, where the two arms and the shaft fuse. The stock is more or less expanded, and may be undivided and edged with numerous fine teeth, or it may be more or less branched, the branches bearing teeth. In exceptional cases the anchors bear arms at both ends. Not infrequently the anchors are asymmetrical, one arm being larger than the other, and occasionally a third arm occurs. The anchors of the posterior end of the body are oftentimes longer than those of the anterior end, and sometimes there are two entirely different kinds of anchors found in a single species. Anchors vary in size from 0.12 to 1.1 mm. in length, those of the latter size being quite easily seen with the unaided eye. They arise as straight rods lying perpendicularly to the long axis of the animal, and therefore at right angles to the rods giving rise to the plates. They are of considerable size before the plate rods appear, and already show the rudiments of the arms, which extend outward at first, and later bend backward. The teeth on the arms, and the branches and teeth on the stock are the last parts to appear. The number of anchors and plates varies greatly, not only with their size, but also with the habits and habitat of the animal. In some species there may be only a few—less than 25, perhaps—to a square centimeter of skin, while in other cases there are from 1,000 to 1,500 per sq. cm. They are often more numerous posteriorly than anteriorly.

The so-called *wheels* (Plates VII and VIII) occur in a number of genera, in several forms, either scattered singly in the skin or collected in little heaps or papillæ. These heaps are generally large enough to be visible to the naked eye, and then appear as small white spots. They are covered only by the very thin epidermis and are easily rubbed off. They occur chiefly on the interambulacra, often in definite longitudinal rows, but are sometimes scattered over the whole body. When the wheels are scattered and not in heaps, they are usually quite widely separated; but they may be crowded, and occasionally so much so as to form several layers and make the body-wall firm and hard. The wheels are sometimes flat or nearly so, but more commonly they are decidedly concave, somewhat saucer-shaped, so that the margin is higher than the center, though the latter may be higher than the surrounding spokes. Most commonly the wheels have 6 spokes, which are rather wide and flat, but in other cases the spokes are narrower and more numerous, from 8 up to 25 in number. The rim of the wheel is usually smooth on its outer margin, though sometimes it bears prominent spines, alternating with the spokes. The inner margin is generally toothed, either with numerous minute teeth or with from 15 to 30 larger teeth which point inward, but it may be perfectly smooth. The center or "hub" of the wheel is usually smooth, but is sometimes rough on the outer end. Its inner end is the point of attachment for a strand of connective tissue, the exact function of which is not known. In size the wheels vary from about 30 to upward of 350μ, the diversity being very noticeable oftentimes in a single individual. The various kinds of wheels arise first either as discs or saucer-like plates, with fluted edges, or as star-shaped bodies (Plate VIII, figs. 9-12). The spokes arise either from the projections on the edge of the plate or from the rays of the star. As they increase in length, they expand at the outer end, and the expanding branches meet and fuse to form the rim of the wheel.

The *curved rods* occur most commonly as supporting rods in the tentacles (Plates IV, V, and VII), but are sometimes found scattered in the body-wall itself. In the former case they are usually more or less branched, toothed, or perforated at each end, though in some cases they are smooth and solid. They show great diversity in size and shape, ranging from 20 to 200μ. Their long axes are generally parallel to the long axis of the tentacle or to that of the digit in which they lie, but they are sometimes collected more or less irregularly near the base of the tentacles, especially on the inner side. The rods which lie scattered in the body-wall may be only very small elongated particles, with smooth, rounded ends (Plate IV, fig. 14), or they may be more or less curved, having the ends somewhat enlarged and often toothed (Plate VII, figs. 4, 7, and 12); or the form may be that of a hook or bracket or an elongated letter S (Plate VII, figs. 5, 6, 9, 10, and 11). The latter are called sigmoid deposits. In such deposits the curves of the opposite ends may lie in the same plane or in planes at right angles to each other. The rods and sigmoid deposits of the body-wall are irregularly scattered, though the latter generally lie at right angles to the longitudinal axis of the animal. The rods range from 20 to 100μ in length, while the sigmoid deposits are larger, usually measuring between 100 and 200μ. The sigmoid deposits arise as simple, smooth, curved rods, which gradually increase in size and curvature until the perfect form is assumed.

The so-called *miliary granules* (Plate IV, figs. 16 and 21) are very small particles of lime, sometimes smooth and rounded, sometimes cross- or star-shaped, and sometimes branched and irregular, which occur not only in the connective tissue of the body-wall, but often in the underlying muscles also, both circular and longitudinal. Generally they occur scattered more or less uniformly in the body-wall, but are sometimes confined to the radii. They are often collected in small heaps or patches, which appear to the naked eye as white spots on the skin. The irregularly branched forms are sometimes called *rosettes* (Plate IV, figs. 18 and 23). In size the miliary granules vary from 3 to 30 μ.

3. The *circular muscles* of the body-wall of all Synaptids run completely around the body-cavity, just without its lining epithelium. In most species the layer is of uniform thickness and continuity in all parts of the body, except that it becomes somewhat better developed near the cloacal opening, for which it forms a sphincter muscle. It may perhaps also thicken on or near the oral disc. In Acanthotrochus, however, the circular muscles occupy only the interradial portions of the body-wall, except at the ends of the animal, where they are continuous, as in other Synaptids.

4. The *longitudinal muscles* of the body-wall are confined to the radii, where they project more or less markedly into the body-cavity, the epithelial lining of which covers them. They are usually single folds or strips, attached anteriorly to the calcareous ring, and posteriorly thinning out and disappearing near the cloacal opening. They are generally most compressed anteriorly, and become flattened near the middle of the body and imperfectly cylindrical at the posterior end. In some cases the anterior part of the muscle may be divided into an outer and an inner portion, and in such cases the inner half is called a *retractor* muscle, and is regarded as homologous with the retractor muscles of Dendrochirotæ; but the constant presence of such muscles in any Synaptid is open to doubt; they are said to be characteristic of *Euapta lappa, Synapta maculata,* and *Chiridota rotifera,* but although I have examined these species, macroscopically and microscopically, both living (except *maculata*) and preserved in alcohol, I have never found the slightest evidence of a retractor muscle. Those of *Chiridota rotifera* are said to be very short and joined by connective tissue to the longitudinal muscle. In this statement lies a probable explanation of the whole difficulty; the anterior portion of the longitudinal muscles, being strongly compressed, may divide more or less incompletely in a plane parallel to the body-wall, and where the division is only partial such an arrangement as is reported for *Chiridota rotifera* would arise, while if the division were completed it would result in the arrangement said to occur in *C. discolor.* Now, as I have examined specimens of both *rotifera* and *discolor* and have failed to find any trace of a separate retractor muscle, I am convinced that the matter is one of individual diversity, or perhaps correlated with age. At any rate, the presence or absence of retractor muscles is a character upon which only the slightest value can be placed for purposes of classification.

5. The *innermost layer* of the body-wall is a simple, epithelial layer, which covers all of the surface bordering on or projecting into the body-cavity. It consists of polygonal cells similar to the ordinary epithelial cells of the outer

surface, but much more flattened. Whether they are provided with cilia or not is a disputed point. Hamann ('84) asserts that cilia are present, but other investigators have failed to find them. My own observations lead me to believe that cilia are not usually present on the cells of this inner epithelium.

Body-cavity.—The body-cavity of the Synaptids is always spacious, and extends from the oral disc to the posterior tip of the body without any marked separation into parts, although the portion around the œsophagus has had a different origin from the rest in the development of the animal. Longitudinally the cavity is divided on the dorsal side by the mesentery, which supports the intestine, and anteriorly it is traversed by strands or folds of tissue which support the œsophagus. All parts of the body-cavity are lined with the thin, flattened epithelium, already described as forming the innermost layer of the body-wall. The fluid contained in the body-cavity is largely water, but contains albuminous material and corpuscle-like cells. It is probably identical with the fluid in the water-vascular system, but may contain more water. So far as known, the body-cavity is always in communication with the water-vascular system through the madrepore bodies and stone-canal. In *Synaptula hydriformis* and probably in *Chiridota rotifera* the body-cavity is in communication with the outside through openings in the wall of the rectum and at times through rupture of the body-wall near the anus. The former openings seem to be permanent, but the latter are only formed when the young are born and apparently heal up thereafter. In the viviparous species just mentioned, the body-cavity fluid must contain nutritious material which serves as food for the young, as the latter grow to considerable size (10 mm. long or more) before birth.

Calcareous ring.—Surrounding the œsophagus in Synaptids, as in all other holothurians, is a circular ring, made up of more or less distinct calcareous plates. Of these, five lie at the anterior ends of the longitudinal muscle bands, which are attached to them, and are called the *radial* pieces, while the remainder are called *interradial.* These plates arise from calcareous bars (Plate VI, fig. 9) which branch more or less irregularly, the branches anastomosing and fusing until solid plates are formed. The plates are generally more or less quadrilateral, but may be higher than wide (*Synaptula hydriformis,* Plate VI, figs. 7 and 8) or approximately square (Plate V, fig. 14) or wider than high (*Leptosynapta roseola,* Plate V, fig. 16). Usually the posterior margin of each plate is slightly concave or even notched, but it is never forked or deeply divided. The anterior margin may be straight or convex, or distinctly pointed (Plate IV, fig. 2), and frequently the radial pieces are either pierced or notched for the passage of the radial nerves; in *Labidoplax digitata* only the three ventral radial pieces are so pierced. Occasionally the radial pieces of the ventral side are better developed than those of the dorsal, or the reverse condition may occur. The number of interradial pieces ranges from five upward, but the most frequent number is seven, the two dorsal interradii each having an extra piece. Where the number of interradial pieces is more than seven, there is usually an agreement between the number of tentacles and the total number of plates in the ring, but several species have been described in which there is no such agreement. It should be borne in mind that new pieces may form in the ring with the growth of the animal, and that such unusual numbers as 16 and 18 plates very possibly are an indication of immaturity. There will probably prove to be a reasonably definite correlation between the number of tentacles and the number of pieces in the calcareous ring, when all the facts are known.

Cartilaginous ring.—In the genera Synapta, Polyplectana and Synaptula and sometimes in Opheodesoma, there is a noticeable ring of cartilage or some similar connective tissue immediately posterior to the calcareous ring (Plate VI, fig. 18). In bulk it may exceed the latter, with which it is in more or less close contact. This ring is often without projections or perforations, but in some cases it is provided with 15 openings, either anteriorly or posteriorly. The presence or absence of this ring has been used as a generic character, but as its development is apparently more or less variable, it is still a doubtful question as to how great a taxonomic value it has. Its function has never been determined, but it probably gives a more or less useful, though flexible, support to the calcareous ring.

Water-vascular system.—Encircling the œsophagus at a greater or less distance behind the calcareous ring or the cartilaginous ring, when the latter is present, is a tube, which forms the central part of the water-vascular system and is known as the circular ring. It is from a fifth to a half of a millimeter in diameter, more or less, according to the size of the individual, and the wall is a thin layer of connective tissue and circular muscles, covered on the outside with the body-cavity epithelium and lined with a very similar layer of cells. From this circular ring arise the tentacle canals, which run, one to each tentacle, passing upward, on the inner side of the calcareous ring. Just before entering the tentacle, each canal is provided with a valve which permits fluid to pass into the tentacle, but prevents its outflow. The number of tentacle canals may be fewer than the number of tentacles, but such cases are due to immaturity or arrested development. In many, if not all, Synaptids, the anterior margin of the calcareous ring projects forward so far (Plate VI, fig. 18) that the outer half of the lower part of the cavity of each tentacle forms a blind sac or rudimentary ampulla, separated by the calcareous ring from the inner half, which is directly continuous with the tentacle canal. The sacs are always very short and closely appressed to the outer side of the calcareous ring. Dependent from the circular canal are the polian vessels (Plate

VI, fig. 6; Plate VII, fig. 29), the size and number of which are very diverse. They are more or less elongated, blind sacs, the diameter of which varies greatly with the amount of fluid contained within. In Synapta and sometimes in Euapta they may be branched; that is, a number of vessels arise from a common stalk-like outgrowth of the circular ring. Comparatively few Synaptids have only a single polian vessel, the great majority having more than two. Many have from 8 to 16, and a few species have 50 or even more. When more than one, the polian vessels are seldom of the same size, and when numerous there is the greatest variety in length. When only one is present, it is generally of very moderate size, usually less than a tenth of the body length. This single polian vessel lies on the left side of the body, usually in the left dorsal interradius; but when more are present, they arise from the ventral portion of the circular ring, and when very numerous they spring from all parts of that ring. The wall of the polian vessel has essentially the same histological structure as the circular ring; in the connective tissue of either there may occur small calcareous particles, but they are never conspicuous or numerous. Arising from the circular ring is still another outgrowth, the so-called "stone-canal," which may be single, or there may be a number. In the great majority of cases the "stone-canal" is a single, unbranched tube, arising in the mid-dorsal interradius and more or less completely inclosed in the mesentery. In Synapta the stone-canal is usually single, but branched, while sometimes in that genus, and commonly in Opheodesoma, a large number of stone-canals are present, arising from almost any part of the circular ring. While the inner end of the stone-canal is in immediate connection with the ring, the outer end is almost always unattached, and bears a more or less prominent and irregular enlargement which corresponds to the madrepore plate of other echinoderms, and is known as the madrepore body. Through the openings in the madrepore body the stone-canal, and hence the entire water-vascular system, is in direct communication with the body-cavity. In *Synaptula hydriformis,* moreover, the madrepore body lies in the mesentery and is attached to the dorsal wall in such a way that there is present at least one opening between the stone-canal and the water outside. This opening is on the dorsal side, just in front of the genital duct. In all Synaptids the wall of the stone-canal consists of only three layers, the outer epithelium, a connective-tissue layer, and an inner epithelium of high, more or less cylindrical cells, which are conspicuously ciliated. There are no muscle fibers anywhere in the tube wall, but the connective-tissue layer contains a large quantity of irregular particles of carbonate of lime, giving that firmness and brittleness to the tube which has led to its being called a *stone-canal.* The madrepore body is mainly a mass of such calciferous connective tissue, more or less extensively pierced by the openings between stone-canal and body-cavity, which are very short tubes, lined with a prominent ciliated epithelium. Owing to this direct connection between the lumen of the water-vascular system and the body-cavity, the fluids contained in the two are essentially identical.

Alimentary canal.—The mouth of Synaptids is a circular opening in the center of the oral disc, around which the tentacles form a single circle, and which constitutes the anterior end of the body. The mouth opens at once into a slender thin-walled œsophagus of variable length, which is encircled by the calcareous ring and water-vascular ring, and which is more or less connected with them and with the body-wall by strands of connective tissue. The œsophagus opens into a more or less well-marked stomach, the thicker and more muscular walls of which usually distinguish it from both œsophagus and intestine. The latter is usually thin-walled and of nearly uniform diameter; it may be short and without a loop (a condition practically unknown among other holothurians) or it may be elongated to such an extent that from the point of union with the stomach it bends forward and runs for a greater or less distance toward the mouth before it bends again and takes its course backward to the vent. The latter is the ordinary arrangement. It terminates in a slight enlargement homologous with the cloaca of the lung-bearing holothurians, but as no other organs enter it, in the Synaptids it is better called the rectum. The vent or anal opening is always terminal. A cross-section through the alimentary tract at any point reveals an outer epithelium, the ordinary lining of the body-cavity; inside of this a very thin layer of connective tissue, following which is a muscular layer consisting first of longitudinal and then of circular fibers; within this is a thick layer of connective tissue, and then the lining epithelium of the canal. The layer of muscles is thickest on the stomach, the walls of which are decidedly muscular. The inner epithelium is more or less glandular, especially in the stomach, and is frequently ciliated, at least in the intestine. Some writers have described a delicate cuticle there instead, but this is possibly a misinterpretation of the appearance of the cilia in preserved material. Wandering cells (often bright red in the living animal) occur more or less abundantly throughout the lining epithelium. The alimentary canal is supported through part or all of its course by a mesentery, usually consisting of three sections. The first supports the œsophagus and stomach and is attached to the body-wall in the mid-dorsal interradius; the second supports that part of the intestine which runs forward from the end of the stomach and is attached in the left dorsal interradius; the third supports the remainder of the intestine and is attached in the right ventral interradius. The second section may be greatly reduced and is practically wanting in those species which have an approximately straight alimentary canal. In other cases the first and second sections of the mesentery run backward considerably posterior to the point where the intestine bends forward, and, being united together over the left dorsal radius, they form a blind sac which Semper has called the "mesenterial canal." In *Myriotrochus minutus* the mesentery is greatly reduced, and there are special connections between the loops of the intestine and with the body-wall. The mesenteries are usually attached a little to one side of the mid-line of the interradius in which they lie. They consist of a very thin layer of connective tissue, with or without muscle fibers and covered on each side with the epithelium of the body-cavity.

Ciliated funnels.—In the body-cavity of all Synaptids, so far as known, except *Rhabdomolgus ruber* and *Labidoplax buskii,* there occur minute, more or less funnel- or cornucopia-shaped bodies conspicuously ciliated over a part of their surface (Plate V, figs. 11, 12, 20, 21; Plate VII, figs. 14, 23, 28). These ciliated funnels are very characteristic of the family, and are not known to occur in any other animals. They are very few in number in *Leptosynapta minuta* and it may be that they will yet be found in the species of Labidoplax and Rhabdomolgus, where they are said to be wanting. They most commonly occur upon the mesenteries close to where the latter join the body-wall, but they may occur on the body-wall itself and on the face of the mesentery also. They may occur in connection with all three sections of the mesentery or only with one or two. The funnels may be individually distinct and uniformly separated, they may occur in small groups, or a number may be united into a cluster having a common stem (Plate VII, fig. 14). They range from less than 80 μ to considerably over a millimeter in length. When connected on a common stalk, the whole group may be nearly a milimeter high, and the individual funnels range from 70 to 250 μ. In any one species the size as well as the arrangement of the funnels is fairly constant, though in some cases two very distinct sorts of funnel occur in the same individual. Thus in *Leptosynapta inhærens* the ordinary funnels are generally less than one-tenth of a millimeter in height, but scattered here and there among them are funnels of a somewhat different shape from four to twelve times as large (Plate V, fig. 20). The stalk of the funnels is always a slender strand of connective tissue covered with an epithelium, both direct continuations of the same tissues of the mesentery or body-wall. In groups having a common stalk, the latter is said to contain muscle fibers. The funnel itself is made up of connective tissue covered on the outer (convex) side with the flattened epithelium of the body-cavity and lined with an epithelium of high, cylindrical, crowded cells, each of which bears a cilium. The exact form of the funnel, the thickness of the various parts, and the size of the space inclosed vary greatly in different species, and to some extent in different individuals of the same species, and in different funnels of the same individual.

Blood system.—In connection with the digestive canal, there are present in the Synaptidæ two long longitudinal vessels, which form the principal portion of the blood system (Plate VI, fig. 6). One of these lies just at the line of union of the mesentery and alimentary canal, and is called the dorsal vessel, while the other is on the opposite side, and is called the ventral vessel. These vessels may be closely appressed to the stomach and intestine or they may be completely separated from them by a greater or less distance. In the former case they are connected with each other by lacunar spaces in the wall of the alimentary canal, but when separated from the latter they are connected with its wall by short cross-vessels which open into the lacunar spaces or into a secondary longitudinal vessel from which lacunæ arise. The ventral blood-vessel runs from the lower end of the œsophagus back as far as the middle of the third section of the alimentary canal, both ends fading out into lacunar spaces. Between the ventral blood-vessel of the first and second sections of the digestive tube (sometimes between second and third, sometimes even between first and third) there are usually present one or more connecting vessels of considerable prominence. The dorsal vessel runs backward about as far as the ventral vessel, but anteriorly it extends to the water-vascular ring, upon the inner surface of which there lies the circumœsophageal ring of the blood-system, in which it terminates. Direct connection between the ventral vessel and this ring has yet to be demonstrated in the Synaptidæ. From the blood-ring arise vessels running into each tentacle along the inner surface, close to the tentacle canals. The genital gland receives its blood-supply directly from the dorsal vessel. Radial blood-vessels are wanting in the Synaptids. The blood is usually colorless, but in some of the larger species it is yellowish. It contains much more albuminous material than the fluid of the water-vascular system; it also contains corpuscles, amœboid cells, and minute granules.

Reproductive system.—The reproductive organs of the Synaptidæ consist of a more or less branched pair of tube-like projections, one on each side of the dorsal mesentery, in which lies the common genital duct, into which they open. The duct is short and opens to the outside by a single pore, in the mid-dorsal interradius, just back of the circle of tentacles. In *Synaptula hydriformis,* however, the duct is not united with the outer epithelium of the body-wall and probably communicates with the exterior by several minute pores. The genital tubes themselves lie in the anterior part of the body-cavity; there is rarely only a single branch on each side, generally several or many branches. Usually the branches or tufts of branches of the two sides are of equal size in adult Synaptids, but in the young, so far as is known, that of the left side is the smaller, and this asymmetrical condition may persist in some adults. The tubes are often somewhat colored, usually yellowish, sometimes green, but more commonly they are white, although the shade varies with the condition of the contents of the tubes. In their finer structure the tubes are found to consist of an outer epithelium continuous with that of the mesentery, and an inner germinal epithelium. Between these there is always present more or less of a connective-tissue layer (though this may be reduced to scattered mesenchyme cells) and a more or less evident layer of longitudinal muscle fibers. In some cases a layer of circular muscle fibers is also said to occur. The finer structure of the genital duct is similar to that of the tubes, but the muscle layers are wanting, and anteriorly the wall of the duct may even be reduced to a single layer of cells. Hermaphroditism is common in the family, but many species are unisexual. In the latter the germinal epithelium gives rise only to eggs or spermatozoa, as the case may be, but in the former the eggs arise on one side of the germinal epithelium, the spermatozoa on the other, or they arise at different places on the inner side or at different times. It is possible that some of the cases reported in which individuals seemed to be of different sexes are simply cases of protandry; but this phenomenon is not certainly known to occur among the Synaptidæ, and in some cases there is no question that eggs and spermatozoa are present and maturing in the same part of the genital tubes and at the same time.

Embryology.

Our knowledge of the embryology of the Synaptidæ is confined to a very few species, particularly *Labidoplax digitata, Synaptula hydriformis, Chiridota rotifera,* and *Tæniogyrus contortus,* and the following account is based upon the observations recorded of them. The eggs range in size from rather more than 100 microns to upwards of 330 microns. They are spherical, contain considerable yolk, which gives them a yellowish or brownish tinge, and are more or less transparent. They are generally set free in the water, but in some cases develop within the body-cavity of the parent, or even in the genital tubes of the mother. Nothing is known positively of the formation of the polar bodies or the process of fertilization, though the latter must, in viviparous forms, take place internally. Segmentation is total and approximately equal (Plate VI, figs. 1 and 2) and results in the speedy formation of a blastula from which the gastrula arises by invagination. The subsequent developmental changes depend very largely upon whether the embryos are protected within the body of the mother or not. If development is so protected, it proceeds directly and with considerable rapidity; but if not, the young Synaptid passes through more or less prolonged larval stages. In any case the archenteron soon bends to one side, and uniting with the body-wall, brings its lumen into connection with the exterior, and this opening forms the water-pore and indicates the dorsal surface of the animal. The archenteron continues its growth forward, however, and, bending downward, unites with the ventral surface of the larva, and the mouth is subsequently formed at that point. In this growth of the archenteron the portion connected with the water-pore comes to lie at one side (the left) and soon is separated as a pouch by itself. This pouch grows backward and constricts, so that its posterior part soon becomes a distinct pouch, which grows out laterally to the right across the dorsal surface of the archenteron onto the right side. The right and left halves of the pouch then separate and become entirely distinct. At this stage, then, we have a larva with a mouth, gut, and anus (the blastopore), a hydrocœl connected with the exterior by a water-tube, and two cœlomic pouches, one on each side of the gut. Scattered throughout the segmentation cavity are more or less numerous mesenchyme cells, which have arisen from the endodermal cells of the archenteron. In those Synaptids which have free-living larval forms, the external appearance of the larva at this stage is very characteristic, and is very similar to the *auricularia* larva of other holothurians. The Synaptid auricularia is a dorsally-flattened, wide, squarish larva with a deep depression on the ventral side (oral vestibule), at the bottom of which opens the mouth. The uniform ciliated coat of the gastrula has given place to a complicated symmetrical series of ciliated bands. A larval nervous system, muscles, and wheel-shaped calcareous bodies are also present. After a time the auricularia becomes barrel-shaped, and the ciliated bands form five encircling rings around the body; this stage is sometimes called the *pupa,* sometimes *barrel-shaped larva.* At the upper or anterior end of the pupa is a very deep, constricted, funnel-shaped space, the vestibule, in the floor of which lies the mouth; the hydrocœl completely encloses the œsophagus, forming the water-vascular ring from which arise the polian vessel and the tentacles; of the latter, five are already indicated, and between each pair are five other outgrowths corresponding to the radial water-canals of pedate holothurians; these may be quite well-marked in the pupa, running back toward the rear of the body; the cœlomic pouches have become fused ventrally, but on the opposite side are still separated by the dorsal mesentery; the rudiments of the calcareous ring have appeared, and the positional organs are well formed. With the growth of the five tentacles the vestibule disappears and the larva assumes the *pentactula* form (Plate VI, fig. 3), characterized by the short, oval body, the absence of ciliated rings and the five prominent tentacles without digits. The muscular and nervous system are fairly distinct and are rapidly assuming the adult condition. The transformation from the pentactula to the adult form is chiefly marked by the appearance of the blood-system, ciliated funnels, and reproductive organs and the increase in the number of the tentacles, with accompanying development of digits. In *Tæniogyrus contortus* the sixth and seventh tentacles appear simultaneously in the lateral dorsal interradii (Plate VII, fig. 13), and subsequently the eighth, ninth, and tenth appear in the other three interradii, but in *Synaptula hydri-*

formis the second quintet of tentacles appear all at the same time. Probably the 10-tentacled larva (Plate VI, fig. 4) is characteristic of all Synaptids. In the viviparous species the auricularia seems to be wanting and the pupa stage is passed through quickly, nor are there any sharp lines between the different steps in the process of development; the pentactula and 10-tentacled larvæ are, however, plainly shown. In other respects there is little essential difference between the development of the oviparous and viviparous species. In the larvæ of *Synaptula hydriformis,* however, there are peculiar glandular organs in the ectoderm, which may have some use in absorbing food material from the body-cavity fluid of the parent. Perhaps these glandular organs are identical with the "contractile rosettes" of certain other Synaptids. (See Becher, :06.) In species with twelve tentacles, the eleventh and twelfth arise, one in each of the two lateral, dorsal interradii; nothing is known of the development of the additional tentacles in species with more than twelve.

In conclusion, the organogeny of the Synaptids may be stated as follows: *Ectoderm:* The epithelium of the entire body surface, including the sensory epithelium of the tentacles, the entire nervous system, the sense-organs, the anterior part of the œsophagus and possibly the posterior part of the rectum arise from the larval ectoderm. *Mesoderm:* The calcareous concretions, the calcareous ring, the pigment-cells and all cartilaginous and connective tissues arise from the mesenchyme cells of the larva, which in turn arise from the archenteron; there is no satisfactory evidence that any muscles are formed from these cells. *Endoderm:* The alimentary canal (except the ectodermal portions already mentioned), the water-vascular system, the entire musculature, the ciliated funnels, the blood-vessels and corpuscles, the reproductive organs, and all internal epithelial tissues arise from the larval endoderm, either directly from the archenteron or from the hydrocœl and cœlomic pouches to which it gives rise.

Physiology.

Comparatively little work has yet been done in studying the functions of various organs of Holothurians or indeed of any Echinoderms, and particularly is this true of Synaptids. Most of our knowledge of the physiology of these animals is the result of casual observation or chance discoveries made while some problem of morphology or embryology was under investigation. What little is known may be conveniently grouped under the following heads:

Motion.—The movements of Synaptids are mainly concerned with the collection of food and the avoidance of enemies, and are dependent upon the fluids within the body-cavity and water-vascular system quite as much as upon the muscles; the calcareous particles in the body-wall also play an important part in the locomotion of many species. In the search for food, the animal is usually fully extended, and while the tentacles clearly assist, the principal means of locomotion is by the alternate contraction and extension of the body-wall, due to muscular movements. The contraction of the longitudinal muscles draws the posterior end of the body forward, and their relaxation, accompanied by the contraction of the circular muscles, forces the anterior end ahead; for since the body-cavity is filled with fluid, the decrease in its diameter, due to the contraction of the circular muscles, necessarily results in its increased length, and this causes a forward movement, since the body is prevented from slipping backward by the marked projection of the calcareous particles. This projection is brought about by the contraction of the circular muscles—a contraction that begins at the posterior end of the body and moves forward to the head. In species which are distinctly subterranean the calcareous particles of the rear of the body are frequently much larger and more numerous than those anteriorly, in accordance with their use. When moving through sand or mud, the tentacles play an important part in the progress by separating and loosening the particles and pressing them apart, thus permitting the anterior end to be forced forward by the contractions of the body muscles. The subterranean species often move about in burrows, gathering food as they go, the glands of the skin providing a secretion which serves to give the walls of the burrows a certain smoothness, as well as increasing their firmness. Synaptas can turn in their burrows, although they do not usually do so, and backward movements are possible, but not frequent. In collecting food, Synaptids do not lie in their burrows, with their tentacles extended on the surface of the sand, waiting for what may be brought them, but they gather it as they creep about, picking it up by the tips of the tentacles and passing it inward to the mouth. The movements of the tentacles and digits are effected partly by the contained fluid of the water-vascular canals, but mainly by the longitudinal muscles lying on the inner surface. Under pressure from behind, due to muscular contraction of polian vesels and perhaps of the water-ring itself, the fluid tends to straighten the tentacles, while the contraction of their longitudinal muscles tends to bend them inward. Movements to avoid enemies are occasionally like those already described, but may take the form of sudden, active, and very powerful muscular contraction. Similar movements may be produced artificially by changes in environment or by unnatural stimuli. The results of these movements depend of course upon the muscular systems involved. When the whole animal is affected, the body becomes reduced in bulk, both the longitudinal and lateral diameters being evidently decreased; the tentacles may be so strongly contracted as to be entirely invisible, crowded as they are into the now concave surface of the oral disc. Contraction of the circular muscles is always more marked than of the longitudinal, and may go so far as to break the body up into a number of fragments. Such disastrous movements, however, probably do not occur under normal conditions. Subterranean species draw back into their burrows when attacked, and may even retreat into them for some distance. Few, if any, Synaptids swim, except in the larval state, but young ones up to 2 cm. in length are sometimes found floating, if not swimming, in the water. They seem to move partly by the aid of the tentacles and partly by undulatory movements of the body. Many species crawl about with more or less activity, by means of the tentacles, and a few forms can climb the glass walls of aquaria, using the glandular sensory epithelium of the outside of the tentacle tips as adhesive organs. In rare cases the calcareous particles of the body-wall assist in climbing about in seaweeds. As for the rate of movement, it of course varies greatly with the individual and the external conditions, but a healthy Synaptid of moderate size can move from 20 to 30 mm. per minute; larger specimens may move more rapidly.

Digestion and absorption.—So far as is known, these processes show no special peculiarities, taking place as they do in a remarkably simple alimentary system. The food pushed into the mouth by the tentacles is carried by the short and narrow œsophagus into the stomach, where it becomes mixed with the digestive secretion of the gastric glands. Digestion begins here, but probably takes place also in the intestine, while absorption, which may take place to a certain extent in the stomach wall, is mainly accomplished by the wall of the intestine, the absorbed food material being received in the two main trunks of blood system through an extensive system of lacunæ in the intestinal wall. The rectum receives and ultimately rejects the excrement. It is possible that the "larval glandular organs" of *Synaptula hydriformis* (see page 61) and the "contractile rosettes" of *Leptosynapta minuta* (see Becher, :06) are absorptive organs, but it is by no means certain what their function is.

Circulation and nutrition.—There is no true circulation in the blood-system of the Synaptidæ, and the so-called blood plays no part in the carrying of oxygen to the tissues or in removing excreta from them. We are to look upon the movements of the fluid as normally away from the digestive system to the various parts of the body, and as carrying simply the absorbed food to its destination. The system thus is essential to normal and healthful nutrition, but cannot be considered as in any true sense a circulatory system. There is no heart or other vascular organ for propelling the fluid, but contractions of the muscles in the wall of the alimentary canal serve to force the fluid products of digestion into the lacunæ and thence into the larger vessels, and from them on and away, while contractions of the muscles in the body-wall and elsewhere may serve to open up the minute lacunar spaces that drink in the nutritious fluid. No proper investigations of the fluid or its movements in a Synaptid have yet been made, and whether the corpuscles play any important part is unknown.

Respiration.—The providing of oxygen for the tissues of the body is not delegated to any particular system, so far as we know, but the needed gas is taken from the water directly through the skin, probably of all parts of the body, but particularly of the tentacles. Probably some oxygen passes entirely through the skin into the body-cavity fluid, whence the alimentary canal and reproductive system may be supplied. Naturally the tentacles and anterior part of the body require more oxygen than other parts, and there is some reason for believing that the oral disc and tentacles are particularly active in respiration. There is no reason for attaching any respiratory function to the blood system, but we as yet know nothing of the actual movements of gases to, from, or in the tissues.

Excretion.—The getting rid of waste matter from the tissues takes place in Synaptids as in other echinoderms, chiefly by means of the wandering cells already referred to (p. 48), but assisted in a large measure by the peculiar ciliated funnels (p. 57) so characteristic of the family. Whether the water-vascular system, the blood system, or the alimentary canal play any part in excretion we do not know. Excreta passes into the body-cavity fluid from all those tissues which it touches, and much or all of this waste matter, certainly if it be in solid particles, is sooner or later swept into the ciliated funnels. It collects there and seems to be seized on by the "wandering cells," which carry it into the connective tissue of the body-wall. Here these cells may remain indefinitely, but probably most of them ultimately pass on through the skin to the water outside. Fluid and gaseous excreta probably pass directly through the skin into the water. As a matter of fact, we really have almost no evidence on the subject of excretion, except observations made on the action of the ciliated funnels, and while collecting solid particles from the body-cavity fluid is undoubtedly an important function of these organs, it is by no means proven that they are exclusively excretory. As for the wandering cells, most statements regarding them are hypothetical, but there is some evidence in support of the view that as the animal grows older, these cells, with their loads of excreta, collect more and more thickly in the skin and cause the darker or brighter colors which large Synaptids show as compared with their young. What the essential difference is between such cells and the normal pigment cells has yet to be shown, but there can be little doubt that there is a definite correlation between color and excretion. Whether the calcareous particles are to be regarded as the product of excretion is an open question.

Sensation.—The senses of a Synaptid are apparently very simple. Touch is the most widely distributed, almost any part of the body responding to a mechanical stimulus, but it is specially keen in the digits of the tentacles, which are exceedingly sensitive. So far as we can interpret the actions of a Synaptid, the sensations caused by a mechanical stimulus is the same as in all other animals, and the character of the object touched is appreciated to a limited degree. In some cases at least food is recognized apparently by the sense of touch only. Sight is seemingly limited merely to the distinguishing between light and shade, and is probably confined to those species which have special light-detecting organs, but it is entirely conceivable that in other species light may in some way act as a stimulus. Experiment has shown that some such sense as that of taste or smell is apparently possessed by those species which have the special gustatory organs or cups on the inner face of the tentacles, and that this sense is located in these cups. The evidence is not conclusive, however, and it is not known whether any such sense exists in other Synaptids or not. The sense of hearing is apparently entirely lacking, but the sense of position is good, and experiment has shown that the difference between going *up* and going *down* is perfectly evident to a moving Synapta. There is no doubt either that this sense is located in the so-called "otocysts" (positional organs) at the base of the tentacles. There is no evidence of anything like intelligence in the actions of Synaptas, and even their movements are apparently not dependent on an intact nervous system or even an uninjured circumoral nerve-ring; for the severing of the nerve-ring in half a dozen places does not, after the first shock is over, interfere with normal coördinated movements. The habit of contracting the body so strongly as to rupture the body-wall is frequent, and may possibly indicate a lack of any such feeling as that which we call pain, but it is out of the question to determine positively whether a Synaptid feels pain or not. Stupefying by means of magnesium sulphate, chloral, etc., is, as a rule, easily accomplished to such an extent as to render the animal unresponsive to any sort of stimulus. The difference between a sandy (or muddy) bottom and a glass (or porcelain) surface is rather slowly detected, but leads to definite alteration of conduct and movement. Changes in the composition of the water (percentage of salts, CO_2, etc.) are readily detected and also lead to altered movements, but it is doubtful how far these are due to nervous stimulation.

Regeneration.—The power of regeneration in Synaptids is quite remarkable in some ways, but as yet very little experimental work has been done to show how great it is. One or more tentacles, even the whole circle, will be reproduced if external conditions are at all favorable, but if the whole oral end is cut off, there seems to be no power of reproducing it. On the other hand, if the body is bisected, the anterior end appears to be able to reproduce the posterior portion, although the latter cannot form a new oral end for itself. This seems to be true, no matter where the bisection is made. Apparently it is not essential that any considerable portion of the alimentary canal or blood system should be left in the regenerating part. No experiments have been carried through to show how far sense-organs or nerves can be reproduced.

Reproduction.—Reproduction in the Synaptidæ is always sexual, but a large number of species, probably the great majority, are hermaphroditic. Fertilization ordinarily takes place in the water, outside the body of the egg-producing individual, but in the viviparous forms it seems to occur in the body-cavity or even in the genital ducts. So far as known, there is nothing like sexual union between two individuals, but the viviparous species are often, if not always, more or less gregarious, so that fertilization is thereby facilitated. In the great majority of cases, the fertilized eggs undergo their development in the water entirely independent of the parent, but in four species they are known to be retained in the body and undergo their development there. In one case (*Tæniogyrus contortus*) the development takes place within the genital tubes, which thus serve as a uterus, but in the other cases (*Synaptula hydriformis, Leptosynapta minuta, Chiridota rotifera*) the body-cavity serves as the brood-pouch. How the eggs get into the body-cavity is not certainly known, but it is supposed that they pass in from the ovaries directly by rupture of the covering epithelium. When and where fertilization takes place, in such a case, are undetermined points, but probably it occurs after the eggs have left the ovary and are free in the body-cavity. If such is the case, the spermatozoa must pass into the cœlum either directly from the hermaphroditic gonads or else indirectly through the wall of the rectum, openings in which are present in *Synaptula hydriformis*. In *Tæniogyrus contortus* the sexes are separate and the spermatozoa must enter the uterus from the outside water. The young remain in the body-cavity of *S. hydriformis* until 5 mm. or more (sometimes 20 mm.) in length, and are then born by a rupture of the body-wall near the rear of the body. In *T. contortus* the young remain in the uterus until 3 mm. long, and then pass out through the genital opening. Little is known as to the frequency with which young are produced or the number of eggs matured at each breeding period, but some of the tropical Synaptas seem to breed throughout the year, while the more northern species are known to mature their reproductive cells only in the spring or summer. The number of eggs produced at each sexual period seems to range from five to several hundred, but the exact limits are not known in even one species.

Ecology.

The Synaptidæ are all marine animals and have a bathymetrical range from above low-water mark to at least 4,200 meters. The very great majority, however, are littoral forms and there are few species occurring at depths of over 350 meters. They are found in all parts of the world, but seem to be most abundant in the region southeast of Asia, where more than half the reported species are said to occur. They appear to be least abundant in the region west of South America, where no species is known to occur. An unusual number of genera occur in the Arctic and Subarctic region, but the number of species there is not large. Several of the tropical species occur in mangrove swamps, where the sea-water is not as saline as on the reefs, and at least one of the Philippine species is known to live ordinarily in distinctly brackish water. As a rule, however, the Synaptids are quite susceptible to impurities in the water and are to be found only where it is clean and well aërated. Three quite distinct groups, in the matter of habitat, can be recognized, though they are not sharply distinguished from each other. First, there are those species which are really subterranean, living buried in the sand or mud and rarely coming out from their burrows. A second group is made up of those species which live under stones and in similar hiding places; and third are those species which live among corals or seaweeds, not concealed, except as their color and form harmonize with their surroundings. The habitat of any given species varies in different regions, so that subterranean species are often found under rocks, and similar situations are sometimes frequented by species which are ordinarily unconcealed. A certain amount of correlation between color and habitat is seen throughout the family, for the brightly colored species are those which live among corals, while the white, colorless, or inconspicuous species are usually subterranean or at least lie concealed under stones. In some cases this correlation is very striking; for example, *Synaptula hydriformis* in Jamaican waters is reddish brown in color, in perfect harmony with the seaweed it inhabits, while at the Bermudas it is more or less bright green, in harmony with the Ulvaceæ among which it lives.

Very little is really known as to the food of the Synaptidæ, but the alimentary canal is usually found well filled with particles of sand and other inorganic substances, which are taken in with the food. The tentacles of a living Synaptid are in almost constant motion, continually bending in toward the mouth, and then curving outward again, and it is often possible to see particles of solid matter being pushed into the mouth. In *Synaptula hydriformis* the food is largely, if not wholly, vegetable, diatoms forming a conspicuous part of it, and it is probable that the same is true of all those species which live in seaweeds. The food of *Leptosynapta inhærens* is organic matter, taken in with the sand through which it burrows, and apparently consists of both animal and vegetable remains; probably all of the subterranean species and those which live under stones feed on similar material. Whether the species which live among corals are carnivorous has yet to be shown; on *a priori* grounds, it is highly improbable.

Like all holothurians, Synaptids are very inactive animals. Unless irritated by some exceptional external stimulus, their movements are slow and uniform. There is no good ground for believing that they are more active during the night than in daylight. Those forms which live under stones appear to be the most restricted in their movements; for while both the subterranean and the free-living forms are more or less continually moving about in search of food, they seem to remain for long periods of time in a single spot. As a rule, Synaptids do not thrive in aquaria, but some of the subterranean forms will do very well if there is an abundance of pure sea-water. The free-living forms are very sensitive to changed conditions and soon die in ordinary aquaria. The length of life and the rate of growth are wholly unknown, though there is reason to believe that both are closely correlated with the abundance of the food supply. It is hard to say whether Synaptids have any enemies of importance or not; so far as we know, they are not sought after by any animals, but it is difficult to see why they would not serve, as well as worms, for food for fishes. Some starfishes and a few mollusks are known to eat holothurians and some Synaptids may be destroyed by such foes. Parasites are quite common; some half dozen sporozoans, a sponge, several trematode worms, a rotifer, a crustacean, and half a dozen mollusks are already known, which live upon or within some Synaptid, and there are doubtless others which have not yet been noted. Some of these probably obtain little, if any, nourishment from their host, but some of the internal forms are true parasites of the most degenerate kind. Whether any of them seriously enfeeble their host is, however, an open question.

Abnormal individuals (aside from some diversity in the number of tentacles) have only been reported in the case of *Synaptula hydriformis*, where the young are sometimes more or less grown together in pairs (Plate VI, fig. 22) or triplets, occasionally even in quartets and quintets. It is more than doubtful whether these monstrosities ever reach maturity, but one adult with only 3 radii and 11 tentacles has been recorded. Additional tentacles and abnormal calcareous particles are frequent and are known in many species. So far as the human race is concerned, the Synaptidæ are absolutely useless; none of them serves as food or even as the source of articles or substances which are of the least value to man, nor do they furnish food for any animal of commercial importance. The geological history of the Synaptidæ is very imperfectly known, but calcareous particles clearly referable to members of the family have been found in Eocene rocks, and there is reason to believe that the family dates back to the Cretaceous period at least.

Taxology.

The classification adopted in this report has already been discussed and fully outlined (pp. 14-17), but a few words may be added here in explanation of the principles which have been used in determining the validity of the genera and species herein accepted. In attempting to distinguish a "good species," it is essential that the possibilities of individual diversity should not be forgotten; for this reason it is unfortunate when it is necessary to describe a new species from a single specimen, but this necessity often arises. As a general rule, however, we may say that any individual Synaptid belongs to that species of its own genus which inhabits the region where it was taken, unless it shows a marked and tangible difference, constant and without any intergrading series, *either in the form or size of the calcareous particles, in the number or form of the tentacles, or in the special localization of the calcareous particles in spots, rows or papillæ.* In case more than one species of the genus occurs in the region where the individual under consideration was taken, the latter will of course be compared with each one and assigned to that one which it most nearly resembles, unless it shows some one or more of the above-mentioned differences. In case such a difference does appear, the individual is then compared with all other known species of the genus, regardless of locality, and in case the difference is still unique, it must then be given a new name. On the other hand, great care must be used to prevent confusing really distinct species from one side of the globe with nearly related ones from the other; on *a priori* grounds, it is to be assumed that a species from the Atlantic Ocean is distinct from its nearest allies in the western Pacific. Even slight differences, if they are constant, may be used to distinguish species from widely separated areas. Of course, however, it is understood that the character must be sufficient to distinguish individuals of the allied species from each other, regardless of whether their geographical habitat is known or not. Of characters used to distinguish species, the most reliable and satisfactory are undoubtedly the chief calcareous particles of the body-wall, their form, size, and distribution; making proper allowance for individual diversity and the possible solutive effects of preserving fluids, these deposits are remarkably constant in any species. The number and form of the tentacles are good characters, if the specimen is unquestionably mature, but differences in the form and abundance of the lesser calcareous deposits, in the number and length of the digits, in the presence or absence of a web or membrane between digits or between tentacles, and in the relative length of the tentacles must all be regarded with great suspicion, especially if only preserved material is available; of course, where plenty of living material is at hand, some of these characters may prove to be of great importance. Color and size are valuable characters in some species, but very little weight can be attached to them except where a large amount of living or fresh material has been examined. Several other external characters, such as roughness or thickness of the body-wall, prominence of verrucæ (see p. 43), and proportion of diameter to length, have been used in describing species, but little or no weight attaches to them, as a rule. Of internal characters, the form of the pieces of the calcareous ring is the best; but even in this there is some individual diversity. The number of polian vessels and stone-canals, the form of the ciliated funnels, the arrangement of the alimentary canal and its mesenteries, the form of the longitudinal muscles (including the presence of so-called "retractors"), and the appearance of the reproductive organs are all characters which are subject to much individual diversity, often according to age, time of year, size, and habitat, and little weight can be placed on them in distinguishing species. Of characters for distinguishing genera, aside from the calcareous particles, the number and the form of the tentacles are the best, and while others may occasionally be used, no great weight attaches to them. The genera used in this report are easily recognizable (except that Molpadia and Caudina are not always distinct from each other), and there need be no difficulty in distinguishing them. Unfortunately the same cannot be said for the species. Many of the latter are very closely related, but still apparently distinguishable, and must be retained for the present, while others are almost certainly based on abnormal or immature individuals. In other cases it is quite possible that two or more species are included under a single name. No doubt the present compiler has made errors in many cases, but it is hoped that in spite of these the classification here offered may prove satisfactory to students of the Synaptidæ, and may be the basis for much further investigation of the taxology of the group.

KEY TO THE SUBFAMILIES OF SYNAPTIDÆ.

A.—No wheels, sigmoid or bracket-shaped particles present in the skin, but usually anchors and perforated plates; deposits rarely wholly wanting; tentacles never peltato-digitate. SYNAPTINÆ

AA.—Wheels, sigmoid or bracket-shaped particles commonly present in the skin, but no anchors; deposits sometimes wholly wanting; tentacles commonly peltato-digitate.

Wheels present or wanting; if present, never with more than six spokes. CHIRIDOTINÆ

Wheels present, with eight or more spokes ....................MYRIOTROCHINÆ

SYNAPTINÆ Östergren, 1898*b*.

Tentacles with the stalk cylindrical or terete, not becoming widened distally, either with digits along each side for most of its length (*pinnate*) or with only one or two digits on each side near the tip (*digitate*) or without digits at all (*simple*). Calcareous deposits, usually anchors and perforated plates, often accompanied by irregular, curved rods or minute particles (*miliary granules*), but any or all of these may be wanting. Hermaphroditic so far as known, except possibly Rhabdomolgus.

In the following keys and descriptions the terms which are used are commonly self-explanatory, but some explanation is needed of those used in reference to the calcareous particles. The term *miliary granules* does not include any particles occurring in the tentacles or in the longitudinal muscles, so that a species in which it is stated that the "miliary granules are wanting'' may have supporting rods in the tentacles and small oval bodies in the longitudinal muscles. When the miliary granules have a number of short curved branches, they are called *rosettes*. The different parts of the *anchor* are the *arms* and the *shaft;* the point where the arms meet and join the shaft is the *vertex,* and this is the *anterior* end; at the opposite (*posterior*) end of the shaft is the *stock.* The *anchor-plate* lies below the anchor, and the end beneath the stock is of course the *posterior* end; it is across this end that the rod extends, which is called the *bow;* the *anterior* end is commonly the wider. In the key to the genus Protankyra the term ''accessory calcareous particles'' is used for any calcareous bodies in the skin (*not* in the tentacles) other than the anchors and their plates.

KEY TO THE GENERA OF SYNAPTINÆ.

A.—Calcareous particles present in form of anchors and anchor-plates.
  B.—Arms of anchor smooth; vertex usually with minute knob-like projections (plate IV, figs. 17, 25).
    C.—Cartilaginous ring posterior to calcareous ring usually wanting; stock of anchor branched irregularly (plate IV, fig. 25).
      Calcareous ring without noticeable anterior projections; stone-canals not numerous; anchor-plates not abruptly contracted at posterior end, but with a large, smooth hole on each side (plate IV, fig. 24). EUAPTA
      Calcareous ring with conspicuous anterior projections; stone-canals numerous; anchor-plates abruptly contracted posteriorly, and thus lacking a large, smooth hole on each side (plate V, fig. 24). OPHEODESOMA
    CC.—Cartilaginous ring commonly present; stock of anchor not branched (plate IV, fig. 17).
      D.—Tentacles numerous, normally 25 .... POLYPLECTANA
      DD.—Tentacles normally 15 or fewer.
        Size very large; anchor-plates subrectangular or irregular, with numerous smooth holes (plate IV, fig. 19) .... SYNAPTA
        Size diverse; anchor-plates rounded in front, narrow behind, with few holes, the largest dentate and regularly arranged (plate VI, figs. 11, 12) .... SYNAPTULA
  BB.—Arms of anchor usually serrate, sometimes smooth; vertex without knobs (plate IV, figs. 3, 8, 12, 15; plate V, figs. 1, 3, 5).
    C.—Tentacles pinnate, with 5-21 (usually more than 7) digits or simply pinnately notched, without digits .... LEPTOSYNAPTA
    CC.—Tentacles digitate with 3-5 digits.
      Anchor-plates abruptly narrowed into a sort of handle (plate V, fig. 23) LABIDOPLAX
      Anchor-plates irregular with numerous holes, not narrowed into a handle (plate IV, figs. 4, 5, 9, 13) .... PROTANKYRA
AA.—Calcareous particles never in form of anchors or perforated plates.
  B.—Tentacles 12, with digits.
    Tentacles pinnate, with 5-13 digits .... ANAPTA
    Tentacles digitate, as in Protankyra, with only 4 digits........ DACTYLAPTA
  BB.—Tentacles 10, without digits................................. RHABDOMOLOUS

EUAPTA Östergren, 1898b.

Tentacles pinnate, 15, occasionally 16; individuals not fully mature often have 12, 13, or 14. Digits numerous, 10-35 on each side. Cartilaginous ring usually wanting. Polian vessels numerous. Stone-canals one or more. Sense-organs, in form of pigment-eyes at base of tentacles on oral disc, often present. Stock of anchors distinctly branched; arms smooth; vertex with some minute knobs. Anchor-plates with large central hole surrounded by six (rarely seven) other large holes, all more or less dentate, and with several holes of variable size and arrangement (one on each side, large), but with smooth margins, at posterior end, where a well-formed and arched bow crosses outer surface of plate.

The Synaptids of this genus are of large size and variable color, shades of brown, dull green, and gray predominating. They occur in shallow water, upon or near reefs in tropical seas. The number of valid species is doubtful, as it is impossible to determine from the material and data now available what is the status of the following forms, which seem to belong here or in one of the next four genera: *Fistularia fusca* and *punctulata* Quoy and Gaimard, 1833; *Oncinolabes mollis* Brandt, 1835; *Synapta intestinalis, raynaldi* and *zebrina* Held, 1857, and *Fistularia vittata* Forskål, 1775 (see under Synaptula, p. 80). The forms here recognized as valid species may not prove, on examination of more extensive material, to be distinct. The differences which are supposed to separate them are really very slight and doubtless variable, and further study of the living animals is necessary to fully determine their relationship.

Key to the Species of Euapta

Base of digits united by a membrane; malformation of anchors more or less frequent; East Indian .... GODEFFROYI

Base of digits not united by a membrane; malformation of anchors very rare; West Indian. LAPPA

Euapta godeffroyi.

Synapta godeffroyi Semper, 1868, p. 231. Calcareous ring and particles, pl. XXXIX, fig. 13.
Euapta godeffroyi Östergren, 1898*b*.

Length.—200–400 mm., with diameter 15–20 mm.

Color.—Yellowish gray or creamy-white, with radii indicated by greenish-brown or pale brown stripes, and the dorsal interradii marked with large, dusky greenish-brown blotches. Young speckled with silvery gray (Bedford, '99*a*).

Distribution.—Reported from Mauritius (Haacke, Ludwig); Thursday Island, Torres Strait (Sluiter); Great Sangir Island, Celebes (Sluiter); Pelew Islands (Bedford); Caroline Islands (Bedford); Fiji Islands (Lampert); Rotuma (Bedford); Samoa (Semper); and Hawaii (Fisher). Apparently ranging throughout the Indo-Pacific region, between 50° E. and 155° W. longitude and 20° N. and 20° S. latitude, although it has not yet been found about either Ceylon or the Philippines.

REMARKS.—Fisher (:07) gives a very good account of the appearance in life and the anatomy of this species. It occurs among pebbles and coral on sandy or gravelly bottoms, in the Hawaiian Islands, but is apparently not very common.

EUAPTA LAPPA.

PLATE IV, FIGS. 23-25.

Synapta lappa Müller, 1850, p. 134. Calcareous ring, with some anatomical details, in Müller, 1854, pl. X, fig. 4; calcareous particles, pl. VI, fig. 17.
Synapta polii Ludwig, 1874, p. 80.
Euapta lappa Östergren, 1898*b*.
Euapta polii Östergren, 1898*b*.

LENGTH.—200–450 mm., with diameter 15–20 mm.

COLOR.—Silvery gray, finely mottled with black and white; interradii often distinctly darker, the specimen appearing imperfectly longitudinally striped; occasionally the ground color is brown and the longitudinal stripes almost black; the numerous white specks are due to the crowded miliary granules.

DISTRIBUTION.—Reported from "West Indies" (Müller); Gomera, off Teneriffe (Théel); Barbados (Ludwig); Jamaica and Porto Rico (Clark); Bermuda (Clark, antea); probably ranging throughout the Caribbean Sea and southward along the coast of tropical America; not yet known from Florida, but extending eastward to the Canary Islands.

REMARKS.—This species is quite common under fragments of coral rock on sandy bottoms near the reefs about Jamaica. It is sluggish in all its movements and apparently feeds on particles of organic matter pushed into the mouth by the tentacles, which seem to be in constant movement. It is not at all subterranean in habit, nor does it seem to occur among the living corals. How long individuals remain under one piece of rock is an open question, but they were never observed moving from one place to another, and it is quite possible that they remain throughout adult life in a single place. At the base of each tentacle is a pair of conspicuous black pigment-spots, though whether they function as light-detecting organs was not determined by the few observations made. Ludwig's description of his solitary specimen from Barbados, which he named *polii*, leaves no doubt in my mind that it is identical with Müller's *lappa*.

OPHEODESOMA Fisher, 1907.

Tentacles pinnate, 14-16. Digits numerous, 10-35 on each side. Polian vessels numerous. Stone-canals numerous. Anchors as in Euapta. Anchor-plates with large central hole surrounded by six (rarely seven) large holes, all more or less dentate; posterior end of plate abruptly narrowed so that there are only a few small, smooth holes there; a bow across plate is, however, present.

The general appearance of the synaptids of this genus is like that of an Euapta or Synapta, and the close relationship of the three genera is obvious. The number of valid species is doubtful, but can only be determined by the examination of much material. All the described species are Indo-Pacific in their distribution.

Key to the Species of Opheodesoma.

A.—Base of digits united by a membrane; color, reddish brown or lighter, either uniform or spotted and marbled with other colors.

Surface of body smooth, not roughened by anchors; cartilaginous ring absent. GLABRA

Surface of body very rough from anchors; cartilaginous ring well developed. SPECTABILIS

AA.—Base of digits not united by a membrane; miliary granules numerous and aggregated into heaps; color, grayish, mottled.

Ground color obscured by numerous irregular spots and narrow dusky bands (sometimes white, without markings).................................... GRISEA

Ground color clear greenish-gray or dusky yellowish-brown, with few large blotches (sometimes wanting) and broad dusky bands, some or all of which may be very indistinct .... SERPENTINA

Opheodesoma glabra.

Plate V, Fig. 24.

Synapta glabra Semper, 1868, p. 12; pl. II. Calcareous ring and particles, pl. IV, fig. 8.
Euapta glabra Östergren, 1898*b*.
Opheodesoma glabra Fisher, 1907.

Length.—300–900 mm., with diameter about 25 mm.

Color.—Uniformly reddish brown, the tentacles greenish brown; according to Sluiter ('94), a large specimen from Saleyer was whitish, but possibly it was bleached by the formalin in which it was preserved.

Distribution.—Reported from Bohol, Philippines (Semper); Cebu, Philippines (Théel); Amboina (Sluiter); Bima and Saleyer, D. E. I. (Sluiter); Thursday Island, Torres Strait (Sluiter); and Fiji Islands (Théel). Probably having the same range as *godeffroyi*, although not yet known from any station west of Bima.

Remarks.—Nothing is recorded of the habitat or habits of this species. It seems to be well characterized by the dark color, smooth, thick skin, scattered miliary granules, numerous stone-canals and polian vessels, and webbed digits, but the constancy of these characters is not beyond question.

Opheodesoma spectabilis.

Opheodesoma spectabilis Fisher, 1907, p. 723; pl. LXVI. Calcareous particles and anatomical details, pl. LXXX, figs. 1, 1*a-d*; pl. LXXXI, fig. 2.

Length.—300-650 mm.

Color.—"In life, reddish-orange spotted with brown, the brown forming transverse more or less interrupted bands; ventral surface posteriorly grayish, spotted with whitish and barred with dark gray. Tentacles, dark dull greenish" (Fisher).

Distribution.—Hawaiian Islands (Fisher).

Remarks.—In view of Fisher's excellent description of this species and his critical comparison of it with *glabra,* I am inclined to suspend judgment and await further material before deciding that the two species are identical. I have to thank Dr. Fisher for sending me an excellent specimen of this most interesting form, which he reports as very common in Pearl Harbor, near Honolulu.

Opheodesoma grisea.

Synapta grisea Semper, 1868, p. 11. Calcareous ring and particles, pl. IV, figs. 6 and 7.
Euapta grisea Östergren, 1898*b*.
Opheodesoma grisea Fisher, 1907.

Length.—300–900 mm., with diameter 20–25 mm.

Color.—Mottled dusky greenish and bluish gray, with narrow dusky lines and irregular spots, the radii appearing as clearer stripes. Sluiter ('94) describes a white variety from Thursday Island, but it is possible the specimens had bleached in the preserving fluid.

Distribution.—Reported from Bohol, Philippines (Semper); Bay at Batavia, Samoa, Timor, Bima, Pater Noster Islands, Sawan and Saleh, D. E. I. (Sluiter); Thursday Island, Torres Strait (Sluiter); Fitzroy Island, Queensland (Bell); and Bowen, Queensland (Théel). Probably with the same distribution as *godeffroyi,* though not yet reported so far east or west.

Remarks.—Were it not for Sluiter's ('88) opinion to the contrary, I should have no hesitation in pronouncing this species identical with the next, but as he has had abundant opportunities for comparing them, I yield to his judgment. The difference in color is hardly of primary importance, while the difference, so often referred to in the calcareous rings, is very intangible. The figure of *grisea* given by Semper ('68) is sufficiently different from that given for *serpentina* by Müller ('54), but Sluiter ('88) particularly says that in *grisea* the anterior prolongations are as long as the rest of the ring is high, thus making the whole structure like Müller's figure. This species seems to be a common reef-frequenting form in the East Indies and along the northern and eastern coasts of Australia, but nothing is recorded of its habits.

Opheodesoma serpentina.

Synapta serpentina Müller, 1850, p. 132. Calcareous ring and attachments in Müller, 1854, pl. IX, fig. 5, and calcareous particles, pl. VI, fig. 16.
Euapta serpentina Östergren, 1898*b*.
Opheodesoma serpentina Fisher, 1907.

Length.—300–900 mm., with diameter 20–25 mm.

Color.—Clear greenish gray or dusky yellowish brown, with or without broad dusky bands and a few dusky blotches; the bands are three or four times as wide as the dusky lines in *grisea*.

Distribution.—Reported from Zanzibar (Selenka, Lampert, Ludwig); Celebes (Müller); Bay of Batavia, Bima, Kur, Amboina, D. E. I. (Sluiter); Ternate (v. Marenzeller); and Pulo Edam, E. I. (Ludwig). Apparently having the same distribution as *godeffroyi*, though it has not yet been taken west of the East India Islands.

Remarks.—Sluiter ('88) says this species is much more rare than *grisea* in the Bay of Batavia, but is easily distinguished by the difference in color, and adds that the calcareous ring is somewhat different. Later ('94) he says that the only way the specimen from Amboina could be distinguished from *grisea* was by the calcareous ring. Lampert ('96) mentions a small specimen with 17 tentacles, notes some interesting color variations, and calls attention to the resemblance to *grisea*. It is very probable that the two species are identical.

POLYPLECTANA, gen. nov.

(πολύς, many, + πλεκτάναι, feelers; in reference to the numerous tentacles.)

Tentacles pinnate, 25, sometimes 26 or 27; individuals are often found with 24 or fewer. Digits numerous, 15–40 on each side. Cartilaginous ring present. Polian vessels very numerous, 20 or more. Stone-canal single. Stock of anchors not branched, though finely toothed; arms smooth, but vertex with some minute knobs. Anchor-plates with large central hole, surrounded by six other large holes, all dentate except the most posterior, which may be smooth, and with two large and several small entire holes at narrower posterior end, where a well-formed and distinctly arched bow crosses outer surface of plate. Miliary granules present, but tentacles without supporting rods.

This genus is monotypic, for I am unable to find any valid character by which to distinguish *Synapta kallipeplos* Sluiter ('88) from the longer and better-known *Synapta kefersteinii* Selenka ('67). As for *Fistularia tenuis* Quoy and Gaimard ('33), I think it very unlikely that the specimen was a Synaptid at all; certainly it is impossible to determine the point positively. The following, then, must be considered the type and only known species.

Polyplectana kefersteinii.

Plate IV, Figs. 20-22.

Synapta kefersteinii Selenka, 1867, p. 360. Calcareous ring and particles, pl. xx, figs. 120-121.
Synapta kallipeplos Sluiter, 1888, p. 217. Calcareous ring and particles, pl. ii, figs. 41-43.
Chondroclœa kefersteinii Östergren, 1898*b*.
Chondroclœa kallipeplos Östergren, 1898*b*.
Synaptula kefersteinii Fisher, 1907.

Length.—250–450 mm., with diameter 10–15 mm.

Color.—Purplish, reddish brown, or dark brown, darker above than beneath, and more or less speckled and spotted with lighter; the spots are probably due to the heaps of miliary granules. In life the color is brownish-green (Fisher).

Distribution.—Reported from Kosseir, Red Sea (Lampert); Amboina, Moluccas (Ludwig, Sluiter); Batavia, Java (Sluiter); Ternate (v. Marenzeller); Rotuma (Bedford); Samoa (Semper); and Hawaii (Selenka, Fisher). Probably occurring, like the preceding genus, throughout the Indo-Pacific region.

Remarks.—Nothing whatever is recorded concerning the habits of this species, except that Sluiter ('88) says of the specimen which he described as *kallipeplos* that it did not hide under stones, but crept about on the corals. I see no reason to doubt that this individual was a large example of *kefersteinii,* in which the tentacles were still incompletely developed. Sluiter's description of the calcareous ring would indicate a unique condition for a mature Synaptid with so many tentacles; but, after comparing his figure with Selenka's, I am inclined to think there is a possible mistake in his interpretation of the condition he found, or possibly in adults of *kefersteinii* the interradial pieces become completely merged together, each quintet becoming a single piece. Sluiter's specimen was much larger than any other that has been recorded and the color was somewhat different, but these differences cannot carry much weight. Semper ('68) says *kefersteinii* is common at Samoa, and it would seem to be common also at Amboina. The specimens from the latter island examined by Ludwig ('88) showed great diversity in the number of tentacles; of 11 specimens, 1 had only 15, 6 had 20, 1 had 22, 2 had 26, and 1 had 27. The 8 examined by Sluiter ('94) were remarkable for the imperfect condition of the calcareous particles, but he does not refer to the number of tentacles; presumably, therefore, they had 25 each, as did those from Rotuma, Kosseir, Samoa, and Hawaii.

SYNAPTA Eschscholtz, 1829.

Chondroclœa Östergren, 1898 (partim).

Tentacles pinnate, 15, occasionally 16; individuals not fully mature have 14 or fewer. Digits numerous, 15–30 on each side. Cartilaginous ring present. Polian vessels very numerous (up to 50) and sometimes branched. Stone-canal single and branched, or there may be two or even a small tuft of them. Stock of anchors finely toothed, but not branched; arms smooth, but vertex, with a few minute knobs, arranged in one or two groups. Anchor-plates sub-rectangular or irregular, much longer than wide, with seven or eight large, and numerous small, smooth holes; at posterior end, on outer side, a well-arched bow crosses plate. Miliary granules abundant, but tentacles without supporting rods.

This is also a monotypic genus (with the type species *maculata*) and may be easily recognized by the large size and the characteristic calcareous particles, while the branched polian vessels and stone-canals are also notable. Théel ('86*a*) considers, with good reason, that Lesson's ('30) *Holothuria oceanica* is synonymous with the single species of this genus. Whether *Oncinolabes forsteri* and *fuscescens* of Brandt ('35), *Holothuria radiosa* of Reynaud (in Lesson '30), *Holothuria tentaculata* of Forster (in de Blainville '21), *Fistularia doreyana* of Quoy and Gaimard ('33), and *Synapta fasciata* of Kuhl and Van Hasselt ('69) also belong here it is impossible to say positively, but some, if not all, of them probably do.

Synapta maculata.

Plates I and IV, Figs. 17-19 and 26.

Holothuria maculata Chamisso and Eysenhardt, 1821, p. 352, pl. xxv.
Synapta mammillosa Eschscholtz, 1829, Hpt. 2, p. 12; pl. x, fig. 1.
Holothuria oceanica Lesson, 1830, p. 99; pl. 35.
Synapta beselii Jäger, 1833, p. 15; Semper, 1868, pl. i. Calcareous particles in Théel, 1886*a*, pl. i, fig. 12.
Synapta oceanica Jäger, 1833.
Synapta mammillosa Jäger, 1833.
Synapta maculata Jäger, 1833.
Synapta astrolabi Held, 1857, p. 269.
Synapta agassizii Selenka, 1867, p. 361.
Synapta Beselli (also *Besellii*) Tenison-Woods, 1880, p. 129.
Chondroclœa beselii Östergren, 1898*b*.

Length.—1–2 meters with diameter not over 50 mm.

Color.—Brown, greenish brown, dark olive-green, or bluish gray, often with large spots and blotches of darker and lighter shades, or less commonly with the dark markings arranged in five longitudinal stripes. The striped form is the *agassizii* of Selenka, which Lampert ('85) considers a valid species and Bedford ('99*a*) a good variety. Further investigation is necessary to determine whether it is entitled to any recognition. Kent ('93) describes and figures *S. beselii* as *bright pink,* and furthermore his figure shows but 10 tentacles. Whether the Australian Synaptid thus figured really exists must be determined by other observers, but if it does, it is obviously not *beselii.*

Distribution.—Reported from Kosseir, Red Sea (Lampert); Zanzibar and Mauritius (Lampert); Seychelles (Ludwig); Indian Ocean (Ludwig); Ceylon (Pearson); Nicobar (Semper); Philippines (Semper); Celebes (Jäger); numerous stations, D. E. I. (Sluiter); Lucipara Islands (Lampert); Ternate (v. Marenzeller); New Guinea (Bedford); Port Douglas, Queensland (Tenison-Woods); Caroline Islands (Semper); New Hebrides (Théel); Marshall Islands, (Chamisso and Eysenhardt); Samoan Islands (Semper); and Society Islands (Eschscholtz, Théel). Evidently commonly and widely distributed throughout the Indo-Pacific region.

Remarks.—There can be no question, I think, that *Synapta mammillosa* Eschscholtz and *Holothuria oceanica* Lesson are identical; and that they are both the same as Jäger's *beselii* hardly admits of question. There is more room for doubt as regards *maculata* Ch. & Eys., but I am entirely satisfied that the holothurian so designated is the same huge Synapta. On the first comparison of the colored figures given by Eschscholtz and by Chamisso and Eysenhardt, it seems incredible that they can both represent the same species, but when we read their descriptions and see how far the plates are from showing the natural colors as they give them, we realize that little weight can be placed on that point. Moreover, Eschscholtz's picture is seemingly taken from a strongly contracted specimen showing big verrucæ, while the specimen of *maculata* was evidently in normal condition. It may be mentioned in passing that Semper's colored figure also represents the animal as having prominent verrucæ, and therefore probably in an unusual state of contraction. While it is not out of the question that *maculata* should be *Opheodesoma grisea* (Semper), the latter species is not known from any of the South Sea Islands, and the evidence, such as it is, all points to *beselii* Jäger as being the species figured by Chamisso and Eysenhardt.

Although so well known to zoölogists, very little is recorded of the habits of this interesting giant Synaptid. Semper ('68) says they move about between the rocks and on the sand of the reefs, but are exceedingly sluggish. On account of their size and appearance they well deserve the name "sea-serpent," which is sometimes applied to them. Studer (see Lampert '89*b*), on the other hand, affirms that their movements among the blocks of coral are remarkably swift for a holothurian. Sluiter ('90) says that those he found in the Bay of Batavia were exactly like *Opheodesoma grisea* in appearance and could only be distinguished by an examination of the calcareous plates; he adds that while he at first overlooked "*beselii*" on this account, more careful investigation convinced him that it was really much more common there than *grisea.*

SYNAPTULA Oersted, 1849.

Heterosynapta Verrill, 1867.
Chondroclœa Ostergren, 1898 (partim).

Tentacles pinnate, 10–15. Digits at least five on each side. Cartilaginous ring present. Polian vessels three or more. Stone-canal single, unbranched. Sense-organs in form of pigment-eyes at the base of tentacles on oral disc, often (always?) present. Stock of anchors finely toothed, but not branched; arms smooth, but vertex with a few minute knobs. Anchor-plates with a large central hole surrounded by six other large holes, all more or less dentate, and with two large and several small smooth holes at the narrow, posterior end, where a well-formed and distinctly arched bow crosses outer surface of plate.

This genus contains an unusually large number of poorly described or imperfectly known species, so that it is exceedingly difficult to determine which are valid. Those which are well known occur upon or among seaweeds and corals, creeping about very slowly by means of their tentacles and the worm-like movements of their bodies, clinging tenaciously to a rough surface by their anchors, and feeding upon diatoms and other micro-organisms. All the known members of the genus are tropical. It is almost certain that some of the oriental species here given as valid are really identical with some of the others, but further and more careful study of plentiful material is necessary to determine their true relationships. Whether *Chiridota verrucosa* and *lumbricoides* (*Synapta lumbricus* Jäger ('33)) of Eschscholtz ('29) and *Fistularia reciprocans* (*Holothuria glutinosa* Lamarck ('16)) and *vittata* of Forskål (1775) really belong to this genus it is simply impossible to say from the available evidence. The Synaptid which Herouard ('93) identified as *reciprocans* is almost certainly *Synaptula nigra;* but, as Forskål's description is practically worthless, it is impossible to determine whether Herouard and he refer to the same animal. As for *vittata,* Müller ('54), Lampert ('85), Ludwig ('86*b*), Bedford ('99*a*), and Sluiter (:01) all profess to have found it, but none of them give any distinguishing characters or add anything to Forskål's (1775) original inadequate description. Their remarks are not altogether consistent, and it is hard even to determine the genus to which the species should be referred. The figures given by Held ('57) show clearly that his specimen was an Euapta. The name had better be entirely discarded and with it, of course, Leuckart's genus Tiedemannia, of which it is the type. Since Oersted ('49) made *Synapta vivipara* (=*H. hydriformis* Le Sueur) the type of a new genus Synaptula, it is clear that this name should have precedence over Östergren's (1898) name Chondroclœa, for Östergren places Oersted's *vivipara* in his later genus. It seems probable, however, that, as at present constituted, Synaptula includes at least two groups of species which further knowledge will necessitate recognizing as separate genera; one of these is best represented by *nigra* and the other by *vivipara.* Should these groups be separated in the future, the former would of course be called Chondroclœa, unless indeed Forskål's *vittata* is rediscovered and found to belong in that genus, which would then, apparently, have to be called Tiedemannia.[1]

KEY TO THE SPECIES OF SYNAPTULA.

A.—Tentacles 15, with numerous digits (20-30 pairs) united at their bases by a thin membrane; color uniform dark brown or violet.......................... NIGRA

AA.—Tentacles 12-13 (often 15 in *recta,* perhaps normally in adults), with 10-30 pairs of digits (pl. VI, fig. 19).

B.—Tentacles normally 12, with 10-20 pairs of digits; viviparous; occidental. HYDRIFORMIS

BB.—Tentacles usually 13 (often 15), with 10-30 pairs of digits; not viviparous so far as known; oriental.

C.—Gonads unbranched; polian vessels few; tentacles very long and slender, with about 10 pairs of digits .... INDIVISA

CC.—Gonads branched; polian vessels numerous; tentacles not excessively elongated.

D.—Miliary granules very minute, simple oval bodies usually arranged in circles; color gray, with darker spots.................. PSARA

DD.—Miliary granules irregular rosettes.

Color, very variable; digits very short.................. RECTA

Color, dark brown-violet, longitudinally striped with white; digits long and united by a delicate membrane............ VIRGATA

AAA.—Tentacles 10

Digits numerous (12-15 pairs), long; color, milk-white or with a rosy tint.. LACTEA

Digits few (5-6 pairs), short; color variable, but not white.......... RETICULATA

SYNAPTULA NIGRA.

Synapta nigra Semper, 1868, p. 12. Calcareous particles, pl. IV, fig. 9.
Synapta orsinii Ludwig, 1886*b*, p. 33.
Synapta reciproquans Herouard, 1893, p. 137.
Chondroclœa nigra Östergren, 1898*b*.
Chondroclœa orsinii Östergren, 1898*b*.

LENGTH.—100–200 mm.; Semper's type was only 60 mm.

COLOR.—Dark brown, deep brownish red or violet, sometimes with a black longitudinal stripe on the outer surface of each tentacle.

DISTRIBUTION.—Reported from Bohol, Philippines (Semper); Australia, and Red Sea (Lampert); Margalla Bay, Assab (Ludwig), and Fontaine de Möise, Red Sea (Herouard). Probably occurs along the entire southern coast of Asia, throughout the East Indian Archipelago, and southward to Australia.

REMARKS.—This is one of the least-known members of the genus, no additional information regarding it having appeared since Semper's original description, save for the localities given by Lampert ('85), the description of a specimen from the Red Sea as a new species (*orsinii*) by Ludwig ('86), and

[1] For an excellent discussion of this point see Fisher (:07), pp. 718–719.

the remarks of Herouard ('93) concerning a specimen, also from the Red Sea, which he identifies with *reciprocans* Forskål. My reasons for believing that these latter specimens are really *nigra* are: (1) Ludwig's description agrees perfectly with Semper's, save for the color, the miliary granules, and the anchors and plates. (2) Herouard's account does not indicate a single difference between his specimen and *nigra,* save the numerous abnormal anchors. (3) The difference in color between Ludwig's specimen and the others is obviously not of great importance. (4) The anchors and plates of Ludwig's specimen are exactly like those of Herouard's. (5) The miliary granules in Herouard's specimen are exactly like those of Semper's. (6) The appearance of the miliary granules in Ludwig's specimen and their scarcity would indicate the possibility at least of partial dissolution. It is practically impossible, therefore, to draw even an arbitrary line of division between the specimens of the three writers, and I am satisfied that they all refer to the same animal. I do not believe, however, that it is possible to determine from the data at hand whether this is one of Forskål's *Fistularias* or not, but I am exceedingly doubtful.

Synaptula hydriformis.

Plate VI.

Holothuria hydriformis Lesueur, 1824, p. 162.
Holothuria viridis Lesueur, 1824, p. 163.
Synaptula vivipara Oersted, 1849, p. vii.
Synapta viridis Pourtales, 1851, p. 14.
Synapta pourtalesii Selenka, 1867, p. 365.
Leptosynapta hydriformis Verrill, 1867.
Leptosynapta pourtalesii Verrill, 1867.
Heterosynapta viridis Verrill, 1867.
Synapta vivipara Ludwig, 1886*b*.
Synapta picta Théel, 1886*a*, p. 10.
Chondroclœa vivipara Östergren, 1898*b*.

Length.—100–150 mm., with diameter from 4 to 9 mm.

Color.—Pale reddish brown to dark greenish brown or even green, more or less mottled and spotted with white; these white specks are really aggregations of the abundant miliary granules. The ground color of the animal corresponds very well with the environment, the reddish tints predominating in case the surroundings are mainly red and brown algæ, while the green tints prevail where the Synaptids live among green algæ.

Distribution.—Reported from West Indies (Oersted); Bermuda (Théel, Clark); Biscayne Bay, Florida (Pourtales); Watling's Island, Bahamas (Clark, antea); Jamaica (Clark); St. Thomas (Lesueur); Guadeloupe (Lesueur); and Abrolhos Reef, Brazil (Ludwig); doubtless occurs in suitable situations throughout the Caribbean Sea, the Gulf of Mexico, and the warm portion of the western Atlantic Ocean, from 32° N. to 18° S. latitude.

Remarks.—This is undoubtedly the best-known member of the genus, as it is very common at Bermuda and in Kingston Harbor, Jamaica, and owing to its being viviparous, it has attracted an unusual amount of attention. In addition to the characters already mentioned, the presence on the oral disc of a pair of pigment-eyes at the base of each tentacle, and the opening of the stone-canal to the outside of the body are notable features of the anatomy. It is a somewhat gregarious Synaptid, numbers of individuals occurring together. They live in tufts and patches of seaweeds, where they creep about by means of their tentacles, the anchors assisting in clinging to the plants. In Bermuda they live chiefly in Ulvaceæ and are correspondingly green, while in Jamaica they occur in Acanthophora (one of the Florideæ) and are very decidedly reddish brown; so that Bermudan and Jamaican specimens appear very different at first sight. They are quite sensitive to changed conditions and do not live well in aquaria. The food consists almost wholly of diatoms. Breeding appears to go on throughout the entire year, for specimens taken in April, May, June, July, September, and December all contained embryos and young at various stages of development. The eggs develop in the body cavity of the parent, and the young ultimately escape through rupture of the body-wall near the anus; as many as 176 young have been taken from a single individual. For a full account of the development, anatomy, and habits of this interesting species, see Clark ('98*a*). There can be no doubt that Lesueur's ('24) *viridis* was a green specimen of *vivipara,* with incompletely developed tentacles, and his *hydriformis* a red individual of the same species. His description of the latter answers admirably to living examples from Jamaica, while his description of the former is sufficiently near (save for its abnormal tentacles) to specimens from Bermuda to leave no doubt in my mind that they are the same. Nor can there be any question that Pourtales' ('51) Synapta from Biscayne Bay, which he called *viridis,* is identical with Lesueur's and Oersted's West Indian species.

Synaptula indivisa.

Synapta indivisa Semper, 1868, p. 13. Calcareous particles, pl. iv, fig. 1.
Chondroclœa indivisa Östergren, 1898*b*.

Length.—40 mm.

Color.—"Translucent reddish gray" (Semper).

Distribution.—Reported from Zamboanga, Mindanao, Philippines (Semper); Rotti, D. E. I. (Sluiter); and Thursday Island, Torres Strait (Sluiter). Apparently confined to the East Indian region.

Remarks.—Nothing has been added to our knowledge of this species since Semper's original description, and no one but Sluiter ('94, :01) has seen a specimen. The undivided gonads, the extraordinarily long and slender tentacles, and the small number (3) of polian vessels are notable characters, but it is by no means improbable that this species will prove to be the young of some other member of the genus, in spite of the fact that in Semper's specimen the gonads were "completely developed." The tentacles were very slender, with 20 digits, and even in alcohol were two-fifths of the body length.

Synaptula psara.

Synapta psara Sluiter, 1888, p. 219.
Chondroclœa psara Östergren, 1898*b*.

Length.—400–500 mm.

Color.—Clear or dark gray, with irregular scattered darker patches, and more or less clearly sprinkled with white dots, due to the calcareous deposits.

Distribution.—Reported from the Bay of Batavia, Java (Sluiter), and Saleyer, D. E. I. (Sluiter). Apparently entirely East Indian.

Remarks.—This species appears to be well characterized by its color and the peculiar miliary granules. Sluiter ('88) says that it has in life the 10 rows of prominent verrucæ characteristic of the large Synaptas, and is in its general appearance very similar to *O. grisea* and *serpentina*. Like those species, it occurs about the reefs.

Synaptula recta.

Synapta recta Semper, 1868, p. 14. Calcareous particles, pl. iv, figs. 2-3.
Synapta striata Sluiter, 1888, p. 216. Anchor and plate, pl. ii, figs. 39-40.
Chondroclœa recta Östergren, 1898*b*.
Chondroclœa striata Östergren, 1898*b*.
Chondroclœa albopunctata Sluiter, 1901, p. 127.
Chondroclœa striata var. *incurvata* Vaney, 1905.

Length.—100–240 mm.

Color.—Apparently very variable; clear grayish yellow, variegated with a network of dark brown or purple lines (Sluiter), or with alternate longitudinal bands of dark and light gray (Bedford), or dark violet finely reticulated with yellowish white (Semper), or striped lilac on a white ground (Pearson); more or less speckled with white, due to the calcareous deposits.

Distribution.—Reported from Bohol, Philippines (Semper); Owen Island, Mergui Archipelago (Bell); Dutch East Indies (Koehler, Sluiter); China Strait, New Guinea (Bedford); near east end of Timor (Sluiter); Batavia, Java (Sluiter); Saleyer (Sluiter); Dutch East Indies (?) (Ludwig); Ceylon (Pearson), and Gulf of Aden (Vaney). Apparently an East Indian species, extending southward to New Guinea and westward to the coast of Africa.

Remarks.—Although Semper lays much stress on the fact that in his type specimen the alimentary canal was straight (that is, without the customary loop), I quite agree with Östergren (:05) that this is purely an individual peculiarity without systematic importance. Accordingly, as Ludwig ('88) hints, we must consider *striata* as identical with *recta,* the difference between the anchors and plates of the two, to which Sluiter ('88) refers, being altogether too slight to carry any weight. Furthermore, I cannot consider *albopunctata* Sluiter (:01) as other than *recta* with unusually abundant miliary granules, although it *may* ultimately prove a valid species. Vaney's (:05) variety *incurvata* is hardly entitled to recognition. It is most interesting, as showing that 15 is probably the normal number of tentacles in the adult, as all of his specimens had 15, and were larger than those reported by Pearson (:03) from Ceylon. The slight peculiarity in the anchors described by Vaney is probably not constant, or it may have been overlooked by other observers. Nothing whatever is recorded as to the habits of *recta.* Semper reports it from water 11–15 m. deep and Sluiter (:01) from 27–54; Bell ('86), Koehler ('95), and Bedford ('99*a*) give no information whatever regarding anatomy, habits, or habitat.

Synaptula virgata.

Chondroclœa virgata Sluiter, 1901, p. 128; pl. I, fig. 5.
Chondroclœa aspera Sluiter, 1901, p. 128.

Length.—200 mm.

Color.—Brown violet, with longitudinal white stripes due to the very numerous miliary granules.

Distribution.—Reported only from Salawatti and Gebe, D. E. I. (Sluiter).

Remarks.—Although it is by no means certain that this species is distinct from the preceding, it may be provisionally accepted; but there does not appear to be any reason for regarding *aspera* Sluiter as other than a young *virgata,* in which the miliary granules are entirely, and the anchors and plates partially, dissolved by some acid preserving fluid; the difference in length of anchors is not great enough to carry any weight, and the difference in number of digits (if difference there be) is doubtless due to difference in age.

Synaptula lactea.

Synapta lactea Sluiter, 1888, p. 216.
Chondroclœa lactea Östergren, 1898*b*.

Length.—Not given, but apparently the size is about the same as in the next species.

Color.—Milk white, varying to clear rose.

Distribution.—Reported only from Batavia, Jedan, and Banda, D. E. I. (Sluiter).

Remarks.—This appears to be a well-marked species, though it has not yet been met with by any one but Sluiter. He says that its manner of life is the same as that of *reticulata,* creeping about on living corals in shallow water.

Synaptula reticulata.

Synapta reticulata Semper, 1868, p. 13. Calcareous ring and particles, pl. iv, figs. 4-5.
Chondroclœa reticulata Östergren, 1898*b*.

Length.—100–160 mm.

Color.—Clear violet or brown, recticulated with dark brown; or (var. *maculata* Sluiter '88) with irregular blotches of dark violet or less often chestnut-brown, sometimes forming irregular broad bands; or (Lampert '89*b*) light gray with five narrow longitudinal, dark violet stripes; or (var. *nigropurpurea* Bedford '99*a*) dark, without markings, "crimson-black" when alive.

Distribution.—Reported from Bohol (Semper); Mermaid Straits (Lampert); Isle of Pines, New Caledonia (Bedford), and numerous stations in the Dutch East Indies (Koehler, Sluiter).

Remarks.—Numerous specimens of this species have been examined by Sluiter, and he regards it as well characterized. Both he and Lampert report individuals with 12 tentacles, and Sluiter's variety, *maculata,* has 11. There is certainly room for suspicion that young individuals (and perhaps adults) of two or more species are confused under the name *reticulata.* In its habits, this Synaptid is remarkable for making its home on living corals, upon which it creeps about very slowly. In its clinging closely to rough surfaces by means of the anchors and its power to climb up a vertical glass plate, *reticulata* resembles *hydriformis.*

LEPTOSYNAPTA Verrill, 1867.

Synapta Östergren, 1898.

Tentacles pinnate, 10–13. Digits usually four or more on each side (rarely three or only two or none). Cartilaginous ring wanting. Polian vessel usually single, rarely more than one. Stone-canal single, unbranched. Sense-organs never in form of pigment-eyes, but occur as minute cups, probably olfactory, on inner face of stalk of tentacles. Stock of anchors finely toothed, but not branched; arms usually with upwardly or outwardly projecting teeth on the outer edge; vertex smooth. Anchor-plates oval or somewhat elongated, with large central hole, surrounded by six other large holes, usually more or less dentate, and two large and several small smooth holes at the narrow posterior end, but without any arched bow crossing the outer surface; at the broad end there are often additional dentate holes; in *ooplax* the plates are often quite asymmetrical and all the holes more or less smooth.

Just why Östergren elected to apply Eschscholtz's name to this group of Synaptids it is difficult to understand. It is clear that Eschscholtz himself intended the large 15-tentacled, oriental forms to be placed here, while he refers Müller's *inhærens* to the genus Chiridota. (Of course this is a self-contradiction, as *inhærens* does not have digitate tentacles, the one distinguishing character which he gives for Chiridota.) It is necessary, therefore, even if it is disagreeable, to change Östergren's selection and use Verrill's ('67) name Leptosynapta for these forms of which *inhærens* is typical. The species *S. bachei* Ayres is an absolute *nomen nudum,* without a word of description or explanation. It is possibly a Chiridota.

The genus as now restricted includes nine species, of moderate or small size, all but one of which occur in the north temperate zone, though some of them range southward into the warmer seas of the tropics, while others occur in the cold waters of the far north. They live in sand or mud, usually burrowing like worms and feeding on the organic matter which they pick out of the dirt with their tentacles; but they are continually taking in grains of sand and other indigestible stuff with the food, so that the alimentary canal is usually filled with such material. They are sluggish in their movements and apparently come out of their burrows only on rare occasions, though they are sometimes found (particularly *roseola*) under rocks and in similar situations.

Key to the Species of Leptosynapta.

A.—Tentacles 12; length usually over 50 mm.
- *B.*—Radial pieces of calcareous ring perforated for passage of the nerves (pl. v, fig. 14).
  - *C.*—Anchors and plates of variable size, but of only one kind.
    - *D.*—Anchors usually under 250 μ, never over 300 μ; plates more or less oval, with smooth margins and not more than 7 or 8 dentate holes.
      - *E.*—Anchor-plates more or less symmetrical, with distinctly dentate holes, more than 125 μ long in posterior part of body and much more than half as long as anchors there.
        - Anchor-arms usually with 4 or more teeth; calcareous particles in longitudinal muscles, oval or dumb-bell-shaped; radial pieces of calcareous ring decidedly concave on the posterior edge; polian vessel usually single .... INHÆRENS
        - Anchor-arms with only 2 or 3 small teeth; calcareous particles in longitudinal muscles C- or doughnut-shaped; radial pieces of calcareous ring scarcely concave posteriorly; polian vessels 3-7. DOLABRIFERA
      - *EE.*—Anchor-plates more or less unsymmetrical, with the holes smooth or with few teeth, less than 125 μ long in posterior part of body and only a little more than half as long as anchors there...... OOPLAX
    - *DD.*—Anchors usually over 250 μ and often over 500 μ; plates elongated, with more or less dentate margin and often more than 8 dentate holes.
      - Anchors not often over 500 μ; plates with 7 to 30 holes.. GALLIENNII
      - Anchors 500 to 800 μ; plates usually with 25 to 40 holes. MACRANKYRA
  - *CC.*—Anchors and plates of two quite distinct kinds (pl. v, figs. 1-4); polian vessels 2-5 .... ACANTHIA
- *BB.*—Radial pieces of calcareous ring not perforated, but simply notched, for the passage of the nerves (pl. v, fig. 16).. ROSEOLA

AA.—Tentacles 10; length 3-50 mm.
- Tentacles with digits; length 30-50 mm. .... DECARIA
- Tentacles without digits; length 3-5 mm. .... MINUTA

Leptosynapta inhærens.

Plate V, Figs. 14, 15, 18, and 20.

Holothuria inhærens O. F. Müller, 1776, p. 232; 1788, p. 35, pl. xxxi.
Chiridota pinnata Grube, 1840, p. 41.
Synapta inhærens Rathke, 1843.
Synapta duvernæa Quatrefages, 1842, p. 19, pls. ii-v.
Holothuria flava Rathke, 1843, p. 138.
Synapta henslowana Gray, 1848, p. 12.
Synapta tenuis Ayres, 1851, p. 11.
Synapta girardii Pourtales, 1851, p. 14.
Synapta pellucida Ayres, 1852*b*, p. 214.
Synapta duvernea Held, 1857, anchor and plate, pl. ii, fig. 1.
Synapta ayresii Selenka, 1867, p. 362.
Synapta gracilis Selenka, 1867, p. 363.
Synapta albicans Selenka, 1867, p. 363.
Synapta bifaria Semper, 1868, p. 14.
Leptosynapta tenuis Verrill, 1867, p. 325.
Leptosynapta inhærens Verrill, 1867, p. 325.
Leptosynapta girardii Verrill, 1874*a*, pp. 361 and 716.
Synapta inhærens Östergren, 1898*b*.
Synapta inhærens Clark, 1899*b*, pls. 10 and 11.
? *Synapta albicans* Clark, 1901*b*.
Synapta inhærens Clark, 1901*a*.

Length.—100–300 mm., with diameter of 5–10 mm.

Color.—White to buffy yellow, with more or less red pigment modifying this ground color; most American specimens have little or no pigment and are thus nearly pure white, while most European specimens are decidedly red. According to Östergren (:05), they are always red, but the majority of those I have from Naples are as white as those from the coast of Massachusetts. Occasionally American specimens are colored exactly like Müller's (1788) figure. Pacific Coast specimens, so far as known, are nearly white.

Distribution.—Reported from a great number of stations along the coasts of both Europe and North America; also from the Red Sea and the mouth of the Congo. These last two stations are almost certainly mistakes, and Östergren (:03) considers the report of its occurrence north of the Arctic Circle as equally unreliable. It undoubtedly occurs on the coasts of Norway, Denmark, Great Britain, France, and Italy, as there are abundant reliable records. On the American Atlantic coast it ranges from Maine to South Carolina, and also occurs at the Bermuda Islands, while on the Pacific coast it has been found at Puget Sound, Washington, and Mendocino, Pacific Grove, and Point Loma, Cal. Its occurrence on the Alaskan coast is still open to doubt. It seems very probable that it is a circumpolar species, ranging southward on the European and American coasts to subtropical waters. It has not, however, been reported from any part of the Asiatic coast, and it has yet to be taken in Bering Sea and the North Pacific.

Remarks.—This species is apparently the central one of the genus from which the others appear to have been derived, and it is, as one would therefore suppose, the most variable of all. Besides the characters already given, it may be added that the number of digits varies (probably with age) from 3–10 on each side, but is usually 5–7, and the terminal one is the longest, with the adjoining ones nearly as long; the sense-cups vary from 2–14 on each tentacle, but there are usually about 8; there is no distinct stomach nor is the intestine conspicuously looped; the ciliated funnels are numerous and of two distinct sizes; reproductive organs long and branched. (For an excellent detailed account of the specific characters, see Östergren :05*a*; for notes on habits, and physiology, see Clark, '99*b*.) Whether the common white Synapta of the New England coast is really distinct from the European species is regarded by Östergren (:05) as an open question, but it is exceedingly difficult to find any differences of importance; those mentioned by Östergren are certainly trivial. A careful comparison between individuals from Norway (for which beautiful specimens my thanks are due Dr. Östergren), Naples, California, and Woods Hole has failed to bring out a single constant difference, although I am not sure that the Pacific Coast form may not prove distinct, when living specimens are studied. The anchors and plates are noticeably smaller in these specimens than in those from Norway, but the Woods Hole and Naples specimens are intermediate and no real line of division can be drawn. Too much emphasis must not be placed on either dimensions or proportions of the calcareous particles, not only because they vary so much, even in specimens from a single locality, but because in measuring such minute objects the "personal equation" is a factor not to be ignored. Östergren suggests that the American form may be regarded as a distinct variety or subspecies, if not a fully accredited species; but I fail to see what would be gained by such a course, and, moreover, I can find no other ground than locality by which to distinguish it. For the present, therefore, I must believe that *inhærens* is (or has been) a circumpolar species and extends its range southward on both coasts of America as well as in Europe.

Leptosynapta dolabrifera.

Synapta dolabrifera Stimpson, 1856, p. 386.

Length.—50–90 mm., with a diameter of about 4 mm.

Color.—Dirty yellowish.

Distribution.—Port Jackson, New South Wales.

Remarks.—Besides the characters given above in the key, there are several others which aid in the recognition of this species. Stimpson's description is accurate, but not very complete, and as nothing further has ever been published, the following notes will be of value: Of the six specimens examined, four had

12 and two had 13 tentacles; each tentacle has 6–10 digits on each side and carries 5–15 sense-cups on its inner face. The stone-canal is single, but there are 3–7 polian vessels. The calcareous ring is narrow and the pieces of which it is composed are scarcely concave on their posterior edges. The anchors are about 230 μ in length and the plates are about 170 by 115 μ; those in the posterior part of the body do not seem to differ in size from those anteriorly. The anchor-arms have only 2 or 3 small teeth and the stock, although convex on its outer edges, is not bent in or curved at the ends as in *inhærens;* it is also less finely toothed, usually having only 12–20 rather coarse teeth. The particles in the longitudinal muscles are very similar to those in *roseola,* but the rods in the tentacles are longer and more slender than in that species, slightly curved and a little enlarged and notched. There can be no question that this species is more closely related to *inhærens* than to any other member of the genus, which, in view of its geographical isolation, is rather remarkable. It differs from *ooplax,* its nearest geographical neighbor, far more than it does from *inhærens.* As yet it is known only from Port Jackson, but it doubtless occurs elsewhere on the Australian coast. It will be interesting to learn its exact geographical range. Stimpson says it occurs "under stones, near low-water mark."

Leptosynapta ooplax.

Synapta ooplax von Marenzeller, 1881, p. 122. Calcareous parts, pl. IV, fig. 1.

Length.—70–150 mm., with diameter of about 5 mm.

Color.—Clear reddish, rosy, or even white.

Distribution.—Reported from Japan (v. Marenzeller); Lifu, Loyalty Islands (Bedford); Dutch East Indies, 103 m. (Sluiter); Funafuti (Bedford); Kokotoni, E. Africa (Lampert); Zanzibar (Ludwig). Apparently a widely distributed Indo-Pacific species; the *inhærens* reported from the Red Sea is very likely *ooplax.*

Remarks.—This Synapta is closely related to *inhærens* and is clearly the Asiatic representative of that species. In addition to the characters already given, however, there are several other points in which it differs. The plates are wider at the posterior end and contain more numerous and irregularly arranged holes, while the seven large holes of the free end have few teeth along the margin or may even be entirely smooth. Bedford ('99*a*) describes the specimens from the Loyalty Islands as a new variety (*lævis*), but as the characters he assigns (smooth, or nearly smooth, margins to all the holes in the plate, biscuit-shaped granules confined to ambulacra and 1–4 polian vessels) are too variable to be of much weight, there is little advantage in giving the form a name. The specimens from Funafuti, in the National Museum, correspond well to Bedford's description of *lævis,* but strangely enough he does not refer *his* specimens from Funafuti to that form. Japanese specimens have 9–11 digits on each tentacle, while those from Zanzibar have from 9 to 13. The latter are interesting further as the host of the remarkable parasitic bivalve, *Entovalva mirabilis.* Lampert's ('96) statement that the difference in proportions between the anchors and plates posteriorly and anteriorly is not due to a difference in the anchors, as v. Marenzeller ('81) says, but to a remarkable difference in the plates, is borne out by my measurements. The following table gives the figures involved, measurements in microns:

Observer.	Anteriorly.		Posteriorly.	
	Length of Anchor.	Plate.	Anchor.	Plate.
v. Marenzeller	119	109	200	109
Lampert	124–140	110–115	120–140	60–90
Clark	157	114	157	86

Leptosynapta gallienii.

Synapta galliennii Herapath, 1865, p. 5.
Synapta sarniensis Herapath, 1865, p. 5.
Synapta saruiensis Herapath, 1865, pl. 1.
Synapta sarniensis Lankester, 1868, p. 53.
Synapta bergensis Östergren, 1905*a*, p. CXXXII. Calcareous particles, fig. 1*a*.

Length.—100–300 mm., but usually about 150.

Color.—Reddish, similar to that of *inhærens.*

Distribution.—Reported only from Guernsey (Herapath, Lankester), Outer Hebrides (McIntosh) and Norway, Sweden, and the Faroes (Östergen). Probably occurs along the entire coast of northern Europe with its outlying islands.

Remarks.—This Synapta is certainly closely related to *inhærens* and is intermediate between that species and the following. Whether there is an unbroken series between the true *inhærens* and the Mediterranean *macrankyra* is still uncertain, but for the present we may conveniently recognize the three species. Östergren (:05*a*) considers the Norwegian form, which he calls *bergensis*, as quite distinct from Herapath's species, but the differences which he mentions (15–17 digits instead of 13, terminal digits no longer than the others, skin thicker and redder, slightly larger anchors, margin of plate not so continuously dentate, more holes in most of the plates) are so trivial, so very variable, and so commonly correlated with the age of the individual, that, when we consider he had only a single specimen of *galliennii* for comparison and that a very large one (250 mm.), we are not justified in regarding the two forms as specifically distinct; and this decision is confirmed by the fact that in the other points which Östergren emphasizes as distinguishing *bergensis* from *inhærens* (a muscular stomach and a decidedly looped intestine) it agrees entirely with *galliennii.* The latter has been quite unanimously regarded as a synonym of *inhærens,* but Östergren makes its right to be recognized quite clear, and the reader is referred to his admirable paper (:05*a*) for a full, clear, and interesting account of this Synapta.

Leptosynapta macrankyra.

Synapta hispida Semon, 1887, p. 272 (non Heller, 1868, p. 71).
Synapta macrankyra Ludwig, 1898*a*, p. 2.

Length.—250–350 mm.

Color.—Reddish, deeper than that of *inhærens* (?).

Distribution.—Mediterranean Sea, near Naples (Semon, Ludwig).

Remarks.—Very little is known of this species, and it may still be regarded as an open question whether it is really distinct from the preceding. It is entirely conceivable that under specially favorable conditions, in some individuals of *inhærens,* the anchors and plates might increase in size to that which we find in *galliennii* and even in *macrankyra,* and in that case the increased number of perforations in the plate would be a natural accompaniment. The rarity of *macrankyra* would thus be easily accounted for. But at present we entirely lack the necessary evidence to determine such a point.

Leptosynapta acanthia.

Plate V, Figs. 1-13 and 22.

Synapta acanthia Clark, 1899*a*, p. 126, pl. iv.

Length.—250–350 mm., with a diameter of about 12 mm.

Color.—Very pale reddish to nearly pure white.

Distribution.—Bermuda Islands (Clark).

Remarks.—Nothing further has been recorded of this species since the original description, except a few field notes (Clark, :01*c*). It is apparently an isolated offshoot from *inhærens.* Östergren's (:05*a*) point in regard to the probable error in the original description of the alimentary canal is well taken. Careful examination of better material shows that the mesentery passes over from the mid-dorsal into the right ventral interradius as in *inhærens*; although a distinct stomach is present, it lies some distance back of the calcareous ring and not near it, as in *galliennii*; *acanthia* further resembles *inhærens* in the absence of any loop in the intestine. Besides the characters already mentioned, this species is notable for the large number (25–30) of sensory cups on each tentacle, and the numerous C-shaped miliary granules distributed over the entire body.

Leptosynapta roseola.

Plate V, Figs. 16, 17, 19, 21.

Leptosynapta roseola Verrill, 1874*a*, p. 422.
Synapta roseola Théel, 1886*a*, p. 25.
Synapta roseola Clark, 1899*b*, p. 24; pls. 10 and 11.

Length.—Rarely exceeding 100 mm.

Color.—Rosy red, sometimes yellowish, sometimes almost brick red.

Distribution.—Southern coasts of Massachusetts, Rhode Island, and Connecticut (Verrill); Bermuda Islands (Clark).

Remarks.—Although often found on the Massachusetts coast with *inhærens*, this species seems to be a more southern form and is particularly abundant in Bermuda, where *inhærens* seems to be rare. Unlike *inhærens*, it is commonly found under stones, and seems to burrow little in the sand. Besides the unique calcareous ring, the small size, slender body, soft thin skin, and few digits (5–9) serve to distinguish *roseola*, while there are also peculiarities in the ciliated funnels, the miliary granules, and the supporting rods of the tentacles.

Leptosynapta decaria.

Synapta decaria Östergren, 1905*a*, p. CXLVI. Calcareous particles, fig. I B.

Length.—30–50 mm., but diameter only 3.

Color.—Whitish.

Distribution.—West coast of Scandinavia (Östergren).

Remarks.—In spite of the presence of 2 or 3 polian vessels, it is not impossible that this is only the young of *inhærens*. There is a striking similarity in the calcareous particles and in the tentacles, the difference in number of digits being simply a matter of age. On the other hand, a comparison of Östergren's description with the remarks on p. 24, referring to fragments of synaptas from Alaska, suggests the possibility that *they* are *decaria*, and that it is a circumpolar species. In view of the very small amount of material available, however, the matter cannot be fully determined at present.

Leptosynapta minuta.

Synapta minuta Becher, 1906, pp. 505-509, with text-figures.

Length.—3–5 mm.

Color.—Practically wanting.

Distribution.—Reported only from the North Sea (Becher).

Remarks.—This curious little synaptid is notable for several reasons, chief among which is its being viviparous. The anchors and plates show some peculiarities and "buttons" are said to be also present.

LABIDOPLAX Östergren, 1898b.

Tentacles digitate, 11 or 12, with 3 or 4 digits. Cartilaginous ring wanting. Polian vessel usually single. Stone-canal single. Stock of anchor toothed but not branched; arms usually toothed; vertex smooth. Anchor-plates with posterior end abruptly narrowed (forming a sort of handle), the bow crossing its outer surface rudimentary or wanting.

This small group of synaptids stands midway between the preceding and the following genus and doubtless indicates the line of connection between the two. They are confined to the Old World, but range from the Arctic Ocean to the tropics. As will be seen from the following artificial key, the genus falls naturally into two sections, and it is by no means certain that the second of these would not be associated more naturally with Protankyra.

Key to the Species of Labidoplax.

A.—Anchor-plates with 7 large, more or less dentate holes in the free end, arranged as in Euapta or Synapta (plate v, fig. 23).
- Tentacles 11, with 3 digits .... BUSKII
- Tentacles 12, with 4 digits .... MEDIA

AA.—Anchor-plates with numerous, irregular, smooth holes (plate v, fig. 25); tentacles 12, with 4 digits.
- *B.*—Anchor-plates, even anteriorly, usually much longer than wide, *i. e.*, width less than .60 of length; width of anchor-arms from tip to tip less than .70 of length of anchor and usually under .55; sense-cups commonly present on inner face of tentacles.
  - Anchors posteriorly 300-500 μ long; anchor-plates with numerous small holes near margin, especially at posterior end, not showing any special arrangement .... DIGITATA
  - Anchors posteriorly 150-300 μ; anchor-plates with few small marginal holes and about 8-10 large holes arranged in 3 or 4 transverse rows...... DUBIA
- *BB.*—Anchor-plates, at least anteriorly, very wide, *i. e.*, width usually more than .70 of length; width of anchor-arms usually .70, sometimes over .80, of length of anchor; no sense-cups on tentacles .... THOMSONII

Labidoplax buskii.

Plate V, Fig. 23.

Synapta buskii McIntosh, 1866, p. 612. Anchor and plate, fig. 6.
Synapta tenera Norman, 1864 (no description).
Labidoplax tenera Östergren, 1898*b*.
Labidoplax buskii Östergren, 1903.
Labidoplax buskii Östergren, 1905*a*, p. CLVI.

Length.—15–30 mm., with diameter about one-tenth as much.

Color.—Pale, transparent grayish, without pigment.

Distribution.—Reported from Outer Hebrides (McIntosh); British Isles (Norman); west coast of Sweden (Théel); and coast of Scandinavia, from Cattegat to Porsanger Fjord, at depths of from 18–405 m. (Östergren). Apparently confined to the northern coasts of Europe.

Remarks.—This curious little synaptid is easily recognized by the unusual number and form of the tentacles, both of which peculiarities are remarkably constant. It has been often confused, nevertheless, with *Leptosynapta inhærens,* according to Östergren (:03), but usually occurs at greater depths and is commonly found on a clay bottom. For a full and admirable description, see Östergren (: 05*a*).

Labidoplax media.

Labidoplax media Östergren, 1905*a*, p. clviii. Calcareous particles, fig. II B.

Length.—30–50 mm.

Color.—Not given, but the skin is said to be "thin, transparent."

Distribution.—Bergen, Norway (Östergren).

Remarks.—The tentacles easily distinguish this species from the preceding and the anchor-plates from all other known synaptids. Nothing more is known of its anatomy or habits than is given by Östergren.

Labidoplax digitata.

Synapta digitata Montague, 1815, p. 22; pl. iv, fig. 6.
Synapta digitata Woodward and Barrett, 1858. Calcareous particles, pl. xiv, figs. 1-17.
Holothuria inhærens Delle Chiaje, 1823, p. 124.
Chiridota chiaii Grube, 1840, p. 41.
Labidoplax digitata Östergren, 1898*b*.

Length.—250–350 mm., with the diameter when fully extended one-thirtieth to one-fortieth as much.

Color.—Yellowish or reddish white, more or less heavily pigmented with brick-red, especially on the dorsal side, which is often sharply in contrast with the lower surface.

Distribution.—Reported from numerous stations on the coasts of Great Britain, France, Spain, Italy, and Austria to depths of 618 m. (Herouard). Lampert ('89) refers a fragment from near the mouth of the Congo to this species, but admits the possibility of error. Probably confined to the coasts of western and southern Europe and perhaps northern Africa.

Remarks.—According to Semon ('87), this species is probably not strictly subterranean, but lives on the bottom, where its rather peculiar coloration is apparently protective. He says further that small individuals do not occur at Naples, although the auriculariæ are common enough. For further notes on habits and physiology, see his paper, and for a very detailed account of the development his later report ('88). Ludwig ('98*a*) says the anchors of this species are from 170 to 310 μ in length, while those which I have measured in the posterior part of specimens from Trieste are from 350 to 500 μ. Ludwig further calls attention to the remarkable "giant" anchors, 700–950 μ long, first figured by Woodward and Barrett ('58), with perfectly smooth arms, which occur in the dorsal interradii of this species. I was unable to find any in the specimens from Trieste, so that I am in doubt as to their value as a specific character.

Labidoplax dubia.

Plate V, Figs. 25 and 28.

Synapta dubia Semper, 1868, p. 10. Calcareous particles, pl. iv, fig. 11.
Synapta incerta Ludwig, 1874, p. 79. Calcareous particles, pl. vi, fig. 3.
Synapta incerta var. *variabilis* Théel, 1886*a*, p. 14. Anchor-plates, pl. i, fig. 5.
Labidoplax dubia Östergren, 1898*b*.
Labidoplax incerta Östergren, 1898*b*.
Labidoplax incerta Sluiter, 1901.

Length.—60–100 mm. Most of the reported specimens are fragments.

Color.—White, dirty-whitish, or reddish, or with a violet tinge; tentacles yellowish.

Distribution.—Reported from Bohol and Zebu, Philippines (Semper); Banka, D. E. I. (Ludwig); Japan (Théel); and Dutch East Indies (Sluiter). Apparently a rare tropical and subtropical East Indian species.

Remarks.—Owing to the small amount and poor condition of the material examined, there is room for difference of opinion as to the validity of Ludwig's ('74) *incerta*, but the differences between his specimen and Semper's ('68) are so slight (miliary granules) or are based on factors so variable in this genus (serration of anchor arms) that I can see no sufficient reason for separating the two, especially as Théel ('86*a*) thinks them probably identical. The specimens from Japan in the National Museum show conclusively that this is a valid species and convince me that *dubia* and *incerta* are identical. I think it possible that Semper ('68) mistook the first beginning of anchor-plates for miliary granules, but even if not, the differences between his figures and Ludwig's ('74) are not important. In the Japanese specimens the miliary granules are very scarce and are usually straight rods, but sometimes resemble Ludwig's figure. The anchor-arms are commonly smooth, but often have one, two, or three teeth, which are sometimes minute and sometimes conspicuous. The plates are commonly quite symmetrical, with three small holes near the tip, the middle one largest, and three, of about the same size, at the posterior end; between these two series are either two large, elongated holes side by side, or one long one and the other divided transversely into two, or both are divided transversely, making a group of four holes. The anchors measured 200–265 μ long, with the arms 80–115 μ across, while the plates are 180–235 μ long and 75–110 μ wide. There are 12 tentacles in each specimen, each with four digits; the presence or absence of a fifth rudimentary terminal digit in this species and its near allies, and in Protankyra, seems to me to be a character depending on the state of contraction and the opinion of the observer. Semper ('68) distinctly says there are no sense-cups on the tentacles, but he only had a single imperfect specimen. In the Japanese specimens there are five or six sense-cups on each tentacle in all of the specimens. They are small and might perhaps be overlooked.

Labidoplax thomsonii.

Synapta thomsonii Herapath, 1865, p. 6.
Synapta digitata from Antrim, Herapath, 1865, pl. I, fig. 5.
Synapta hispida Heller, 1868, p. 71.
Synapta digitata (partim) v. Marenzeller, 1893, p. 17. Anchor and plate, pl. II, fig. 6.
Synapta thomsonii Ludwig, 1898*a*.
Synapta thomsonii Östergren, 1898*b*.
"*Synapta johnstonii* Herapath," Lo Bianco, 1899, p. 476.

Length.—250–350 mm., with diameter, when fully extended, of about one-fortieth as much.

Color.—Like *digitata*.

Distribution.—Reported from Carrickfergus, North Ireland (Herapath); Concarneau, Brittany (Barrois); Naples (Ludwig); Adriatic Sea (v. Marenzeller). Apparently the range coincides with that of *digitata*.

Remarks.—Although vouched for by such observers as Herapath and Ludwig, the status of this species is not beyond question. Marenzeller considered his specimens merely as a form of *digitata*. Five specimens which I received from Naples in 1898 as *digitata* all lack the sensory cups and the giant anchors, while the anchor-plates are similar to those described by Ludwig for *thomsonii*. It seems remarkable, however, that all of these specimens should belong to this species, when they were probably selected at random. Certainly further study of *digitata* and this, its nearest ally, is greatly needed.

PROTANKYRA Östergren, 1898*b*.

Tentacles digitate, 10–12, rarely 13 or 14. Digits two (rarely one only) on each side. Cartilaginous ring wanting. Polian vessels 2–10, or rarely only one. Stone-canal usually single, but rarely there are several. Stock of anchors more or less branched or only finely toothed; arms usually serrate; vertex without knobs. Anchor-plates without a handle, with numerous irregular perforations and with a more or less imperfectly developed bow across outer surface of posterior end; plates and perforations also, with either smooth or dentate margins.

The Synaptids of this, the largest genus of the family, are of medium or small size and dull color. With few exceptions, they occur only in tropical or subtropical waters and are specially characteristic of the Indo-Pacific region, where more than three-fourths of them occur. In most cases only one or two individuals of a species are known, so that specific limits are very hard to determine, but those herein accepted seem to have characteristic calcareous deposits. While most of the species occur in shallow water (under 100 m.), seven of them are from depths of over 1,000 m., and all known synaptids from such great depths belong in this genus. Little is known of their habits, and even the appearance in life is unrecorded for the great majority. The following key is based of necessity upon the size and form of the calcareous particles. When it is realized, however, that we do not at present know how greatly these may vary, not only in the individuals of a species, but in different parts of one individual, skepticism as to the validity of some of these species is bound to arise, and this is increased by the knowledge that in several cases only fragments of the animal, whether anterior or posterior is uncertain, are known. The two New Zealand species described by Hutton ('72), *uncinata* and *inequalis,* are absolutely indeterminable (see Dendy, '97) and are therefore omitted.

KEY TO THE SPECIES OF PROTANKYRA.

A.—Tentacles 12; entirely marine.

B.—Anchors and plates all of one kind, though they may vary somewhat in size.

C.—Anchors not conspicuously asymmetrical.

D.—Anchor-plates more or less elongated and irregular in outline, with comparatively few (20-50) holes; these have smooth margins, and one or more of those near center of plate are conspicuously larger than the others, and are polygonal or elliptical in shape (plate v, fig. 26; plate iv, figs. 4 and 5).

E.—Stock of anchor not branched (plate iv, fig. 3); accessory calcareous bodies not in the form of elongated slender, straight, or bent rods.

F.—Plates more or less asymmetrical (plate v, fig. 26).

Accessory calcareous bodies in the form of small oval, notched or irregular short rods, perhaps sometimes wanting. CHALLENGERI

Accessory calcareous bodies in the form of large, irregular perforated plates .... BICORNIS

FF.—Plates nearly symmetrical, with a single pair of large elliptical holes at center and a number of smaller ones at each end (plate iv, figs. 4 and 5) .... DUODACTYLA

EE.—Stock of anchor branched (as in fig. 25, plate iv); accessory calcareous bodies long, slender rods, either straight or bent, often notched at the tip.................................... SLUITERI

DD.—Anchor-plates more or less oval or elliptical, usually with numerous (40-150) holes, but sometimes with only 20-50; these are more or less circular, are often dentate, and near center of plate are usually somewhat larger than near margin (plate iv, figs. 9 and 13).

E.—Anchors 400 μ or less in length.

F.—Anchors over 200 μ in length; stock a conspicuous undivided bar at right angles to shaft (plate v, fig. 29).

Accessory calcareous bodies small, oval or somewhat constricted particles .... VERRILLI

Accessory calcareous bodies, dichotomously divided and branched rods, which often become so complicated as to form perforated plates (plate v, fig. 30)..... BIDENTATA

FF.—Anchors mostly under 200 μ; stock widened and irregularly divided (plate v, fig. 31); accessory calcareous bodies much as in *bidentata*.......................... AUTOPISTA

EE.—Anchors 500 μ or more in length; accessory calcareous bodies curved rods, or simple, short, oval, or somewhat constricted granules, or wholly wanting.

F.—Stock of anchor more or less branched, dichotomously or irregularly divided, often denticulate, but not finely serrulate (plate IV, fig. 12).

G.—Anchors very large, usually over 700 μ; accessory calcareous bodies present.

H.—Anchor-plates about as long as anchors, much longer than wide; at least the larger holes at center with dentate margins (plate IV, fig. 13).

Anchor-arms dentate, nearly half as long as anchor .... BRYCHIA

Anchor-arms without teeth, about one-third the length of anchor.................. SUSPECTA

HH.—Anchor-plates much shorter than anchors, three-fourths as wide as long or more.

I.—Accessory calcareous bodies, simple oval or ellipsoidal particles.

Holes at center of plate not much larger than others; stock of anchor not divided into a number of slender anastomosing branches. ACULEATA

Holes at center of plate much the largest; stock of anchor with slender anastomosing branches .... CONFERTA

II.—Accessory calcareous bodies, curved rods with ends often enlarged, and notched............ ERRATA

GG.—Anchors from 500-700 μ in length; no accessory calcareous bodies.

H.—Plates more or less concave, with about 100 holes (plate IV, fig. 9).

Anchor-arms distinctly serrate....... ABYSSICOLA

Anchor-arms without teeth............. PACIFICA

HH.—Plates flat, with less than 50 holes......... TRISTIS

FF.—Stock of anchor usually finely serrulate, often slightly notched or forked, but not at all branched or divided (plate v, fig. 32).

G.—Anchors about 600 μ in length.

Anchor-arms and holes of anchor-plates with many teeth. INSOLENS

Anchor-arms with 5 or 6 teeth and holes in plates with 1-3 teeth or none........................ BENEDENI

GG.—Anchors over 1 mm. long.

Plate abruptly contracted posteriorly and provided with very numerous, small, entire holes (plate v, fig. 33). RODEA

Plate not abruptly contracted; provided with holes of very unequal size .... DENTICULATA

CC.—Anchors conspicuously asymmetrical (plate IV, fig. 15; plate v, fig. 36).

D.—Accessory calcareous bodies in the form of perforated plates.

Accessory perforated plates normally with 4 dentate holes (plate v, fig. 35) .... ASYMMETRICA

Accessory perforated plates normally with 10 dentate holes (plate v, fig. 34) .... LUDWIGII

DD.—Accessory calcareous bodies in the form of small cruciform or branched rods (plate IV, fig. 16). Anchors grotesquely asymmetrical (fig. 15). PETERSI

BB.—Anchors and plates of two distinct sorts, differing especially in size; large anchors with serrate arms.

Large anchor-plates with comparatively few (less than 100) holes; these are rather large, polygonal, and smooth; small anchors with smooth arms; accessory calcareous bodies, small cruciform or branched rods. PSEUDO-DIGITATA

Large anchor-plates with numerous (150 or more) holes; these are small, circular, and dentate; small anchors with serrate arms; accessory calcareous bodies, minute oval granules.................................. BANKENSIS

AA.—Tentacles 10; brackish water.. SIMILIS

PROTANKYRA CHALLENGERI.

PLATE V, FIG. 26.

Synapta challengeri Théel, 1886*a*, p. 14. Calcareous particles, pl. I, fig. 4.
Protankyra challengeri Östergren, 1898*b*.
Protankyra challengeri var. *Sibogæ* Sluiter, 1901, p. 131; pl. III, fig. 5.
Protankyra timida Koehler and Vaney, 1905, p. 108. Calcareous particles, pl. XV, figs. 33-35.
Protankyra albatrossi Fisher, 1907, p. 728. Calcareous particles, pl. LXXXI, figs. 1, 1*a*, and pl. LXXXII, figs. 4, 4*a–c*.

LENGTH.—80–100 mm.

COLOR.—Reddish, yellowish or whitish, sometimes with a lilac tinge.

DISTRIBUTION.—Reported from near the Fiji Islands, 252 m. (Théel); from near Aru, Arafura Sea, 1,788 m. (Sluiter); near Andaman Islands, 1,010 and 1,170 m. (Koehler and Vaney); Hawaiian Islands, 257–1,586 m. (Fisher).

REMARKS.—The anchor-plates ally this species to the preceding genus, with which it is a sort of connecting link. Sluiter's specimens were so nearly like Théel's that the slight differences in color, anchor-plates, and abundance of miliary granules are not enough to warrant our regarding the form as a distinct variety; neither is the difference in the depths at which they were taken sufficient to affect their identify; nor can the slight differences mentioned by Koehler and Vaney (:05) as distinguishing *timida,* and by Fisher (:07) as distinguishing *albatrossi,* warrant our regarding those as distinct species. The anchors are from 240–350 μ in length and their plates from 180–270 μ. There are two polian vessels and the usual single stone-canal, and in Fisher's (:07) specimens there were sense-cups on the tentacles.

Protankyra bicornis.

Protankyra bicornis Sluiter, 1901, p. 131. Calcareous particles, pl. x, fig. 15.

Length.—115 mm., with diameter about 5.

Color.—Unrecorded.

Distribution.—Reported from near Timor, 828 m. (Sluiter).

Remarks.—This is a very notable species, unique not only in the remarkable perforated plates, but in the presence of only a single digit on each side of the tentacle, and of four or five stone-canals, while there is only one polian vessel. The anchors are comparatively infrequent, about 330 μ long, and their plates are only 245 μ long and about half as broad. The accessory plates are much more numerous and are sometimes 350 μ in diameter; their perforations are circular and entire. On the whole, *bicornis* is one of the most interesting holothurians discovered by the "Siboga."

Protankyra duodactyla.

Plate IV, Figs. 1-7.

Protankyra duodactyla Clark (antea, page 26).

Length.—60 mm., with diameter about 8.

Colors.—Clear deep gray.

Distribution.—Reported from off the coast of Washington in 1,000 m., and from near Unalaska, Aleutian Islands, in 1,777 m. (Clark).

Remarks.—This species is related to the preceding in the presence of only a single pair of digits on each tentacle, but there are no accessory calcareous bodies; there are, however, irregular branched and perforated rods in the tentacles. The anchors are 300–360 μ and the plates about 320 μ in length, but few of the latter are complete and only rarely is the bow present. There are two polian vessels and a single stone-canal.

Protankyra sluiteri.

Plate V, Fig. 27.

Protankyra sibogæ Sluiter, 1901, p. 132. Calcareous particles, pl. x, fig. 16.
Protankyra sluiteri Fisher, 1907, p. 729.

Length.—More than 110 mm.

Color.—Unrecorded, but the skin is "thin" and "transparent."

Distribution.—Reported from north of Sumbawa, East Indies, 794 m. (Sluiter).

Remarks.—This is another of the "Siboga's" interesting discoveries, unique in the form of the accessory calcareous bodies, in the presence of teeth on the shaft of the anchor, and also, if Sluiter's figure is correctly drawn, in the direction of the teeth towards, instead of away from, the tips of the arms. As the only specimen was a fragment, nothing is known of the internal anatomy. Fisher's change of name for this species seems to be necessary.

Protankyra verrilli.

Plate V, Fig. 29.

Synapta verrilli Théel, 1886*a*, p. 12. Calcareous particles, pl. i, fig. 1.
Protankyra verrilli Östergren, 1898*b*.

Length.—About 23 mm.

Color.—Yellowish white (in alcohol).

Distribution.—Reported from near Cape York, Australia, 14 m. (Théel).

Remarks.—The simple calcareous particles is the principal character to distinguish this species from the next; but the small size, pale color, and tendency of the anchors to be asymmetrical are other differences. There were four polian vessels and a single stone-canal in the type.

Protankyra bidentata.

Plate V, Fig. 30.

Synapta bidentata Woodward and Barrett, 1858, p. 365. Calcareous particles, pl. xiv, figs. 23-25.
Synapta molesta Semper, 1868, p. 9. Calcareous particles, pl. iv, fig. 13.
Synapta distincta v. Marenzeller, 1881, p. 123. Calcareous particles, pl. iv, fig. 2.
Protankyra bidentata Östergren, 1898*b*.
Protankyra molesta Östergren, 1898*b*.
Protankyra distincta Östergren, 1898*b*.

Length.—30–100 mm.; diameter nearly one-fourth as much, according to Woodward and Barrett, but their specimen must have been greatly contracted.

Color.—Reddish gray, reddish violet, or clear reddish; according to Woodward and Barrett, their preserved specimen was "devoid of color."

Distribution.—Reported from China (Woodward and Barrett); Bohol, Philippines (Semper); Japan (v. Marenzeller, Théel); and Amoy (Ludwig).

Remarks.—Lampert ('85) is probably correct in identifying *molesta* Semper with *bidentata* Woodward and Barrett, but why he should have deliberately ignored the latter name, which has ten years' precedence and is accompanied by a good description and excellent figures, it is hard to see. The differences between *bidentata* and *distincta* are so slight and the calcareous particles of the latter so variable (see Théel, '86), that it is hard to believe they are not identical, especially since their geographical distribution is the same. The type specimen of *distincta* is a fragment, and all of Théel's specimens were also incomplete. Semper says there are four polian vessels and one stone canal.

Protankyra autopista.

Plate V, Fig. 31.

Synapta autopista v. Marenzeller, 1881, p. 123. Calcareous particles, pl. iv, fig. 3.
Protankyra autopista Östergren, 1898*b*.

Length.—More than 20 mm.; diameter of only known fragment, 6 mm.

Color.—Reddish brown.

Distribution.—Reported from Miya Bay, Japan (v. Marenzeller).

Remarks.—The very small size of the anchors and the peculiar shape of the stock easily distinguish this species, and yet it may be that the type and only known specimen is simply the anterior part of the body of a peculiar individual of the preceding species.

Protankyra brychia.

Plate IV, Figs. 12-14.

Synapta brychia Verrill, 1885*b*, p. 539.
Protankyra brychia Östergren, 1898*b*.

Length.—160 mm.; diameter about one-sixteenth as much.

Color.—Purplish brown or gray (in alcohol).

Distribution.—Off Cape Hatteras, 1,688 m. (Verrill).

Remarks.—The very large anchors and plates, a millimeter or more in length, are arranged in approximately three longitudinal rows in each interradius. Verrill says the anchor-arms are smooth; but that is not the case in the fully-developed anchors, which have about six teeth on each arm. There are no accessory calcareous bodies in the skin. There are at least two polian vessels and one stone-canal. The tentacles are unknown.

Protankyra suspecta.

Protankyra suspecta Sluiter, 1901, p. 132. Calcareous particles, pl. x, fig. 14.

Length.—More than 70 mm.; only a fragment known.

Color.—Not recorded.

Distribution.—Buton Straits, D. E. I., 148 m. (Sluiter).

Remarks.—This is another of the discoveries made by the "Siboga," and also, unfortunately, another of the species known from only a slight, headless fragment. Although related to the preceding species, the differences are obvious.

Protankyra aculeata.

Synapta aculeata Théel, 1886*a*, p. 13. Calcareous particles, pl. I, fig. 3.
Protankyra aculeata Östergren, 1898*b*.

Length.—More than 65 mm.; only fragments known.

Color.—Light brownish or dirty white.

Distribution.—Coast of Japan, 621 meters (Théel).

Remarks.—This interesting species has the anchors 1.1 mm. long and the plates only about two-thirds as much. The anchors vary greatly in shape and sometimes even have flukes at both ends. In the type specimen the miliary granules occurred in a double row in each radius and were of a simple oval form.

Protankyra conferta.

Protankyra conferta Koehler and Vaney, 1905, p. 105. Calcareous particles, pl. XV, figs. 26-29.

Length.—More than 72 mm.; only fragments known.

Color.—Brownish.

Distribution.—Recorded from near Ceylon, 1,450 m., and off Masulipatam, Madras, 1,220 m. (Koehler and Vaney).

Remarks.—This is one of the deep-sea species taken by the "Investigator," and regarding which we know all too little. The anchors are strikingly like those of *brychia* except in the length of the arms.

Protankyra errata.

Protankyra errata Koehler and Vaney, 1905, p. 106. Calcareous particles, pl. XV, figs. 14-16.
Protankyra inflexa Koehler and Vaney, 1905, p. 109. Calcareous particles, pl. XV, figs. 30-32.
"*Ankyroderma marenzelleri* Théel" Walsh, 1891.

Length.—32–110 mm. and more; diameter about one-sixteenth as much.

Color.—Not recorded.

Distribution.—Reported from near Andaman Islands, 234–270 m., and from Gulf of Bengal, 738–864 m. (Koehler and Vaney).

Remarks.—The characters distinguishing *inflexa* from *errata* are too slight to justify us in keeping them separate, and it is probable that both are forms of *aculeata*, which is apparently a very variable species. Koehler and Vaney are authority for saying this species is Walsh's *Ankyroderma marenzelleri*.

PROTANKYRA ABYSSICOLA.

PLATE IV, FIGS. 8-11.

Synapta abyssicola Théel, 1886*a*, p. 14. Calcareous particles, pl. I, fig. 11.
Protankyra abyssicola Östergren, 1898*b*.

LENGTH.—65 mm.; diameter about 5.

COLOR.—Dark yellowish (in alcohol), with considerable reddish pigment at base of tentacles on inner side.

DISTRIBUTION.—Reported from tropical mid-Atlantic, 4,230 m. (Théel); off coast of New Jersey, 2,468 m. (Théel); off coast of Senegal, 3,200 m. (R. Perrier); Gulf of Mexico, 2,259 m. (Clark, antea). Probably distributed throughout the deeper parts of the Atlantic Ocean.

REMARKS.—One of the interesting discoveries of the "Challenger" was this abyssal Synaptid, which has since been taken several times. It is little modified by the great depth at which it lives and shows no special peculiarities of structure. There are seven polian vessels. Although miliary granules are wanting in the skin, the longitudinal muscles contain the usual oval particles, and there are nearly straight supporting rods in the tentacles.

PROTANKYRA PACIFICA.

Synapta abyssicola var. *pacifica* Ludwig, 1894, p. 174. Calcareous particles, pl. XVIII, figs. 13-19.

LENGTH.—85 mm.; diameter about 5.

COLOR.—Yellowish white or greenish gray.

DISTRIBUTION.—Reported only from outside the Gulf of Panama, in 3,000–3,189 m. (Ludwig).

REMARKS.—As the characters mentioned by Ludwig, which distinguished the Pacific from the Atlantic specimens, appear to be constant, there is no reason why this should not be regarded as a distinct species. The anchors and plates are really quite distinct in the two species, when compared side by side. The internal anatomy is not peculiar, but there were ten polian vessels in the specimen examined by Ludwig.

PROTANKYRA TRISTIS.

Protankyra tristis Koehler and Vaney, 1905, p. 107. Calcareous particles, pl. XV, figs. 17-18.

LENGTH.—More than 25 mm.

COLOR.—Grayish white.

DISTRIBUTION.—Off northern Madras, India, 2,358 m. (Koehler and Vaney).

REMARKS.—Although this species seems nearly related to *aculeata*, the small size of the anchors appears to distinguish it. Unfortunately, however, it is known only from an anterior fragment.

Protankyra insolens.

Plate V, Fig. 32.

Synapta insolens Théel, 1886*a*, p. 13. Calcareous particles, pl. i, fig. 3.
Protankyra insolens Östergren, 1898*b*.

Length.—40–110 mm.

Color.—Yellowish white.

Distribution.—Reported from Torres Strait, 51 m. (Théel), and from near the Aru Islands, 57 m. (Sluiter).

Remarks.—This "Challenger" species was found again by the "Siboga," and may be easily recognized by the anchors, which are 600–650 μ long and nearly 500 μ broad, with 12–18 teeth on each arm; the broadly oval plates with numerous dentate holes are also characteristic. There are five polian vessels and a single stone-canal.

Protankyra benedeni.

Synapta benedeni Ludwig, 1881*a*, p. 55. Calcareous particles, pl. iii, figs. 19-20.
Protankyra benedeni Östergren, 1898*b*.

Length.—22–35 mm.; diameter about one-fourth as much; obviously the specimens were greatly contracted.

Color.—Whitish.

Distribution.—Reported only from coast of Brazil (Ludwig).

Remarks.—Ludwig says that the whole appearance of this Synaptid is like that of *Labidoplax digitata*, but the anchors and plates are so obviously different there is no doubt of the distinctness of the two species. The miliary granules are minute rods, rounded at the ends and constricted at the middle. There are six polian vessels and one stone-canal.

Protankyra rodea.

Plate V, Fig. 33.

Synapta rodea Sluiter, 1890, p. 108. Calcareous particles, pl. i, figs. 10-14.
Protankyra rodea Östergren, 1898*b*.

Length.—Up to 250 mm.

Color.—Carmine red.

Distribution.—Reported from Bay of Batavia; Lombok; Timor; and near Madura, D. E. I., 330 m. (Sluiter).

Remarks.—The huge anchors and plates, the minute miliary granules, and the conspicuous color make this species a notable one. There are two polian vessels. In his original description Sluiter says the calcareous ring consists of 17 pieces; it would be interesting to know whether further observations confirm this peculiar number. This species lives in mud near the coral reefs.

Protankyra denticulata.

Protankyra denticulata Koehler and Vaney, 1905, p. 105. Calcareous particles, pl. xv, figs. 36-39.

Length.—Over 70 mm.; diameter, 12 mm.; known only from a fragment.

Color.—Brownish.

Distribution.—Off Madras, India, 738 m. (Koehler and Vaney).

Remarks.—Although allied to *rodea*, the shape of the plates easily distinguishes this species.

Protankyra asymmetrica.

Plate V, Figs. 35 and 36.

Synapta asymmetrica Ludwig, 1874, p. 78. Calcareous particles, pl. vi, fig. 2.
Protankyra asymmetrica Östergren, 1898*b*.

Length.—40 mm.

Color.—"Colorless."

Distribution.—Reported from Banka, Sunda Islands (Ludwig, Théel); Saleyer and near Madura, 82 m., D. E. I. (Sluiter).

Remarks.—The remarkable accessory calcareous plates with their four symmetrical holes and the peculiar anchors would seem to be sufficiently diagnostic, but Sluiter (:01, p. 129; Pl. X, fig. 13) describes and figures still other remarkable accessory calcareous bodies, in the form of curious double-headed rods. It is virtually certain that neither Ludwig nor Théel would have overlooked such calcareous bodies, so we are safe in assuming that they were not present in the specimens from Banka. The question naturally arises whether their presence in Sluiter's specimens would not indicate an important specific difference, but we must await further material before we attempt to decide the point. Ludwig's specimen had four polian vessels and one stone-canal. The anchors are 500 μ and their plates about 400 μ in length, and the accessory plates are about 50 μ in diameter.

Protankyra ludwigii.

Plate V, Fig. 34.

Synapta ludwigii Sluiter, 1890, p. 108. Calcareous particles, pl. i, figs. 4-9.
Protankyra ludwigii Östergren, 1898*b*.

Length.—40 mm.

Color.—Ranges from carmine-red to "colorless," with a reddish tinge on the tentacles.

Distribution.—Reported from Bay of Batavia; near Timor, 73 m.; and near Flores, 247 m. (Sluiter).

Remarks.—While evidently allied to the preceding species, the very different accessory calcareous plates are an excellent mark of distinction. The anchors are about 500 μ in length and their plates only a little shorter; the accessory plates are about 80 μ in diameter. There are only two polian vessels and one stone-canal.

Protankyra petersi.

Plate IV, Figs. 15 and 16.

Synapta petersi Semper, 1868, p. 230. Calcareous particles, pl. xxxix, fig. 12.
Protankyra petersi Östergren, 1898*b*.

Length.—130 mm.

Color.—Clear reddish.

Distribution.—Reported only from Amboina (Semper).

Remarks.—The type specimen of this interesting species still remains unique. The curious grotesque anchors are accompanied by normal plates perforated with numerous smooth holes. Nothing is known of the habits, habitat, or anatomy.

Protankyra pseudo-digitata.

Synapta pseudo-digitata Semper, 1868, p. 9. Calcareous particles, pl. iv, fig. 12.
Synapta innominata Ludwig, 1874, p. 79. Calcareous particles, pl. vi, fig. 4.
Protankyra pseudo-digitata Östergren, 1898*b*.
Protankyra innominata Östergren, 1898*b*.

Length.—60 mm.

Color.—Not recorded.

Distribution.—Reported from Bohol, Philippines, 27 m. (Semper); Philippines (Ludwig); and Macasser (Sluiter).

Remarks.—Ludwig himself expressed the opinion that his species was possibly identical with Semper's, and Lampert ('85) emphasizes the point. There is little doubt that such is the case. Ludwig had only a fragment 10 mm. long for his description and Semper had lost his only specimen when he wrote his description. He says it was similar to *Labidoplax digitata* in appearance, and Sluiter (:01) tells us there are 12 tentacles, each with four digits.

Protankyra bankensis.

Synapta bankensis Ludwig, 1874, p. 78. Calcareous particles, pl. vi, fig. 1.
Protankyra bankensis Östergren, 1898*b*.

Length.—More than 75 mm.; only fragments known.

Color.—Whitish with a reddish tinge.

Distribution.—Reported only from Banka, Sunda Islands (Ludwig, Théel).

Remarks.—This species is certainly nearly related to the preceding and it is an open question whether they are not identical. The differences in the calcareous particles are not beyond the range of individual diversity.

Protankyra similis.

Plate II, Fig. 2.

Synapta similis Semper, 1868, p. 10; pl. III, fig. 2. Calcareous particles, pl. IV, fig. 14.
Protankyra similis Östergren, 1898*b*.

Length.—60–100 mm.

Color.—Semper gives the color as "transparent reddish," but the colored figure is pale fawn color with purplish tints.

Distribution.—Reported only from Bohol, Philippines (Semper).

Remarks.—The anchors and plates of this species are very much like the large ones of *P. pseudo-digitata,* and the accessory calcareous bodies also resemble those of that species. There is a single stone-canal and one or two polian vessels. Semper says this is one of the commonest and most interesting of the Philippine synaptids, living in the mud of brackish, mangrove swamps. It is well known to the natives and is called "dapan-dapan" in Visayan. It should perhaps be made the type of a distinct genus.

ANAPTA Semper, 1868.

Tentacles pinnate, 12. Digits 2–6 on each side and a long terminal one. Cartilaginous ring wanting. Polian vessels several (5–7). Stone-canal single. Anchors, perforated plates, wheels, and sigmoid bodies entirely wanting, the only calcareous particles in the skin being small oval or ellipsoidal bodies, and even these may be wanting.

This small group is closely related to Leptosynapta, but is of course easily distinguished therefrom py the entire absence of anchors. Östergren ('98*b*) considers that Sluiter's ('88) species *subtilis* is based on an abnormal individual, and he accordingly omits it; but since Sluiter especially states that the animal was examined when fresh, and consequently its peculiar characters cannot be due to decalcification, there is no reason to doubt its authenticity. Were it a regenerating synaptid, the calcareous ring would be normal and there would be some indications of calcareous bodies. Ludwig ('92*b*) proposes to include in Anapta, *Toxodora ferruginea* Verrill and *Scoliodota japonica* (v. Marenzeller), but the affinities of these two species seem to be so clearly with the Chiridotinæ that it would be very misleading to place them here.

Key to the Species of Anapta.

A.—Calcareous particles present in the skin, longitudinal muscles or tentacles.
Size large (up to 190 mm.); calcareous bodies scattered everywhere in the skin. GRACILIS
Size small (under 100 mm.); calcareous bodies confined mainly to radii or longitudinal muscles and tentacles; those of latter often slightly branched at the end.... FALLAX
AA.—Calcareous particles wanting.. SUBTILIS

Anapta gracilis.

Plates II, Fig. 1; VII, Figs. 19-23.

Anapta gracilis Semper, 1868, p. 17; pl. III, fig. 1. Calcareous particles, pl. IV, figs. 10-15.

Length.—Up to 190 mm.

Color.—Pale purplish brown (rosy in the figure given), with numerous white papillæ.

Distribution.—Reported only from Manila, Philippines (Semper).

Remarks.—It seems strange that such a large and well-characterized species as this has not been met with since its original discovery, nearly 40 years ago. The calcareous ring, ciliated funnels, reproductive organs, and sensory-cups on the tentacles are all very much like those of a Leptosynapta.

Anapta fallax.

Anapta fallax Lampert, 1889*b*, p. 848.

Length.—Up to 80 mm.

Color.—In life, flesh color, reddish anteriorly, the tentacles clear rose-red; in alcohol, yellowish brown or yellowish white.

Distribution.—Reported from off Cape Blanco, Argentina, 114 m. (Lampert); Stanley Harbor, Falkland Islands, and southern coast of Tierra del Fuego (Ludwig); Punta Arenas, Susanna Cove and Calbuco, Chile (Ludwig); near Wellington Island, Chile (Clark, antea). The range apparently includes all the coasts of South America and neighboring islands south of 40° S., where the water is less than 125 m. deep.

Remarks.—This is decidedly the best known of the three species, but it is somewhat difficult to see from the descriptions published any important difference between it and the preceding species. Ludwig's ('98*c*) statement, "wohl aber finden sich bei einzelnen, aber nicht bei allen, Exemplaren, in den Längsmuskeln, sehr zahlreiche, kurze, fast ovale Kalkstäbchen und in den Fühlern, * * *, kleine, klammerförmige * * * Kalkkörperchen," leaves one in doubt as to whether some of his specimens entirely lacked all calcareous particles or not, and if so, whether it might not have been due to acid alcohol. However, the geographical isolation of this species is so marked, it cannot be confused with any other, and it may well be considered distinct until its identity with *gracilis* is shown by a more careful study of the two species. According to Ludwig ('98*b*), *fallax* lives "am strande, im Sande."

Anapta subtilis.

Anapta subtilis Sluiter, 1888, p. 211.

Length.—Not given: "nur etwa dreimal so lang als breit."

Color.—Brownish, with numerous, clear yellowish white papillæ.

Distribution—Reported only from the Bay of Batavia (Sluiter).

Remarks.—Sluiter distinctly says that the absence of calcareous particles could not be due to impure alcohol, for he examined the animal when "ganz frisch." Östergren ('98*b*) expresses the opinion that this is only a regenerating individual of some synaptid, but that would not account for the entire lack of calcareous particles. Although the type specimen is still unique, it must be allowed to stand as a valid species until we have more light on the subject.

DACTYLAPTA, gen. nov.

(δάκτυλα, fingers, + ἅπτω, to fasten or bind; in reference to the tentacles and to correspond to Synapta, etc.)

Tentacles digitate, 12. Digits only four, two on each side, as in Protankyra. Calcareous particles, only short, curved rods, scattered in the skin.

This genus is instituted for the following unique species.

Dactylapta dubiosa.

Anapta (?) *dubiosa* Koehler and Vaney, 1905, p. 109. Calcareous particles and calcareous ring, pl. xv, figs, 11-12.

Length.—30 mm. and more; only an anterior fragment known.

Color.—Brown.

Distribution.—Reported only from Gulf of Bengal, 738 m. (Koehler and Vaney).

Remarks.—Although there is at least a possibility that this specimen, upon which a new species and genus is based, is only a diseased or abnormal Protankyra, we must for the present admit its validity. The form of the tentacles and of the calcareous deposits shows that the species bears the same relation to Protankyra that Anapta does to Leptosynapta, and it must therefore be placed in a distinct genus, so that this relationship may be emphasized.

RHABDOMOLGUS Keferstein, 1862.

Tentacles without digits, simply "am Rande leicht gelappt," 10. Cartilaginous ring wanting. Calcareous ring remarkably weak. Polian vessel one. Stone-canal one, but non-calcareous. Ciliated funnels wanting. Calcareous particles wholly wanting. Sexes separate (?).

The remarkable holothurian upon which Keferstein based this genus is in many ways much like a young synapta, and since no other zoölogist met with it, each succeeding writer has been more and more inclined to reject the genus and species altogether. Ludwig ('98*b*) places it in a foot-note and doubts its validity, and Östergren ('98*b*) ignores it entirely. It was therefore a matter of considerable surprise when Ludwig (:05) announced the rediscovery of Rhabdomolgus, and his complete report is awaited with keen interest.

Rhabdomolgus ruber.

Rhabdomolgus ruber Keferstein, 1862, p. 34; pl. xi, fig. 30.

Length.—5 mm. with diameter of .6 mm. (preserved material).

Color.—Bright red or carmine.

Distribution.—Reported from St. Vaast (Keferstein) and "Sudspitze von Helgoland" (Ludwig).

Remarks.—Keferstein secured only a single specimen, and that was floating near the surface, so that the question was raised as to whether the animal is pelagic. Ludwig (:05), however, has conclusively shown that under normal conditions it is a bottom form. It breeds in August; the sexes seem to be separate and the eggs are large.

CHIRIDOTINÆ Östergren, 1898*b*.

Tentacles with stalk short, becoming widened distally where it bears 3–10 digits on each side; the digit-bearing portion forms a sort of disc which can in many cases (perhaps always?) be drawn downward in contraction, more or less into the basal portion of the stalk; such tentacles may be called peltato-digitate. Cartilaginous ring wanting. Stone-canal single. Eye-spots wanting. Gustatory organs seldom present. Calcareous deposits either six-spoked wheels or conspicuous sigmoid or C-shaped bodies, or both, often accompanied by curved or straight rods or oval miliary granules; rarely minute curved rods only are present, or deposits are wholly wanting. Sexes apparently separate in many species, perhaps in all.

In the following keys and descriptions there are few terms which require any explanation, for nearly all are of the kind which carry their own meaning. The term "sigmoid" bodies is used for curved rods which bear a more or less close resemblance to that form of the Greek letter sigma, which is used at the termination of a word; that is to say, each end is curved, but in opposite directions, and very often in planes at right angles to each other. When rods are found in which the ends curve inward towards each other and in the same plane, they are called C-shaped or "bracket"-shaped particles. Both sigmoid and C-shaped rods may occur in the same individual.

Key to the Genera of Chiridotinæ.

A.—No sigmoid bodies; wheels present, collected in little papillæ (plate vii, fig. 24).
 Tentacles 12 (10-14); ciliated funnels mostly single and scattered (plate vii, figs. 23, 28) .... Chiridota
 Tentacles 18 (16-20); ciliated funnels mostly single and scattered (plate vii, figs. 14) .... Polycheira

AA.—Sigmoid or bracket-shaped bodies or minute curved rods present (plate vii, figs. 3, 6, 9, 10, 11, 27).
 B.—Wheels present, in papillæ .... Tæniogyrus
 BB.—Wheels present, but scattered .... Trochodota
 BBB.—Wheels wanting.
  Sigmoid bodies present .... Scoliodota
  Sigmoid bodies wanting; minute curved rods present .... Toxodora

AAA.—Deposits wholly wanting .... Achiridota

CHIRIDOTA Eschscholtz, 1829.

Dactylota Brandt, 1835.
Liosoma Brandt, 1835.
Trochinus Ayres, 1852.
Lioderma Bronn, 1860.

Tentacles 12, exceptionally 13 or even 14. Digits 3–10 on each side, the terminal pair the longest. (Although Semper, Lampert, and others speak of a terminal unpaired digit, it is very doubtful whether such normally occurs. The number of digits on a tentacle may be odd, but examination will show that this is due to an extra digit on one side at the base of the series.) Polian vessels numerous, 3–20. No gustatory organs are known to occur. Ciliated funnels usually single, sometimes collected into little groups, but not forming true stalked clusters. Calcareous deposits in the form of 6-spoked wheels (Plate VII, figs. 8, 15, 26) collected in little papillæ containing 10–80 of divers sizes (Plate VII, fig. 24); no sigmoid deposits, but small curved rods with enlarged ends are often present (Plate VII, figs. 16, 27), and minute oval miliary granules, or somewhat larger rod-shaped particles, frequently occur in connection with the longitudinal muscles.

The species of this genus are of small or moderate size and of variable color. They are widely distributed in both warm and cold seas, but no one species, except perhaps *lævis,* has a very extensive range, so far as our present knowledge shows. They occur chiefly in shallow water, often along shore, but are frequently met with at depths of 500–1,000 m. and sometimes down to 3,000–3,200 m. Specific differences are very difficult to determine satisfactorily, for the number and length of digits on the tentacles is closely correlated with age and size, while the number and arrangement of wheel-papillæ appear to show a similar correlation. Thus full-grown specimens of *rotifera* have the wheel-papillæ very numerous all over the body and the ventral surface is not distinguishable from the dorsal; but in young specimens, 20–40 mm. long, the wheel-papillæ of the ventral side are few and confined to a single series in each interradius, and such specimens therefore closely resemble *rigida* (Plate II, fig. 3). The presence or absence of miliary granules along the radii seems to be another variable feature, for Ludwig ('98*b*) has shown that in some specimens of *pisanii* these granules are abundant, in others infrequent, and in still others entirely wanting. In the light of these facts, it is not strange that the number of species in the genus and their geographical distribution are still uncertain. The species described by Müller ('50) as *pygmæa* is apparently a young *lævis* or possibly *rotifera* (Selenka ('67) says it is West Indian), while the form called *rubeola* by Quoy and Gaimard ('33) is absolutely unidentifiable at present, and it may not be one of the Chiridotinæ at all. The same is true of *Synapta coriacea* Agassiz ('52), which has been considered a synonym of *Chiridota lævis.* The holothurian called *Aspidochir mertensi* by Brandt ('35) is thought by Ludwig ('81*b*) to be a Chiridota.

Key to the Species of Chiridota.

A.—Wheel-papillæ numerous, more or less uniformly scattered all over the body, with no evident arrangement in longitudinal series; digits 8-14. (In young specimens, papillæ may be very few on ventral side.)

B.—Numerous curved rods (plate VII, fig. 27), with more or less branched ends scattered all over interambulacra.. ROTIFERA

BB.—No such rods in interambulacra.

Miliary granules of longitudinal muscles, minute oval particles; polian vessels 5-10 .... FERNANDENSIS

Miliary granules of radii longer than diameter of wheels; polian vessels 15-20. STUHLMANNI

AA.—Wheel-papillæ numerous or few, confined to interambulacra, and there forming more or less irregular longitudinal series, less abundant on ventral side and often wholly wanting there.

B.—Digits of tentacles about 20; wheel-papillæ in 5 irregular series; numerous minute crescent-shaped bodies in skin....................................... VIOLACEA

BB.—Digits of tentacles generally fewer than 16 (very rarely 18).

C.—Wheel-papillæ very few and only in right and left dorsal interambulacra; stellate, perforated plates (plate VII, fig. 25) in skin...........MARENZELLERI

CC.—No stellate plates in skin.

D.—Numerous "buttons" ("schnallenförmiger Hautkalkkörper") in skin; wheel-papillæ in 5 simple longitudinal series............... EXIMIA

DD.—No "buttons" in skin.

E.—Curved rods, with enlarged ends (plate VII, figs. 16 and 27), which may be smooth or spinous, or even branched, scattered in skin, at least along ambulacra.

F.—Size large, up to 200 mm.; color more or less purple; wheel-papillæ confined almost wholly to mid-dorsal interambulacrum.

Curved rods very small (40-60 μ), confined to ambulacra, and distinctly curved ....REGALIS

Curved rods larger (80-120 μ), uniformly scattered, and commonly almost straight .... UNISERIALIS

FF.—Size small, under 100 mm.; color not purple; wheel-papillæ and rods more or less generally present in all the interambulacra.

Color red or reddish; wheel-papillæ numerous dorsally; occurs about coral reefs ....RIGIDA

Color whitish; wheel-papillæ in an irregular single row in each interambulacrum; occurs in mangrove swamps. INTERMEDIA

EE.—No such curved rods in skin.

F.—Size small, usually under 100 mm. (rarely twice that); color in life yellowish, pink, red or purple, becoming whitish, grayish, yellowish, dusky or purplish red in alcohol; wheel-papillæ, of course, white.

Wheel-papillæ very large, 1-1.5 mm. in diameter; polian vessels few, only 4-5; austral.......................PISANII

Wheel-papillæ smaller and polian vessels numerous, 10-20 or more; boreal .... LÆVIS

FF.—Size large, up to 300 mm.; color prevailingly grayish, with more or less red pigment in skin........................DISCOLOR

Chiridota rotifera.

Synapta rotifera Pourtales, 1851, p. 15.
Chirodota rotifera Stimpson, 1860. Ludwig, 1881*a*, p. 41; pl. III, figs. 1-15.
Chiridota rotifera Ludwig, 1892*b*.

Length.—Up to 100 mm.; usually about 50.

Color.—Reddish or purplish, with light tentacles and numerous white wheel-papillæ.

Distribution.—Reported from Biscayne Bay, Florida (Pourtales); Brazil (Ludwig, Verrill, Rathbun); Jamaica (Clark); Key West, Florida (Clark, antea); and Bermuda (Clark). Apparently a typical West Indian species, with the same distribution as *Synaptula hydriformis.*

Remarks.—This is one of the best known and most distinctly characterized species of the genus, and is of particular interest because it is viviparous—a fact first noted by Ludwig ('81*a*); the eggs undergo their development in the body cavity of the mother, as in *Synaptula hydriformis.* It occurs commonly under stones and fragments of coral on sandy beaches or among living corals, in shallow water, and is somewhat gregarious, a number often being found under the same stone.

Chiridota fernandensis.

Chiridota fernandensis Ludwig, 1898*c*, p. 446.

Length.—Up to 100 mm.

Color.—In life, brownish yellow; in alcohol, whitish yellow; very numerous small wheel-papillæ, white.

Distribution.—Reported only from the Island of Juan Fernandez (Ludwig).

Remarks.—This species was collected by Dr. Ludwig Plate in March, 1898. He seems to have found it quite common, as some 20 specimens were taken. Nothing is recorded of its habits or habitat.

Chiridota stuhlmanni.

Chirodota stuhlmanni Lampert, 1896, p. 67.
Chiridota stuhlmanni Östergren, 1898*b*.

Length.—80 mm.

Color.—Yellowish, with white wheel-papillæ, each of which has a rust-red dot.

Distribution.—Reported only from Tumbatu, East Africa (Lampert).

Remarks.—This seems to be a very well characterized species, of which, however, only a single specimen is as yet known. The remarkably large (210–266μ), straight rods confined to the ambulacra, and the very numerous polian vessels are striking features.

Chiridota violacea.

Chirodota violacea Müller, 1849, p. 379; 1850, p. 137.
Chiridota violacea Ludwig, 1892*b*.

Length.—300 mm. or more, with a diameter of only 6–8 mm.

Color.—Not given, presumably violet or purple.

Distribution.—Reported from Ibo, near Mozambique (Müller); Amirante Islands (Bell). Semper ('69) gives "Zanzibar," but Ludwig ('99) says that is probably a mistake, as Semper's note apparently refers to Müller's original specimen in the Berlin Museum.

Remarks.—Although commonly attributed to Peters, the original description of this species is obviously by Müller, and, so far as known, Peters never published one word about it; there is no reason, therefore, why the name should be written *violacea* Peters, even if that collector did select the name. Bell ('84) is the only zoölogist who has been fortunate enough to meet with this species since its original discovery, but unfortunately he does not consider that fact sufficient justification for giving any information whatever in regard to the specimen (or specimens?) collected by the "Alert." The large size of this species and the number of digits make it an unusually interesting form.

Chiridota marenzelleri.

Plate VII, Figs. 24, 25.

Chiridota marenzelleri R. Perrier, 1904*b*, p. 370, with text figures.

Length.—33–36 mm., with a diameter of 10–11.

Color.—Reddish above, deepest along the mid-dorsal region, with a network of fine dark lines like cracks; yellowish white beneath.

Distribution.—Reported only from Magellan Strait (R. Perrier).

Remarks.—So well characterized is this species by its unique coloration, its still more unique stellate calcareous particles, its few wheel-papillæ (6 in one and 9 in the other dorso-lateral interambulacrum), and its tentacles (having only three pairs of digits, the terminal the largest), that one is almost inclined to assign it generic rank; but, after all, the only character which would clearly mark such a genus is the form of the stellate bodies, and we are scarcely prepared to accord that feature alone such distinction.

Chiridota eximia.

Chirodota eximia Haacke, in Möbius, 1880, p. 47.
Chiridota eximia Ludwig, 1892*b*.

Length.—Not given.

Color.—Not given.

Distribution.—Reported only from Fouquet's Reef, Mauritius (Möbius).

Remarks.—Although this species is apparently well characterized, it is difficult to understand just what form the "schnallenförmige" particles have, and in view of the results of Ludwig's ('83) reëxamination of the material on which Haacke based his numerous (14) new species, we may be pardoned if we are very skeptical regarding this Chiridota, which Ludwig was unable to examine.

Chiridota regalis.

Chiridota regalis Clark (antea, p. 28).

Length.—Up to 200 mm., with a diameter of about 6 mm.

Color.—More or less deep, royal purple, deepest anteriorly; more grayish posteriorly.

Distribution.—Coast of Japan, 198–300 m. (Clark).

Remarks.—Although quite nearly related to *uniserialis* and also to *discolor,* which it approaches in size and general appearance, this seems to be a well-marked species.

Chiridota uniserialis.

Chiridota uniserialis Fisher, 1907, p. 733; pl. lxxxi, fig. 4, and pl. lxxxi, figs. 5, 5*a-c*.

Length.—150 mm., with diameter of 7–9 mm.

Color.—Dark purple or pale lilac.

Distribution.—North of Molokai, Hawaiian Islands, 590–745 m. (Fisher).

Remarks.—This species appears to be very close to the preceding, but the difference in the size, form, and distribution of the C-shaped rods is quite striking. Fisher notes well-developed retractor muscles in *uniserialis,* but I found none in *regalis.* The wheel-papillæ in *regalis* are often very numerous (70–80 or more), of very variable size, and most numerous *anteriorly,* where they may occur in the lateral interambulacra, while in *uniserialis* they are 9–50 in number, of conspicuous size, confined strictly to the mid-dorsal interambulacrum, and often most numerous *posteriorly.*

Chiridota rigida.

Plates II, Fig. 3; VII, Figs. 26-29.

Chirodota rigida Semper, 1868, p. 18; pl. iii, fig. 3. Calcareous particles, pl. v, figs. 3 and 13.
Chirodota liberata Sluiter, 1888, p. 212. Calcareous particles, pl. ii, fig. 44.
Chirodota amboinensis Ludwig, 1888, p. 819.
Chiridota rigida Ludwig, 1892*b*.
Chiridota liberata Ludwig, 1892*b*.
Chiridota amboinensis Ludwig, 1892*b*.
Chiridota hawaiiensis Fisher, 1907, p. 731; pl. lxxxi, fig. 5, and pl. lxxxii, figs. 3, 3*a-é*.

Length.—25–75 mm.

Color.—Red of some shade, ranging from reddish brown and reddish purple to rose-red; tentacles whitish; wheel-papillæ white.

Distribution.—Reported from Bohol, Philippines (Semper); Bay of Batavia, Kur-reef, Lucipara and Binongka, D. E. I. (Sluiter); Pulo Edam and Amboina (Ludwig); Rotuma and China Straits, New Guinea (Bedford); and Hawaiian Islands (Fisher). Apparently well distributed throughout the entire East Indian region.

Remarks.—Since Sluiter's description of *liberata* is obviously erroneous (he speaks of three ventral interradii), it is evident that his specimens were very similar to *rigida,* and as they were quite small, there can be little doubt that they were young ones of that species. Ludwig's *amboinensis* is apparently well within the limits of variation which such a species as *rigida* commonly shows and cannot be distinguished therefrom, and the same appears to be true of Fisher's *hawaiiensis.* This species occurs around coral reefs, either among the dead (less commonly, the living) corals or in holes in the blocks of coral rock.

Chiridota intermedia.

Chiridota intermedia Bedford, 1899*b*, p. 846. Calcareous particles, pl. LIII, fig. 6.

Length.—20–30 mm.

Color.—Whitish, transparent posteriorly.

Distribution.—Reported only from the Mangrove swamp, Funafuti (Bedford).

Remarks.—Although this species is strikingly like a young *rigida,* the unusual habitat and the pale color make it seem probable that it is really quite distinct. Bedford says that the C-shaped calcareous particles rarely become S-shaped, "a condition which is normal in *C. contorta,*" etc. No ordinary change of form would in itself make the calcareous particles of *rigida* (Plate VII, fig. 27) and *intermedia* like the sigmoid bodies of *Tæniogyrus* (Plate VII, figs. 9–11); these latter are an entirely distinct sort of calcareous deposit.

Chiridota pisanii.

Chirodota pisanii Ludwig, 1886*b*, p. 29. Calcareous particles, pl. II, fig. 14.
Chirodota purpurea Théel, 1886*a*, pp. 15 and 35. Calcareous particles, pl. II, fig. 1.
Chirodota purpurea Lampert, 1889*b*, p. 851.
Chirodota pisanii Lampert, 1889*b*, p. 851.
Chiridota pisanii Ludwig, 1892*b*.

Length.—30–130 mm.

Color.—Red of some shade, varying from dark purple-red to rosy-white; the color becomes either intensified or bleached in alcohol; the longitudinal muscles sometimes show through as white stripes.

Distribution.—Reported from Calbuco, Porto Lagunas (Chonos Archipelago); Punta Arenas and Susanna Cove (Magellan Strait), Chile (Ludwig); Port Bridge, Tierra del Fuego (Ludwig); Orange Bay and Punta Arenas, Chile (R. Perrier); and Falkland Islands (Théel). Apparently ranges on both coasts of South America and among the neighboring islands to about 42° S. lat.

Remarks.—This species is of particular interest because, although quite different from its southern allies, it is strikingly similar to the widely distributed northern species, *lævis*. Curiously enough, Ludwig does not in any of his several papers ('86*b*, '98*b*, and '98*c*) make any reference to this similarity, and yet it is quite noticeable. Indeed, it is hard to draw any sharp line between the two species, although *pisanii* is apparently redder, with fewer and larger wheel-papillæ and polian vessels, and oftentimes has minute oval calcareous grains in the longitudinal muscles. The southern species occurs in sand or mud along shore or out to a depth of about 100 m.

Chiridota lævis.

Holothuria lævis Fabricius, 1780, p. 353.
Holothuria pellucida Vahl in O. F. Müller, 1806, p. 17.
Chiridota lævis Grube, 1851, p. 41.
Trochinus pallidus Ayres, 1852*c*, p. 243.
Chirodota tigillum Selenka, 1867, p. 366.
Chirodota typica Selenka, 1867, p. 366.
Chirodota lævis Duncan and Sladen, 1881, p. 12; pl. I, figs. 14-19.
Chirodota læve Lockington, 1885, p. 180.
Chirodota abyssicola von Marenzeller, 1893, p. 19; pl. I, fig. 5.

Length.—Up to 200 mm., but usually 50–100.

Color.—Usually pinkish, sometimes bright pink, sometimes pinkish brown, sometimes nearly transparent and colorless, rarely grayish or yellowish.

Distribution.—Reported from numerous stations on the east coast of America from 42° N. lat. northward; from Greenland, from Spitzbergen, and from the northern coasts of Europe above 66° N. lat. Concerning its occurrence in the Pacific Ocean, see antea, p. 28. The bathymetrical range in the North Atlantic is commonly from low water to about 100 m., but von Marenzeller's *abyssicola* was taken in 2,870 m., north of the Azores, and specimens from the Pacific were taken in over 3,000 m.

Remarks.—The large series of specimens of a Chiridota, apparently this species, discussed on p. 28, shows that *lævis* has either not yet been clearly and accurately defined, or else has a remarkable geographical and bathymetrical range. It is entirely distinct from the following species, but in the present state of our knowledge it is surprisingly hard to draw a sharp line between them. No constant character by which to distinguish the deep-water forms has yet been pointed out, so that the interesting "species" *abyssicola* must be regarded as identical with *lævis*. Sandy, more rarely muddy, bottoms are the favorite resorts of *lævis*, but it also occurs sometimes among stones and seaweeds.

Chiridota discolor.

Chiridota discolor Eschscholtz, 1829, p. 12; pl. x, fig. 2.
Liosoma sitchænse Brandt, 1835, p. 58.

Length.—Up to 300 mm., with a diameter of 10–15.

Color.—Whitish, yellowish, grayish, reddish, or brownish, the shade depending on the abundance or scarcity of red pigment scattered in the skin and the degree of contraction of the body.

Distribution.—Reported from Sitka, Alaska (Eschscholtz), and Okhotsk Sea (Grube). For other localities, see antea, p. 27. Apparently common on the northwest coast of America and the northeast coast of Asia.

Remarks.—There is no doubt that this is a valid species, but its specific and geographical limits have yet to be ascertained. It lives under stones, in loose sand along shore, but also appears to range outward into water 1,000 m. or even more in depth.

POLYCHEIRA, gen. nov.

(πολύχειρος, many handed; in reference to the numerous palmate tentacles.)

Tentacles 18, exceptionally 17 or 19. Digits 9–16 on each side, the terminal pair the longest. Polian vessels numerous, 6–19. Gustatory organs do not occur. Ciliated funnels collected into stalked clusters. Calcareous deposits similar to those in Chiridota.

This is a monotypic genus including only the wide-ranging and somewhat variable species to which the following names have been given:

Polycheira rufescens.

Plate VII, Figs. 14-18.

Chirodota rufescens Brandt, 1835, p. 59.
Chirodota panænsis Semper, 1868, p. 19. Calcareous particles, pl. v, figs. 1 and 21.
Chirodota vitiensis Semper, 1868, p. 19. Calcareous particles, pl. v, figs. 8 and 20.
Chirodota variabilis Semper, 1868, p. 20. Calcareous particles, pl. v, figs. 6, 7, 9-11, 19.
Chirodota dubia Semper, 1868, p. 21. Calcareous particles, pl. v, fig. 4.
Chirodota incongrua Semper, 1868, p. 22. Calcareous particles, pl. v, fig. 5.
Chirodota refuscens Théel, 1886*a*, p. 36.
Chiridota dubia, incongrua, panænsis, rufescens, vitiensis Ludwig, 1892*b*.

Length.—60–100 mm.

Color.—Variable, ranging from very dark violet through clear reddish to almost colorless.

Distribution.—Reported from Bonin Islands (Brandt); Bay of Manila, Panaon bei Surigao, and north Luzon (Semper); Singapore (Théel); Hongkong (Lampert, Ludwig); Sunda Straits, *not* Bay of Batavia (Sluiter); Timor (Ludwig); Amboina (Ludwig, Sluiter); Japan (Ludwig); Ternate (von Marenzeller); Ceylon (Bell, Walter); Fiji Islands (Semper); Cape York, Australia (Semper); Loyalty Islands and Blanche Bay, New Britain (Bedford); Tumbatu (Lampert); Roepang (Lampert), and numerous places in the D. E. I. (Sluiter). Apparently distributed throughout the Indo-Pacific region, except perhaps in the northwestern part.

Remarks.—The collection and examination of such a large amount of material as is indicated by the above list of localities where this species occurs leaves little room for doubt that all of the Indo-Pacific Chiridotas with 16–19 tentacles must be referred to this one species. Semper ('68) himself was skeptical about *dubia* and *incongrua,* while the numerous specimens reported in the past twenty years show clearly that *panæensis* and *vitiensis* are not constantly distinguishable. The last-named species is usually ascribed to Gräffe, because Semper ('68) attributes it to him; but Dr. Gräffe never published a word about it, and Semper himself is really responsible for its description. Semper says that *panæensis* occurs among large stones near low-water mark, but nothing else is recorded of either habitat or habits.

TÆNIOGYRUS Semper, 1868.

Sigmodota Studer, 1876.

Tentacles peltato-digitate, 10 or 12. Digits 5–7 on each side, the terminal pair longest. Polian vessel single, or there may be several. No gustatory organs. Ciliated funnels not in stalked clusters. Calcareous particles consist of wheels collected in papillæ and large sigmoid bodies about 200 μ long scattered in the skin; no miliary granules in either skin or longitudinal muscles.

This seems to be a well-characterized genus intermediate between Chiridota and Trochodota. The two species it contains are apparently quite distinct from each other. They are confined to the southern hemisphere, but a specimen of Tæniogyrus is recorded from the Hawaiian Islands by Fisher (:07) which is probably an undescribed species nearly allied to *contortus.*

Key to the Species of Tæniogyrus.

Tentacles 10; polian vessel single; sigmoid bodies in papillæ, at least dorsally...AUSTRALIANUS
Tentacles 12; polian vessels 6 or 7; sigmoid bodies not in papillæ................CONTORTUS

Tæniogyrus australianus.

Chirodota australiana Stimpson, 1856, p. 386.
Tæniogyrus australianus Semper, 1868, p. 23.
Sigmodota australiana Östergren, 1898*b*.

Length.—30–50 mm.

Color.—Yellowish

Distribution.—Port Jackson, New South Wales (Stimpson).

Remarks.—This very interesting species, rediscovered in the collection of the National Museum, is well worthy of the generic distinction, which Semper accords it. Like *Leptosynapta dolabrifera,* it is known only from Port Jackson, where Stimpson ('56) says it occurs under stones near low-water mark. The wheel-papillæ are conspicuous, but occur only in the dorsal interambulacra and are most abundant anteriorly. The sigmoid bodies are also in papillæ which are very abundant all over the body, but are largest and most noticeable dorsally. Each papilla contains six or eight sigmoid bodies. The calcareous ring is very narrow, much as Dendy ('97) figures it for *Trochodota dunedinensis*. The genital glands are distinctly branched. Each of the five specimens at hand has only ten tentacles.

Tæniogyrus contortus.

Plate VII, Figs. 8-13.

Chirodota contorta Ludwig, 1874, p. 80. Calcareous particles, pl. vi, fig. 6.
Sigmodota purpurea Studer, 1876, p. 454 (non Lesson).
Chirodota purpurea Bell, 1881, p. 101.
Chirodota studerii Théel, 1886*a*, p. 33.
Chiridota contorta Ludwig, 1892*b*; 1898*b*, p. 73; pl. iii, figs. 37-42.
Sigmodota contorta Östergren, 1898*b*.

Length.—20–45 mm.

Color.—Very variable, ranging in life from orange through various shades of red and purple to brownish violet; tentacles lighter, white to orange-red; alcoholic material varies from yellowish white or gray to brownish red or violet.

Distribution.—Reported from Port Gallant, Punta Arenas, the Elizabeth Islands, and stations in Strait of Magellan (Théel, Bell, Ludwig); Canal de Washington (R. Perrier); eastern coast of Patagonia (Lampert, Ludwig); Navarin Island, south of Tierra del Fuego (Ludwig); between Patagonia and Falkland Islands (Théel); South Georgia (Lampert); Marion Island (Théel); Kerguelen Island (Studer, Théel); near Madura Island, D. E. I., 82 m. (Sluiter). Apparently ranging from Kerguelen to the Strait of Magellan, across the southern Indian and Atlantic Oceans.

Remarks.—This interesting species has had a peculiar history, which is admirably told by Ludwig ('98*b*), who also gives a very readable account of the morphology and development. It is found in sand and mud near low-water mark, or more commonly at depths of 10–220 m. It is especially remarkable for its breeding habits. The eggs undergo their development in the genital tubes of the mother, and consequently the species is not only viviparous but is unique among holothurians in the possession of uteri. One cannot avoid the feeling that a careful comparison of good material from Kerguelen and its vicinity with material from the Strait of Magellan and the Falkland Islands will show that there are two distinct species in these widely separated districts. The specimens reported from the East Indies by Sluiter (:01) probably represent a third species, while that from Hawaii (Fisher, :07) is very likely a fourth; but of course it is not impossible that *contortus* does occur throughout the southern hemisphere, and even extends its range northward into the East Indies and among the Pacific islands.

TROCHODOTA Ludwig, 18_2.

Tentacles 10. Digits 2–6 on each side. Polian vessel single. Stone-canal single. Calcareous ring of 10 slender pieces, the radial not pierced for passage of nerves. Gustatory organs sometimes (always?) present on tentacles. Calcareous deposits consist of sigmoid bodies (Plates VII, figs. 2 and 6) (90–160 μ in length) either scattered irregularly through the skin or arranged in circles or in little groups; with these are associated wheels, like those of Chiridota, but scattered through the skin and never collected in wheel-papillæ.

This is a very natural and well-defined group, first set off by Ludwig ('92*b*) under the name Trochodota. Its geographical distribution is remarkable, for while one of the species occurs only at New Zealand, a second is found only about the southern end of the American continent and the third is confined to the Bay of Naples. The last is, however, such a small species and so difficult to find that its range may really be very much greater than is supposed.

Key to the Species of Trochodota.

A.—Wheels about 150-180 μ in diameter; sigmoid bodies normally with one end rolled inward, the other curved outward in a different plane, and neither end enlarged (plate VII, fig. 6).
 Wheels scattered all over the body; genital tube unbranched.......... PURPUREA
 Wheels confined to 3 dorsal interradii; genital tubes somewhat branched. DUNEDINENSIS

AA.—Wheels about 80 μ in diameter; sigmoid bodies not as above, often thickened at one end (plate VII, fig. 3) .... VENUSTA

Trochodota purpurea.

Holothuria (Fistularia) purpurea Lesson, 1830, p. 155; pl. 53, fig. 1.
Chirodota purpurea Jäger, 1833.
Chiridota purpurea Brandt, 1835.
Sigmodota purpurea Studer, 1876, p. 454 (partim).
Chirodota australiana Théel, 1886*a*, p. 16.

Chirodota studeri Lampert, 1889*b*, p. 849. Calcareous particles, pl. XXIV, fig. 12.
Trochodota studeri Ludwig, 1892*b*.
Sigmodota studeri Östergren, 1898*b*.
Trochodota purpurea Ludwig, 1898*b*, p. 83. Calcareous particles, pl. III, figs. 43-45.

Length.—Up to 40 mm.

Color.—Variable; yellowish, reddish, or brownish, more or less dusky or with red spots; Lesson gives the color in life as carmine-red to purple-red.

Distribution.—Reported from Falkland Islands (Lesson, Ludwig); Strait of Magellan (Lampert, Ludwig, R. Perrier); Lennox Island and Picton Island, south of Tierra del Fuego (Ludwig). Apparently occurs only around the Falkland Islands and the extreme southern parts of the American continent.

Remarks.—This species has been the source of much confusion, but Ludwig ('98*b*) seems to have straightened out the synonymy with great accuracy. It occurs commonly among the so-called "roots" of Laminaria and other algæ, but may perhaps also live in sand or mud, at depths of less than 20 m. The sigmoid bodies are scattered all over the body and lie at right angles to the longitudinal axis.

Trochodota dunedinensis.

Chirodota dunedinensis Parker, 1881, p. 418.
Chiridota dunedinensis Ludwig, 1892*b*.
Chirodota dunedinensis Dendy, 1897, p. 26. Calcareous particles, pl. III, figs. 1-8.
Trochodota dunedinensis Ludwig, 1898*b*.
Sigmodota dunedinensis Östergren, 1898*b*.

Length.—Up to 50 mm.

Color.—Pale yellowish; in life, with minute red spots.

Distribution.—Reported only from Otago Harbor, New Zealand (Parker, Dendy, Ludwig).

Remarks.—Parker speaks of dark spots on the inner side of the tentacles, which are not affected by alcohol, but neither Dendy nor Ludwig refer to them, and we can only surmise as to whether they are gustatory organs, such as Semon ('87) says occur in *venusta*. The habitat of this species appears to be like that of the preceding, among seaweeds, in shallow water. It appears to be rare, for the specimens examined by both Dendy and Ludwig were from the original lot collected by Parker, and so far as I can learn, no others have been collected. There can no longer be any question as to the complete distinctness of this species from *Tæniogyrus australianus*. Dendy and Ludwig have each intimated that the two species were probably identical, and I have for several years considered them so, but the material of *australianus* in the National Museum has shown the error of such a belief.

Trochodota venusta.

Plate VII, Figs. 1-4.

Chirodota venusta Semon, 1887, p. 276; pl. 9, figs. 1-2; pl. 10, figs. 8, 14, 15.
Trochodota venusta Ludwig, 1892*b*.
Sigmodota venusta Östergren, 1898*b*.

Length.—Up to 27 mm.

Color.—Nearly transparent, with a reddish tinge, due to very minute pigment-cells in the skin.

Distribution.—Reported only from the Bay of Naples (Semon).

Remarks.—This curious little species occurs among the roots of eel-grass and is apparently quite rare. Nothing is known of it beyond Semon's original account. He speaks of sensory-organs on the tentacles, but gives no details in regard to them.

SCOLIODOTA, gen. nov.

(σκολιὸς, crooked, + δοτός, granted, given; in reference to the crooked sigmoid bodies and to agree in termination with Chiridota.)

Tentacles 10. Digits 10 or more. Wheels wanting; calcareous particles sigmoid bodies only, commonly arranged in groups.

This is a monotypic genus, apparently quite closely related to Tæniogyrus, confined to the East Indian region, but ranging from Japan to Australia.

Scoliodota japonica.

Plate VII, Fig. 5.

Chirodota japonica von Marenzeller, 1881, p. 123.
Chirodota japonica Théel, 1886*a*, p. 17. Sigmoid bodies, pl. ii, fig. 3.
Anapta japonica Ludwig, 1892*b*.
Sigmodota japonica Östergren, 1898*b*.

Length.—More than 40 mm. (v. Marenzeller) and up to 170 mm. (Théel).

Color.—In life, blood-red (v. Marenzeller); in alcohol, whitish gray or pale brownish violet, with numerous small dark red or violet papillæ (Théel).

Distribution.—Reported only from Eno-sima, Japan (v. Marenzeller) and Port Jackson, Australia (Théel).

Remarks.—Théel says that his specimens were highly incomplete, and it is not impossible that they represent a species quite distinct from the Japanese one, although, so far as I can see from the specimens in the National Museum, they agree perfectly with v. Marenzeller's description. It is not at all likely that wheels are normally present in this species, but much more extensive material is necessary before the matter can be considered settled beyond question.

TOXODORA Verrill, 1882.

Tentacles 12. Digits numerous, 10–16. Wheels wanting; calcareous particles consist exclusively of "minute, slender plates in the shape of a bow or parenthesis with the ends incurved."

This is another monotypic genus. Its relationship with Chiridota is perfectly obvious, but wheels appear to be consistently wanting. The calcareous particles are very small, only about 60 μ in length, and closely resemble the C-shaped rods of *Chiridota rotifera*.

Toxodora ferruginea.

Toxodora ferruginea Verrill, 1882, p. 220.
Chirodota ferruginea Théel, 1886*a*.
Anapta ferruginea Ludwig, 1892*b*.
Sigmodota ferruginea Östergren, 1898*b*.

Length.—30 mm. or more, with a diameter of 5–10 mm.

Color.—Reddish brown, from the minute pigment-cells with which the skin is thickly filled.

Distribution.—Reported only from several stations south of Nantucket and Marthas Vineyard, in 140–280 m. (Verrill).

Remarks.—Thanks to the kindness of Professor Verrill and Miss Rathbun, I have had the opportunity of examining specimens of this interesting species. I find that the calcareous deposits are very much like the C-shaped particles of some species of Chiridota. But there is no indication that wheels are, or ever have been, present, and the species therefore cannot be placed in that genus.

ACHIRIDOTA, gen. nov.

(ἀ privative + *chiridota;* i. e., not chiridota.)

Tentacles peltato-digitate, 12. Digits small and rather numerous (6–8 pairs). Deposits entirely wanting. Polian vessel single, large. Calcareous ring well-developed.

This genus seems to be required for the following unique species, which bears the same relation to Chiridota that Anapta does to Leptosynapta and that Dactylapta does to Protankyra.

Achiridota inermis.

Anapta inermis Fisher, 1907, p. 730; pl. LXXIII, fig. 2, and pl. LXXXII, fig. 1.

Length.—About 100 mm.; greatest diameter, 14–20 mm.

Color.—Bleached grayish, profusely covered with small reddish-brown or yellowish-brown spots, most abundant anteriorly.

Distribution.—Hawaiian Islands, 466–772 m. (Fisher).

Remarks.—This singular species, of which Fisher had eleven specimens from seven stations, is very much like Chiridota in general appearance, but the single polian vessel and the entire absence of deposits separate it distinctly from that genus.

MYRIOTROCHINÆ Östergren, 1898*p*.

Tentacles digitate, much as in Chiridota, but weaker, with 2–8 digits on each side.[1] Cartilaginous ring, light-detecting and gustatory organs, and true ciliated funnels wanting. Polian vessel and stone-canal single. Calcareous deposits in the form of wheels, always with more than six spokes and never collected in wheel-papillæ. Other calcareous deposits very rare. Sexes separate. Size small. Distribution, arctic and subarctic, rarely north temperate.

This well-characterized little group has been made known to science almost exclusively through the efforts of the Scandinavian zoölogists—Danielssen, Koren, M. Sars, Théel, and Östergren—and to the last two in particular are we greatly indebted for careful and accurate work. All of the Myriotrochinæ are so small that they would be easily overlooked by careless workers, and as they occur in mud and sand, often at considerable depths, it is not strange that, with the exception of the largest and commonest species, very few specimens have been found. The group has for many years been supposed to consist of three monotypic genera, but the admirable work of Östergren has shown us that one of these genera contains at least four species. None of the terms used in the keys or descriptions require any explanation.

Key to the Genera of Myriotrochinæ.

A.—Wheels of only one kind, with 10-25 spokes.
Rim of the wheels with numerous large teeth projecting horizontally inward (plate VIII, figs. 17, 18, 19, 22) .... Myriotrochus
Rim of the wheel with scattered, somewhat pointed knobs, not projecting horizontally inward (plate VIII, fig. 13) .... Trochoderma
AA.—Wheels of two kinds, with 8-11 spokes (plate VIII, figs. 4 and 5) ...... Acanthotrochus

MYRIOTROCHUS Steenstrup, 1851.

Oligotrochus M. Sars, 1866.

Tentacles 10 or 12. Calcareous deposits consist of wheels with 10–25 spokes, and with numerous large, flat, sharp teeth projecting horizontally inward from the rim; these wheels vary greatly in size and in abundance, but all have the same general appearance. No other calcareous deposits in the skin and rarely in the tentacles.

Our knowledge of this genus has been revolutionized by Östergren's recent papers (:03, :05*a*, and :05*b*). Although two of the species have 10 tentacles and two have 12, it does not seem to be possible to divide the genus into two natural groups, either by that or any other character.

Key to the Species of Myriotrochus.

A.—Tentacles 12. Size moderate, 30 mm. or more.
Wheels numerous all over the dorsal surface, infrequent or wanting ventrally, 140-330 μ in diameter, with 12-25 (average about 17) spokes and 16-35 (average about 26) teeth (plate VIII, fig. 22) .... rinkii

[1] Figures 16 and 21, plate VIII, give very erroneous representations of the tentacles of Myriotrochus.

Wheels few, usually less than 30, confined to anterior and posterior parts of dorsal surface, 55-95 μ in diameter, with 11-16 spokes and 17-26 teeth (plate VIII, fig. 17). VITREUS

AA.—Tentacles 10. Size very small, less than 20 mm.

Calcareous rods present in tentacles; wheels of two sizes, with few intermediates, 55-80 μ and 100-150 μ, with 13-16 spokes and 18-26 teeth............. MINUTUS

No calcareous rods in tentacles; wheels 130-225 μ, with 12-15 spokes and 24-30 teeth. THÉELI

MYRIOTROCHUS RINKII.

PLATE VIII, FIGS. 21-22.

Myriotrochus rinkii Steenstrup, 1851, p. 55; pl. III, figs. 7-10.
Chiridota brevis Huxley, 1852, p. CCXI.
Myriotrochus rinkii Théel, 1877, p. 2; pl. I.

LENGTH.—40–65 mm., the diameter one-fourth or one-fifth as much.

COLOR.—In life, "half-transparent" and "red" like "*Synapta inhærens*" (Östergren); alcoholic material is whitish, yellowish, or greenish.

DISTRIBUTION.—Reported from numerous stations between Bering Sea on the west to about 71° E. long., north to at least 82° N. lat., and south (on the east coast of North America) to at least 45° N. lat., but on the Scandinavian coast not south of 70° N. lat.; also reported by Théel ('86*a*) from the northern coast of Asia, so that there is good reason to believe the species is really circumpolar. The bathymetric range is from 2 to 666 meters.

REMARKS.—Although this species has such an extensive range, it exhibits comparatively little variation. Östergren (:03), in his interesting account of this species, points out that in the most northerly specimens the number of spokes is 70–80 per cent of the teeth, while in southern examples it is only 54–60 per cent. (See antea, p. 30.) In high arctic regions this species is sometimes found in water only 2 or 3 m. deep; usually, however, from 5–100 m., and in the southern part of its range it occurs chiefly at depths of from 60 to more than 300 m. Nothing is recorded of its habits except Östergren's statement that it shows "only a little tendency to autotomy."

MYRIOTROCHUS VITREUS.

PLATE VIII, FIGS. 15-20.

Oligotrochus vitreus M. Sars, 1866, p. 200.
Myriotrochus rinkii Auct., 1877-1898, partim.
Myriotrochus vitreus Östergren, 1898*b*, 1903.

LENGTH.—Up to 60 mm.

COLOR.—Perfectly transparent in life, with sometimes a greenish or (near ends of body) reddish tinge; alcoholic specimens are less transparent.

DISTRIBUTION.—Reported only from coast of Norway, from Skäger Rack to Skraawem, in depths of 100–700 m. (Östergren).

Remarks.—Östergren (:03) appears to have clearly established the right of this species to recognition. In addition to the differences between it and the preceding species already mentioned, Östergren emphasizes the form of the longitudinal muscles, which are broad, flat, and thin in *vitreus,* even anteriorly, instead of narrow and much compressed anteriorly, as in *rinkii;* and the tendency of *vitreus* to autotomy.

Myriotrochus minutus.

Myriotrochus minutus Östergren, 1905*b*, p. cxciv, fig. I A.

Length.—6–10 mm.

Color.—Practically wanting; body-wall thin and nearly transparent.

Distribution.—Reported only from the coast of Korea, at a depth of 60–65 m. (Östergren).

Remarks.—This little synaptid is of special interest because of its having numerous supporting rods in the tentacles, in which it is unique in the subfamily; and its having the alimentary canal connected with the body-wall in a manner somewhat different from that of any other holothurian. Its geographical position is also unique, no other member of the subfamily occurring anywhere nearly so far south.

Myriotrochus théeli.

Myriotrochus théeli Östergren, 1905*a*, p. clix.

Length.—12–15 mm.

Color.—White, half transparent.

Distribution.—Reported only from northwest of Jan Mayen, 72° 42′ N. and 14° 49′ W., at a depth of about 2,000 m. (Östergren).

Remarks.—This interesting species is notable for the great depth at which it is found, showing that, like Acanthotrochus, it is a true deep-sea form. Only five specimens have been taken.

TROCHODERMA Théel, 1877.

Tentacles 10. Calcareous deposits consist exclusively of wheels with 10–16 spokes; the rim with scattered somewhat pointed knobs, but without teeth projecting horizontally inward. These wheels lie in the skin in so many layers as to make the body-wall quite firm.

This monotypic genus is easily recognized by the form of the wheels, which are quite different from those of any other synaptid.

TROCHODERMA ELEGANS.

PLATE VIII, FIGS. 7-14.

Trochoderma elegans Théel, 1877, p. 11; pl. II.

LENGTH.—10–15 mm.

COLOR.—Silvery white.

DISTRIBUTION.—Reported from Nova Zembla and Sea of Kara (Théel *et al.*).

REMARKS.—The geographical distribution of this species is somewhat doubtful, owing to the unfortunate error of Stuxberg (see Östergren :03, p. 16, footnote) in confusing *Myriotrochus rinkii* with it. It lives in comparatively shallow water, 9–220 m.

ACANTHOTHOCHUS Danielssen and Koren, 1879.

Tentacles 12. Calcareous deposits consist exclusively of wheels, but these are of two perfectly distinct kinds; of these the smaller usually have 11 spokes and 22 or more large inwardly directed teeth, as in Myriotrochus, while the larger usually have 8–10 spokes, and alternating with them 8 outwardly projecting spines.

This remarkable monotypic genus is still known only from the original specimens of its describers.

ACANTHOTROCHUS MIRABILIS.

PLATE VIII, FIGS. 1-6.

Acanthotrochus mirabilis Danielssen and Koren, 1879, p. 115; also 1882, p. 35, pl. VI.

LENGTH.—10–12 mm.

COLOR.—Wanting; skin nearly transparent, "with glittering points."

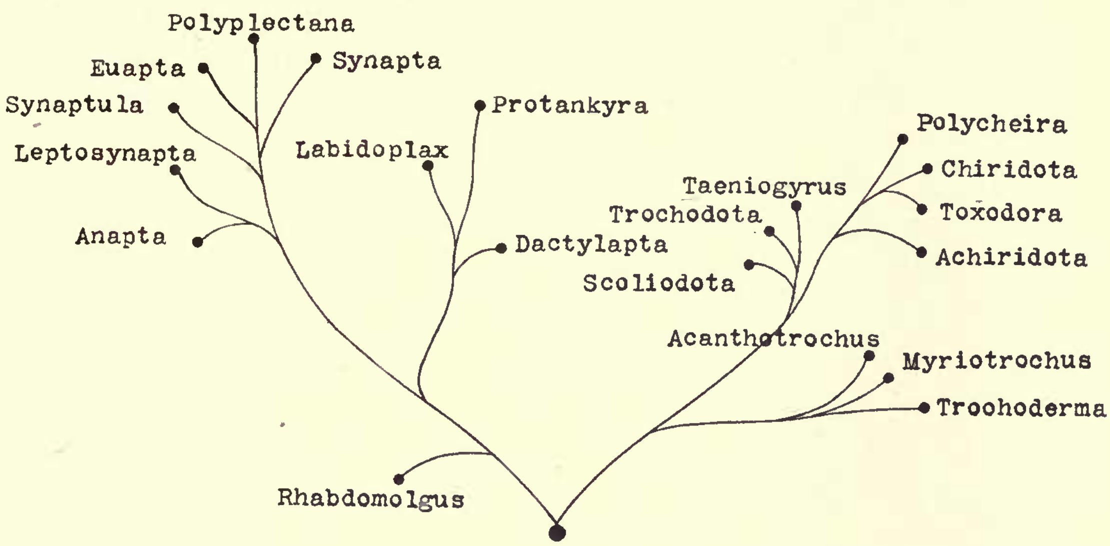
DISTRIBUTION.—Reported only from between Spitzbergen and Norway, in 1,203–2,030 m. (Danielssen and Koren).

REMARKS.—Nothing further is known of this interesting species beyond the descriptions and figures of Danielssen and Koren.

CONCLUDING REMARKS ON THE SYNAPTIDÆ.

INTERRELATIONSHIPS.

Having thus characterized the 21 genera and 88 species of Synaptidæ known to science at the present day, it may be of interest to attempt to show in graphic form the relationship which they seem to have to each other. There is every reason to believe that the ancestor of the group was a small 10-tentacled apodous holothurian, and there is some reason for believing that the earliest well-formed calcareous particles were wheel-shaped, for such particles are the first to appear in the auricularia of Labidoplax (see Semon, '88). In the face of such knowledge of echinoderm embryology as we have, we can hardly believe that such a condition as occurs in Rhabdomolgus, the entire absence of calcareous particles, is to be regarded as ancestral. Whether the tentacles of the earliest synaptids were digitate or pinnate cannot be positively determined; the earliest tentacles of the Synaptidæ with pinnate tentacles (see Clark, '98*a*) are simple and then pinnate, and of the Chiridotinæ (see Ludwig, '98*b*) are digitate almost from the start; in Labidoplax, however (see Semon, '88), the tentacles are simple before becoming digitate. On the whole, it seems probable that the earliest synaptids had 10 simple tentacles and a few more or less wheel-shaped deposits. From this form have diverged two quite distinct branches, one losing the wheels and developing anchors, the other developing various forms of wheels. The interrelationships of the genera might then be represented as follows:



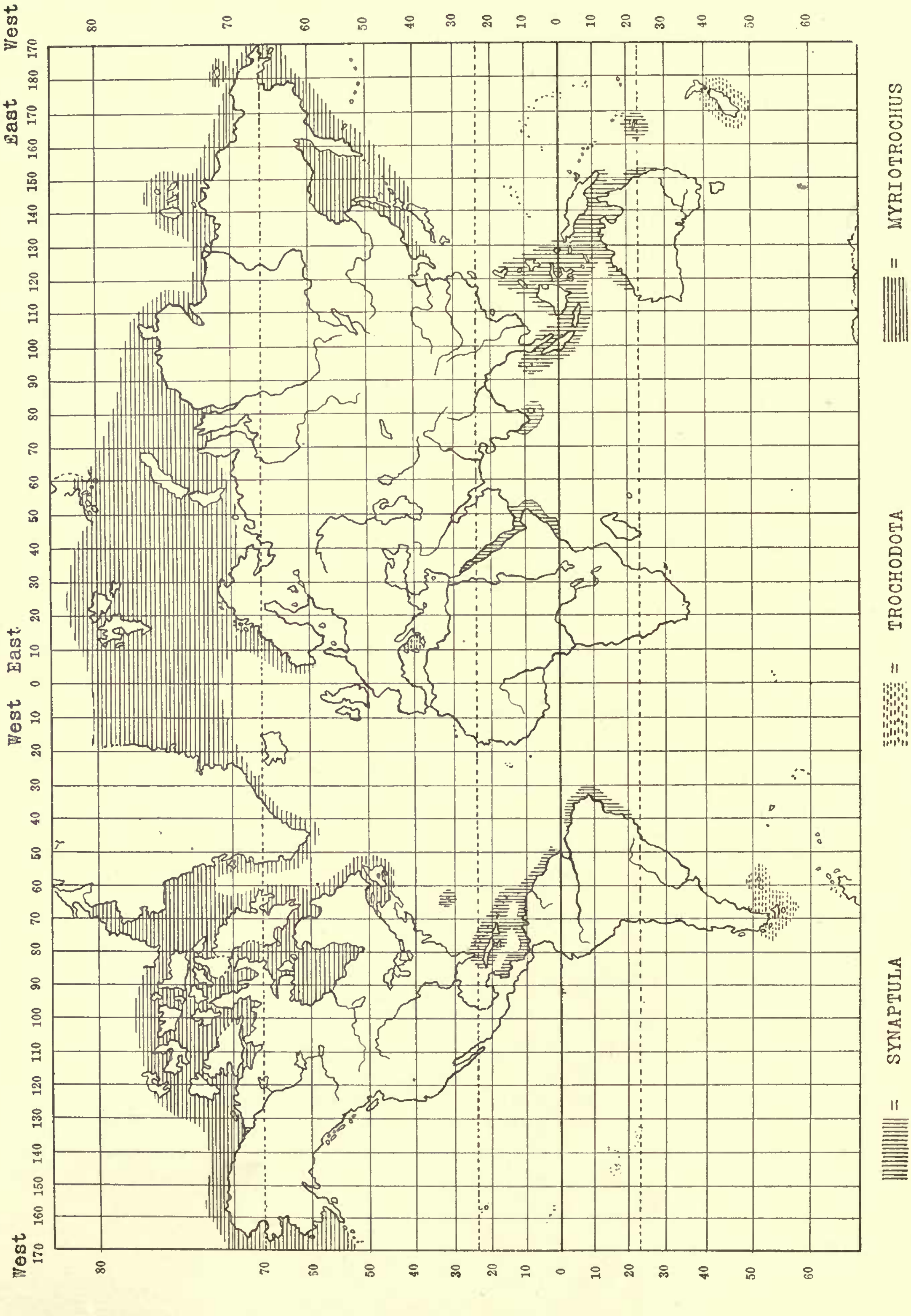
10-tentacled

Ancestral Form

It will appear then that Rhabdomolgus is the nearest living representative of the ancestral stock, though not necessarily close to it, while Polyplectana, Protankyra, Polycheira, and Acanthotrochus are the most highly specialized forms of their respective branches.

Geographical Distribution.

In considering the distribution of the foregoing genera and species we may well consider simply the littoral regions proposed by Ortmann (*Grundzüge der Marinen Thiergeographie,* 1869), so few of the Synaptidæ are truly abyssal forms and these almost exclusively of the genus Protankyra. We are at once struck by the fact that the Indo-Pacific region is easily the most important geographical area for synaptids, no less than fifteen genera having representatives there, and ten of these (six monotypic, however) may be considered as distinctly Indo-Pacific genera. The Atlantic Boreal subregion has repre-



Map Showing the Distribution of Three Genera of Synaptidae.

sentatives of seven genera, of which four (two monotypic) are really characteristic. The Arctic region is characterized by the three genera (two monotypic) of Myriotrochinæ, and three other genera are represented there. The Antarctic region has two characteristic genera, while four other genera occur there. No synaptids are known from the West American region or the Guinea subregion, and there are no characteristic genera in the East American region nor in either the Mediterranean or Pacific Boreal subregions. One genus, Chiridota, cannot be considered characteristic of any single region; of all synaptid genera it is the most truly cosmopolitan. As regards the abyssal region (over 1,000 m.), Protankyra, Chiridota, Myriotrochus, and Acanthotrochus are represented there, but the two latter are characteristically Arctic forms and only extend a little way into the Boreal subregions, so that we are justified in saying that the only truly abyssal Synaptids known are a few species of Protankyra and Chiridota. The following table will show these facts of distribution in a convenient way. The * indicates that the genus is characteristic of the region, ** that it is not found elsewhere, and the figures in parentheses indicate the number of species occurring in that region.

Indo-Pacific Littoral Region:
- Euapta (1).
- ** Opheodesoma (4).
- ** Polyplectana (1).
- ** Synapta (1).
- * Synaptula (7).
- * Protankyra (17).
- * Anapta (2).
- ** Dactylapta (1).
- ** Polycheira (1).
- ** Achiridota (1).
- ** Scoliodota (1).
- Chiridota (6).
- Leptosynapta (1).
- Labidoplax (1).
- Tæniogyrus (1).

Antarctic Littoral Region:
- * Tæniogyrus (2).
- * Trochodota (2).
- Leptosynapta (1).
- Anapta (1).
- Chiridota (3).
- Scoliodota (1).

Atlantic Boreal Subregion:
- * Leptosynapta (7).
- * Labidoplax (4).
- ** Rhabdomolgus (1).

Atlantic Boreal Subregion (continued):
- ** Toxodora (1).
- Protankyra (1).
- Chiridota (1).
- Myriotrochus (2).

Arctic Circumpolar Subregion:
- * Myriotrochus (2).
- ** Trochoderma (1).
- ** Acanthotrochus (1).
- Leptosynapta (1).
- Labidoplax (1).
- Chiridota (2).

Pacific Boreal Subregion:
- Leptosynapta (1).
- Chiridota (1).
- Myriotrochus (1).

East American Littoral Region:
- Euapta (1).
- Synaptula (1).
- Leptosynapta (3).
- Chiridota (1).

Mediterranean Subregion:
- Leptosynapta (2).
- Labidoplax (2).
- Trochodota (1).

Abyssal Region:
- Protankyra (7).
- Chiridota (2).

We know too little about the range of the great majority of the species to attempt any study of geographical distribution more in detail; but it is interesting to note the striking difference between the Arctic and Antarctic faunas, for, excepting *Chiridota lævis* and *Leptosynapta inhærens,* both of which are very wide-ranging and very poorly delimited, none of the 25 species occurring in the Arctic and Boreal subregions have any near relatives in the Antarctic region, and the 10 species occurring in the latter region are, with one or two possible exceptions, entirely confined within its limits. Moreover, the northern regions have five very characteristic genera, entirely unrepresented south of the equator, while the southern fauna possesses two characteristic genera, each of which seems to have only an aberrant member north of the equator. It is difficult to reconcile these facts with any rational "theory of bipolarity."

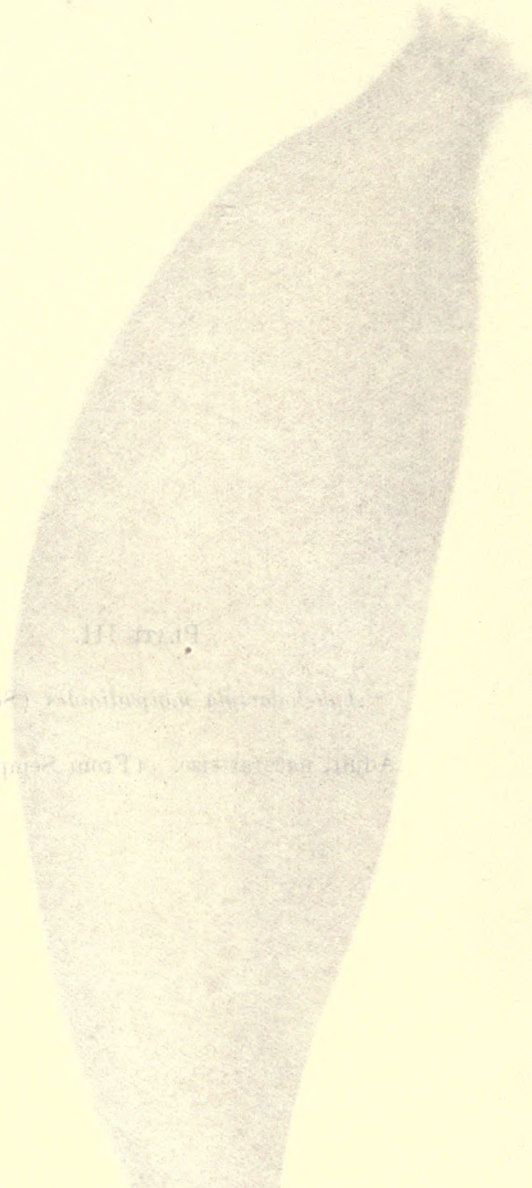
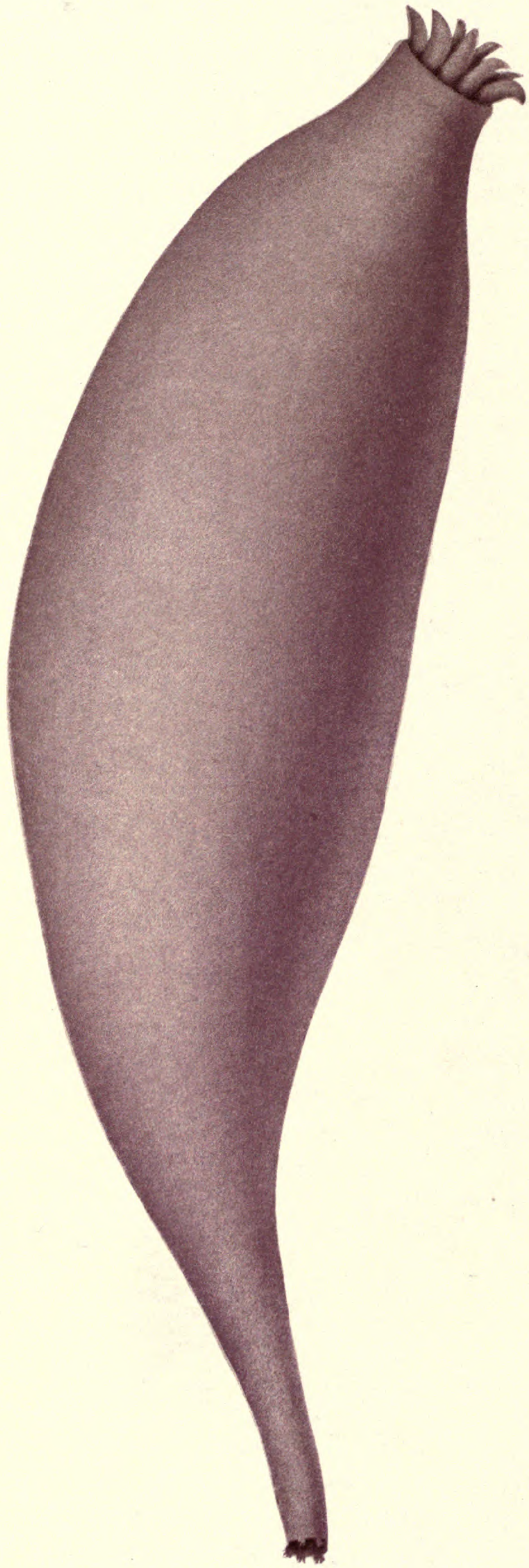


PLATE III.

Aphelodactyla molpadioides (Semper).

Adult, natural size. (From Semper, 1868.)



Aphelodactyla molpadioides (Semper)

PART IV.

THE MOLPADIIDÆ.

Order ACTINOPODA Ludwig.

External appendages of the water-vascular system arise only from the well-devoloped radial canals.

Family MOLPADIIDÆ, J. Müller.

More or less elongated, rather stout holothurians, with an anterior, flat, circular oral disc and generally tapering posteriorly into a more or less evident caudal portion; with well developed respiratory trees, but with water-vascular system greatly reduced; 15 (in only one species, 10) circumoral tentacles, simple or digitate, usually with conspicuous ampullæ, are present; radial water vessels are present, but, except for a few very rudimentary papillæ at their posterior termination, they are rarely associated with any outgrowths of the body-surface; circular muscles are interrupted at each radius, and each radial longitudinal muscle usually consists of two parallel bands; no special sense-organs are present, nor are there ciliated funnels on the mesenteries or wall of the body cavity; calcareous deposits, commonly in the form of tables, fusiform rods, or perforated plates, usually present; anchors sometimes occur, but wheels and sigmoid bodies do not; phosphatic deposits (see page 143) often present.

Morphology.[1]

Form and size.—The body is generally of considerable diameter in proportion to its length, the ratio ranging from nearly equal in some young specimens to about 1:10 in some old and fully extended individuals; excluding the caudal appendage, the length is not often more than three or four times the diameter, although of course much depends on the amount of contraction. The caudal appendage is commonly quite evident (see Plates IX, X, XI, XIII), but is entirely wanting in Acaudina and is more or less indistinct in several species of other genera. It is commonly from one-twelfth to one-third of the total length, but may be more than one-half in Caudina and rarely so in Molpadia. The largest member of the family is apparently *Aphelodactyla molpadioides* (Plate III), which is sometimes 210 mm. long and correspondingly stout; *Caudina arenata* undoubtedly reaches a greater length, perhaps 250 mm. when fully

[1] In the preparation of this section I am particularly indebted to Gerould's admirable report on *Caudina arenata* (1896), which has never been surpassed as a study of holothurian morphology.

extended, but is much more slender. The smallest species (*Eupyrgus pacificus*) is only 6 or 7 mm. long, but the diameter is one-half as much. The great majority of the species, however, approach the maximum rather than the minimum extreme, and few Molpadids, when fully mature and normally extended, are less than 50 mm. long.

Color.—The usual ground color in this family is pale gray, which may be unmarked and even untinted, but is usually shaded with brown, dull red or rosy, and is often spotted or blotched with red, brown, or purple of some shade. The ultimate color effect depends in most cases on the degree of development of the deposits in the skin, for the occurrence of real pigment is unusual. In Acaudina, however, the color is very dark, although there are no colored deposits, and in some species of Molpadia a purple, or less commonly an orange or a brown, pigment is present, which more or less considerably modifies the color. The excessive development of calcareous deposits in a thin skin may give rise to an almost pure white surface, while a similar excessive development of the phosphatic deposits (see p. 143) may make the surface appear deep red, purple, brown, or nearly black; in these latter cases the oral disc and tail are almost always white by contrast. All intergradations occur, even in a single species, between very light color and very dark; in such cases there is reason to believe the older the individual the darker it becomes. Except Acaudina, species lacking phosphatic deposits are seldom dark or noticeably colored, but occasionally a species is met with which has a distinct color. Such, for example, is *Aphelodactyla molpadioides* (Plate III), which Semper figures of a uniform purplish red, and its near relative *A. punctata,* which is blotched with orange. The color is seldom different dorsally from what it is ventrally, but occasionally the upper side is darker. It is not unusual for the anterior end to be more heavily blotched and shaded than is the posterior portion of the animal. The colors seem to be little affected by alcohol or other preserving fluids, except that rosy shades are commonly lost, and the reds, browns, and purples are deepened. The body-wall may be quite thin and translucent, and then the longitudinal muscles show as five deeper bands; but alcohol makes it opaque, and the longitudinal muscles may then be concealed, though their position is usually indicated by the furrows in the body-surface, caused by the contraction of the transverse muscles.

Body-surface.—The surface of the body in the Molpadiidæ is often quite rough, on account of the calcareous deposits in the skin, but where these are inconspicuous or lacking, the surface is commonly smooth and may be even slimy. Verrucæ, such as occur in the Synaptidæ, and pedicels and papillæ are practically unknown. Very rarely, long, slender papillæ occur in the mid-dorsal interambulacrum and hardly more common is it for rudimentary pedicels to occur near the ends of the body. Gland cells occur in the skin, most commonly on the anterior part of the body, and especially on the tentacles, but in only a few cases are they abundant enough to make the surface very slimy. The mucus is, however, frequently abundant enough to cause sand and mud to adhere, and if such individuals are placed in alcohol the mucus is hardened and the mud and sand then persist. In a few cases the calcareous deposits are abundant enough to make the body-wall very firm and even brittle, while in other cases the abundance of phosphatic deposits gives considerable rigidity. In the latter case, however, the surface is quite smooth. As a rule, the skin is much thinner and rougher in the young than in adults, and in some species the young may have a thin and very rough skin, while the fully mature specimen is perfectly smooth and has quite a thick skin.

Tentacles.—The number of tentacles in the Molpadiidæ is almost invariably 15 (Plate X, fig. 2), except in the singular genus Ceraplectana, in which there are only 10 (Plate XIII, fig. 6). Of course individuals are occasionally met with which have 14, and much more rarely one sees a specimen with 16. In Ceraplectana there are two tentacles in each interradius, while in all other cases, so far as known, there are not three in each interradius, as might be supposed, but four in the mid-dorsal interradius, three in each of the latero-dorsal interradii, three in one of the ventral interradii, and two in the other. Whether it is the right or left ventral interradius which has three tentacles seems to depend on the individual. The tentacles are always relatively short and rather stout. They are simple and undivided in some species (Plate XII, fig. 22), and are then usually soft and flexible, but may be firm and horny. Most commonly there is a single short digit on each side, near the tip, so that there are apparently three digits with the terminal one largest; occasionally there are two or even, in very large specimens, three digits on each side, those nearest the base being the smallest. In other cases the tentacles bear two pairs of digits of approximately equal size, so arranged that one pair is at the tip, closely followed by the other; there is then no terminal unpaired digit (Plate X, fig. 2). In some cases the terminal pair is distinctly larger than the second, but more commonly if one pair is larger it is the latter. The tentacles are of equal size, though of course they need not always be equally extended in a living, or equally contracted in a preserved specimen. They are hollow, containing as they do the tentacular canals of the water-vascular system. These canals pass directly into the digits, extending to their tips. The wall of the tentacle is made up of a thin cutis overlying a layer of columnar epithelium, beneath which is a thin connective tissue layer, which does not normally contain calcareous deposits. The cavity of the tentacle is lined with an epithelium, and between it and the connective tissue is a layer of longitudinal muscle fibers. Circular muscles are probably not present, although they are said to occur in Molpadia. Exterior to the muscles, on the inner side of the tentacle, is a layer of nervous tissue.

The external epithelium is thickest on the digits, where it may be more than twice as thick as it is on the body; it contains both nerve and gland cells. Tentacle ampullæ are commonly, but not always, present.

Sense-organs.—The only structures in the Molpadiidæ which can be called sense-organs are the tentacles, which are undoubtedly important organs of touch, except possibly in Ceraplectana. The immediate seat of tactile sensations is in sensory nerve cells, which are scattered all through the covering epithelium of the body. They are considerably elongated, and the inner end is probably directly continuous with a nerve fiber; the outer end, however, is not ciliated or peculiar in any way. They are most abundant in the digits, where they are collected into groups forming very simple and primitive "sense-buds" or touch-papillæ.

Nervous system.—The nervous system of a Molpadid is not essentially different from that of any other holothurian. It consists of the customary circumoral ring, flattened antero-posteriorly so as to be from two to five times as wide as deep, five radial longitudinal nerve trunks, 15 tentacle nerves, and 10 bucco-pharyngeal nerves. The circumoral ring is about one-fourth of a mm. in width and one-twentieth to one-tenth in thickness, and lies beneath a connective tissue layer immediately internal to the base of the tentacles. On its inner face there is a deep, narrow furrow. It consists of delicate fibers interspersed with numerous ganglion cells, which are much more abundant than in the radial nerves; the ring is covered on its anterior and inner sides by an evident epithelial layer, the nuclei of which are small and deep-staining and apparently are associated with a non-nervous supporting tissue, fibers of which run among the nerve fibers but across the nerves. The radial nerves consist of two parts, a thick outer band, crescentic in cross-section, and a thin, inner band, closely appressed to the outer, separated only by a thin layer of connective tissue. This inner band shows a median longitudinal furrow throughout most of its length, and anteriorly divides into two branches, which subdivide and innervate the neighboring muscles, both longitudinal and transverse, and thus disappears; posteriorly it terminates in a slight enlargement. The outer band runs backward to the termination of the radius beside the cloacal opening. The muscles, both transverse and longitudinal, are apparently innervated by branches from the inner band, while the outer band chiefly supplies the integument. Both bands send nerves to the rudimentary pedicels at the ends of the ambulacra. The histological structure of the bands is similar to that of the circumoral ring. The tentacle nerves arise from the posterior outer portion of the circumoral ring and run upward on the inner face of the tentacles, forming a wide sheet, thickest mesially, near its base, and diminishing in width and thickness as it passes upward. Its histological structure is similar to that of the radial nerves. It gives off solid branches of fibers running directly to the touch-papillæ and isolated fibers running to single neuro-epithelial cells. The bucco-pharyngeal nerves run radially inward from the nerve ring to the buccal sphincter muscle and then turn backward along the pharynx; they consist simply of nerve-fibers, among which are interspersed ganglion cells; they innervate the oral disc and the pharynx, both muscles and epithelia. The arrangement of the bucco-pharyngeal nerves in the interradii corresponds remarkably to the number of tentacles; there is in any given interradius one less bucco-pharyngeal nerve than the number of tentacles; thus the mid-dorsal interradius has three bucco-pharyngeal nerves, while one of the ventral interradii has only one. Each radial nerve is accompanied on its inner side by a tube-like cavity closed at both ends, called the *hyponeural canal.* A similar space exists on the outer side of the radial, on the upper and inner sides of the circumoral, and on the inner side of the tentacle nerves, and these are known as the *epineural canals.* These canals are lined, at least on the sides away from the nerves, by a very thin epithelium, and are believed by Gerould ('96) (and Greeff, '72, and Herouard, '89) to be normal structures, though other investigators believe them to be artefacts.

Body-wall.—The body-wall of the Molpadids is very variable in thickness, according to the amount of connective tissue it contains. While frequently very thin and translucent, it is in some species remarkably thick, and in old specimens may measure several millimeters in a cross-section. It consists of five parts, as in the Synaptidæ: a cutis and a layer of epithelial cells which with the cutis make up the epidermis; a layer of connective tissue in which lie the calcareous bodies, pigment, etc.; a layer of transverse muscles; in the radii the longitudinal muscles; and an inner epithelium, which lines the body-cavity.

1. *Epidermis.*—The cutis is a thin, transparent structureless layer secreted by the epithelial cells and exhibiting no special peculiarities. The epithelial cells are of the same three sorts which occur in synaptids, ordinary supporting cells, sensory cells, and gland cells. The former are the most abundant and really make up the epidermis; they are vertically elongated, polygonal cells, which taper into a point at the inner end, so that they extend into the connective tissue layer, and thus no sharp line of division between the latter and the epidermis appears. On the digits of the tentacles these epidermal cells are as much as 50 μ in vertical length, but on the anterior part of the body they are only 20 μ, and posteriorly still less. The sensory and gland cells are scattered irregularly in the epidermis, but are much more abundant anteriorly and especially on the tentacles. The former are usually isolated and the inner end tapers into a fiber connected with a ganglion cell lying in the connective-tissue layer; the outer end may taper to a point or not. In the tentacles these sensory cells are associated in groups, forming the touch-papillæ to which reference has already been made. The gland cells are of the kind known as tubular and always occur singly.

2. The *connective-tissue layer* makes up the greater part of the wall, although, as already stated, its thickness varies greatly. Apparently it increases with age. It is thinnest anteriorly, just behind the tentacles, but becomes rapidly thicker, reaching its maximum near the middle of the body and becoming thinner again posteriorly. As in the Synaptidæ, it is made up of fibrous prolongations of bipolar or stellate cells, lying embedded in a homogeneous matrix. As fibers are very abundant, however, while the cells are rather infrequent, it is possible that many of the fibers have no cellular connections. Superficially the fibers are more or less entwined among the calcareous bodies, and so run in all directions; but in the deeper parts of the layer they run more or less parallel to the body surface. The *wandering-cells,* which stain readily with eosin (in Molpadia), but do not take carmine, are scattered in some numbers in the connective-tissue layer and among the epidermal cells. They consist of a mass of highly refractive spherules imbedded with a nucleus in a small quantity of hyaline protoplasm. The shape, as is usual with amœboid cells, is very variable. There are also *pigment-cells* in the conective-tissue layer of some Molpadids, although they are more commonly wanting. They are more or less irregular cells, with numerous fine branches, and contain a coloring matter, most commonly purple or brown, but sometimes reddish, orange, or yellowish. They are often aggregated in certain areas, thus giving rise to spots and blotches of color. In most cases the pigment is not affected by pure alcohol.

The *calcareous deposits* of the body-wall occur in the connective tissue and are only wholly wanting in a few cases. They are most abundant posteriorly, and are often present near the cloacal opening when they are not to be found elsewhere. They are formed by special mesenchyme cells, consist of almost pure carbonate of lime, and first appear as simple rods or X-shaped particles, which by continual growth and more or less regular dichotomous branching give rise to the various kinds of deposits characteristic of the different genera and species. They exhibit a very great variety of form and are accordingly difficult to classify, but we may for convenience group them under five heads: tables, shallow closed cups, perforated plates, fusiform bodies, and anchors. Commonly only one or two of these kinds occur in a single individual or species, but some specimens of Molpadia exhibit all but the second. The *tables* (Plates XI, figs. 9–11; XII, figs. 23–25, 28, 29; XIII, figs. 15–16) exhibit the greatest possible variety of form and are often so irregular and grotesque as to be quite unworthy of their name. In their simplest condition they consist of a ring (forming the disc) from which three or four vertical rods arise, more or less connected with each other by cross-bars (forming the spire), but in some cases the ring is itself incomplete and distorted, and there may be only a rudimentary spire. More commonly the disc is a somewhat circular plate with 4–12 perforations, usually symmetrically arranged and bearing a spire made up of three or four vertical rods more or less closely united by cross-bars. The tables are usually rather small, the diameter of the disc ranging from 60 to 300 μ; the spire is usually about equal to the diameter of the disc, but may be much more. In the discs of some of the largest and most perfect tables there may be as many as 70 perforations. The *shallow, closed cups* (Plate IX, figs. 4, 5, 11, 12, 13) are the least common form of deposits, occurring only in certain species of Caudina. They consist of a strongly concave plate through which are four large, symmetrically placed, equal and similar perforations. A conspicuous cross-shaped piece is so placed in the mouth of this shallow cup that each arm of the cross is immediately over the middle portion of each perforation. The margin of the cup is usually more or less octagonal, and there are often rounded knobs present at the end of each arm of the cross and half way between. When fully and normally developed, these bodies are the most symmetrical and ornamental deposits occurring among the Molpadiidæ, but they are often only partially developed, or they may be hypertrophied, especially in the caudal region. The relative thickness of the cross-arms and the margin of the cup, as compared with the diameter of the perforations, is very variable. The *perforated plates* (Plates IX, figs. 3, 8; X, fig. 4; XII, figs. 2, 5–12, 14) exhibit the greatest diversity in form and appearance; they may be nearly circular, or more or less triangular or square, or they may have one or more conspicuous projections (''arms'' or ''handles''), which may be perforated like the plate itself, or not. When a single handle is present, we have what are called ''racquet-shaped rods,'' and these are generally arranged in groups, called ''rosettes,'' with the large, perforated ends more or less overlying one another at the center. The surface of perforated plates may be provided with stout thorns or irregular projections, usually sharp, but it is commonly quite smooth. The perforations may be few and very small or more numerous and larger; commonly there are from 10–50, but there may be 60 or 70. The size of the plates is quite variable, but their greatest diameter is commonly from 100–400 μ, not including any handle. The *fusiform bodies* or *rods* (Plate XI, figs. 6–8, 13) in their typical form are elongated, rounded particles, with more or less attenuated but blunt ends, slightly flattened and enlarged at the middle and with three or four small perforations in the center of the flattened part. They lie at right angles to the long axis of the body and are often so abundant as to form a more or less distinct layer; they are most likely to be present in the extreme posterior part of the body. On the one hand they pass into the tables by the development of a spire, the enlargement of the flattened area, and the disappearance of the attenuate ends (Plate XI, fig. 12), and intermediate particles in all stages of development are often found. On the other hand they may become flattened and perforated at the ends, and thus pass by gradual transitions into the perforated plates; such intermediate forms are very common.

The *anchors* (Plates X, fig. 8; XII, fig. 5) occur only in the genus Molpadia, in some species of which they occur throughout life, while in others they are present only in youth, and in still others they are apparently never present. They were formerly supposed to be characteristic of a genus "Ankyroderma." They differ essentially from the anchors of the Synaptidæ, and their presence has no bearing whatever on the question of the relationship of that family with the Molpadiidæ. Although in a few species anchors are present in connection with a single perforated plate, in most species where they occur at all they are associated with a rosette of racquet-shaped, perforated plates, the number of which varies from three to eight in each rosette. The anchors lie at nearly right angles to the plates, though they are of course capable of movement, and ordinarily they stand out evidently from the body-surface. The attached end is never flattened and branched or serrate, as in the Synaptidæ, but is enlarged and circular in outline and perforated with several holes, the number and arrangement of which is quite variable. The free end of the anchor is provided with two (rarely three or four) arms, which are coarsely serrate with from two to six teeth. Commonly the anchors are broken off by the rough treatment the animal receives in a dredge or trawl, and the basal parts are then likely to be mistaken for peculiar cups or tables.

Besides the various sorts of calcareous bodies just described, the connective tissue of Molpadids often contains peculiar spheroidal, ovoidal, or ellipsoidal bodies, 10–100 μ, more or less, in diameter, of a characteristic yellow, brown, or red color (Plate XI, fig. 14). The color varies greatly in different individuals, but is apparently lightest in youth and darkest in old age. It first appears as a pale brownish-yellow shade, becomes more and more abundant. For many years the chemical nature of these deposits was unknown and they have commonly been called the "colored bodies," "red bodies," "wine-red bodies," or "colored calcareous bodies;" but as there was reason to think they were not calcareous, the latter name has been little used. These bodies first appear as mere spherical granules, but increase in size by the continued deposit of similar material in concentric layers, and this concentric structure is usually obvious. Oftentimes two, or even three, of these granules become enclosed ultimately in a common layer, so that the colored body seems to have been formed around two (or three) centers simultaneously. One of the remarkable things about these deposits is that they may be formed through the change of calcareous particles. (See Plate XII, figs. 10–12.) Various writers (Théel, '86*a*; Ludwig, '94; Koehler and Vaney, :05, *et al.*) have noted the gradual coloring of a calcareous deposit and its ultimate disappearance into small groups of "colored bodies." There is no doubt that the number of "colored bodies" increases with the age of the individual, and there is good reason to believe that in many cases at least such increase is accompanied by a constant decrease in the calcareous bodies. (See antea, p. 19.) In young specimens the colored bodies, even if not wholly wanting, are often so small and few that they cannot be seen without magnification; but as the animal grows they become more numerous, are collected together in groups and patches, and appear to the unaided eye as spots or blotches of various shades. In still older specimens these blotches tend to merge together, and gradually the entire body-surface may become a uniform deep purplish red, red brown, or even almost black. If calcareous deposits still persist, they will be found normally outside the deeper-lying "colored bodies." In 1901 Mr. W. L. Sperry, then of Olivet College, kindly undertook for me a chemical examination of these colored bodies, making use of specimens of *M. oölitica, intermedia,* and *musculus.* Just after he had gone far enough to prove that the chemical elements involved were chiefly phosphoric acid and iron, Mörner's (:02) paper appeared with an account of his similar investigations. Mr. Sperry continued his work far enough to confirm Mörner's analyses; so that the composition of these remarkable "colored bodies" may be considered as settled. Mörner gives the result of his analysis as $FePO_3+4\ H_2O=66.2$, $Fe(OH)_3=20.2$ and $CaCO_3=6.4$. Mr. Sperry's analysis differed from this only in a few details, the most interesting of which was the probable presence of Mg. There is also reason to believe that the amount of $CaCO_3$ is subject to much variation; probably when calcareous particles are first transformed into the colored bodies, $CaCO_3$ is the most important substance present, and as the color deepens, it decreases rapidly in amount. Apparently the calcium as well as the CO_2 is excreted as these changes take place. In view of their remarkable composition, we are justified in referring to the "colored bodies" as "PHOSPHATIC DEPOSITS," in distinction from the "calcareous deposits" so characteristic of holothurians. The presence of phosphatic deposits is limited among Echinoderms, so far as is now known, to about 20 species of Molpadids, all but two of which belong to the genus Molpadia. The "round" spicules with a "radiate" appearance, described and figured by Danielssen and Koren ('82) in connection with their account of *Trochostoma thomsonii,* have not been met with by other investigators, and Théel ('86*a*) is doubtless correct in considering them as artifacts.

3. The *transverse muscles* lie just beneath or within the connective-tissue layer, and, unlike the arrangement in the Synaptidæ, are confined for the most part to the interradial areas. The fibers are inserted in the connective tissue a little to the side of each radius, and may be so few that when the animal is extended they do not form a continuous layer. Just behind the tentacles they are more numerous, and are continuous across the radii, thus forming a circular muscle which serves as a sort of anterior sphincter when the tentacles and oral disc are retracted. In Caudina and Aphelodactyla, and probably in all Molpadids where the connective-tissue layer is sufficiently thick, there run out into

that layer, from the transverse muscles, irregularly scattered tubules made up of muscle fibers arranged in the form of a hollow cylinder. While it is not impossible that these are the last vestiges of the ambulacral vessels, such a view seems very doubtful, as the tubules are never connected with the radial water-vessels, but always with the transverse muscle. Gerould ('96) thinks that they serve to support the transverse muscles and to unite more firmly the various parts of the integument. Semper ('68) mistook them for rudimentary ambulacral vessels, and Danielssen and Koren ('82) and Sluiter ('80) have apparently fallen into a similar error; yet it should be added that Gerould failed to find similar tubules in the skin of either *Molpadia antarctica* or *Ankyroderma jeffreysii* (*M. oölitica* juv. ?); both of these species, however, have a very thin skin.

4. The *radial longitudinal muscles* are arranged in pairs in most of the Molpadiidæ, but in Eupyrgus and Himasthlephora they form a single band, as in the Synaptidæ. (See Plates XII, fig. 27, and XIII, fig. 4.) They lie on each side of the radial water-vessel, but anteriorly the interradial edges of each pair of muscles curve inward until they meet, while the adradial edges also merge together just beneath or inside the radial vessel, and thus the two muscles form a single hollow tube, which loses its lumen where it is attached to the radial plate of the calcareous ring. This single muscle band may be of considerable length and more or less laterally compressed; the connection between the edge attached to the body-wall and the edge extending into the body-cavity may be reduced to a mere sheet of connective tissue (see Perrier, :04*a* and :05) or may even be severed entirely. As the inner portion is connected with the calcareous ring, we should have in the latter case what have been called *retractor* muscles. But the formation of such retractors appears to be a very uncommon, if not an altogether exceptional, event, possibly only occurring in certain individuals, perhaps very old ones, and the presence or absence of such retractors cannot be considered as having any value in taxonomy. Moreover, when strongly contracted the ordinary longitudinal muscles may appear as though they were special retractors, and in such cases the presence or absence of "retractor muscles" becomes a matter of personal opinion of the investigator. Posteriorly the muscles of each radial pair become semicylindrical trunks which may simply lie side by side or actually coalesce. They finally terminate in the connective tissue about the cloacal opening.

5. The *inner epithelium* is the innermost layer of the body-wall, and consists of flat, polygonal cells, which are everywhere provided with cilia.

Body-cavity.—The body-cavity of the Molpadiidæ is very capacious and shows no particular peculiarities. In those forms which have a caudal appendage the body-cavity within that appendage is generally reduced, and is nearly filled up by the strands of muscular and connective tissue connecting the alimentary canal and the body-wall. So far as known, the body-cavity is never in normal communication with the outside, but it is connected through the madrepore body and stone-canal with the water-vascular system, and the fluid with which it is filled is probably not essentially different from that in the water-vessels.

Calcareous ring.—The calcareous ring in the Molpadiidæ is as a rule very well developed and in the great majority of cases is remarkably wide, the radial pieces (except in Eupyrgus (Plate XII, fig. 19), Himasthlephora (Plate XIII, fig. 2) and Gephyrothuria) being provided with conspicuous bifurcate posterior prolongations (Plate XII, fig. 3). So far as known, there are always five radial and five interradial pieces which make up the ring, the latter being much the smaller. The supposed exceptions in "*Embolus pauper*" and "*Liosoma arenicola*" are obviously based on mutilated or imperfect specimens, or else on hasty or careless examination. There is usually no appreciable asymmetry in the ring, though occasionally the ventral half is somewhat better developed than the dorsal. The interradial pieces are much smaller than the radial, are symmetrical, slightly concave behind, and have a single median point in front; on each side of this point the plate is a little flattened or hollowed for the reception of a tentacle ampulla or the attachment of the basal part of the tentacle canal. The radial pieces are perfectly symmetrical only in Ceraplectana (Plate XIII, fig. 7), where each has a single anterior median point to which the longitudinal muscle is attached; no tentacles are associated with the radial pieces in this genus. In all the other genera the radial pieces are much broader than the interradial and are provided with two anterior projections, which, however, are not just alike. One is broader than the other and serves for the attachment of the longitudinal muscle (Plate IX, fig. 2); it is sometimes perforated for the passage of the radial nerve (?). The lateral radial pieces of both sides are so placed that the attachment of the muscle is on the lower or ventral projection, while a tentacle ampulla or the base of a tentacle canal lies just dorsal to it. The ventral radial piece has the muscle attached sometimes to the right, sometimes to the left projection, but the tentacle canal is always between the projections. No cartilaginous ring, posterior to the calcareous one, ever occurs in the Molpadiidæ.

Water-vascular system.—The circular canal lies just posterior to the calcareous ring, with which it is often more or less united by strands of connective tissue. Its lumen is a millimeter, more or less, in diameter, while its wall is exceedingly thin. The wall consists of an epithelial layer of ciliated cells, continuous with that elsewhere in the body-cavity; a layer of connective tissue consisting chiefly of fibers running parallel to the direction of the canal and containing numerous wandering cells; a thin, structureless membrane; a layer of muscle fibers which run around the canal (at right angles to its direction) and are thus truly "circular" muscles, and an internal epithelium of flat, ciliated cells. From the circular canal arise five radial and two interradial tubes; the former become the "radial canals" of the body-wall and give rise to the tentacle canals, while the latter are the stone-canal and polian vessel. The stone-canal is always single and unbranched in the Molpadiidæ; it leaves the circular canal in the median dorsal interradius and lies between the two layers of the dorsal mesentery; it is an irregular, twisted tube, proportionately small, running forward and upward, to terminate within the body-cavity in a whitish madrepore plate or body. This madreporite is flattened on one side and more or less convex on the other; it contains a central cavity which is directly continuous with the lumen of the stone-canal and opens into the body-cavity through numerous pore-canals, which may be more or less branched. According to Danielssen and Koren ('82), in Molpadia the madreporite is not at the end of the stone-canal, but the latter terminates in the body-wall beyond it. The stone-canal and madreporite consist of connective tissue covered externally with the flat, ciliated epithelium of the body-cavity and lined internally with a layer of still more conspicuously ciliated cells. In the stone-canal these latter cells are low and cubical on the side next the mesentery, but become much higher on the opposite side; the cilia which they carry are about equal to the height of the cell. According to Danielssen and Koren, the stone-canal of Molpadia contains abundant calcareous deposits, but in *Caudina arenata* these are wholly wanting. The madreporite, however, always consists chiefly of closely interlocked, irregularly branching, calcareous bodies. The polian vessel, like the stone-canal, is always single and unbranched in the Molpadiidæ; it leaves the circular canal in the left ventral interradius. It varies considerably in size, but is always relatively small. The histological structure is similar to that of the circular canal, only the layer of circular muscle fibers is much thicker. The radial canals are largest where they leave the circular canal, and become rapidly smaller by giving off three branches, from which the tentacle canals are formed. Each radial canal runs forward on the inner or axial side of a radial piece of the calcareous ring, just anterior to which it gives off the tentacle canals, either one on each side at the same level, and then the third one further up, or all three at different levels; then it bends backward along the inner or axial side of the hyponeural canal and runs to the extreme posterior tip of the body, where it terminates in one, three, or more rudimentary ambulacral appendages. In its histological structure the radial canal differs from the circular canal chiefly in the absence of any circular muscles; the external covering of a ciliated epithelium is also lacking after it turns backward in the body-wall, save as it is indirectly covered on its inner side by the lining of the body-cavity. On the side of the radial vessel next to the hyponeural canal there are present some longitudinal muscle fibers between the connective tissue and the epithelium lining the radial canal, and a few of these may accompany the vessel nearly to the circular canal, in which region they would of course lie on the inner or axial side. The tentacle canals are not peculiar histologically (see p. 137), but are provided with valves consisting of connective tissue and radial muscle fibers covered with epithelial cells on both sides. These valves are situated with the concave side toward the tentacle, and thus prevent the passage of fluid *from* the tentacle canals. Gerould ('96, p. 47) says the valve is in the "radial canal near its junction with a tentacular vessel," which might mean that there is one valve or that there are three valves in each radial canal; but in his explanation of Plate VI, fig. 77, he says the section is through "a tentacular canal * * * showing the valve of the tentacle," which indicates that there are 15 of these valves, as we would expect, placed one in each tentacle canal. In most Molpadids each tentacle canal not only runs forward with the tentacle, but extends backward on to the outside of the calcareous ring to which it is closely attached (see Plates X, fig. 1; XI, fig. 3). Commonly this backward extension is prolonged considerably past the posterior margin of the ring and hangs free in the body-cavity as a "tentacle-ampulla." These ampullæ are not histologically peculiar, save that the longitudinal muscles of the tentacles extend backward only into the outer anterior wall. The occurrence of well-marked ambulacral appendages is confined to the genera Himasthlephora (Plate XIII, fig. 1) and Gephyrothuria, where each of the two dorsal radial vessels gives rise to a very few (2–5) ambulacral canals, which are provided with ampullæ (Plate XIII, figs. 3, 4) and connect with the remarkable lash-like papillæ characteristic of those two genera. In Gephyrothuria and all other Molpadids the radial canals run backward to the cloacal opening, where they terminate in "anal papillæ." These papillæ are often very insignificant, but may be very distinct; their walls generally contain an unusual number of calcareous bodies, but may be wholly free from them. Their presence or apparent absence in preserved specimens is dependent not only on the amount of contraction, but on individual diversity and possibly to some extent on age. Although commonly single, the anal papillæ may be accompanied by two, or even more, somewhat smaller lateral ambulacral vessels, so that there is a small group of papillæ at the end of each radius, and even when the anal papillæ are very small and apparently single, a pair of lateral vessels may be present beneath the skin, as Gerould has shown to be the case in *Caudina arenata*. In histological structure these vessels and the anal papillæ are similar to the pedicels of other holothurians; the wall consists of a thin, connective-tissue membrane, a layer of longitudinal muscles and a lining epithelium; the anal papillæ have an outside layer of connective tissue containing blood sinuses and often calcareous bodies and are covered with the ordinary pody-wall epithelium. In Himasthlephora the group of pedicel-like outgrowths are at the *base* of the caudal appendage, and rudimentary pedicel-like bodies also occur at the anterior end of the body, but apparently none of these are now in connection with the radial canals. The fluid contained in the water-vascular system is probably not essentially different from that in the body-cavity, since there is constant communication possible through the madreporite, but there are a much larger number of corpuscles and wandering cells in the contents of the water-vascular system. The corpuscles are yellowish when seen singly, but in mass appear to be red. The lumen of the polian vessel is sometimes nearly filled with dark-brown, apparently dead, wandering cells.

ALIMENTARY CANAL (Plate X, fig. 1).—The *mouth* is a circular opening in the center of the oral disc at the anterior end of the body and is connected with the stomach by a straight, rather short tube, which is commonly called the *pharynx,* although it corresponds to the œsophagus of the Synaptidæ and is not specially modified in any way. The *stomach* is simply a slight enlargement of the alimentary canal and is relatively short (say one-tenth of the total length). It opens posteriorly into the *small intestine,* which extends backward only a short distance and then bends abruptly forward for a greater or less distance, finally turning backward, ventral to the other viscera, as a *large intestine,* which runs to the posterior tip of the body. The hinder part of the large intestine is rather abruptly enlarged where it receives the respiratory trees and forms the *cloaca,* the length of which is closely associated with the development of the caudal appendage. The various sections of the canal as here given are not, as a rule, sharply set off from each other, although, according to Gerould, they can be easily distinguished in living or freshly killed specimens of Caudina. They all have a very similar histological structure, consisting of an outer epithelium continuous with that of the body-cavity, a thin layer of connective tissue, a muscular layer, a thick layer of connective tissue, and a lining epithelium. The relative development of these layers differs in the different parts of the canal. The pharynx when relaxed is somewhat larger at the mouth than where it joins the stomach, but may be wholly closed anteriorly by the well-developed sphincter muscle, composed of circular muscle fibers which gradually thin out on the oral disc. Posteriorly, the muscle layer of the pharynx contains longitudinal fibers within the circular series; the epithelial lining of the pharynx contains many gland cells, is covered by a delicate cuticle, and is thrown into longitudinal folds. The pharynx is held in position by 10 longitudinal series of connective-tissue strands containing muscle fibers; these unite it with the inner surface of the calcareous ring, and are called *suspensors* by Gerould. In the wall of the stomach the longitudinal muscle layer is very well developed, as is the circular series, while the lining epithelium, consisting of high columnar and gland cells, is covered with a delicate cuticle.

In the small intestine the longitudinal muscle layer is practically wanting, while the lining epithelium is remarkable for the absence of gland cells and cuticle. In the large intestine the epithelial lining is much the same, as it is also in the cloaca, but in the latter the longitudinal muscle layer is functionally replaced by about 20 isolated, irregularly arranged, small longitudinal muscles lying outside the circular layer. The numerous strands connecting the cloaca with the body-wall are similar in structure to the suspensors of the pharynx already referred to. In Eupyrgus the walls of the cloaca are strengthened by five large calcareous plates lying in the interradii (Plate XII, figs. 18, 26), while in Aphelodactyla the cloacal wall contains irregularly branched calcareous particles (Plate X, fig. 6). Throughout the alimentary canal, wandering cells in various forms (perhaps stages of development) are abundant, particularly in the internal epithelial layer. The mesentery which supports the alimentary canal consists of a very thin sheet of connective tissue containing isolated muscle fibers running in various directions and covered on both sides by the epithelium of the body-cavity. That part which supports the pharynx, stomach, and first part of the small intestine is attached to the body-wall on the right side of the dorsal interradius; the part which supports the forward-running section of the small intestine passes over into the left dorsal interradius, close beside the left dorsal radial muscle; when the large intestine bends backward, the mesentery bends sharply to the left and crosses into the *right* ventral interradius, where sooner or later it terminates. In *Caudina arenata* it only gives attachment to the large intestine for a short distance, but the latter is supported by "two sheets of separate muscular strands," arising in the posterior part of the right and left dorsal interradii, close to the right and left ventral radial muscles.

Respiratory trees (Plates X, fig. 1; XII, fig. 26).—The respiratory trees consist of two branches, the *right* and *left,* which either arise separately from the enlarged part of the cloaca or have a common opening into that organ; in the latter case there may be quite a distinct common trunk of greater or less length. The right branch consists of a single main tube, with more or less numerous and conspicuous lateral out-growths, and may run forward clear to the calcareous ring. The left branch, when fully developed, consists of two main tubes, one of which is associated with the large intestine, and may be called *ventral,* while the other lies in close connection with the blood plexus of the small intestine, and may be called *dorsal.* Although the right branch is commonly larger than either the left dorsal or left ventral alone, the left branch as a whole has a much greater capacity than the right. In Eupyrgus (Plate XII, fig. 26), however, the left branch is undivided and only equals the right in size, both being quite rudimentary, and a similar condition exists in Gephyrothuria and Himasthlephora. The histological structure of the respiratory trees is strikingly like that of the intestine. The outermost layer is a thin epithelium of very flat, irregularly polygonal, ciliated cells, followed by a thin layer of connective tissue. Then comes a muscle layer, the fibers of which run in all directions parallel to the surface, but the innermost are circular and are more numerous than the outer oblique and longitudinal fibers; then follows a thick connective tissue layer, and lastly an inner epithelium. Presumably the less developed the trees are, the less well developed will the muscle layer be. There are no openings by which the trees can communicate with the body-cavity, but all the branches end blindly.

Cuvier's organs (Plate X, fig. 10).—The occurrence of these organs in the Molpadiidæ is still open to considerable doubt. They have only been reported in a few specimens of Caudina from Chile, and no account of their finer structure has yet appeared. They are said to consist of a small tuft of spherical bodies of a brown color, somewhat like a bunch of grapes in form, attached to the cloaca near the base of the respiratory trees. That these organs are homologous with the true Cuvier's organs of other holothurians is by no means sure.

Blood system.—The arrangement of the hæmal lacunæ is very similar to what it is in the Synaptidæ, but has been studied carefully only in *Caudina arenata*. In this species Gerould ('96) recognizes four parts to the system: circular lacunæ, intestinal lacunæ, lacunæ of the reproductive organs, and tentacular and radial lacunæ. "The circular lacunæ, which form the center of the system, occupy the connective tissue of the wall of the stomach immediately behind the circular canal of the water-vascular system." They occur in the numerous out-growths of the outer layer of connective tissue of the stomach. The ring is therefore diffuse and ill-defined. The intestinal vessels occur, one on the dorsal, the other on the ventral side of the alimentary canal. Gerould does not say whether they are connected with the circular lacunæ or not, but as he says they contain numerous blood-corpuscles, while other parts of the system do not, it would appear that there is no direct connection. No statement is made either as to connection between dorsal and ventral vessels, but presumably they are connected by lacunæ in the intestinal wall. The ventral vessel on the stomach and first part of small intestine is connected by several cross-branches with that of the second section of the intestine, while at the anterior bend of the intestine the two parts of the ventral vessel are connected by a delicate sheet of anastomosing vessels. "The two parts of the dorsal intestinal vessel are likewise connected by anastomosing cross-vessels." The lacunæ of the reproductive organs run longitudinally in the connective tissue of the wall; no statement is made as to their connections. The radial and tentacular vessels arise from the circular lacunæ on the inner or axial side of the tentacle canals and run outward into the tentacles; the main vessel bends backward with the radial canal and runs clear to the cloacal opening, lying between the radial water-vascular and hyponeural canals; at the extreme posterior end of the body a circular lacuna surrounds the cloacal opening and unites the radial vessels. None of the lacunæ or vessels has any epithelial lining or any other indication of definite walls, save that the intestinal vessels have the superficial appearance of true vessels; the interior, however, is "filled with loose strands and cells of connective tissue." The fluid within the system is a colorless plasma with occasionally wandering cells, and in the intestinal vessels numerous blood-corpuscles which give the vessels in the living animal a pinkish color.

Reproductive system.—The reproductive organs of the Molpadiidæ consist of the same parts which occur in other holothurians—*i. e.,* a genital duct and tufts of genital tubules. The duct opens to the exterior in the mid-dorsal interradius just back (1–5 mm.) of the tentacles, and the outlet is often indicated by a more or less prominent genital papilla, of a somewhat conical shape and sometimes as much as 2–3 mm. in length. The duct runs downward from the tip of this papilla into the dorsal mesentery, and then backward for some little distance (5–25 mm.) to the point where it divides, and terminates in tufts of genital tubules hanging free in the body-cavity, one on each side of the mesentery (Plate XI, fig. 3). The wall of the duct consists chiefly of connective tissue, lying in which are the longitudinal muscle fibers and wandering cells; outside is the usual flattened peritoneal epithelium, while the interior of the tube is lined with a strongly ciliated, columnar epithelium. In *Caudina arenata* (according to Gerould, '96) this inner epithelium is composed of elongated, spindle-shaped *collar-cells,* the flagella of which are conspicuously long. At the outer end of the duct is a small sphincter muscle of a few circular fibers, while at the opposite end, where the duct divides, a circular muscle layer outside the connective-tissue layer is present in each branch. The genital duct of the male is usually much smaller near the outer end than posteriorly, where there is sometimes a spindle-shaped enlargement. The genital tubules make up a tuft of 6–8 or more on each side of the mesentery, the number of tubules probably increasing with age. The tuft of the left side is sometimes the larger. The tubules may be very short (5–10 mm.) or long, at times reaching clear to the posterior end of the body-cavity; they may be simple and undivided or dichotomously branched. Their wall is made up of the usual peritoneal epithelium, a thin layer of circular muscle fibers, a layer of connective tissue, in which are conspicuous blood lacunæ, and an inner germinal epithelium, which is not uniform and continuous throughout, but scattered in more or less irregular masses. As the sexes are always separate in the Molpadiidæ, the product of this epithelium will be either eggs or spermatozoa, as the case may be. In *Caudina arenata* the sexes can be distinguished by the color of the tubules, which, however, is due to their contents and not to any pigment. In the mature male the tubules are light yellow, while in the female they are pale brown.

Embryology.

Nothing whatever is known of the embryology of the Molpadiidæ, save that Gerould ('96) has studied the oögenesis (and to some extent the spermatogenesis) of *Caudina arenata.* The mature ovum is about 200 μ in diameter, and has a conspicuous and peculiar micropyle. The mature spermatozoan is about 60 μ long, with the head about 3.6 μ in diameter.

Physiology.

Almost nothing is yet known of the vital activities of the Molpadiidæ, for few zoölogists have ever had the opportunity of carrying on extended observations on living specimens. Sluiter ('88) has kept specimens of *Aphelodactyla punctata* alive in aquaria, and Gerould ('96) has had similar success with *Caudina arenata,* but neither has published any extensive account of the physiology or habits of these species.

Motion.—The movements of the Molpadiidæ are accomplished by muscular contraction, aided by the fluids in the tentacles and body-cavity. It is possible that in some cases (such as in young Molpadiæ) the calcareous particles may assist; but certainly, in many cases, the deposits of the body-wall play no part. Movement forward is possible only when the animal is buried in the sand or mud. If placed on the surface, the first movements are downward, and continue until the animal is buried. The movement, either downward or forward, is accomplished partly by swallowing the sand or mud immediately in front of the oral disc, but chiefly by backward and forward radial movements of the tentacles; these movements are effected by the alternate contraction of the longitudinal muscles of their outer and inner sides. The contractions of the muscles of the body-wall do not appear to play any important part in progressive movements, but are actively concerned in respiration (*q. v.*). The rate of progressive movement is exceedingly slow, perhaps averaging about 1 mm. per minute.

Digestion and absorption.—The food passing into the stomach doubtless undergoes the first stages of digestion there; but, if we may infer anything from the distribution of the blood-vessels, the chief activity of the alimentary canal is in the small intestine. In that region and the first part of the large intestine probably all the absorption occurs, but nothing is really known as to the physiology of the digestive system.

Circulation and nutrition.—Here again we have to infer from structure, for we know nothing definitely. The extensive hæmal system would seem to indicate that the absorbed food material is transported by it to all parts of the body, but there is obviously no true circulation of the fluid, the plasma simply moving outward into the tissues, bearing the essential food. The indigestible material finally passes into the cloaca and is thence washed out by the currents of water from the respiratory trees.

Respiration.—According to the observations of Gerould ('96), the tentacles seem to play an important part in obtaining the all-essential oxygen for the use of the body. The fluid contained in the water-vascular system contains numerous colored corpuscles which appear to react toward oxygen like true blood-corpuscles, and there is a continuous circulation of the fluid, at least in the tentacles. The flow is forward on the inner side to the tip of the terminal pair of digits, and then back and outward to the tip of the other pair; then backward into the ampulla. "When aëration becomes poor, the tentacles and buccal region become distended with the water-vascular fluids and the posterior part of the body becomes pale and contracted." Elsewhere (page 10) Gerould says: "The color, which depends upon the state of aëration of the blood, varies from pink to a purplish hue." Apparently the word "blood" is used here to include all the fluids of the body which contain blood-corpuscles (water-vascular, body-cavity, and hæmal). But respiration is also greatly facilitated by the so-called respiratory trees, and it is probably chiefly from these that the body-cavity and hæmal fluids get their oxygen. Indeed, when we consider the habit of most Molpadids of lying buried in mud and sand, with only the tip of the tail above the surface, it seems probable that the tentacles play an important part in respiration only under unusual conditions. Both Sluiter ('88) and Gerould ('96) are agreed that water is forced out of the respiratory trees and drawn into them through the cloacal opening "by the alternate contraction and relaxation of these organs and of the wall of the body. The latter, by reason of its natural rigidity, resumes its normal shape when its circular muscles are relaxed, and so increases the capacity of the body-cavity, thus bringing about an influx of water. These movements are accompanied by the correlated opening and closing of the cloacal opening through the alternating contractions of the radial and sphincter muscles." Sluiter says that in Aphelodactyla there were two or three respiratory movements per minute, and Gerould found that in Caudina the same is true; he says further that the cloacal opening was "generally kept open 18–20 seconds, and then closed for 13–17 seconds," and that while there is some irregularity in the length of the periods, that "of dilation always slightly exceeds that of closure." Aside from the fact that such regular respiratory movements would not be likely to occur if the function of the "trees" was purely excretory, the intimate relation between that organ and the intestinal hæmal vessels, which contain numerous blood-corpuscles, would lead us to believe that the bringing in of oxygen was one of its important functions. Very possibly oxygen may also be obtained through the skin by corpuscles in the radial water-vascular canals and particularly near their posterior termination.

Excretion.—That the respiratory trees function to some extent as excretory organs seems very probable, not only because they are the most obvious organs to which such a function could be assigned, but because the same organs in pedate holothurians are known to play that part. Excreta is probably gathered not only from the fluid of the body-cavity, but from the hæmal system also. The presence of wandering cells in large numbers throughout the body is evidence that excretion by means of those peculiar cells is continually going on. Whether the change of calcareous deposits into phosphatic bodies is associated with excretion is still to be demonstrated.

Sensation.—Aside from the sense of touch, Molpadids are not known to possess any capacity for sensation. No observations have been recorded that show reaction to any other than mechanical stimuli, except Sluiter's ('88) statement that Aphelodactyla shows its oral end above the mud only at night. If this is really the case, it might indicate a reaction to light, which would be very interesting, as no light-detecting organs are known to occur in the family. It is probable that the tentacles and the cloacal papillæ are the most important seats of the tactile sense.

Regeneration.—No observations have been recorded as to the possibility of regeneration among the Molpadiidæ.

Reproduction.—The method of reproduction is exclusively sexual and the sexes are always separate. No viviparous species are known nor any which care for the young in any way. Nothing whatever is known as to the extrusion, fertilization, or segmentation of the eggs, nor as to the time, place, and conditions of breeding. In *Caudina arenata,* Gerould ('96) found that the spermatozoa were mature and extruded in February, March, and April, but he failed to secure mature ova.

Ecology.

The Molpadiidæ are all marine animals and have a bathymetrical range from a little below low-water mark to at least 3,900 m. The great majority, however, occur only at depths of more than 100 m., and consequently little is known of their habits. Although occurring in all parts of the world, they seem to be most abundant in the Indo-Pacific region, while comparatively few are known from the tropical and subtropical Atlantic. They are common in both the Arctic and Antarctic oceans, though the number of species in those regions is not large. So far as is known, the Molpadids show great similarity of habitat and habits and are found only on soft sandy or, more commonly, muddy bottoms. Here they lead an almost exclusively subterranean life, only disturbed by the rare appearance of a dredge or trawl, or the occasional intrusion of some fish in search of a meal. Those which live in shallow water near shore are occasionally disturbed by heavy gales, which ultimately succeed in digging them out and washing them up on shore; probably fourfifths of the specimens of *Caudina arenata* which have been collected have been the victims of such gales. The food of the Molpadids seems to be exclusively the organic matter which they digest out of the sand and mud which passes into the mouth with every forward movement. Whether this mud is sucked in or pushed in by the tentacles is not known. Apparently the Molpadids are the least active of all holothurians, and it would seem to be the case that they often lie unmoved for hours, if not days, at a time. Sluiter ('88) says that his specimens of Aphelodactyla in captivity were more active at night than during the day, as they then showed the oral disc and tentacles above the mud; it is probable, however, that this change of position was due to the condition of the water (amount of oxygen, etc.) rather than to absence of light. The shallow-water species of Caudina and Aphelodactyla seem to thrive well in aquaria, with proper care, and it is to be hoped that we may soon have more information in regard to their habits and physiology. The Molpadids are often eaten by bottom-feeding fishes, but are not known to have other enemies. No parasites have yet been described of which they are hosts. The Molpadiidæ are of no value whatever to man in any direct way, though as an article of food for fishes they may play a slight part in benefiting him. Nothing whatever is known of their geological history.

Taxology.

The classification of the Molpadiidæ herein adopted and the reasons therefor are fully discussed on pages 17–21, and the principles which have governed the acceptance or the rejection of species are essentially the same as those which were used in connection with the Synaptidæ. (See antea, pp. 68–70.) Here as there, the form and distribution of the calcareous particles is the most important character for distinguishing species, but in the Molpadiidæ the phosphatic deposits are also to be taken into account. Color, size, and body-form are usable characters in some cases, and the texture of the body-wall is also of importance at times. Of characters for distinguishing genera the number and form of the tentacles and digits, the presence or absence of ampullæ and posterior projections on the radial pieces of the calcareous ring, and the presence or absence of a caudal appendage are the best; but size and the development of phosphatic deposits are sometimes to be considered. Most of the genera here recognized are quite distinct groups, but it must be acknowledged that Caudina and Molpadia intergrade, while it is extremely likely that Himasthlephora is a synonym of Gephyrothuria. The situation among the species is much worse, for both Molpadia and Caudina contain badly confused species and groups of species and Aphelodactyla is little better off. It is sincerely hoped, however, that the attempt here made to bring some kind of order out of this chaos may prove a useful foundation for the future work, which shall satisfactorily solve all of the perplexing riddles which the taxology of this family presents.

KEY TO THE GENERA OF MOLPADIIDÆ.

A.—Body surface with no appendages whatever; skin usually with either calcareous or phosphatic deposits, or both; calcareous ring usually with posterior prolongations; tentacles usually with ampullæ.

B.—Tentacles 15, soft.

C.—Tentacles with 3-7 digits.

D.—Posterior end of body tapering, usually with a more or less conspicuous caudal appendage; calcareous particles various.

Tentacles with 3-7 short, blunt digits, counting the distinct terminal portion (plate XI, fig. 1); caudal appendage (plate XIII, fig. 14) usually less (sometimes more) than one-third of total length, sometimes not distinctly set off from body, which generally has colored phosphatic deposits in skin .... MOLPADIA

Tentacles with 2 pairs of rather long, pointed digits (plate X, fig. 2); terminal digit practically wanting; caudal appendage (plate IX, figs. 1, 6, and 9) one-third or more of total length, usually abruptly distinct from body, which very rarely has colored phosphatic deposits in skin .... CAUDINA

DD.—Posterior end of body blunt and rounded, without a trace of a caudal appendage; calcareous particles, thick plates with a few sharp projections and small perforations................................ ACAUDINA

CC.—Tentacles simple, without digits (plate XII, fig. 22).

Tentacles without ampullæ; radial pieces of calcareous ring, without posterior prolongations; size very small, under 25 mm.................EUPYRGUS

Tentacles with ampullæ; radial pieces of calcareous ring with posterior prolongations; size large, 40-200 mm. ..................APHELODACTYLA

BB.—Tentacles 10, horny and undivided (plate XIII, fig. 6).............CERAPLECTANA

AA.—Body surface with a few whiplash-like appendages in mid-dorsal interambulacrum; no calcareous or phosphatic deposits; calcareous ring with no posterior prolongations; tentacles without ampullæ.

Caudal appendage long and slender; tentacles with 4 digits......HIMASTHLEPHORA

No caudal appendage (or perhaps a rudimentary one); tentacles with only 2 digits. GEPHYROTHURIA

MOLPADIA Cuvier, 1817.

Haplodactyla Grube, 1840 (non Semper).
Liosoma Stimpson, 1857 (non Brandt).
Embolus Selenka, 1867.
Trochostoma Danielssen and Koren, 1877.
Ankyroderma Danielssen and Koren, 1879.

Tentacles 15, with one, sometimes two, rarely three, pairs of digits and a terminal digit which is commonly the largest of all. Body rather stout, usually with a distinct but short caudal portion, which is generally much less than one-third of the total length. Radial pieces of calcareous ring with conspicuous bifurcate posterior prolongations. Calcareous deposits in the form of tables, often very imperfect; perforated plates, and more or less fusiform rods. In many cases anchors are also present in connection with either a single irregular plate or a group of 2–8 plates, which are often racquet-shaped and form a rosette from which the anchor rises. Phosphatic deposits of a yellow, brown, or deep-red color are very commonly present.

This large and widespread genus is most unsatisfactorily known and we are only just beginning to realize the difficulty of distinguishing real specific limits within it. Of the 27 species here listed only seven are known from any considerable number of specimens, while of the remaining 20, six are known from only a single specimen each, and eight others from fewer than five specimens. Some will probably prove to be forms (perhaps different ages) of a single species, while in other cases, such as *musculus,* there are probably several distinct species included under one name. There is room for wide difference of opinion as to the validity of many species here admitted, and of many of the combinations of species, previously held to be distinct, here made. There can be little question, however, that, in some of the species at least, the presence of anchors is associated with immaturity and that with increasing age there is a gradual transformation of the calcareous deposits, beginning with the anchors and rosettes, into the peculiar, colored, phosphatic bodies. Of the significance of this change we know nothing. (For a full discussion of the evidence, see antea, p. 18). The species of Molpadia occur only in deep water and on muddy or fine sand bottoms. The bathymetrical range is from 35 to 3,900 m., but they rarely occur in less than 200 and not commonly in more than 2,000 m. Apparently cold water and a soft bottom are essential to them. It would be well if we could leave out of account in the following key all reference to the anchors and their plates, but in the present state of our knowledge that cannot be done. They have, however, been ignored as far as possible. I have been unable to find any descriptions in any of Verrill's publications of three species attributed to him, namely, *Trochostoma abyssicola, Trochostoma ayresii,* and *Ankyroderma limicola.* They seem to be "*nomina nuda*" and are consequently ignored. I am unable to identify Cuvier's type species (*holothurioides*) with any of the species known today, but I have very little doubt that the specimen was an example of *musculus.* As there *is* room for doubt, however, it seems to me unwise to attempt to replace the universally used name by the earlier one. On the other hand, I cannot include Cuvier's species in my key or otherwise, for from a modern point of view it has no distinctive characters. I have therefore placed it doubtfully as a synonym of *musculus.* In using the following key it should be borne in mind that young individuals of any species may lack phosphatic deposits, while very old specimens may lack calcareous deposits. In at least one species (*musculus* as here defined), and possibly in others, phosphatic deposits appear to be absent at times in otherwise normal adults. More than ordinary care should therefore be exercised.

Key to the Species of Molpadia.

A.—Anchors wanting, or, if present, with only 2 arms and associated with a rosette of 3-8 perforated plates (plate XII, fig. 5).

B.—Phosphatic deposits present, often in abundance.

C.—No true supporting rods, fusiform bodies or elongated perforated plates present, though the discs of the tables may be narrowed and drawn out into a rod at each end.

D.—Tables of body often very irregular and distorted; sometimes wholly wanting, the disc seldom with more than 8 holes (those in the tail may have 20-30 holes).

E.—Tables with a more or less distinct disc, having 2-8 or more (usually 3-6) holes, often with irregular outline and marginal projections (plate X, fig. 14).

F.—Tables of moderate size, the disc 90-350 μ in diameter, usually with only one spire.

G.—Tables often wanting in skin of body, present in tail; disc quite asymmetrical; spire of moderate height and often with teeth or branches at top.

Discs of tables in tail narrowed and elongated, the ends drawn out into rods; spire usually of a single rod (plate X, fig. 14) .... OÖLITICA

Discs of tables not specially narrowed nor elongated; spire very irregular .... CONCOLOR

GG.—Tables present in skin of body; disc rather symmetrical, with 3-6 or more holes; spire high (plate X, fig. 15; plate XII, fig. 15).

Discs of tables in tail not specially narrowed nor with numerous holes .... INTERMEDIA

Discs of tables in tail somewhat narrowed and drawn out at the ends, with numerous (10-30) holes (plate X, fig. 15*c*) .... ANDAMANENSIS

FF.—Tables very small, the disc less than 70 μ in diameter, often with 3 or 4 small, incomplete spires (plate X, fig. 16). SIMILIS

EE.—Tables of body less regular, often without distinct disc or spire, or with the rods composing the disc not united at their outer ends.

F.—Tables of the body-wall over 150 μ across, with a disc composed of 6 or more slender diverging rods usually not united at their outer ends .... AFFINIS

FF.—Tables much smaller, not provided with such a disc.

Body tables more or less circular, about 60-70 μ in diameter; caudal tables well formed, with conspicuous spire. . BORETZII

Body tables very irregular, 90-100 μ across; caudal tables not specially different (plate XIII, figs. 15 and 16). . . . AMORPHA

DD.—Tables more regular, with very high spire, and the disc more or less circular, with 12-40 holes .... TURGIDA

CC.—Supporting rods, fusiform bodies, or elongated perforated plates present, at least in the tail (plate XI, figs. 6, 7, 8, and 13).

D.—Fusiform bodies rod-like, usually with narrow, rounded, unperforated, and undivided ends, occurring all over the body, sometimes flattened and widened in the tail.................................. MUSCULUS

DD.—Fusiform bodies with flat, widened ends, or replaced by more or less elongated perforated plates.

E.—Fusiform bodies largely replaced by big perforated plates (plate x, fig. 18).

Some of the tables with discs having 40-60 holes (plate x, fig. 17) .... MAROCCANA

No such tables..... .... LORICATA

EE.—Fusiform bodies transformed into very flat rods or narrow plates, with an expanded middle portion.

Ends of the flat rods expanded and perforated (plate x, fig. 19). PERFORATA

Ends of the narrow plates not expanded and perforated. PAUPERA

BB.—No colored phosphatic deposits present in the skin.

C.—Skin thin, often translucent, and usually more or less rough; tail usually abrupt and slender.

D.—No supporting rods or elongated fusiform bodies present in caudal region.

E.—Tables very small, regular, with disc about 100 μ in diameter, usually with 3, but often with more, holes; spire 150 μ high, or even more. BLAKEI

EE.—Tables much larger and spires proportionally much lower.

F.—Skin very thin and delicate, gray, with more or less yellowish-brown coloring anteriorly and dorsally; deposits in body-wall, except in caudal region, usually wanting in specimens over 40 mm. long; in caudal region (and in body-wall of young specimens), tables with more or less circular discs, perforated by 6 or more large holes, are generally present..... ANTARCTICA

FF.—Skin not so thin and delicate; not so colored; tables abundant in body-wall.

Tables with rounded, regular discs, with 3-6 (rarely more) circular holes .... PARVA

Tables with more or less irregular disc; holes usually oval, with outer end somewhat pointed................ ARCTICA

DD.—Conspicuous supporting rods present in caudal region.

E.—Large, smooth, irregular plates, with 60-70 holes present.. AGASSIZII

EE.—No such plates.

F.—Spires of tables and of caudal supporting rods also, with a greatly expanded and spiny top .... ELONGATA

FF.—Spires not commonly with an expanded and spiny top.

Supporting rods of caudal region with wide ends and a prominent spire (plate x, fig. 20); tables with a tapering spire, commonly of a single piece (plate x, fig. 21). GRANULATA

Supporting rods with tapering ends and a low central projection.

Tables with a spire of 3 or 4 rods united by 4 or 5 cross-bars (plate x, fig. 22)....................... DISPAR

Tables not provided with such a spire....... MUSCULUS

CC.—Skin thick, smooth, and leathery; posterior end of body tapering, but a distinct caudal appendage is wanting............................. ARENICOLA

AA.—Anchors present, but if associated with more than a single plate, some of them have 3 or 4 arms.

B.—Anchors with only 2 arms and associated with a single plate.

C.—Anchor-plates large, about 400 μ long (plate x, fig. 23).

Many tables with trifid base, the ends of each of the 3 arms expanded and perforated (plate x, fig. 24) .... BREVICAUDATA

None of the tables with trifid base .... MARENZELLERI

CC.—Anchor-plates small, about 130 μ long (plate x, fig. 9).

Tables with more or less irregular, often trifid base.........CONCOLOR juv.

No tables at all present.. TRIDENS

BB.—Anchors commonly with 3 or 4 arms (plate x, fig. 25)..............POLYMORPHA

Molpadia oölitica.

Plate X, Fig. 14.

Chirodota oölitica Pourtales, 1851, p. 13.
Molpadia borealis Sars, 1859, p. 174.
Molpadia oölitica Selenka, 1867.
Embolus pauper Selenka, 1867, p. 359.
Trochostoma thomsonii Danielssen and Koren, 1878, pp. 229-256; pls. I-III.
Trochostoma (*Molpadia*) *boreale* Danielssen and Koren, 1879, pp. 124-126, 137; pls. V and VI, figs. 1-5.
? *Ankyroderma jeffreysii* Danielssen and Koren, 1879, pp. 128-133, 135-137; pls. V and VI, figs. 11-19.
Trochostoma thomsonii maculatum Danielssen and Koren, 1882, p. 94; pl. XIII, figs. 5-6.
Trochostoma boreale Hoffman, 1882.
Trochostoma (*Molpadia*) *oöliticum* Danielssen and Koren, 1882.
Trochostoma oölithicum Lampert, 1885.
Trochostoma oöliticum Théel, 1886*a*.

Length.—100–135 mm., the diameter of the body about one-fourth as much; the caudal appendage short and not often abruptly distinct.

Color.—In life grayish green and violet are the prevailing colors, while in preserved specimens dull gray and reddish or dark brown predominate; the oral disc and caudal appendage are noticeably light-colored in contrast. The exact coloration depends on the development of the phosphatic bodies; where these are few, the general color is gray, with little brown, but when these are abundant the color becomes more and more brown; in some specimens these deposits become so numerous that the body is almost black.

Distribution.—Reported from numerous stations in the North Atlantic and Arctic oceans, from Florida Reef (Pourtales) and West Indies (Théel) to Spitzbergen and north thereof (Ludwig); also eastward through Barents and Kara seas to Cape Chelyuskin, Siberia (Stuxberg); in the eastern Atlantic it is not known south of 62° N., while in the western Atlantic and Arctic oceans it is not known north of Labrador or west of the Faroes. Its real home seems to be the Arctic Ocean, north of Europe and western Siberia, with a long southwestward extension to Newfoundland, Florida, and the West Indies. The reported occurrence at Point Barrow, Alaska (Murdock), would seem to indicate a circumpolar range.

Remarks.—This is not only the longest-known but perhaps also the best-known species, thanks to the careful investigations of Danielssen and Koren (see their report, 1882, pp. 42–65 and 67–76, and Plates VII–XIII). It seems probable that, in spite of their care, differences were emphasized and intergrading features neglected, so that no less than three species were made by them out of a few specimens of this single form. Of course it is by no means certain that *Ankyroderma jeffreysii* is identical with the Trochostomas, but there is little reason to doubt it. The specimens of Ankyroderma reported have been mostly under 50 mm. and 75 mm. is the maximum given. On the other hand, Danielssen and Koren refer to specimens of Trochostoma 10 and 20 mm. long; they do not say, however, whether the calcareous deposits of these specimens were examined. There can be no question that *borealis* and *oölitica* are identical, for the latter is simply based on individuals in which the phosphatic deposits are excessively developed. The calcareous particles of all ages are fully figured by Danielssen and Koren.

Molpadia concolor.

Trochostoma concolor Koehler and Vaney, 1905, p. 91; pl. v, fig. ix. Calcareous particles, pl. xiii, figs. 16-18.

Trochostoma concolor caudatum Koehler and Vaney, 1905, p. 92. Calcareous particles, pl. xiii, figs. 19-22.

Ankyroderma contortum Koehler and Vaney, 1905, p. 100. Calcareous particles, pl. xiv, figs. 8-13.

Ankyroderma intermedium Koehler and Vaney, 1905, p. 102. Calcareous particles, pl. xv, figs. 19-25.

Length.—125–150 mm., with a diameter of 45–60; in the adult, the caudal appendage is not sharply distinct, but in young specimens it may be one-fourth of the total length.

Color.—Grayish, more or less tinged and marbled with chestnut-brown, orange-red, or bluish violet; in adults the latter tint is very marked; oral disc and caudal appendage whitish.

Distribution.—Reported from the coast of Kistna and Gulf of Bengal, three stations of the "Investigator" (Koehler and Vaney).

Remarks.—This species, though representing *oölitica* in the Indian Ocean, appears to be quite distinct from the northern form. The specimens collected by the "Investigator," although few in number, seem to show the transition from young to adult form very well. It should be stated, however, that one of the specimens described as *A. intermedium* was 115 mm. long and is therefore of maximum size for an Ankyroderma. The variety of color shown by these specimens is noteworthy, but we know very little yet about the constancy of color in the Molpadiidæ, and what little we do know makes us skeptical of its value for specific distinctions. The calcareous particles of all ages are fully figured by Koehler and Vaney.

Molpadia intermedia.

Plate XII, Figs. 5-15.

Trochostoma intermedium Ludwig, 1894, p. 161. Calcareous deposits, pl. xvi, figs. 7-21.

Length.—110–140 mm., the caudal appendage about 20–25 per cent of the total length.

Color.—Gray or yellowish gray, more or less spotted, blotched and concealed by the reddish-brown or reddish-violet color caused by the phosphatic deposits.

Distribution.—Reported from Gulf of Panama and Gulf of California (Ludwig) and numerous stations along the Pacific coast of North America (Clark, antea).

Remarks.—This is undoubtedly the common Molpadia of the North Pacific, and while it is nearly related to *oölitica,* it is very readily distinguishable. It is one of the species in which the young are provided with anchors and rosettes (antea, pp. 18 and 33), and even large specimens often show the presence of a few.

Molpadia andamanensis.

Plate X, Fig. 15.

Trochostoma antarcticum Lampert, 1889 (non Théel, 1886*a*).
Trochostoma andamanense Walsh, 1891, p. 203.
Trochostoma scabrum Sluiter, 1901, p. 119. Calcareous particles, pl. x, fig. 9.
Trochostoma scabrum spinosa Sluiter, 1901, p. 119. Calcareous particles, pl. x, fig. 10.
Trochostoma andamanense Koehler and Vaney, 1905, p. 90. Calcareous particles, pl. xiii, figs. 11-15.

Length.—90–150 mm., of which the caudal appendage is about 8–12 per cent.

Color.—"Dirty flesh-color with closely placed deep chocolate spots, the crown (tentacles) being a sort of raw-meat color" (Giles, in Walsh, loc. cit.). "In spirit, the ground color has become greenish gray and the spots are more or less blood-red. The tentacles are yellow and between each two there is, near the base, a blue-black triangular mark" (Walsh, loc. cit.). Curiously enough, Koehler and Vaney do not refer to the color, so that we do not know whether the remarkable coloration of the tentacles and oral disc given by Walsh is a constant feature or not. Sluiter describes the color very much as it occurs in other members of the genus—more or less yellowish brown, brownish red, or dark violet, according to the individual; the color of the body varies evidently with the development of the phosphatic deposits; the caudal appendage is always white or whitish.

Distribution.—Reported from New Guinea (Lampert); Andaman Sea (Walsh); four of the "Siboga" stations in the East Indies (Sluiter), and six of the "Investigator" stations in the Gulf of Bengal and near Ceylon (Koehler and Vaney).

Remarks.—Although Walsh considered this species near to *antarctica,* and Sluiter, and Koehler and Vaney regard it as nearly related to *granulata,* it appears to be quite distinct from either, and well characterized by the presence of the phosphatic deposits and the peculiar but well-formed tables of the caudal region. Considering the meagerness of Walsh's description and the absence of any figures, it is not strange that Sluiter failed to recognize *andamanensis* in his East Indian specimens. There can be little question, however, of the identity of the two forms; nor can there be much doubt that the little "Trochostoma" from New Guinea brought home by the "Gazelle" and considered by Lampert ('89) to be *antarctica,* really is *andamanensis.*

Molpadia similis.

Plate X, Fig. 16.

Ankyroderma simile Théel, 1886*a,* p. 40; pl. xi, fig. 2. Calcareous particles, pl. ii, fig. 5.

Length.—100–110 mm.

Color.—Dirty gray and yellowish brown.

Distribution.—Reported only from Yokohama, Japan, 621 m. (Théel).

Remarks.—This is one of the species known from only a single specimen, but it appears to be quite unique, unless indeed it should prove to be the adult of *roretzii;* the small size of the tables is a striking point of resemblance between the two.

Molpadia affinis.

Ankyroderma affine Danielssen and Koren, 1879, pp. 133-137; pls. v and vi, figs. 22-28.

Length.—50–75 mm.

Color.—Gray or grayish green; the oral disc and caudal appendage whitish.

Distribution.—Reported from north of Norway (Danielssen and Koren); Kara Sea (Clark, antea); and Caribbean Sea (Théel). The range possibly coincides with that of *oölitica.*

Remarks.—I was at first inclined to consider this species as simply a form of *oölitica* or possibly *arctica,* but the calcareous tables seem to be quite unique, and the species is certainly as valid as many others in this perplexing genus. As Ludwig (:00*a*) does not distinguish it from *jeffreysii,* we cannot tell exactly what the northern distribution of *affinis* is.

Molpadia roretzii.

Haplodactyla roretzii v. Marenzeller, 1877, p. 29; pl. iv, fig. 1.
Ankyroderma roretzii v. Marenzeller, 1881, p. 124. Calcareous particles, pl. iv, fig. 4.

Length.—55 mm., of which the caudal appendage is 12; diameter about 30 mm.

Color.—Dark violet-brown, with the caudal appendage white.

Distribution.—Reported only from Japan (v. Marenzeller).

Remarks.—This is another species known from only a single specimen, and while it appears to be distinct from *similis,* it will not be at all surprising if they prove to be identical. Théel ('86*a*) is undoubtedly right in considering the tables with a single, and always broken, spire figured by von Marenzeller as the basal portions of the anchors, which von Marenzeller seems not to have found.

Molpadia amorpha.

Plate XIII, Figs. 14-22.

Molpadia amorpha Clark (antea, p. 31).

Length.—100–115 mm., of which the tail is only one-tenth; diameter 30–40 mm.

Color.—Gray, more or less spotted or blotched with dark purplish, especially anteriorly, where the color may be nearly uniformly dark.

Distribution.—Reported only from off the southern coast of Chile in 200–350 m. (Clark).

Remarks.—This species seems to be quite constant in its characters, so far as adults are concerned. As no young specimens are available, it is not known whether anchors and plates ever occur.

Molpadia turgida.

Molpadia turgida Verrill, 1879*a*, p. 473.
Trochostoma turgida Verrill, 1885*b*.
Trochostoma turgidum Théel, 1886*a*.

Length.—90–125 mm.

Color.—Reddish or purplish brown; skin thin, semi-translucent.

Distribution.—Reported from Massachusetts Bay, 72–180 m., Gulf of Maine, Casco Bay, Bay of Fundy, off Nova Scotia, and Gulf of Saint Lawrence (Verrill).

REMARKS.—No one seems to have seen this species except the describer and he unfortunately has given us no figures. The tables, however, seem to be quite characteristic and it is probable that the species is entirely distinct from *oölitica*.

MOLPADIA MUSCULUS.

PLATE XI.

? *Molpadia holothurioides* Cuvier, 1817, vol. IV, p. 24.
Molpadia musculus Risso, 1826, p. 293.
Haplodactyla mediterranea Grube, 1840, p. 42.
Haplodactyla musculus Semper, 1868.
Molpadia violacea Studer, 1876, p. 454. Calcareous particles, Théel, 1886*a*, pl. II, fig. 4.
Ankyroderma musculus Petit, 1883.
Ankyroderma perrieri Petit, 1883, p. 162.
Ankyroderma hispanicum Petit, 1883, p. 163.
Trochostoma violaceum Théel, 1886*a*.
Ankyroderma danielsseni Théel, 1886*a*, p. 39. Calcareous particles, pl. II, fig. 6.
Ankyroderma musculus Ludwig, 1891*a*, p. 569. Calcareous particles, pl. XXIX.
Ankyroderma danielsseni Ludwig, 1894, p. 164. Calcareous particles, pl. XVII, figs. 1-9.
Ankyroderma spinosum Ludwig, 1894, p. 171; pl. XVII, fig. 10. Calcareous particles, pl. XVIII, figs. 1-12.
Ankyroderma musculus Perrier, 1903, p. 529.
Ankyroderma musculus Koehler and Vaney, 1905, p. 95.
Ankyroderma musculus acutum Koehler and Vaney, 1905, p. 97. Calcareous particles, pl. XIV, figs. 4-7.

LENGTH.—100–160 mm., of which the tail is 10–25 per cent; the diameter is about one-fifth of the total length.

COLOR.—Very variable; gray and red-brown, with more or less of a violet tinge; in old specimens the color may be very dark, the gray being entirely concealed, while in young specimens the color may be uniformly gray, with or without a yellow-brown cast.

DISTRIBUTION.—Reported from the Mediterranean and North Atlantic (Ludwig, Koehler, Perrier); Kerguelen Islands (Studer); southern Chile (Théel); Gulf of Panama, Galera Point, Cocos Island, Acapulco, and Gulf of California (Ludwig); off Chile, the Galapagos Islands, and southern California; and in Monterey Bay, California, 36–54 m. (Clark); seven "Siboga" stations in D. E. I. (Sluiter); Andamans, Kistna, Ceylon, and Gulf of Bengal (Koehler and Vaney). Apparently cosmopolitan, excepting only the Arctic and North Pacific oceans.

REMARKS.—Ludwig is authority for the identity of Risso's, Grube's, and Petit's species, while the collections of the United States National Museum leave no doubt of the identity of *violaceum* and *danielsseni*. Perrier asserts the identity of *musculus* and *danielsseni*, and Koehler and Vaney not only maintain the correctness of his position, but add Ludwig's *spinosum* to the list of synonyms. For my part, I believe that at least three species are confused under the above synonymy; but as Perrier, and Koehler and Vaney have had far more material of *musculus* for study than is accessible to me, I defer to their judgment. It seems to me very likely that *musculus* is a small species, confined to the Mediterranean Sea and eastern Atlantic Ocean, which never outgrows its Ankyroderma stage, while *violaceum* is a quite different and much larger species. As for *spinosum*, I believe it, too, will prove to have constant specific characters. Some of the specimens of *danielsseni* in the National Museum collection are remarkable for the apparent absence of phosphatic deposits, and I think it quite possible that these are really a fourth species. But these questions can only be settled when a large amount of material of all ages from the Mediterranean Sea, Atlantic, South Pacific, tropical Pacific, Indian and south Indian oceans can be brought together and carefully compared.

Molpadia maroccana.

Plate X, Figs. 17, 18.

Ankyroderma maroccanum R. Perrier, 1898, p. 1666; 1903, p. 533. Calcareous particles, pl. xxii, figs. 9-15.

Length.—Not given; presumably 20–35 mm.

Color.—Not given; presumably grayish, more or less mottled with red-brown or violet.

Distribution.—Reported only from off Cape Ghir, Morocco, 2,210 m. (R. Perrier).

Remarks.—Although four specimens of this form were taken, it is by no means certain that the differences between it and the preceding species are constant; but, as Perrier says, in the present state of our knowledge the two are well separated from each other.

Molpadia loricata.

Ankyroderma loricatum R. Perrier, 1898, p. 1666; 1903, p. 535. Calcareous particles, pl. xxii, figs. 23-28.

Length.—55 mm., of which the tail is 7; diameter, 10–15 mm.

Color.—Very deep red-brown; tail grayish.

Distribution.—Reported only from off Senegal, 1090–2324 m. (R. Perrier).

Remarks.—Of this form three specimens were taken by the "Talisman" in 1883. It is very close to the preceding species, with which it may be identical, and its separateness from *musculus* is therefore open to question. The latter was taken by the "Talisman" at a neighboring station off Senegal, but in much shallower water.

Molpadia perforata.

Plate X, Fig. 19.

Ankyroderma perforata Sluiter, 1901, p. 121. Calcareous particles, pl. x, fig. 8.

Length.—Up to 140 mm., of which the tail is about one-seventh; diameter, 30 mm.

Color.—Grayish; in mature specimens, with red-brown spots.

Distribution.—Reported only from four "Siboga" stations in D. E. I. (Sluiter).

Remarks.—This appears to be one of the species in which anchors are present even in adults. The rosettes are made up of 3–5 racquet-shaped rods, which are widened at the free end and are perforated throughout. The colored phosphatic deposits are said by Sluiter to be absent in the specimens 40 mm. or less in length. The form of the tables and supporting rods seems to be very characteristic.

Molpadia paupera.

Trochostoma pauperum Koehler and Vaney, 1905, p. 93. Calcareous particles, pl. xiii, fig. 23.

Trochostoma ecalcareum Koehler and Vaney, 1905, p. 94. Calcareous particles, pl. xiii, fig. 24.

? *Ankyroderma musculus undulatum* Koehler and Vaney, 1905, p. 99. Calcareous particles, pl. xv, fig. 13.

Length.—68–75 mm., of which the very short tail is less than one-twelfth; diameter, about 30 mm.

Color.—Clear gray or grayish, with the tail reddish or violaceous; the skin, on its inner surface, is said to be dark violaceous.

Distribution.—Reported only from "Investigator" stations 279 (540 m.) and 280 (803 m.), Gulf of Bengal; perhaps also station 250 (800 m.) (Koehler and Vaney).

Remarks.—This is apparently a species much like *oölitica* in the rapid loss of calcareous deposits and excessive development of the phosphatic bodies. The supporting rods of the tail are very characteristic and it seems quite possible that the small Ankyroderma reported by Koehler and Vaney from station 250 as a variety (*undulatum*) of *musculus* is really the young of the present species. There appears to be no good reason for separating *ecalcareum* from *pauperatum*, as only one specimen was taken, and the absence of deposits may have been accidental.

Molpadia blakei.

Trochostoma blakei Théel, 1886*b*, p. 16. Calcareous table, fig. 8.

Length.—60–75 mm., of which about one-tenth is tail.

Color.—Whitish, grayish, or very pale brownish.

Distribution.—Reported from near Grenada, 1,720 m. (Théel); coast of Senegal, 3,655 m. (R. Perrier), and Gulf of Mexico, 2,126 m. (Clark).

Remarks.—This is a remarkably well-characterized species, but as Théel neglects to give any dimensions for the curious little tables, it has been easy to mistake some specimens of *parva* for *blakei*. Several specimens of *parva* were labeled *blakei* by me, and I then decided the two were synonymous, and it was only when I found a specimen of the true *blakei* that I realized my mistake. Perrier's (:03) specimen was very small, but the tables are characteristic, at least as far as the dimensions go. The differences he points out between his specimen and Théel's are interesting and may possibly prove to be specific.

Molpadia antarctica.

Trochostoma antarcticum Théel, 1886*a*, p. 44. Calcareous particles, pl. ii, fig. 7.

Length.—Up to 92 mm., the tail only 3–5, and the diameter 20–25.

Color.—Gray, colored or blotched with yellowish brown, especially anteriorly and dorsally.

Distribution.—Reported from southern coast of Chile (Théel, Clark); Gulf of Mexico (Théel), and off Alexander Land, Antarctic Ocean (Herouard).

Remarks.—Théel has expressed some doubt as to the validity of this species, but it is clear from the material in the United States National Museum that the southern form is quite distinct from either *arctica* or *borealis*. As for the three specimens from the Gulf of Mexico, which Théel ('86*b*) assigns to *antarctica*, I am strongly inclined to believe they represent quite a distinct, and probably undescribed, species. The species *arctica* and *antarctica* are nearly allied and young specimens might easily be confused, but specimens over 50 mm. are readily distinguished. The skin in *antarctica* is very thin and delicate, and even specimens 14 mm. long have no anchors or rosettes, so the species apparently has no *ankyroderma* stage. The single specimen which Herouard (:01) had, seems to have been of this species, although he implies that the absence of calcareous deposits was due to decalcification. Regarding Lampert's ('89) record of this species from New Guinea, see under *andamanensis*.

Molpadia parva.

Trochostoma arcticum Marenzeller, var. *parva* Théel, 1886*b*, p. 17.
Trochostoma arcticum Marenzeller, var. *cœruleum* Théel, 1886*b*, p. 17.

Length.—60–80 mm., of which about one-tenth is tail.

Color.—Yellowish gray, often with a violet tinge, especially anteriorly; in some specimens the violet color is very marked.

Distribution.—Reported from off Grenada, 749–996 m. (Théel); south of Nantucket, 2,695 m., and Caribbean Sea, 1,613 m. (Clark).

Remarks.—The difference between the calcareous deposits of this species and *arctica* is so obvious and apparently so constant that it does not seem likely the two species can be identical. In some specimens of *parva* the tables are remarkably uniform in having only 3 holes in the disc. Such tables resemble in form those of *blakei,* but are very much larger and the spire is much lower in proportion.

Molpadia arctica.

Haplodactyla arctica v. Marenzeller, 1877*b*, p. 29; pl. iv, fig. 1.
Trochostoma arcticum Danielssen and Koren, 1879, p. 126.
Trochostoma boreale Ludwig, 1900*a*, partim.

Length.—Up to 190 mm. when fully extended, of which the tail is scarcely one-tenth; diameter about 30 mm.

Color.—Whitish, grayish or brownish gray, more or less strongly tinged with violet.

Distribution.—Reported from north of Nova Zembla (v. Marenzeller); Kara Sea (Théel); Finmark (Danielssen and Koren). Apparently an Arctic species, confined to the cold waters north of Europe.

Remarks.—Ludwig's opinion that this species is identical with *boreale* Danielssen and Koren does not seem to me justified by the material at hand. The skin in *arcticum* is thin and rough and always lacks phosphatic deposits, so that the general appearance is quite different from the other Arctic species. So far as recorded, no specimens have been taken which are evident connecting links between the two forms, and for the present at least it seems to me they ought to be kept separate. So far as known, this species never has anchors or rosettes.

Molpadia agassizii.

Ankyroderma agassizii Théel, 1886*b*, p. 19.

Length.—80 mm., of which the tail is one-fourth.

Color.—Light grayish, inclining to violet.

Distribution.—Reported only from Bequia, 2,712 m., and from an unknown West Indian station, 1,904 m. (Théel).

Remarks.—This notable species is well characterized by its thin, rough, brittle body-wall, filled with perforated plates. There are also tables, somewhat like those of *arctica,* present, and anchors and rosettes. The rods making up the rosettes have the large end perforated with 25 or more holes. A thick layer of fusiform supporting rods with the middle enlarged and perforated is found in the tail.

Molpadia elongata.

Trochostoma elongatum Koehler and Vaney, 1905, p. 92; pl. I, fig. 5. Calcareous particles, pl. XIV, figs. 1-3.

Length.—49 mm., of which the tail is more than half; the diameter of the body is only 8 mm.

Color.—Grayish.

Distribution.—Reported only from the Gulf of Bengal, 1,660 m. (Koehler and Vaney).

Remarks.—In the remarkable development of the tail, this species approaches Caudina, but the calcareous deposits are quite like Molpadia. Only one specimen is known; it is said to show only 10 tentacles, but apparently no dissection was made to determine the actual number present. Of course, if there are only 10, the species does not belong in Molpadia, and it becomes an interesting question whether it is nearly allied to Ceraplectana.

Molpadia granulata.

Plate X, Figs. 20-21.

Trochostoma granulatum Ludwig, 1894, p. 158. Calcareous particles, pl. XV, figs. 7-9, and pl. XVI, figs. 1-6.

Length.—75–110 mm., of which the tail is about one-seventh.

Color.—Dusky yellowish or yellowish gray to brownish yellow; sometimes very dark at the ends; skin thin, translucent, and rough.

Distribution.—Reported from three "Albatross" stations off coast of Central America, 2,848–4,017 m. (Ludwig); near Amboina, 798 m. (Sluiter), and near Ceylon, 3,443–3,585 m. (Koehler and Vaney). Apparently distributed in the deep parts of the tropical Indian and Pacific oceans.

Remarks.—Although only a few specimens of this species are known, they come from such widely separated localities and show such diversity in size (26–110 mm.) that it is probably safe to say that *granulata* does not have anchors and rosettes at any age. Koehler and Vaney consider this species very near *andamanensis* Walsh, but the differences appear to be more striking than the resemblances.

Molpadia dispar.

Plate X, Fig. 22.

Ankyroderma dispar Sluiter, 1901, p. 122. Calcareous particles, pl. X, fig. 6.

Length.—30 mm., of which the tail is nearly one-third.

Color.—Not given; skin thin and rough.

Distribution.—Reported only from near Celebes, 462 m. (Sluiter).

Remarks.—This is another of the species known from only a single individual, and as that one is obviously immature, it is possible that it will prove to be the young of some previously known species.

Molpadia arenicola.

Plate XII, Figs. 1, 2.

Liosoma arenicola Stimpson, 1857, p. 525.
Trochostoma arenicola Théel, 1886*a*.

Length.—110–135 mm., with the diameter one-third or one-fourth as much.

Color.—Dirty whitish, blotched with tawny reddish.

Distribution.—Reported only from the vicinity of San Pedro, California (Stimpson, Théel, Clark), where it appears to be quite common.

Remarks.—This species, remarkable for its limited distribution, is well characterized by the color, the absence of a distinct caudal appendage, the thick, smooth skin, and the absence of calcareous deposits in the body-wall. In most individuals numerous branched rods and perforated plates are to be found in the skin of the posterior tip of the body, but in old specimens even these may be wanting. Phosphatic deposits are apparently never present. Stimpson's error in saying the calcareous ring consists of five pieces is so obvious, it seems strange Lampert ('85) should have copied it without comment.

Molpadia brevicaudata.

Plate X, Fig. 24.

Ankyroderma brevicaudatum Koehler and Vaney, 1905, p. 99. Calcareous particles, pl. xv, figs. 1-10.

Length.—18–25 mm., with the diameter about 15 mm.; the tail is 3–6 mm. long.

Color.—Grayish, somewhat spotted with red.

Distribution.—Reported only from one "Investigator" station in the Gulf of Bengal, 330 m. (Koehler and Vaney).

Remarks.—Although four specimens of this species were taken, they are apparently young, and we probably do not yet know the adults; but the calcareous deposits are quite unique and make the species easily recognizable.

Molpadia marenzelleri.

Plate X, Fig. 23.

Ankyroderma marenzelleri Théel, 1886*a*, p. 41. Calcareous particles, pl. iii, fig. 1.

Length.—26 mm.

Color.—Reddish violet, dappled.

Distribution.—Reported only from near New Zealand, 1,260 m. (Théel).

Remarks.—This unique species is based on a single incomplete individual, which is so well characterized by its calcareous deposits that it could not be assigned to any other species. Besides the tables and the remarkable anchor-plates, which usually have three rather long arms, numerous phosphatic deposits are present. The caudal portion of the type specimen was lost or destroyed when it was taken.

Molpadia tridens

Plate X, Figs. 8, 9.

Ankyroderma tridens Sluiter, 1901, p. 122. Calcareous particles, pl. x, fig. 7.

Length.—Up to 80 mm., of which the tail is about one-fourth.

Color.—Gray, with numerous small red-brown spots.

Distribution.—Reported only from the Dutch East Indies, 330–462 m. (Sluiter).

Remarks.—This is a most interesting species, remarkable for the absence of all calcareous deposits save anchors and plates and the presence of numerous phosphatic deposits, thus reversing the usual condition, where numerous phosphatic deposits are associated with the disappearance of anchors and plates. Sluiter's account of the appearance of the deposits is further evidence to show that calcareous particles in Molpadia become transformed into the colored phosphatic bodies.

Molpadia polymorpha.

Plate X, Fig. 25.

Ankyroderma polymorphum Koehler and Vaney, 1905, p. 103. Calcareous particles, pl. xiv, figs. 14-19.

Length.—50 mm., of which the tail is 15; the diameter of the body is only 10 mm.

Color.—White, tinged with reddish.

Distribution.—Reported from the Gulf of Bengal, 1,242–1,656 m. (Koehler and Vaney).

Remarks.—As only a single specimen of this form was taken, one cannot avoid the suspicion that it may be only a young and aberrant *concolor*. It is impossible to tell from the description given whether the anchors are associated with a single plate or with a rosette of such plates.

CAUDINA Stimpson, 1853.

Molpadia Müller, 1850; Semper, 1868; non Cuvier, 1817.

Tentacles 15, with 2 pairs of digits, the distal pair longer than the proximal; no terminal unpaired digit. Body rather stout, more or less tapering posteriorly and usually with a distinct caudal portion, which is generally one-third of the total length or even more. Radial pieces of calcareous ring with conspicuous, bifurcate, posterior prolongations. Calcareous deposits of very various kinds, with no particular kind characteristic of the genus. Phosphatic deposits are usually entirely wanting and are known to occur in only one species.

The holothurians composing this genus may usually be recognized by the form of the body, but there is no doubt that the differences between Caudina and Molpadia are very slight and of little significance. The geographical distribution of the genus is interesting; three species are confined to the eastern coast of the United States, two occur on the North American Pacific coast, and the three others occur on the coast of Chile, one of these ranging to New Zealand, Australia, the East Indies, and Japan. Little is known of their habits, save that they live buried in sand or mud with the tip of the caudal region exposed; they burrow by means of the tentacles, aided by movements of the body, and feed on the organic matter in the sand or mud, which they take into the mouth. Besides the following eight species, "*Trochostoma albicans glabra*" (Théel, 1886*a*, p. 46), which appears to be closely related to *C. albicans,* should probably be recognized as a ninth species.

Key to the Species of Caudina.

A.—No colored phosphatic deposits in skin.
- *B.*—Calcareous deposits in the form of tables with perforated discs and conspicuous spires (plate x, figs. 11, 12).
  - Discs of tables 90-140 μ in diameter; spire rather low and irregular, usually of 4 somewhat converging rods .... ARENATA
  - Discs of tables 150-270 μ in diameter; spire rather high and pointed, of 3 converging rods .... ALBICANS
- *BB.*—Calcareous deposits not tables.
  - *C.*—Calcareous deposits more or less well formed, shallow cups perforated by 4 holes and closed by a cross, the bars of which are just over the holes, the relative proportions of solid parts and holes varying very greatly (plate IX, figs. 4, 5, 11, 12, 13).
    - *D.*—Nearly all the cups complete and symmetrical, with rounded knobs on margin (fig. 4).
      - Caudal appendage very distinct ....CHILENSIS
      - Caudal appendage not apparent, the body simply tapering to a blunt point .... OBESACAUDA
    - *DD.*—Nearly all the cups incomplete and more or less asymmetrical, without knobs (figs. 11-13) .... CONTRACTACAUDA
  - *CC.*—Calcareous deposits more or less flat, perforated plates of no particular form.
    - Plates with sharp projections on the surface (plate x, fig. 13)..CALIFORNICA
    - Plates almost perfectly smooth (plate IX, fig. 8)...........PLANAPERTURA

AA.—Colored phosphatic deposits present in skin .... PIGMENTOSA

Caudina arenata.

Plate X, Figs. 1, 2, 11.

Chirodota arenata Gould, 1841, p. 345.
Chirodota arenata Ayres, 1852*a*, p. 143.
Caudina arenata Stimpson, 1853, p. 17.
Caudina arenata Gerould, 1896, pp. 17-74; pls. III-X.

Length.—100–175 mm., rarely up to 250 mm.; caudal appendage usually about 35–40 per cent of total length.

Color.—In life, pink to purplish; in preserved specimens, milky white to pale brown, usually grayish.

Distribution.—Reported from Newport, Cuttyhunk and Vineyard Sound, Chelsea Beach, Revere Beach, and Massachusetts Bay (Gould, Pourtales, Verrill, Kingsley, Gerould, et al.); Grand Manan (Ludwig); Milne Bank, Northumberland Strait and Pointe du Chêne, New Brunswick (Whiteaves).

Remarks.—Although this species has been taken in large numbers at Revere Beach, Mass., and in smaller numbers at Newport, R. I., and Chelsea Beach, Mass., nearly all these specimens have been picked up on the shore after severe storms. Few specimens have ever been dredged. Gerould's ('96) explanation of this is undoubtedly correct; the animals live buried in rather firm sand, only the tip of the tail being at the surface, so that an ordinary trawl or dredge does not reach them; but, as they live in comparatively shallow water (1–35 meters), a heavy sea gradually washes them out of the sand and casts them upon the shore. Gerould's admirable paper is a complete account of all that we know about this species.

Caudina albicans.

Plate X, Fig. 12.

Trochostoma albicans Théel, 1886*a*, p. 44; pl. XI, fig. 3. Calcareous particles, pl. III, fig. 2.
Trochostoma albicans var. *glabra* Théel, 1886*a*, p. 46.
Caudina arenata var. *armata* Théel, 1886*b*, p. 17.
Caudina arenata var. *armata* Gerould, 1896, p. 19. Calcareous particles, pl. III, figs. 34-37.

Length.—75–115 mm., of which 20–35 are caudal appendage.

Color.—In preserved specimens, grayish or whitish.

Distribution.—Reported from off the east coast of the United States between Cape Cod and Cape Hatteras, in 1,600–2,235 m. (Théel, Clark); near New Zealand, 1,260 m. (Théel); off coast of Senegal, 3,200 m. (R. Perrier), and Gulf of Bengal, 486–738 m. (Koehler and Vaney).

Remarks.—It is only with the greatest hesitation that I venture to unite two species, placed by so careful a worker as Théel in separate genera; but I am entirely at a loss to find any satisfactory ground upon which they can be separated. Of course if the difference in tentacles were constant, it would separate them easily; but I feel sure that this supposed difference is due entirely to difference in the amount of contraction, and the similarity of the calcareous deposits is so striking, I cannot doubt that *armata* is a synonym of *albicans*. Although resembling the preceding species, this deep-water form is easily recognized by the characteristic tables. As no connecting specimens are known, there is no reason why it should not be given full specific rank. I feel quite sure that the specimens from New Zealand are specifically distinct, and that those from the Indian Ocean are either like the New Zealand form or are a third species.

Caudina chilensis.

Molpadia chilensis J. Müller, 1850, p. 139. Calcareous particles, 1854, pl. vi, fig. 14, and pl. ix, fig. 1.
Molpadia australis Semper, 1868, p. 233. Calcareous particles, pl. xxxix, fig. 14.
Molpadia coriacea Hutton, 1872, p. 17.
Microdactyla caudata Sluiter, 1880, p. 348; pl. vi, fig. 1.
Caudina ransonnetii v. Marenzeller, 1881, p. 126. Calcareous particles, pl. iv, fig. 5.
Caudina meridionalis Bell, 1883, p. 58. Calcareous particle, pl. xv, fig. 1.
Caudina caudata Ludwig, 1883, p. 158.
Caudina coriacea Théel, 1886*a*, p. 47. Calcareous particles, pl. iii, fig. 4.
Caudina rugosa R. Perrier, 1904*a*, p. 16. Calcareous particles, 1905, pl. iv, figs. 10-12.
Caudina pulchella R. Perrier, 1905, p. 117. Calcareous particles, pl. v, figs. 14-17.
Caudina coriacea brevicauda R. Perrier, 1905, p. 121; fig. N in text.

Lenth.—60–150 mm., of which the caudal appendage may be more than half.

Color.—Milk white to yellowish brown.

Distribution.—Reported from Chile (J. Müller); Picton Island, Chile (R. Perrier); New Zealand (Hutton, Théel, et al.); Australia (Semper, Lampert); East Indies (Sluiter); China (v. Marenzeller), and Japan (Ludwig). Apparently the most widely ranging member of the genus, occurring throughout the southern and western portions of the Pacific Ocean.

Remarks.—The form of the body in this species is apparently quite variable, the caudal appendage in some specimens exceeding half the total length, while in other cases it is apparently much less and correspondingly inconspicuous; thus Müller ('50), Semper ('68), and Lampert ('85) make no reference to a caudal appendage, though the last two say the body has the usual "Haplodactyla" form. According to Semper's figure ('68, Plate IX), this would indicate a caudal appendage only about one-fourth of the length. A comparison of the descriptions and of the figures of the calcareous deposits given by Müller, v. Marenzeller, and Théel leaves little doubt that they were dealing with individuals of a single species, while Lampert's comments on *australis* and *coriacea* show that Semper's species is the same. Ludwig has given cogent reasons for declining to accept Sluiter's genus Microdactyla at its face value, and we are safe in considering that remarkable holothurian as a strongly contracted *chilensis*. Perrier's descriptions and figures (: 05) throw a great deal of light on the proportions and anatomy of this interesting species. Although M. Perrier had only seven specimens at hand, he regards them as representing five distinct forms, one being the type specimen of *ransonnetii,* one the type of *rugosa,* one the type of *pigmentosa,* two type and topotype of *pulchella,* and two type and topotype of *coriacea brevicauda.* Unfortunately, however, he fails to make clear any characters, upon which reliance can be placed, for separating these so-called species; for size, color, proportions, and texture and surface of the body-wall are all characters which vary greatly with the individual and with the method of killing and preserving. Moreover, too close similarity in deposits must not be expected in such a variable group as the Molpadiidæ, and while we may for the present recognize *pigmentosa* (q. v.), all of M. Perrier's other names appear to fall into the above given list of synonyms. Any other course would necessitate a new name for every specimen which showed any individual variation—a factor in the case for which M. Perrier apparently fails to allow. Müller ('50) describes and figures ('54) some remarkable organs in his type of *chilensis* which he calls Cuvier's organs, but that they are homologous with the Cuvier's organs of the Holothuriidæ is exceedingly doubtful. (See antea, p. 150.) It is very interesting to note that Perrier's specimen of *pigmentosa* shows the same curious structures. It is somewhat exasperating that the name *chilensis* must be retained for a species which is most common apparently in New Zealand and occurs in the East Indies and Japan.

Caudina obesacauda.

Plate XI, Figs. 1-5.

Caudina obesacauda Clark (antea, p. 38).

Length.—115 mm., of which the tail may be estimated at about one-third.

Color.—Pale brown.

Distribution.—Reported only from Marco, Florida, and Galveston, Texas. (See antea, p. 38.)

Remarks.—This species is very near the preceding, and were it from New Zealand or Australia instead of Florida, it would be difficult to show any real difference between it and *chilensis,* for it is very doubtful whether the difference in the form of the body is of any significance. Until we have further light on the shape of the body in *chilensis, obesacauda* may retain a dubious independence.

Caudina contractacauda.

Plate IX, Figs. 9-13.

Caudina contractacauda Clark (antea, p. 38).

Length.—70 mm., of which more than one-third is caudal appendage.

Color.—Very pale brown.

Distribution.—Reported only from near the Aleutian Islands (Clark).

Remarks.—Although undoubtedly near the two preceding species, this form may be readily recognized by the very different calcareous deposits. It may be considered the North Pacific representative of *chilensis*.

Caudina californica.

Plate X, Fig. 13.

Caudina californica Ludwig, 1894, p. 155. Calcareous deposits, pl. xv, figs. 1-6.

Length.—98 mm., of which 42 are caudal appendage.

Color.—Yellowish gray.

Distribution.—Reported only from the vicinity of Lower California, 2,850 m. (Ludwig); 85 m. (Clark, antea).

Remarks.—This is a well-marked and perfectly distinct species, of which only the few specimens in the National Museum are known. The small specimen, collected in only 85 m. of water, may belong to a different and hitherto-undescribed species, but in view of the very scanty material, it seems wiser to consider it a young *californica*. The plates in this small specimen are mostly less than half as large as in the type and have only 2–8 holes, which are very large in proportion to the size of the plate. The knobs on the surface of the plate are rounded or blunt, instead of being sharp. The plates are not at all crowded, but lie rather evenly distributed through the skin.

Caudina planapertura.

Plate IX, Figs. 6-8.

Caudina planapertura Clark (antea, p. 37).

Length.—67 mm., of which 27 are caudal appendage.

Color.—Gray with minute light-brown blotches, which are so numerous dorsally as to give a brownish tinge there.

Distribution.—Reported only from Wellington Island, Chile, 350 m.

Remarks.—This species is remarkably distinct from any other member of the genus, owing to the smooth, perforated plates, but superficially it closely resembles *arenata*.

Caudina pigmentosa.

Caudina pigmentosa R. Perrier, 1904*a*, p. 16.

Length.—125 mm., of which 55 are caudal appendage.

Color.—Grayish red.

Distribution.—Reported only from Tierra del Fuego (Perrier).

Remarks.—This is indeed, as Perrier says, a most remarkable and interesting species, a puzzling connecting link between Caudina and Molpadia. The tentacles and caudal appendage, as well as the basis of the curious deposits, ally it with Caudina, while the red phosphatic layers of the deposits are very much like Molpadia. The longitudinal muscles show a tendency to form retractors where they join the calcareous ring, and most remarkable of all is the presence of a bunch of Cuvier's organs similar to those which Müller describes for *chilensis*. It is not impossible that this is simply an old and abnormal (perhaps diseased) specimen of *chilensis*, but we are not justified at present in assuming that such is the case. Were it not for the red deposits, however, it is not probable that any one would question the reference of this individual to *chilensis*.

ACAUDINA, gen. nov.

(*a*, privative, + *caudina;* in reference to the marked difference from *Caudina*.)

Tentacles 15, with only two small digits. Body cylindrical, stout, not having a caudal portion and not even tapering posteriorly. Radial pieces of calcareous ring with very conspicuous, bifurcated, posterior prolongations. Calcareous deposits in the form of thick plates, with few, small perforations and a number of conspicuous, sharp projections. Phosphatic deposits wanting.

This genus is established for the following remarkable species, which is very different in color, form, and calcareous deposits from any other member of the family. Its relationships are very doubtful, though the calcareous particles seem to ally it more closely with Caudina than with any other genus.

Acaudina demissa.

Plate XII, Figs. 3, 4.

Molpadia demissa Sluiter, 1901, p. 110; pl. iii, fig. 4. Calcareous particles, pl. x, fig. 11.

Length.—160 mm., the diameter about 45.

Color.—Dark brown-violet, with irregularly scattered, oval clear spots, caused by aggregations of the calcareous plates.

Distribution.—Reported only from Madura Strait, northeast Java, 330 m. (Sluiter).

Remarks.—Although Sluiter had only a single specimen, he made such good use of that one that we have a very satisfactory knowledge of the morphology of this noteworthy holothurian.

EUPYRGUS Lütken, 1857.

Echinosoma Semper, 1868.

Tentacles 15, simple and without digits or ampullæ. Body tapering posteriorly into a short but distinct caudal appendage. Radial pieces of calcareous ring with no posterior prolongations, or with very slight ones on those of the ventral side. Longitudinal muscles simple and unpaired. Calcareous deposits in the form of tables with perforated disc and high spire. Phosphatic deposits wanting.

This interesting genus of very small holothurians was long monotypic, but Östergren (:05*b*) has recently added a second species. Although the tentacles lack digits, Eupyrgus has little in common with Aphelodactyla and its relationships are quite obscure. It is even a debatable question whether it has not sprung from a different ancestry than that of the other Molpadiidæ. The type species is a distinctly Arctic animal, but the recently discovered one is found farther to the south. Verrill's ('85*b*) *Echinosoma abyssicola,* recorded from off the New England coast in 3,718 m., is a simple *nomen nudum,* and is very possibly an Echinocucumis or perhaps a Sphærothuria.

Key to the Species of Eupyrgus.

Some or all of the calcareous tables stout, with disc 190-300 μ in diameter, perforated with 20-30 (often fewer, rarely more) holes .... scaber

Tables more slender, with base 125-250 μ, perforated with 40-60 (rarely fewer, often more) holes .... pacificus

Eupyrgus scaber.

Plate XII, Figs. 16-27.

Eupyrgus scaber Lütken, 1857, p. 22.
Echinosoma hispidum Semper, 1868, p. 44.

Length.—9–12 mm., with a diameter of about 5.

Color.—Grayish.

Distribution.—Reported from between Port Hood, Cape Breton and eastern point of Prince Edward Island, and off Bonaventure Island (Whiteaves); Salmon Bay, Caribou Island and Long Island, Cateau Bay (Packard); southern Labrador (Verrill); Greenland (Lütken, et al.); Spitzbergen (Ljungman, Théel, et al.); Barents Sea (D'Urban et al.); Kara Sea (Stuxberg); Finmark (Norman); and coast of Alaska (Clark, antea); in depths of 7–480 m.; also from Indian Ocean (Walsh).

Remarks.—Although long known, this species has been little studied and no good figures of the animal or its deposits were published until recently (Norman

:03). Semper ('68) gives some good anatomical details, including a figure of the cloaca, which shows the presence of five large calcareous plates, forming "anal teeth" such as occur in *Thyone briareus* and some other holothurians. The reported occurrence of this species in the Indian Ocean in comparatively shallow water, by Walsh ('91), is open to serious doubt, although Alcock (:02) seems to consider the record correct. Koehler and Vaney (:05) make no reference to either the species or the record, which is rather remarkable. In view of the fact, for which they vouch, that Walsh mistook a Protankyra for an Ankyroderma, we may be pardoned for doubting his identification of an Indian holothurian as Eupyrgus. In the Standard Natural History (Lockington '85), *Eupyrgus scaber* is classed as an Apneumonous Apoda, and is said to be "the simplest of all holothurians," although Semper's figures were published nearly 20 years before. It is unfortunate that such a blunder should occur in what is really a "standard" natural history.

Eupyrgus pacificus.

Plate XII, Figs. 28-29.

Eupyrgus pacificus Östergren, 1905*b*, p. cxcvi. Calcareous particles, fig. 1*b*.

Length.—3–7 mm., with a diameter of 2–3.

Color.—Not given, but presumably grayish.

Distribution.—Reported only from coast of Korea, 60–65 m. (Östergren).

Remarks.—As Östergren has compared his specimens, of which there were three, with specimens of *scaber* of the same size, there is little reason to question the validity of this species. It is possible, however, that a more complete knowledge of individual diversity in *scaber* and of its geographical range may show that *pacificus* is identical with it, particularly since *scaber* is now known to occur along the Alaskan coast.

APHELODACTYLA, nom. nov.

(ἄφελος, not rough, simple, + δάκτυλα (poetic plural) fingers; in reference to the undivided tentacles.)

Haplodactyla Semper, 1868; non Grube, 1840.

Tentacles 15, simple and without digits, but with ampullæ. Body more or less tapering posteriorly, but there is no distinctly set-off caudal appendage. Calcareous ring very broad, the radial pieces with evident, but short, posterior prolongations. Calcareous deposits often wanting (usually present at extreme posterior end), and when present relatively insignificant, in the form of small oval or dumbbell-shaped bodies or perforated plates. Phosphatic deposits wanting.

Semper's ('68) great monograph, with its wealth of anatomical detail, first introduced this interesting genus to zoölogists, but he unfortunately made use of Grube's name, which was really a synonym of Cuvier's genus Molpadia. As Semper's mistake has not hitherto been corrected, it is now necessary to give the genus a new name. Geographically, Aphelodactyla is interesting because of its very limited distribution. Although nine species or varieties have been named, they are all from the East Indian region, extending only to Ceylon on the west and to Waigiou Island, near New Guinea, on the southeast; curiously enough, the same species occurs at these two extremes. All are shallow-water forms, occurring from about low-water mark to only about 60 m. The species are all imperfectly known and it would not be surprising if future study of sufficient material should show that there are only two, or perhaps three, distinct species in the genus.

KEY TO THE SPECIES OF APHELODACTYLA.

A.—Skin more or less opaque and pigmented.
B.—Calcareous particles sometimes wanting, sometimes present only near cloacal opening, sometimes frequent, especially posteriorly, in the form of small oval bodies, and more or less irregular, perforated plates (plate x, figs. 4, 5).
Color uniform reddish violet or purplish; plates when present rather regular, thick, with few small perforations .... MOLPADIOIDES
Color clear violet, marked with orange; plates when present very irregular, sometimes with numerous perforations .... PUNCTATA
BB.—Calcareous particles small, oval, or thick C-shaped, or dumbbell-shaped, bodies. AUSTRALIS
AA.—Skin more or less glassy and transparent, sometimes without pigment.
Calcareous particles wholly wanting.................................. PELLUCIDA
Calcareous rods with projecting knobs present near cloacal opening...... HYALOEIDES

APHELODACTYLA MOLPADIOIDES.

PLATES III AND X, FIGS. 3-7.

Haplodactyla molpadioides Semper, 1868, p. 41; pls. IX; X, figs. 2*a*, 4, 5, 9; pl. XIII, 1-3.
Haplodactyla molpadioides sinensis Semper, 1868, p. 43. Calcareous particles, pl. X, fig. 2; pl. XIII, fig. 4.
Haplodactyla ecalcarea Sluiter, 1901, p. 118.

LENGTH.—Up to 210 mm., with a diameter about one-fourth as much.

COLOR.—Uniform reddish violet or purplish.

DISTRIBUTION.—Reported from Bohol and Cebu, Philippines (Semper); China (Semper); Sumbawa, D. E. I. (Sluiter), and Ceylon (Bell).

REMARKS.—Although so beautifully figured and well described by Semper, this species is still very unsatisfactorily known. Few specimens are in collections and its relationships to other members of the genus are still much in doubt. The single small specimen (35 mm.) taken by the "Siboga," and which Sluiter named *ecalcarea*, seems to be most probably a young individual of this species.

Aphelodactyla punctata.

Haplodactyla punctata Sluiter, 1888, p. 209. Calcareous particles, pl. II, figs. 31-35.

Length.—Up to 160 mm.

Color.—Clear violet with orange blotches and spots; tentacles colorless, speckled with orange.

Distribution.—Reported only from Batavia Bay and Samana Bay, D. E. I. (Sluiter).

Remarks.—Thanks to Sluiter's ('88) investigations, we really know something about this species, which appears to be distinct from *molpadioides*, though a sufficient series of specimens may show that the two are identical. It is common in the mud of Batavia Bay, where it lives with only the cloacal opening above the surface. It lives well in an aquarium, but remains buried in the mud, showing the anterior end only at night. Respiration is slow, the contractions and expansions of the cloaca only occurring two or three times per minute. The calcareous deposits show a great deal of diversity in form.

Aphelodactyla australis.

Haplodactyla holothurioides Selenka (non Cuvier), 1868, p. 115. Calcareous particles, pl. VIII, figs. 13, 14.
Haplodactyla australis Semper, 1868, p. 233.
Haplodactyla andamanensis Bell, 1887*a*, p. 139.

Length.—75–105 mm.

Color.—Coffee-brown, dusky brown, or reddish gray.

Distribution.—Reported from Waigiou, northwest of New Guinea (Selenka); Timor and Padang (Ludwig); Andaman Islands (Bell), and Ceylon (Thurston, Ludwig). Apparently the most widely distributed of the genus.

Remarks.—Very little is known of this species, beyond the existence of a few specimens in European museums. I follow Ludwig in considering *andamanensis* synonymous with *australis*, as he has examined several specimens and his long experience makes him a safe guide; but the differences between *australis* and *molpadioides* are not much greater than those which were supposed to separate *australis* and *andamanensis*, so I am by no means sure that the present species is tenable beyond question.

Aphelodactyla pellucida.

Haplodactyla molpadioides pellucida Semper, 1868, p. 42. Anatomical details, pl. x, figs. 1, 3, 6.
Haplodactyla pellucida Sluiter, 1901, p. 117.

Length.—40–75 mm.

Color.—Not given; "glassy, translucent" (Sluiter); Semper figures (Plate X, fig. 3) a bright brownish-yellow pigment cell from the skin.

Distribution.—Reported from Bohol and Cebu, Philippines (Semper); Saleyer, D. E. I. (Sluiter).

Remarks.—There seems very little reason for separating this species from *molpadioides,* but Sluiter, who has probably studied more specimens of this genus than any other zoölogist, considers it recognizable, and we may well defer to his judgment until further evidence is in. The reproductive glands are said to be unbranched and the calcareous ring much narrower than in *molpadioides.*

Aphelodactyla hyaloeides.

Haplodactyla hualoeides Sluiter, 1880, p. 345; pl. v.
Haplodactyla hualoeides Sluiter, 1880, p. 345; pl. v.

Length.—35 mm.

Color.—Colorless and glassy, like Salpa.

Distribution.—Reported from Batavia (Sluiter); Amoy (Ludwig), and Samana Bay, D. E. I. (Sluiter).

Remarks.—Although only four specimens of this remarkable species are known, it would appear to be very distinct from any other member of the family. The reproductive organs are well developed, so there is no good reason for considering it immature. Besides the deposits near the cloacal opening, Ludwig found branched rods in the walls of the genital tubes.

CERAPLECTANA Clark (antea, p. 39).

Tentacles 10, simple, unbranched, horny and pointed, provided with normal ampullæ. Body nearly cylindrical, but tapering posteriorly into a well-developed caudal appendage. Radial pieces of calcareous ring with marked, but not deeply forked, posterior prolongations. Calcareous deposits in the form of irregular branched plates or straight rods, perforated near the middle, and usually with a single, sharp, outwardly directed spine. Phosphatic deposits present.

The relationships of this curious genus are evidently with Molpadia, as shown by the shape of the body, the calcareous ring, and the deposits in the skin, but the tentacles are very distinctive. Koehler and Vaney (:05) report a Molpadia from the Gulf of Bengal (*elongata*) in which only 10 tentacles showed, but they say nothing of the form or structure of those; the use of the word "dix" looks very much like a slip of the pen, as no comment is made on the unusual number.

Ceraplectana trachyderma.

Plate XIII, Figs. 5-13.

Ceraplectana trachyderma Clark (antea, p. 39).

Length.—Up to 80 mm., of which about one-fourth is tail; diameter, 10–20 mm.

Color.—Gray mottled with numerous small patches of red-brown.

Distribution.—Reported only from "Albatross" Station 3603, near the Aleutian Islands, 3,188 m. (Clark).

Remarks.—This is one of the "Albatross'" most interesting discoveries in the way of holothurians and adds another to the long list of remarkable animals acquaintance with which science owes to that vessel. The three specimens taken occurred on a bottom of "blue ooze."

HIMASTHLEPHORA Clark (antea, p. 40).

Tentacles 15, with four digits of which the terminal pair are the largest; without ampullæ. Body nearly cylindrical, rather stout, terminating abruptly in a long, slender caudal portion. Mid-dorsal interambulacrum with 4–6 whip-lash-like papillæ. Rudimentary pedicel-like outgrowths near both the anterior and posterior ends of the body. Genital papilla prominent, 2 mm. or more in length. Respiratory trees small and delicate. Longitudinal muscles simple, flattened and unpaired. Calcareous ring of 10 pieces, rather stout and synapta-like with no posterior prolongations. No calcareous or phosphatic deposits in skin. Careful examination of two specimens failed to show a stone-canal.

The specimens on which this genus is based were collected in 1886 and examined by me in 1900. In 1905 appeared the description of the following genus, and it occurred to me at once that the "Investigator's" novelty is very closely allied to this one discovered by the "Albatross," if not actually congeneric with it. The most obvious difference between the two is in the shape of the body—that is, the presence or absence of a caudal appendage. I considered it present very plainly in the four "Albatross" specimens, while Koehler and Vaney consider it wanting in the two "Investigator" specimens. I am now unable from the available material to satisfy myself beyond doubt on this point. An apparent caudal appendage was present in all four specimens, but the condition of the material was such that even the stained sections prepared would not permit me to determine whether the appendage was a normal outgrowth covered with skin or an evagination of part of the alimentary canal, which is unfortunately ruptured and macerated beyond satisfactory examination. The position of the clusters of pedicel-like outgrowths at the base of the appendage is suspicious, and a study of the description and figures given by Koehler and Vaney increases the suspicion that the apparent tail is not a normal outgrowth. On the other hand, its presence in all four specimens and its general appearance argue in favor of its being a caudal appendage, especially since the respiratory trees were in their normal position in the body-cavity. If the appendage were an evagination, it seems as though the respiratory trees must have been injured or disturbed. Aside from this doubtful appendage, Himasthlephora differs from Gephyrothuria in the number of digits on the tentacles, the presence of a prominent genital papilla, the smaller number of dorsal papillæ, and the presence of rudimentary pedicel-like outgrowths. None of these differences, however, will stand very critical examination, and if the two species are shown, by the collection and study of further material, to be alike in the presence or absence of a caudal appendage, it seems to me very probable that they are congeneric, and Himasthlephora must become simply a synonym of Gephyrothuria. As regards the relationship of these interesting holothurians to other genera, it seems to me clear that they are closely related to Caudina, although in the unpaired longitudinal muscles, the absence of tentacle-ampullæ, of posterior prolongations on the radial pieces of the calcareous ring, and of phosphatic deposits they resemble Eupyrgus. They certainly belong to the Molpadiidæ. The number and form of the tentacles and the general appearance is very characteristic, and the presence of rudimentary ambulacral appendages is not of nearly sufficient importance to warrant the formation of a new family. Gerould ('96) long since demonstrated their presence in *Caudina arenata*. It might be possible to form a subfamily of Himasthlephora and Gephyrothuria, but in the present imperfect state of our knowledge of these forms, such a step seems to me inadvisable and undesirable.

Himasthlephora glauca.

Plate XIII, Figs. 1-4.

Himasthlephora glauca Clark (antea, p. 40).

Length.—28 mm., of which 9 is tail; diameter about 8 mm.

Color.—Uniform pale gray; tentacles and genital papilla brownish.

Distribution.—Reported only from "Albatross" Station 2678, off the coast of Georgia, 1,316 m. (Clark).

Remarks.—Nothing remains to be added to the remarks on page 41, save that this species appears to be much smaller and more dully colored than the following, although the specimens were apparently sexually mature. They occurred on a bottom of "light gray ooze," with which they must have corresponded in color almost exactly.

GEPHYROTHURIA Koehler and Vaney, 1905.

Tentacles 15, with only two (?) digits, without ampullæ. Body nearly cylindrical, rather stout, with no caudal portion (?). Mid-dorsal interambulacrum with 7–9 whiplash-like papillæ. Pedicel-like outgrowths and genital papilla wanting. Calcareous ring without posterior prolongations. Calcareous and phosphatic deposits wanting.

The peculiarities of this genus have been fully discussed in connection with the preceding, to which it is at least most closely related.

Gephyrothuria alcocki.

Gephyrothuria alcocki Koehler and Vaney, 1905, p. 79; pl. v, figs. 6-8.

Length.—Up to 50 mm., with a diameter of 17.

Color.—Rosy.

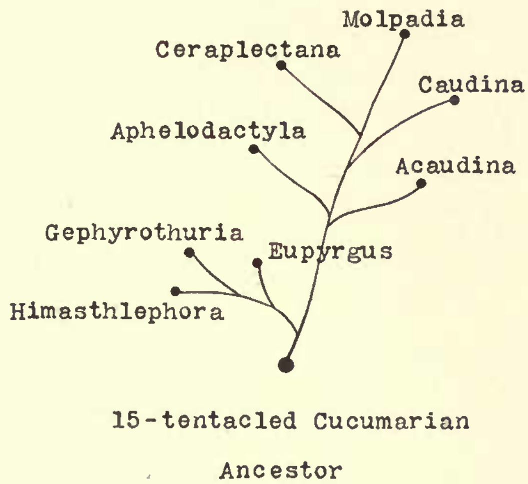
Distribution.—Reported only from "Investigator" Station 278, near Ceylon, 3,442 m. (Koehler and Vaney).

Remarks.—The larger size and brighter color distinguish this from the similar species of the American coast, aside from the generic differences already discussed. The tentacles were so much contracted that it could not be decided satisfactorily what the number of digits is.

CONCLUDING REMARKS ON THE MOLPADIIDÆ.

Interrelationships.

Having thus characterized the 8 genera and 46 species of Molpadiidæ known to science at the present day, it may be worth while to attempt to show in graphic form the relationship which they have to each other. There is good reason for believing that the ancestor of the group was a 15-tentacled pedate holothurian, probably one of the Cucumariidæ, or at any rate most nearly related to that family. Beyond this point our arrangement of the genera is largely a matter of personal opinion; but there will probably be general agreement that Himasthlephora is nearest to such an ancestral form, because of its still possessing rudiments of pedicels, as well as dorsal papillæ, and its lack of tentacle ampullæ; Gephyrothuria is of course very little further removed. But the absence of calcareous deposits in the skin and of posterior prolongations to the radial pieces of the calcareous ring in these genera are probably not ancestral, but are more recent modifications. We may rank Acaudina next because of the shape of the body, and follow with Caudina, the species with long and distinct tails being farthest from the original form. It is natural to consider Aphelodactyla as a modified Caudina, but it is probably just as near to Acaudina. The connection between Caudina and Molpadia is obvious and the dividing line is hard to draw, while Ceraplectana is apparently a striking modification of the latter. As for Eupyrgus, there is room for wide difference of opinion, but it is apparently a much modified genus, which may have had a different origin from the rest of the family, or may have been derived from a form near Gephyrothuria. Assuming that the latter has been the more probable course of development, the relationships of the genera might then be represented as follows:



Geographical Distribution.

In considering the distribution of the foregoing genera we will use the same system that served us in the discussion of the Synaptidæ, even though a large proportion of the Molpadiidæ are abyssal forms. We are at once struck by the fact that there is no one particular region characterized by an exceptional number of genera, although three occur in the Pacific Boreal subregion and four in the Indo-Pacific region; of the latter, two are characteristic, but of the former there are none, although we might ignore the depth at which Ceraplectana occurs and consider it a fourth and characteristic genus. Besides Ceraplectana, two genera are exclusively Abyssal and two others occur in that region. The most widely distributed genus, Molpadia, occurs in practically all parts of the world where collections at depths of 200 m. or more have been made, and Caudina also has a wide range, though it is properly a littoral genus with only two abyssal species, and a distribution much like Chiridota (see p. 133); but Molpadia is strictly littoral only in the case of a very few species, and chiefly in the Arctic or Antarctic regions. The following table will show these facts of distribution in a convenient way; an * indicates that the genus is characteristic of the region, ** that it is not found elsewhere; the figures in parentheses indicate the number of species occurring in that region or subregion:

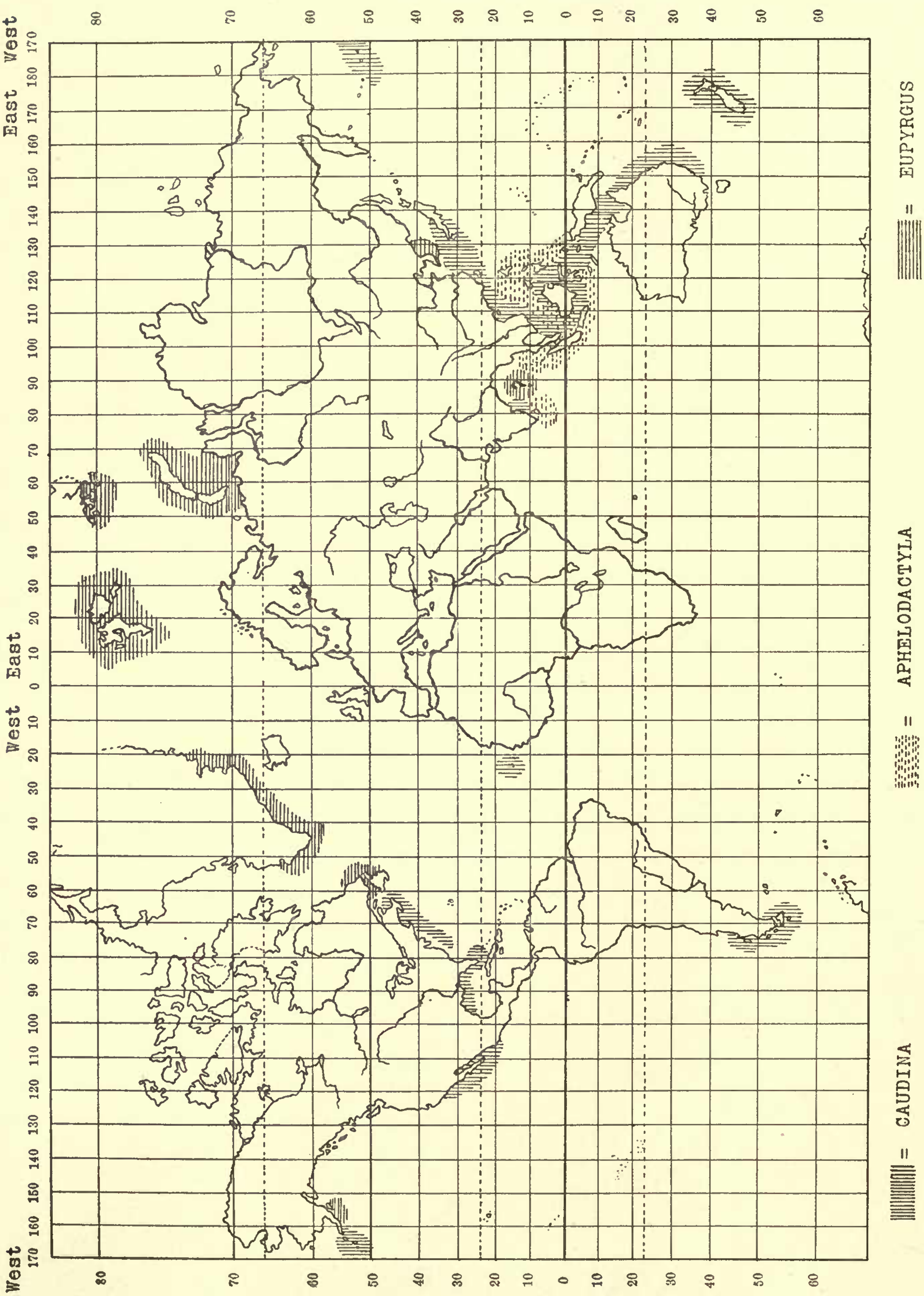
Abyssal Region:
- * Molpadia (16).
- ** Ceraplectana (1).
- ** Gephyrothuria (1).
- ** Himasthlephora (1).
- Caudina (2).

Indo-Pacific Littoral Region:
- ** Aphelodactyla (5).
- ** Acaudina (1).
- Caudina (1).
- Molpadia (12).

Atlantic Boreal Subregion:
- Eupyrgus (1).
- Molpadia (4).
- Caudina (1).

Arctic Circumpolar Subregion:
- Eupyrgus (1).
- Molpadia (2).

Pacific Boreal Subregion:
- Eupyrgus (2).
- Caudina (1).
- Molpadia (3).



Map Showing the Distribution of Three Genera of Molpadiidæ

Antarctic Littoral Region:
Caudina (3).
Molpadia (3).

East American Littoral Region:
Caudina (1).
Mediterranean Subregion:
Molpadia (1).
West American Subregion:
Molpadia (2). ?
Guinea Subregion:
Molpadia (1). ?

We know too little of the range of the great majority of the species to make profitable or worth while any attempt at a study of their distribution. It might be added, however, that the Molpadiidæ afford no support to the so-called "theory of bipolarity," for the southern species of Molpadia and Caudina are perfectly distinct from the northern forms, and there is no representative of Eupyrgus or of Ceraplectana in southern seas.

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EXPLANATION OF PLATES

Figures on the following plates, which are not new, are credited to the author from whom they are taken, but such figures are not always copies; they are sometimes reduced in size and the shading is often modified; occasionally details are changed to make the figure more representative of the species which it illustrates. Where the magnification of the original figure was not given, it has been estimated as nearly as possible from the data available, but a question-mark indicates the uncertainty.

PLATE I. (See frontispiece, facing page 11.)

Synapta maculata (Chamisso and Eysenhardt).

Figure 1. Anterior end of adult, with verrucæ, natural size. (From Semper, 1868.)
2. Anterior end of adult, without verrucæ, natural size.

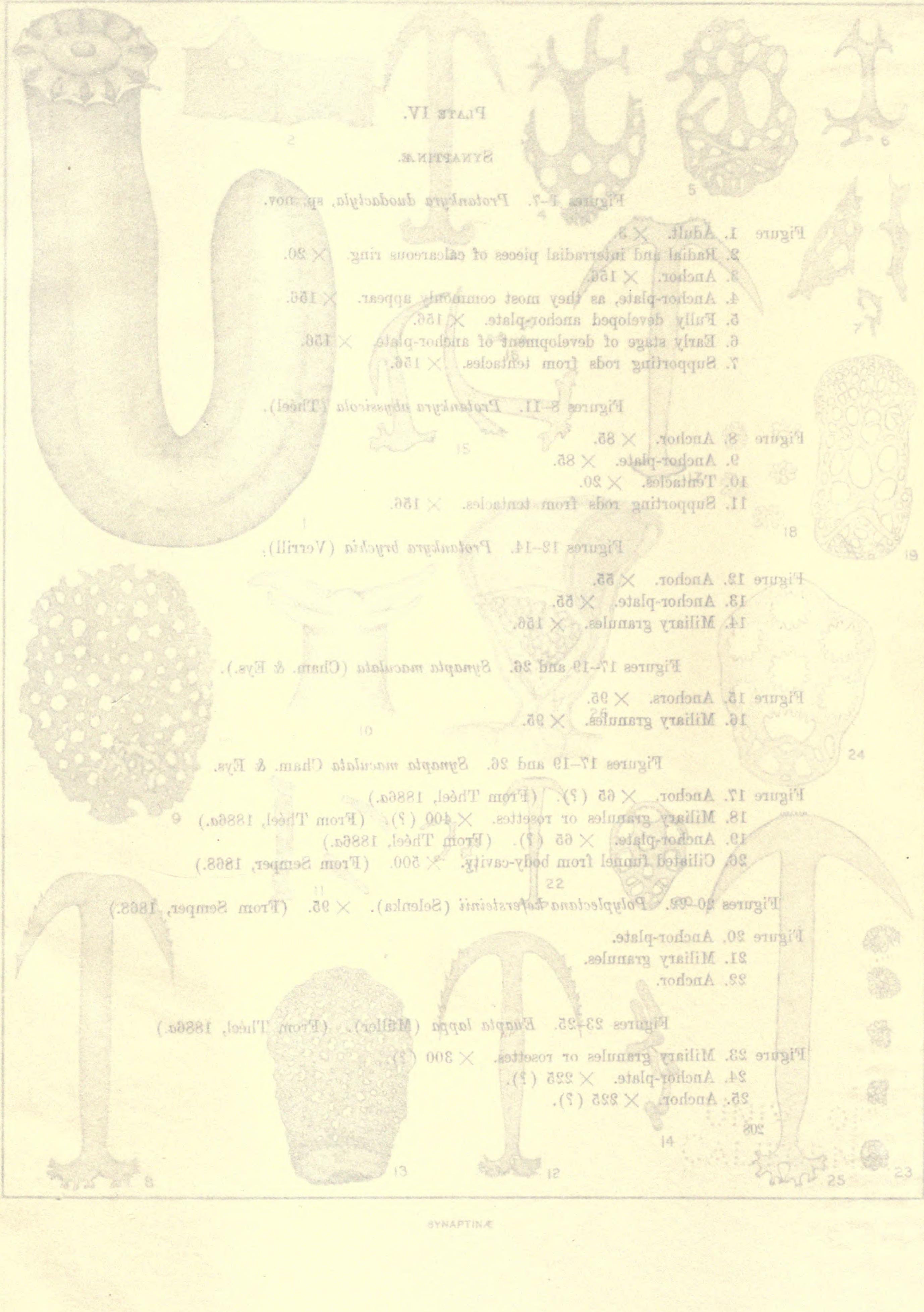
PLATE II. (See page 42.)

Figure 1. *Anapta gracilis* Semper.
2. *Protankyra similis* (Semper).
3. *Chiridota rigida* Semper.
All natural size and from Semper, 1868.

PLATE III. (See page 135.)

Aphelodactyla molpadioides (Semper).

Adult, natural size. (From Semper, 1868.)



SYNAPTINÆ

Plate IV.

Synaptinæ.

Figures 1–7. *Protankyra duodactyla,* sp. nov.

Figure 1. Adult. × 3.
2. Radial and interradial pieces of calcareous ring. × 20.
3. Anchor. × 156.
4. Anchor-plate, as they most commonly appear. × 156.
5. Fully developed anchor-plate. × 156.
6. Early stage of development of anchor-plate. × 156.
7. Supporting rods from tentacles. × 156.

Figures 8–11. *Protankyra abyssicola* (Théel).

Figure 8. Anchor. × 85.
9. Anchor-plate. × 85.
10. Tentacles. × 20.
11. Supporting rods from tentacles. × 156.

Figures 12–14. *Protankyra brychia* (Verrill).

Figure 12. Anchor. × 55.
13. Anchor-plate. × 55.
14. Miliary granules. × 156.

Figures 17–19 and 26. *Synapta maculata* (Cham. & Eys.).

Figure 15. Anchors. × 95.
16. Miliary granules. × 95.

Figures 17–19 and 26. *Synapta maculata* Cham. & Eys.

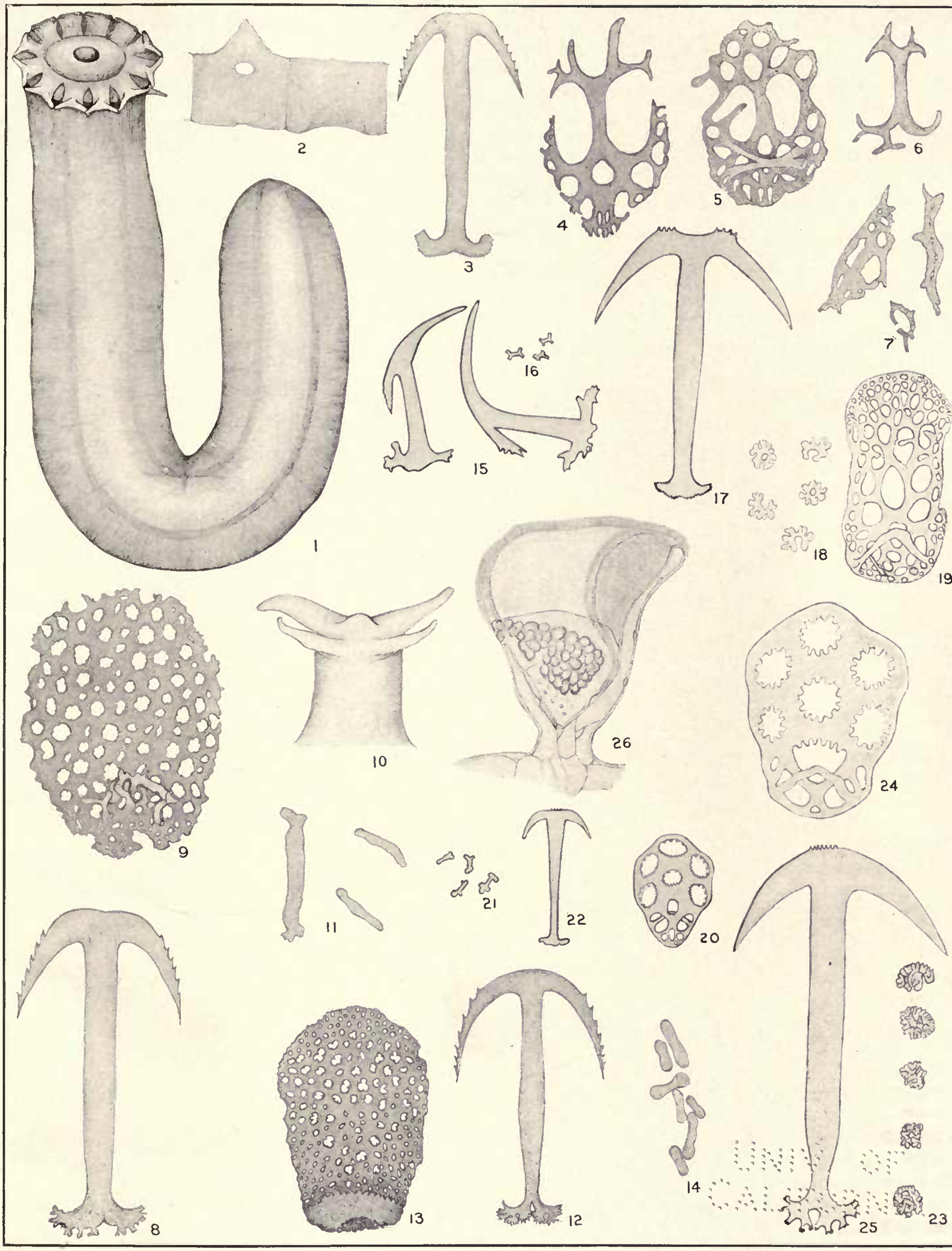
Figure 17. Anchor. × 65 (?). (From Théel, 1886*a*.)
18. Miliary granules or rosettes. × 400 (?). (From Théel, 1886*a*.)
19. Anchor-plate. × 65 (?). (From Théel, 1886*a*.)
26. Ciliated funnel from body-cavity. × 500. (From Semper, 1868.)

Figures 20–22. *Polyplectana kefersteinii* (Selenka). × 95. (From Semper, 1868.)

Figure 20. Anchor-plate.
21. Miliary granules.
22. Anchor.

Figures 23–25. *Euapta lappa* (Müller). (From Théel, 1886*a*.)

Figure 23. Miliary granules or rosettes. × 300 (?).
24. Anchor-plate. × 225 (?).
25. Anchor. × 225 (?).



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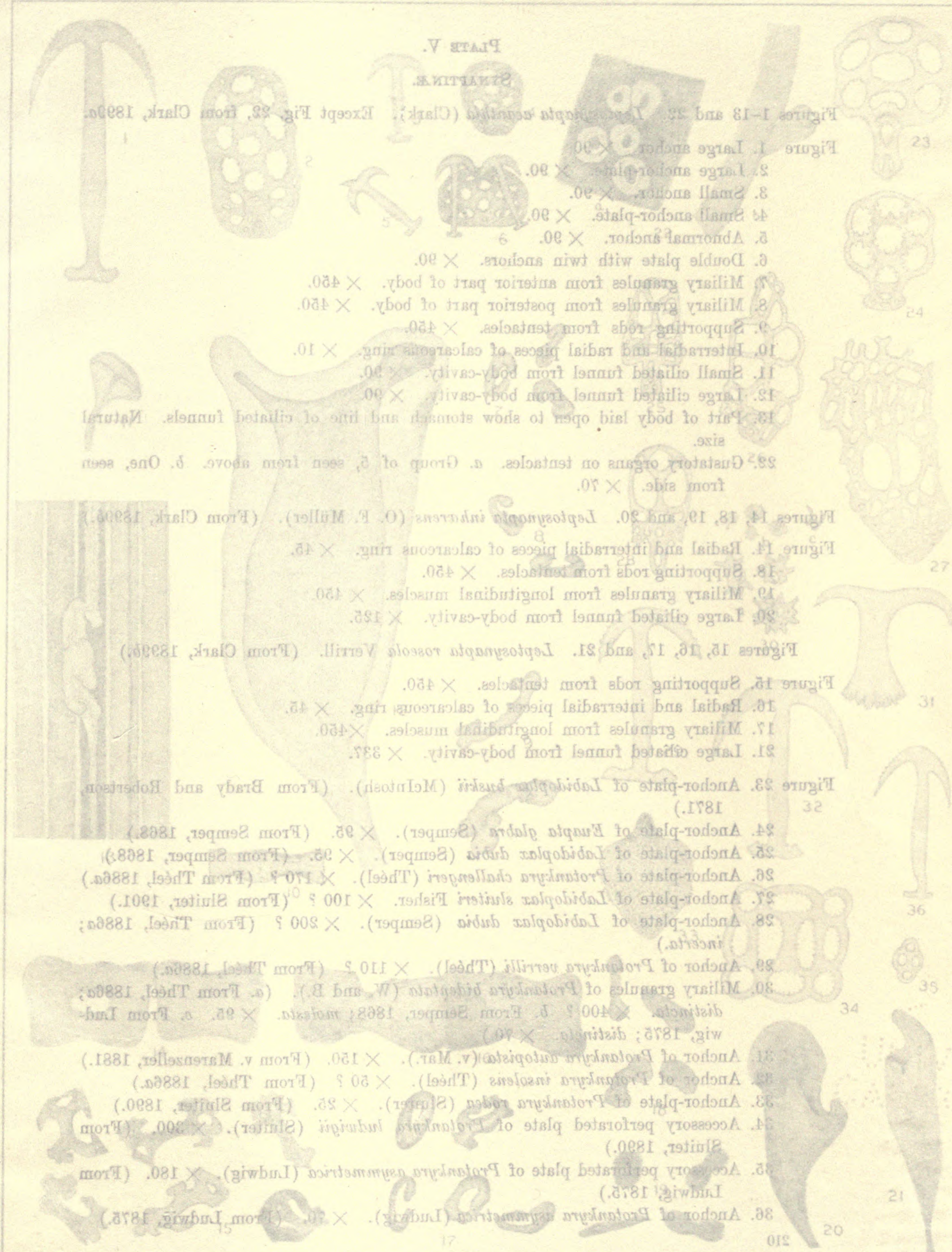


SYNAPTINÆ

Plate V.

Synaptinæ.

Figures 1–13 and 22. *Leptosynapta acanthia* (Clark). Except Fig. 22, from Clark, 1899*a*.

Figure 1. Large anchor. × 90.
2. Large anchor-plate. × 90.
3. Small anchor. × 90.
4. Small anchor-plate. × 90.
5. Abnormal anchor. × 90.
6. Double plate with twin anchors. × 90.
7. Miliary granules from anterior part of body. × 450.
8. Miliary granules from posterior part of body. × 450.
9. Supporting rods from tentacles. × 450.
10. Interradial and radial pieces of calcareous ring. × 10.
11. Small ciliated funnel from body-cavity. × 90.
12. Large ciliated funnel from body-cavity. × 90.
13. Part of body laid open to show stomach and line of ciliated funnels. Natural size.
22. Gustatory organs on tentacles. *a*. Group of 5, seen from above. *b*. One, seen from side. × 70.

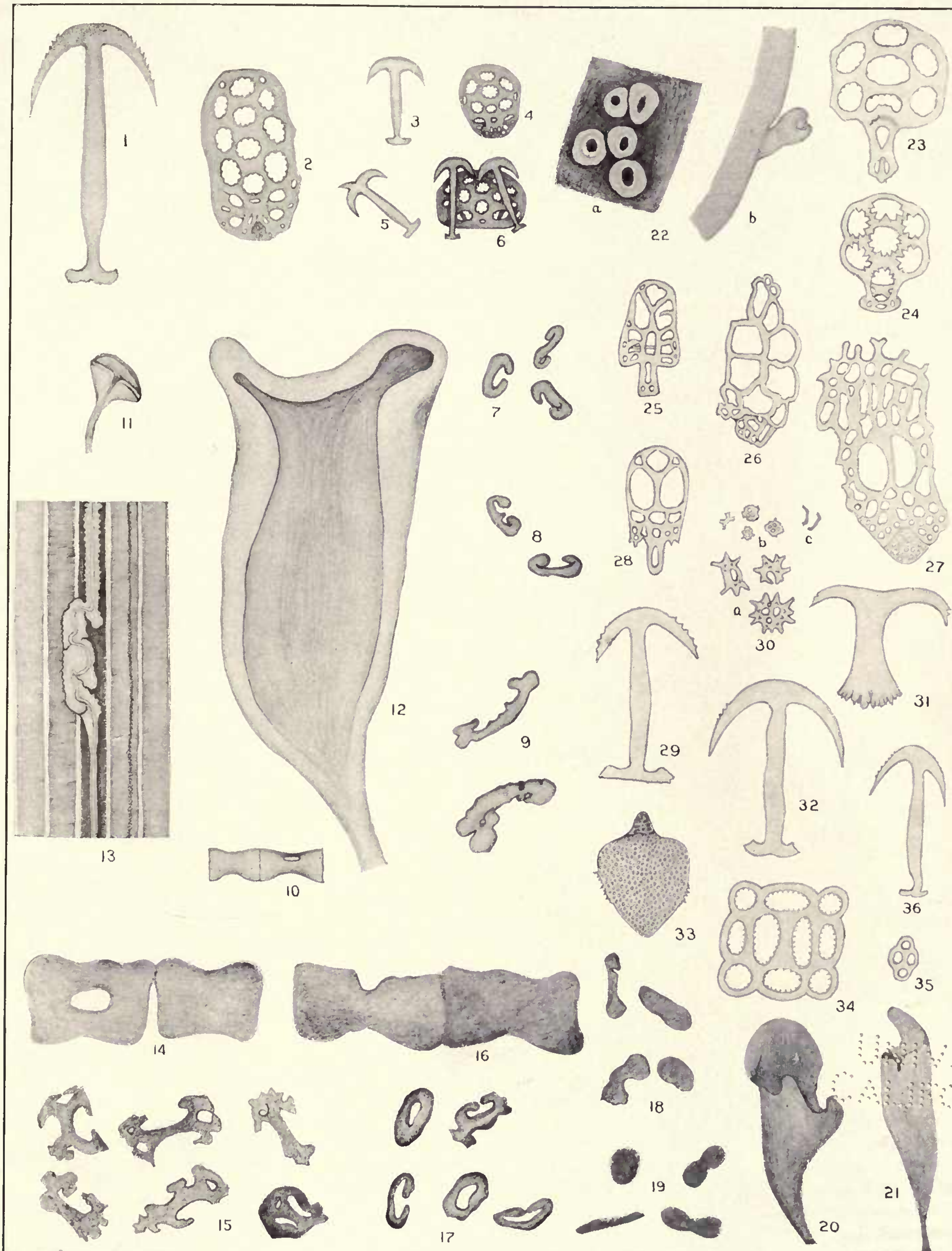
Figures 14, 18, 19, and 20. *Leptosynapta inhærens* (O. F. Müller). (From Clark, 1899*b*.)

Figure 14. Radial and interradial pieces of calcareous ring. × 45.
18. Supporting rods from tentacles. × 450.
19. Miliary granules from longitudinal muscles. × 450.
20. Large ciliated funnel from body-cavity. × 125.

Figures 15, 16, 17, and 21. *Leptosynapta roseola* Verrill. (From Clark, 1899*b*.)

Figure 15. Supporting rods from tentacles. × 450.
16. Radial and interradial pieces of calcareous ring. × 45.
17. Miliary granules from longitudinal muscles. ×450.
21. Large ciliated funnel from body-cavity. × 337.

Figure 23. Anchor-plate of *Labidoplax buskii* (McIntosh). (From Brady and Robertson, 1871.)
24. Anchor-plate of *Euapta glabra* (Semper). × 95. (From Semper, 1868.)
25. Anchor-plate of *Labidoplax dubia* (Semper). × 95. (From Semper, 1868.)
26. Anchor-plate of *Protankyra challengeri* (Théel). × 170 ? (From Théel, 1886*a*.)
27. Anchor-plate of *Labidoplax sluiteri* Fisher. × 100 ? (From Sluiter, 1901.)
28. Anchor-plate of *Labidoplax dubia* (Semper). × 200 ? (From Théel, 1886*a*; *incerta*.)
29. Anchor of *Protankyra verrilli* (Théel). × 110 ? (From Théel, 1886*a*.)
30. Miliary granules of *Protankyra bidentata* (W. and B.). (*a*. From Théel, 1886*a*; *distincta*. × 400 ? *b*. From Semper, 1868; *molesta*. × 95. *c*. From Ludwig, 1875; *distincta*. × 70.)
31. Anchor of *Protankyra autopista* (v. Mar.). × 150. (From v. Marenzeller, 1881.)
32. Anchor of *Protankyra insolens* (Théel). × 50 ? (From Théel, 1886*a*.)
33. Anchor-plate of *Protankyra rodea* (Sluiter). × 25. (From Sluiter, 1890.)
34. Accessory perforated plate of *Protankyra ludwigii* (Sluiter). × 300. (From Sluiter, 1890.)
35. Accessory perforated plate of *Protankyra asymmetrica* (Ludwig). × 180. (From Ludwig, 1875.)
36. Anchor of *Protankyra asymmetrica* (Ludwig). × 70. (From Ludwig, 1875.)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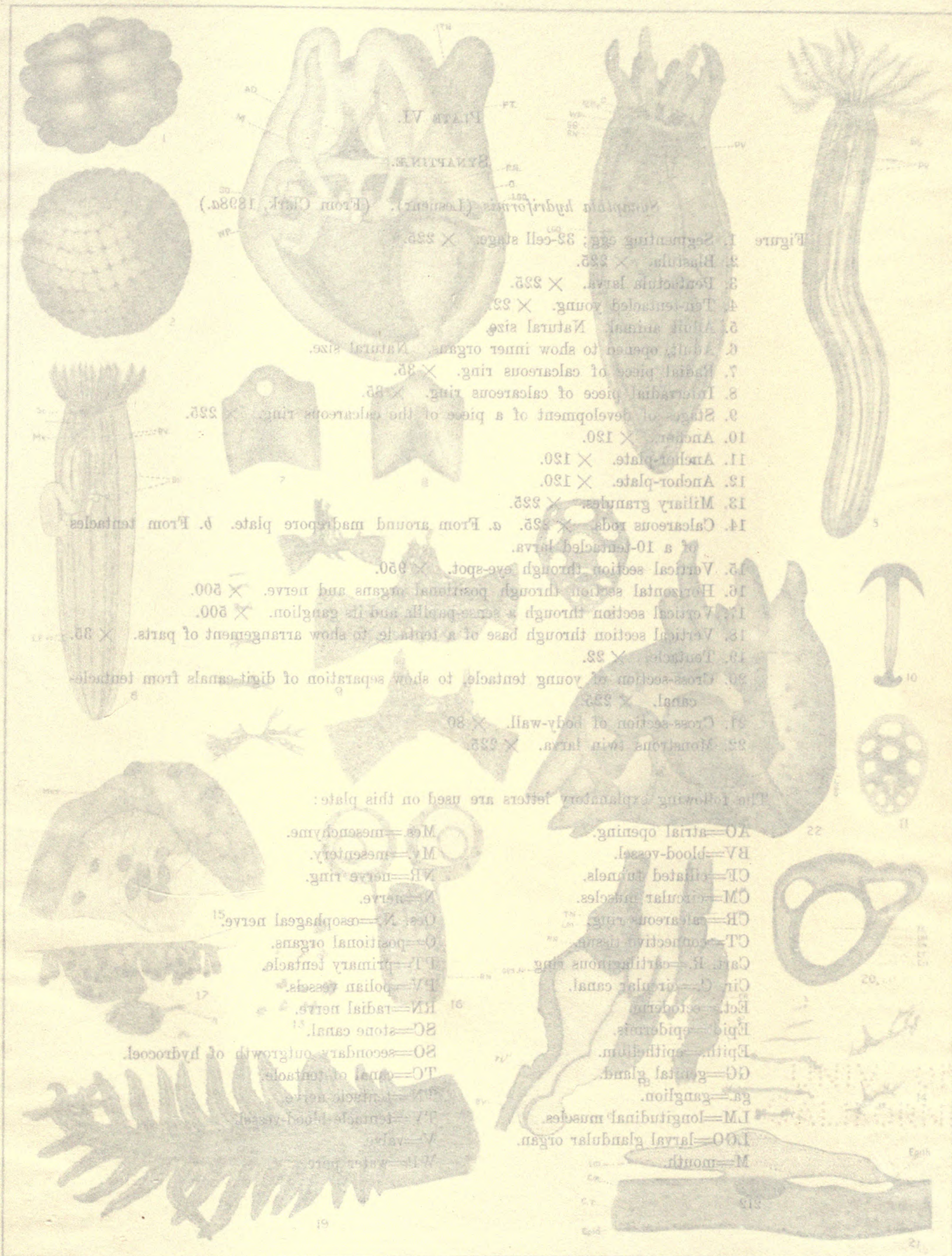
SYNAPTINÆ



SYNAPTULA HYDRIFORMIS (Lesueur)

Plate VI.

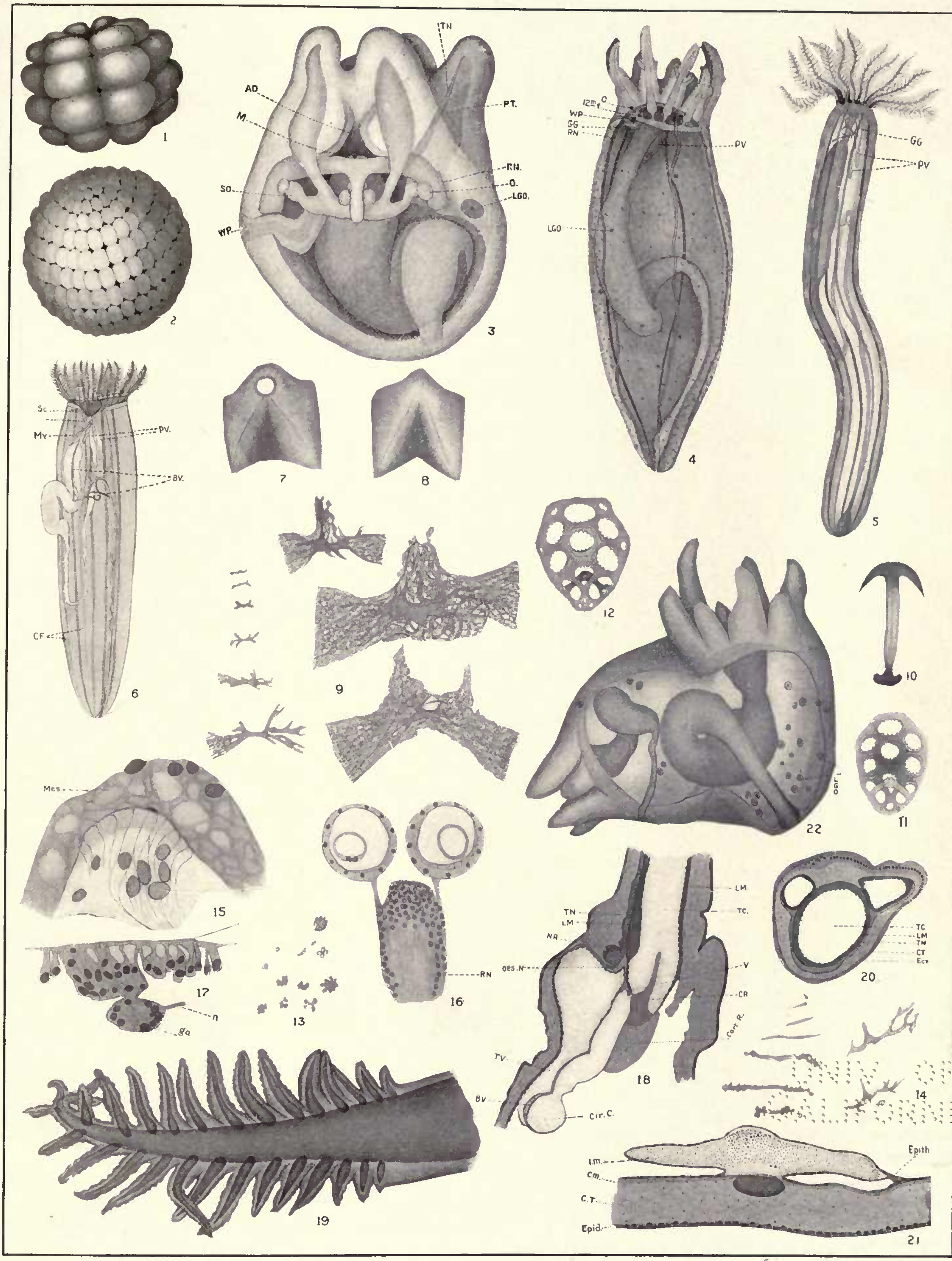
Synaptinæ.

Synaptula hydriformis (Lesueur). (From Clark, 1898*a*.)

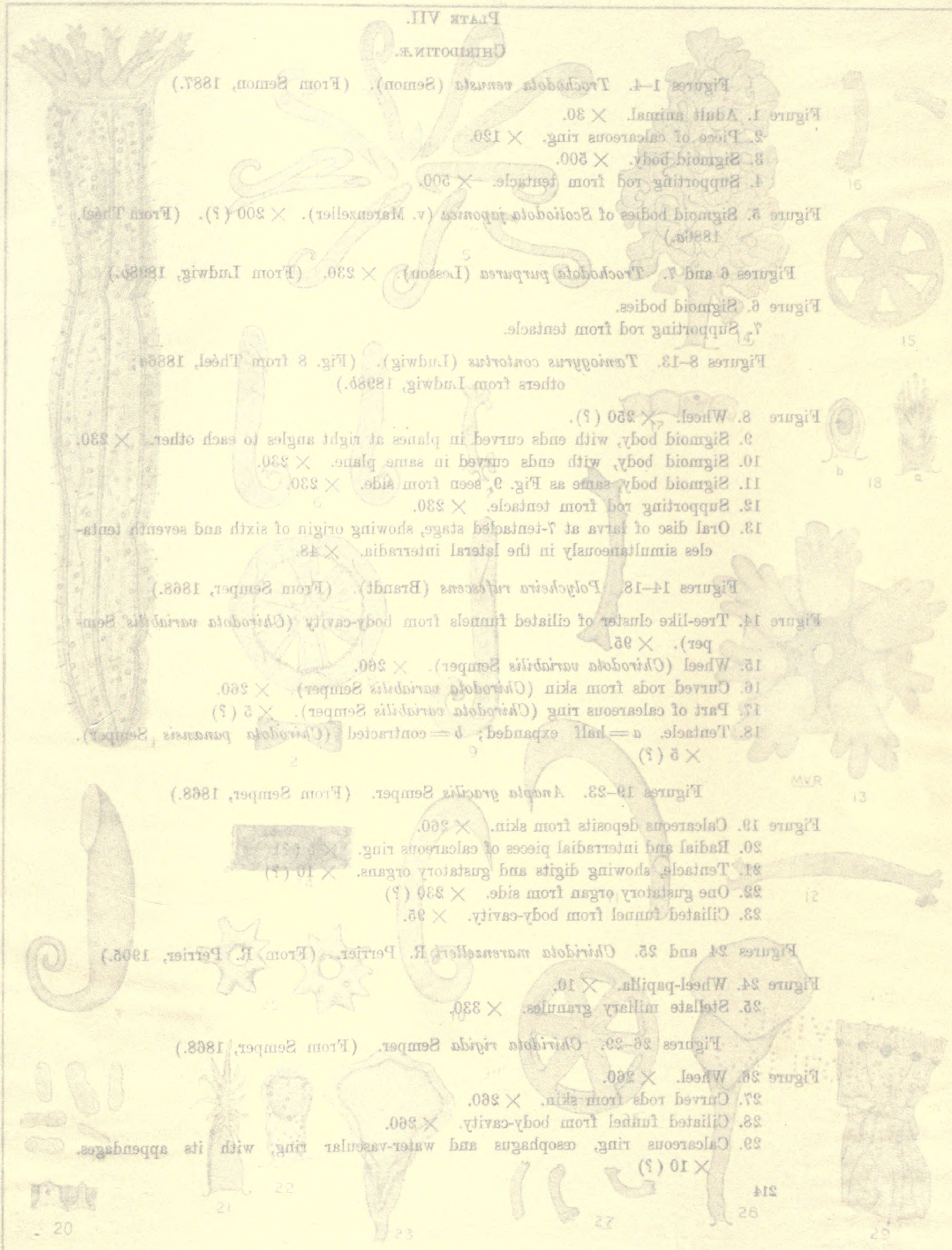
Figure 1. Segmenting egg; 32-cell stage. × 225.
2. Blastula. × 225.
3. Pentactula larva. × 225.
4. Ten-tentacled young. × 22.
5. Adult animal. Natural size.
6. Adult, opened to show inner organs. Natural size.
7. Radial piece of calcareous ring. × 35.
8. Interradial piece of calcareous ring. × 35.
9. Stages of development of a piece of the calcareous ring. × 225.
10. Anchor. × 120.
11. Anchor-plate. × 120.
12. Anchor-plate. × 120.
13. Miliary granules. × 225.
14. Calcareous rods. × 225. *a*. From around madrepore plate. *b*. From tentacles of a 10-tentacled larva.
15. Vertical section through eye-spot. × 950.
16. Horizontal section through positional organs and nerve. × 500.
17. Vertical section through a sense-papilla and its ganglion. × 500.
18. Vertical section through base of a tentacle, to show arrangement of parts. × 35.
19. Tentacle. × 22.
20. Cross-section of young tentacle, to show separation of digit-canals from tentacle-canal. × 225.
21. Cross-section of body-wall. × 80.
22. Monstrous twin larva. × 225.

The following explanatory letters are used on this plate:

AO=atrial opening.
BV=blood-vessel.
CF=ciliated funnels.
CM=circular muscles.
CR=calcareous ring.
CT=connective tissue.
Cart. R.=cartilaginous ring
Cir. C.=circular canal.
Ect.=ectoderm.
Epid.=epidermis.
Epith.=epithelium.
GG=genital gland.
ga.=ganglion.
LM=longitudinal muscles.
LGO=larval glandular organ.
M=mouth.
Mes.=mesenchyme.
My.=mesentery.
NR=nerve ring.
N=nerve.
Oes. N.=œsophageal nerve.
O=positional organs.
PT=primary tentacle.
PV=polian vessels.
RN=radial nerve.
SC=stone canal.
SO=secondary outgrowth of hydrocoel.
TC=canal of tentacle.
TN=tentacle nerve.
TV=tentacle blood-vessel.
V=valve.
WP=water pore.



SYNAPTULA HYDRIFORMIS (Lesueur)



CHIRIDOTINÆ

Plate VII.

Chiridotinæ.

Figures 1–4. *Trochodota venusta* (Semon). (From Semon, 1887.)

Figure 1. Adult animal. × 30.
2. Piece of calcareous ring. × 120.
3. Sigmoid body. × 500.
4. Supporting rod from tentacle. × 500.

Figure 5. Sigmoid bodies of *Scoliodota japonica* (v. Marenzeller). × 200 (?). (From Théel, 1886*a*.)

Figures 6 and 7. *Trochodota purpurea* (Lesson). × 230. (From Ludwig, 1898*b*.)

Figure 6. Sigmoid bodies.
7. Supporting rod from tentacle.

Figures 8–13. *Tæniogyrus contortus* (Ludwig). (Fig. 8 from Théel, 1886*a*; others from Ludwig, 1898*b*.)

Figure 8. Wheel. × 250 (?).
9. Sigmoid body, with ends curved in planes at right angles to each other. × 230.
10. Sigmoid body, with ends curved in same plane. × 230.
11. Sigmoid body, same as Fig. 9, seen from side. × 230.
12. Supporting rod from tentacle. × 230.
13. Oral disc of larva at 7-tentacled stage, showing origin of sixth and seventh tentacles simultaneously in the lateral interradia. × 48.

Figures 14–18. *Polycheira rufescens* (Brandt). (From Semper, 1868.)

Figure 14. Tree-like cluster of ciliated funnels from body-cavity (*Chirodota variabilis* Semper). × 95.
15. Wheel (*Chirodota variabilis* Semper). × 260.
16. Curved rods from skin (*Chirodota variabilis* Semper). × 260.
17. Part of calcareous ring (*Chirodota variabilis* Semper). × 5 (?)
18. Tentacle. *a* = half expanded; *b* = contracted (*Chirodota panæensis* Semper). × 5 (?)

Figures 19–23. *Anapta gracilis* Semper. (From Semper, 1868.)

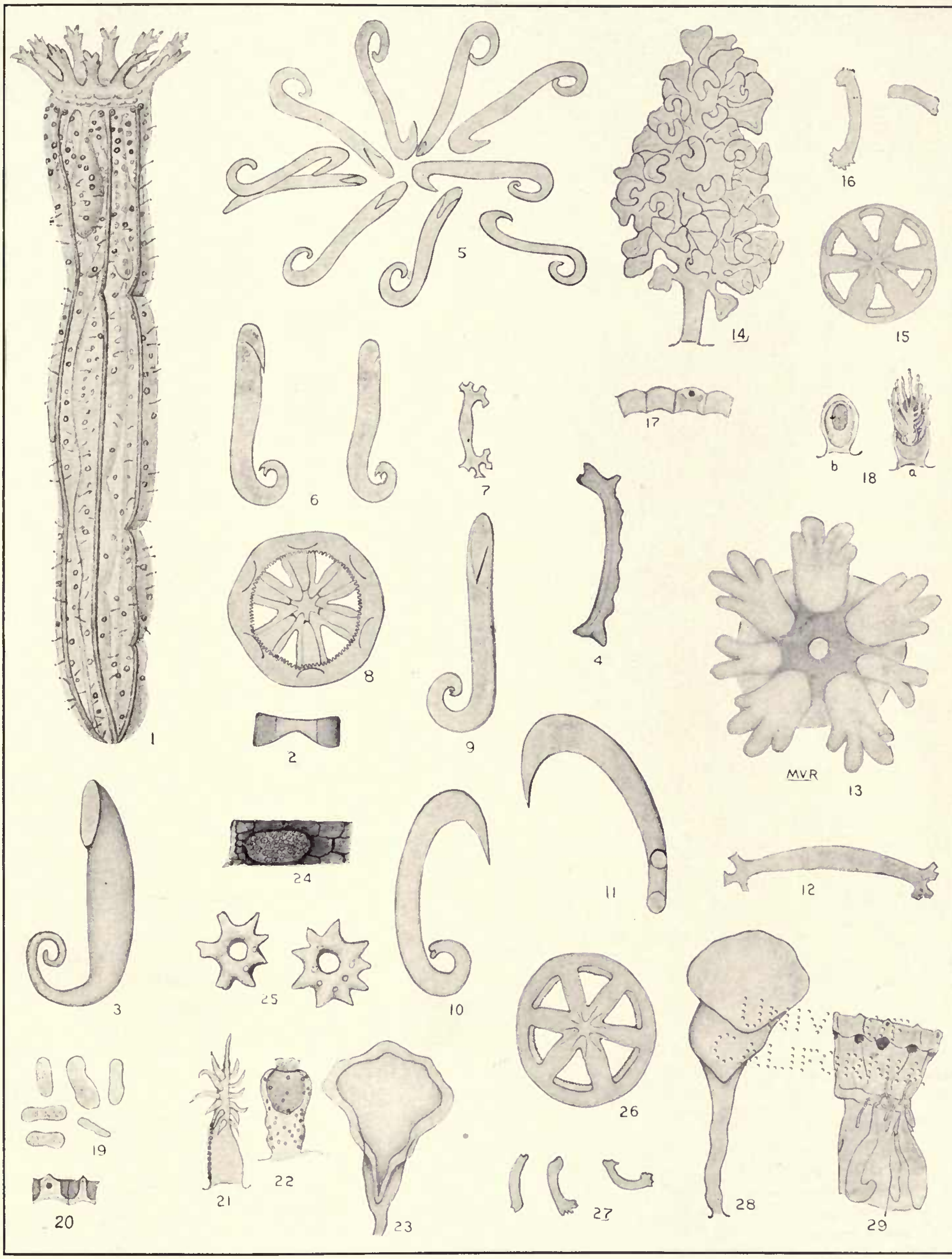
Figure 19. Calcareous deposits from skin. × 260.
20. Radial and interradial pieces of calcareous ring. × 5 (?)
21. Tentacle, showing digits and gustatory organs. × 10 (?)
22. One gustatory organ from side. × 230 (?)
23. Ciliated funnel from body-cavity. × 95.

Figures 24 and 25. *Chiridota marenzelleri* R. Perrier. (From R. Perrier, 1905.)

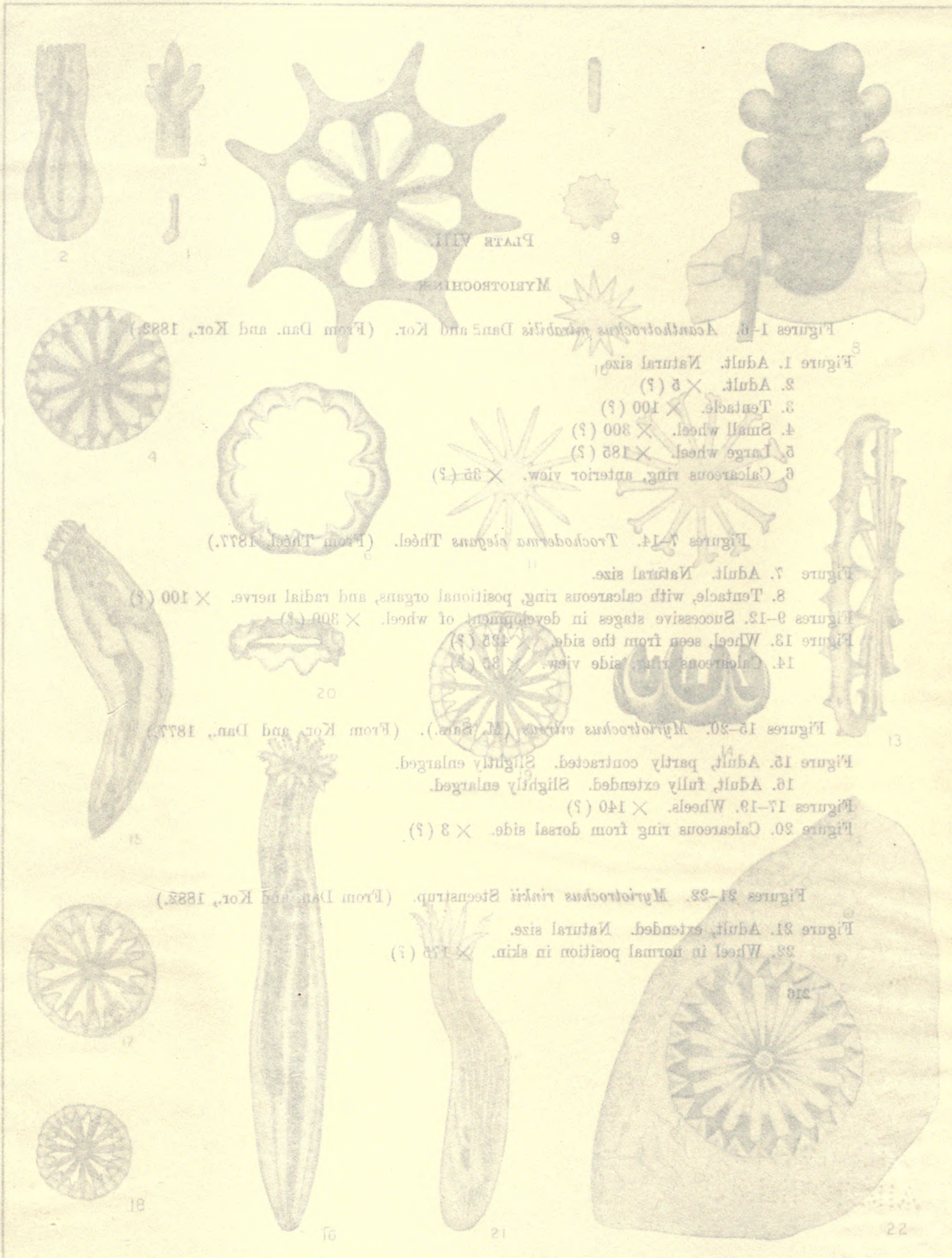
Figure 24. Wheel-papilla. × 10.
25. Stellate miliary granules. × 330.

Figures 26–29. *Chiridota rigida* Semper. (From Semper, 1868.)

Figure 26. Wheel. × 260.
27. Curved rods from skin. × 260.
28. Ciliated funnel from body-cavity. × 260.
29. Calcareous ring, œsophagus and water-vascular ring, with its appendages. × 10 (?)



CHIRIDOTINÆ



MYRIOTROCHINÆ

Plate VIII.

Myriotrochinæ.

Figures 1–6. *Acanthotrochus mirabilis* Dan. and Kor. (From Dan. and Kor., 1882.)

Figure 1. Adult. Natural size.
2. Adult. × 5 (?)
3. Tentacle. × 100 (?)
4. Small wheel. × 300 (?)
5. Large wheel. × 185 (?)
6. Calcareous ring, anterior view. × 35 (?)

Figures 7–14. *Trochoderma elegans* Théel. (From Théel, 1877.)

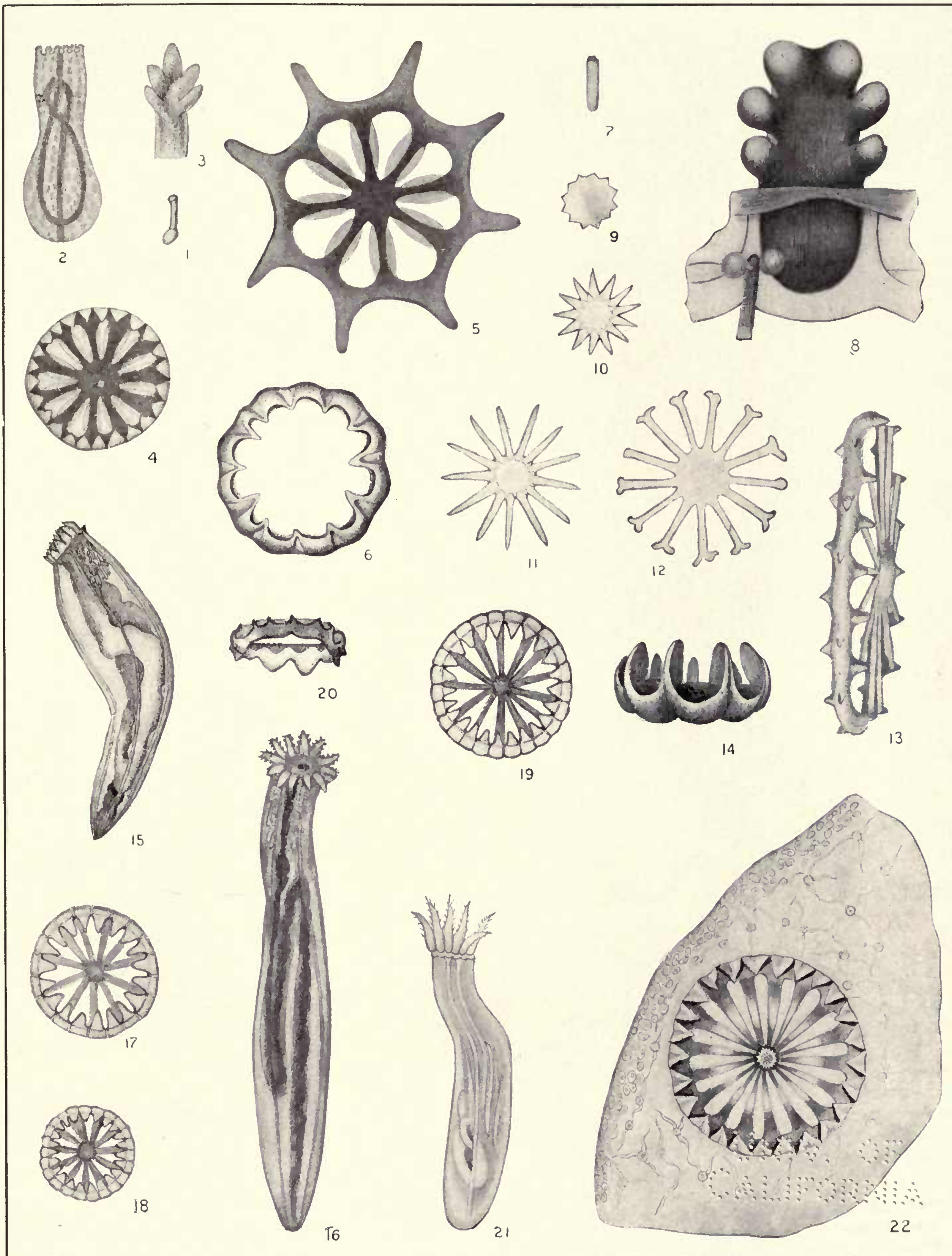
Figure 7. Adult. Natural size.
8. Tentacle, with calcareous ring, positional organs, and radial nerve. × 100 (?)
Figures 9–12. Successive stages in development of wheel. × 300 (?)
Figure 13. Wheel, seen from the side. × 425 (?)
14. Calcareous ring, side view. × 35 (?)

Figures 15–20. *Myriotrochus vitreus* (M. Sars.). (From Kor. and Dan., 1877.)

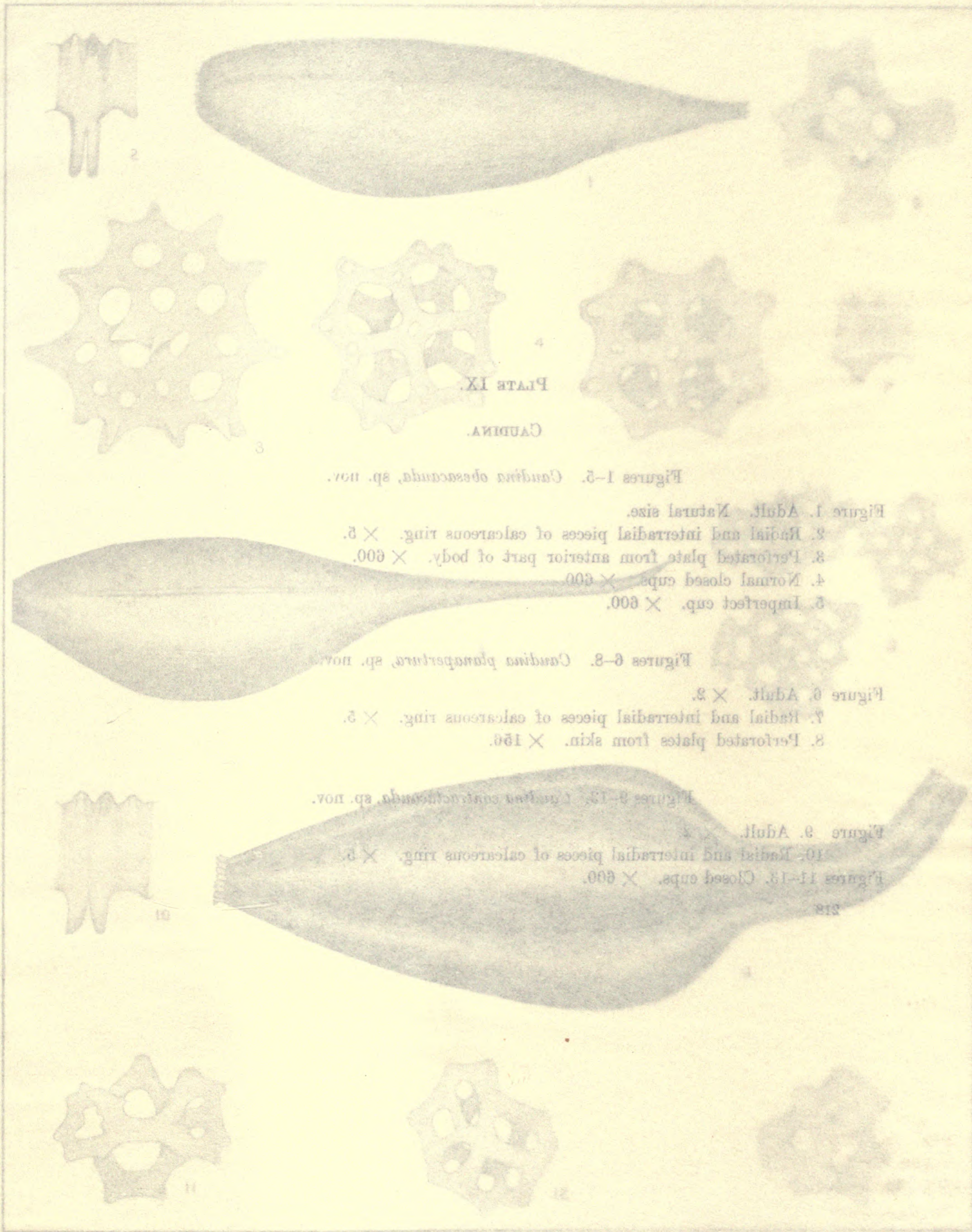
Figure 15. Adult, partly contracted. Slightly enlarged.
16. Adult, fully extended. Slightly enlarged.
Figures 17–19. Wheels. × 140 (?)
Figure 20. Calcareous ring from dorsal side. × 3 (?)

Figures 21–22. *Myriotrochus rinkii* Steenstrup. (From Dan. and Kor., 1882.)

Figure 21. Adult, extended. Natural size.
22. Wheel in normal position in skin. × 175 (?)



MYRIOTROCHINÆ



CAUDINA

Plate IX.

Caudina.

Figures 1–5. *Caudina obesacauda,* sp. nov.

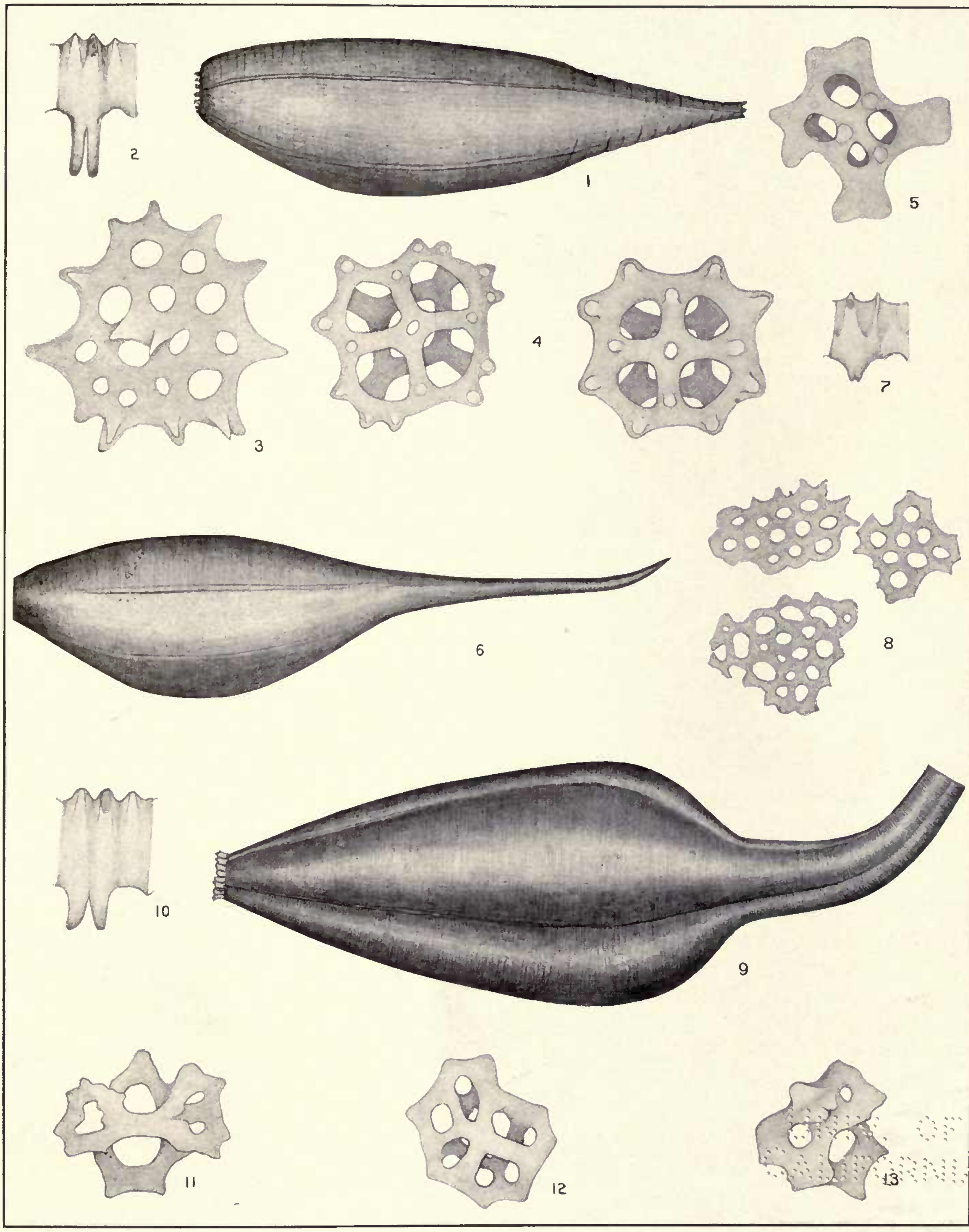
Figure 1. Adult. Natural size.
2. Radial and interradial pieces of calcareous ring. × 5.
3. Perforated plate from anterior part of body. × 600.
4. Normal closed cups. × 600.
5. Imperfect cup. × 600.

Figures 6–8. *Caudina planapertura,* sp. nov.

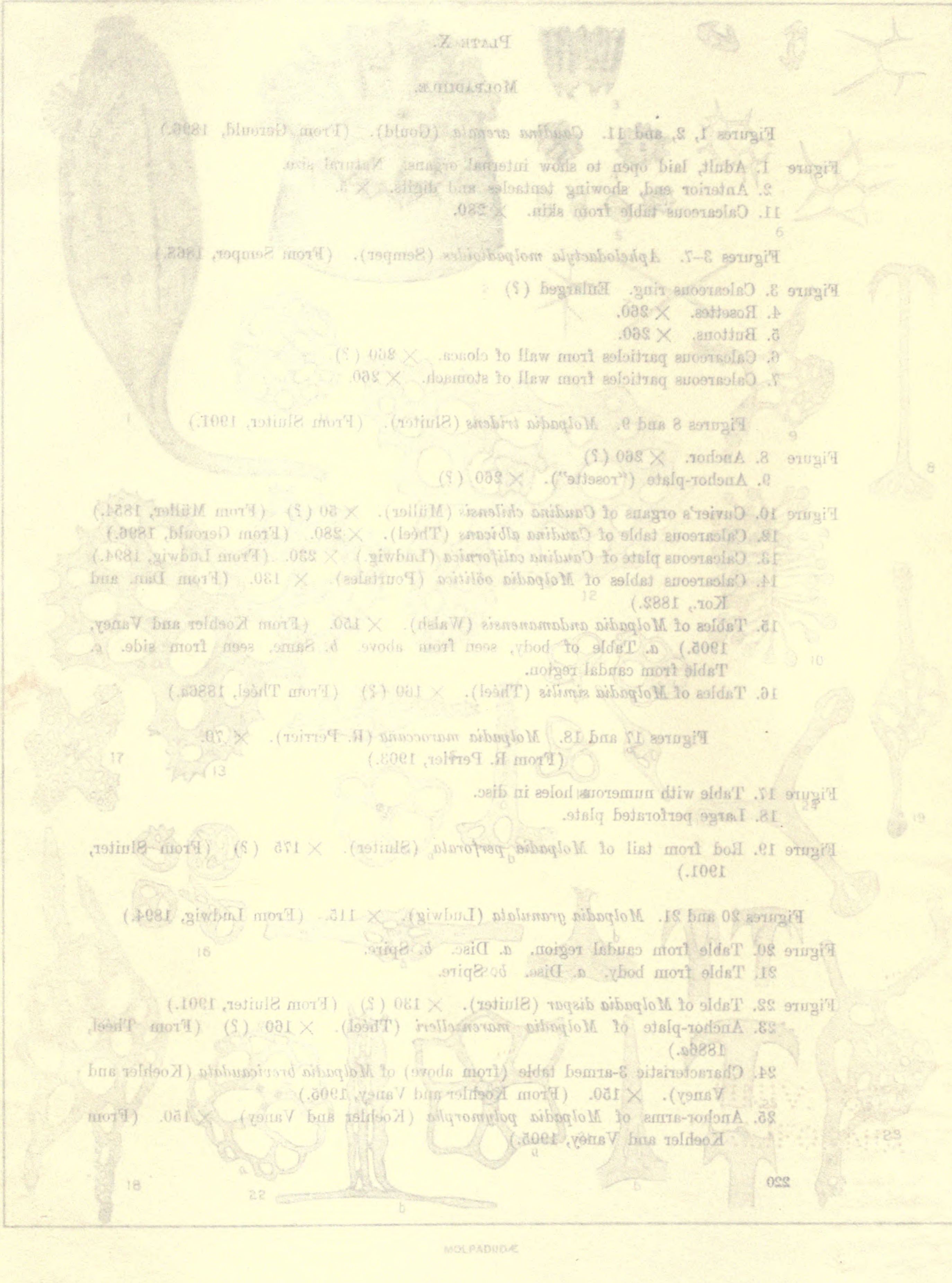
Figure 6. Adult. × 2.
7. Radial and interradial pieces of calcareous ring. × 5.
8. Perforated plates from skin. × 156.

Figures 9–13. *Caudina contractacauda,* sp. nov.

Figure 9. Adult. × 2.
10. Radial and interradial pieces of calcareous ring. × 5.
Figures 11–13. Closed cups. × 600.



CAUDINA



MOLPADIIDÆ

Plate X.

Molpadiidæ.

Figures 1, 2, and 11. *Caudina arenata* (Gould). (From Gerould, 1896.)

Figure 1. Adult, laid open to show internal organs. Natural size.
2. Anterior end, showing tentacles and digits. × 5.
11. Calcareous table from skin. × 280.

Figures 3–7. *Aphelodactyla molpadioides* (Semper). (From Semper, 1868.)

Figure 3. Calcareous ring. Enlarged (?)
4. Rosettes. × 260.
5. Buttons. × 260.
6. Calcareous particles from wall of cloaca. × 260 (?).
7. Calcareous particles from wall of stomach. × 260.

Figures 8 and 9. *Molpadia tridens* (Sluiter). (From Sluiter, 1901.)

Figure 8. Anchor. × 260 (?)
9. Anchor-plate ("rosette"). × 260 (?)

Figure 10. Cuvier's organs of *Caudina chilensis* (Müller). × 50 (?) (From Müller, 1854.)
12. Calcareous table of *Caudina albicans* (Théel). × 280. (From Gerould, 1896.)
13. Calcareous plate of *Caudina californica* (Ludwig.) × 230. (From Ludwig, 1894.)
14. Calcareous tables of *Molpadia oölitica* (Pourtales). × 130. (From Dan. and Kor., 1882.)
15. Tables of *Molpadia andamanensis* (Walsh). × 150. (From Koehler and Vaney, 1905.) *a*. Table of body, seen from above. *b*. Same, seen from side. *c*. Table from caudal region.
16. Tables of *Molpadia similis* (Théel). × 160 (?) (From Théel, 1886*a*.)

Figures 17 and 18. *Molpadia maroccana* (R. Perrier). × 70.
(From R. Perrier, 1903.)

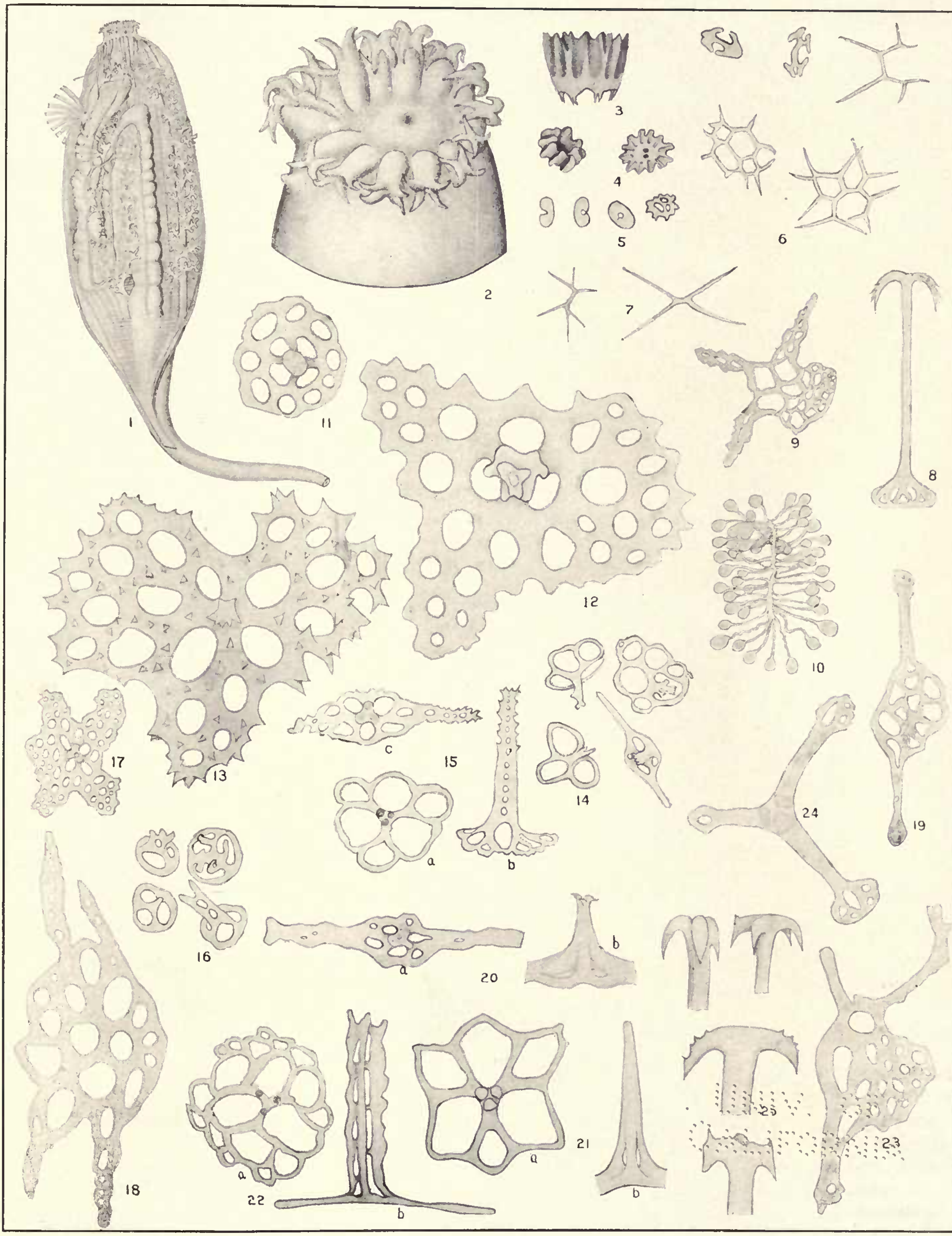
Figure 17. Table with numerous holes in disc.
18. Large perforated plate.

Figure 19. Rod from tail of *Molpadia perforata* (Sluiter). × 175 (?) (From Sluiter, 1901.)

Figures 20 and 21. *Molpadia granulata* (Ludwig). × 115. (From Ludwig, 1894.)

Figure 20. Table from caudal region. *a*. Disc. *b*. Spire.
21. Table from body. *a*. Disc. *b*. Spire.

Figure 22. Table of *Molpadia dispar* (Sluiter). × 130 (?) (From Sluiter, 1901.)
23. Anchor-plate of *Molpadia marenzelleri* (Théel). × 160 (?) (From Théel, 1886*a*.)
24. Characteristic 3-armed table (from above) of *Molpadia brevicaudata* (Koehler and Vaney). × 150. (From Koehler and Vaney, 1905.)
25. Anchor-arms of *Molpadia polymorpha* (Koehler and Vaney). × 150. (From Koehler and Vaney, 1905.)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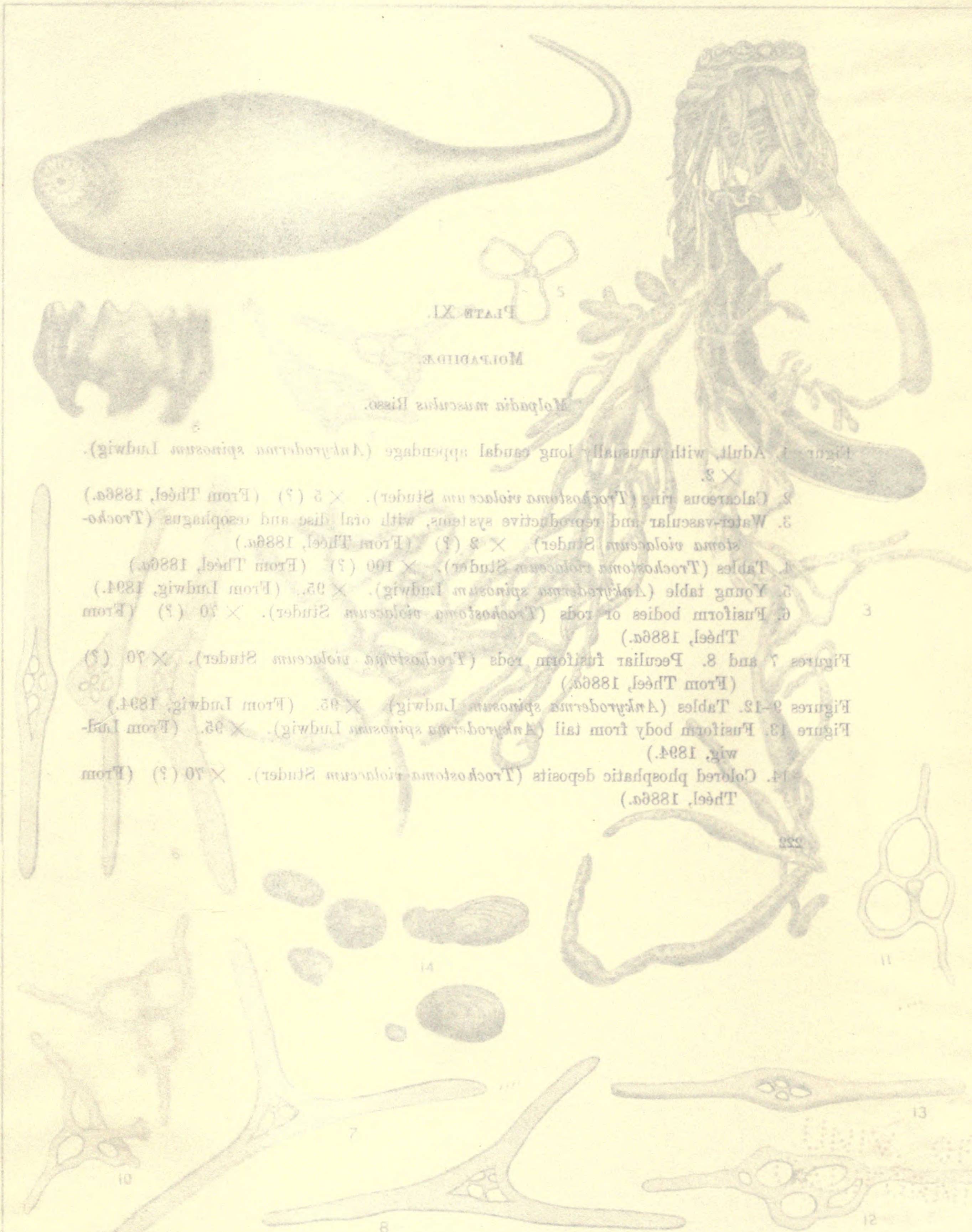
MOLPADIIDÆ



MOLPADIA MUSCULUS

Plate XI.

Molpadiidæ.

Molpadia musculus Risso.

Figure 1. Adult, with unusually long caudal appendage (*Ankyroderma spinosum* Ludwig). × 2.

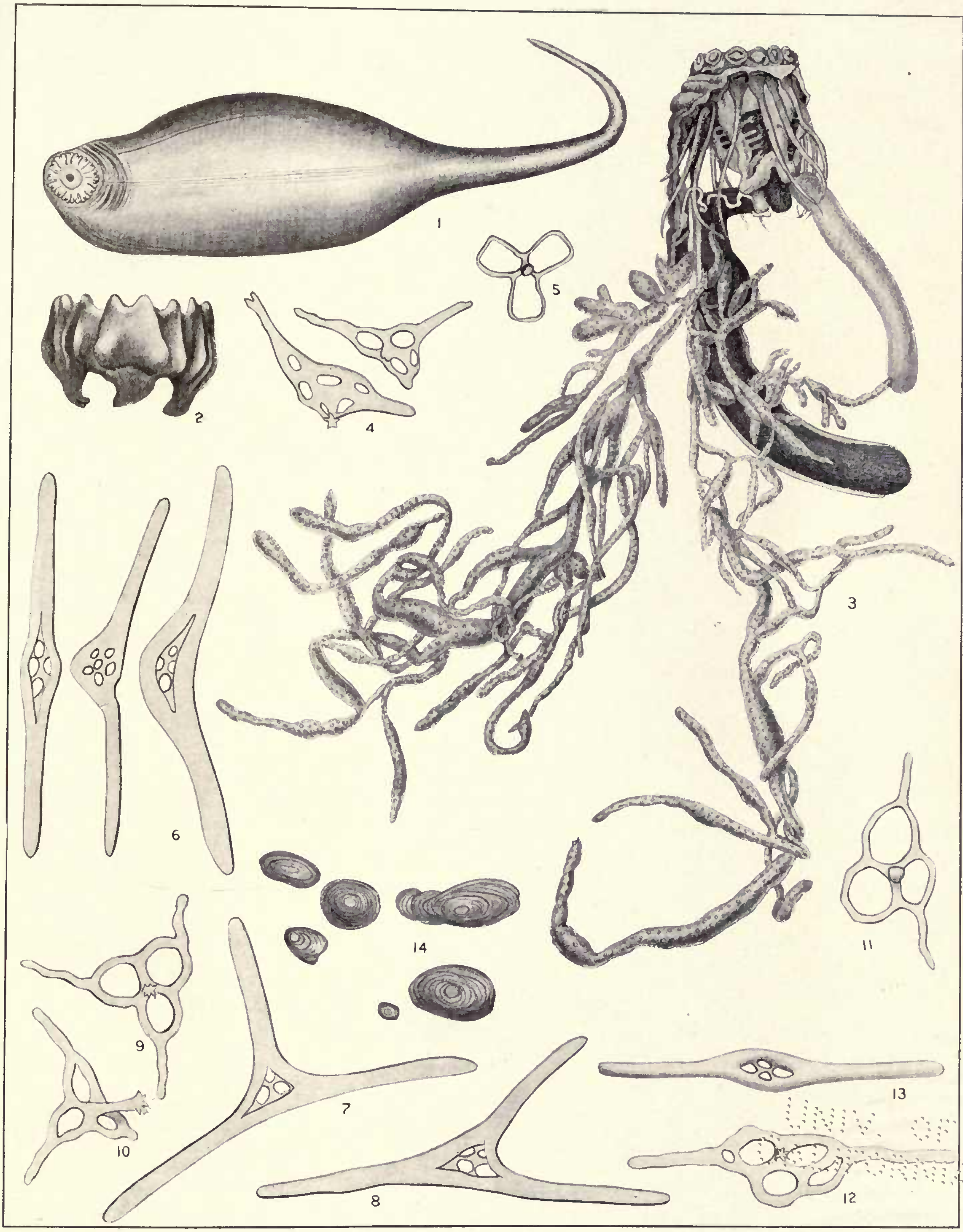
2. Calcareous ring (*Trochostoma violaceum* Studer). × 5 (?) (From Théel, 1886*a*.)
3. Water-vascular and reproductive systems, with oral disc and œsophagus (*Trochostoma violaceum* Studer). × 2 (?) (From Théel, 1886*a*.)
4. Tables (*Trochostoma violaceum* Studer). × 100 (?) (From Théel, 1886*a*.)
5. Young table (*Ankyroderma spinosum* Ludwig). × 95. (From Ludwig, 1894.)
6. Fusiform bodies or rods (*Trochostoma violaceum* Studer). × 70 (?) (From Théel, 1886*a*.)

Figures 7 and 8. Peculiar fusiform rods (*Trochostoma violaceum* Studer). × 70 (?) (From Théel, 1886*a*.)

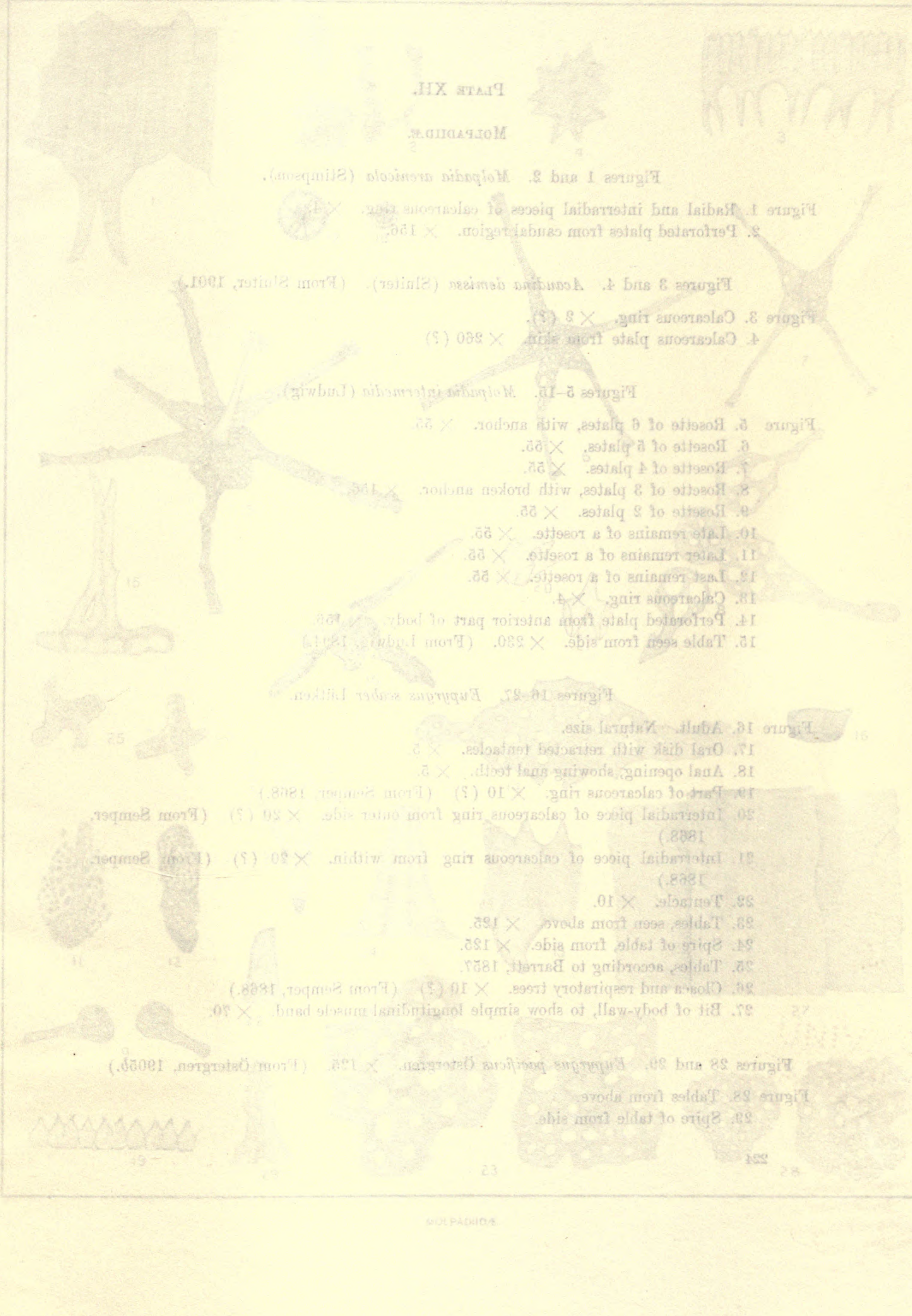
Figures 9–12. Tables (*Ankyroderma spinosum* Ludwig). × 95. (From Ludwig, 1894.)

Figure 13. Fusiform body from tail (*Ankyroderma spinosum* Ludwig). × 95. (From Ludwig, 1894.)

14. Colored phosphatic deposits (*Trochostoma violaceum* Studer). × 70 (?) (From Théel, 1886*a*.)



MOLPADIA MUSCULUS



MOLPADIIDAE

Plate XII.

Molpadiidæ.

Figures 1 and 2. *Molpadia arenicola* (Stimpson).

Figure 1. Radial and interradial pieces of calcareous ring. × 4.
2. Perforated plates from caudal region. × 156.

Figures 3 and 4. *Acaudina demissa* (Sluiter). (From Sluiter, 1901.)

Figure 3. Calcareous ring. × 2 (?).
4. Calcareous plate from skin. × 260 (?)

Figures 5–15. *Molpadia intermedia* (Ludwig).

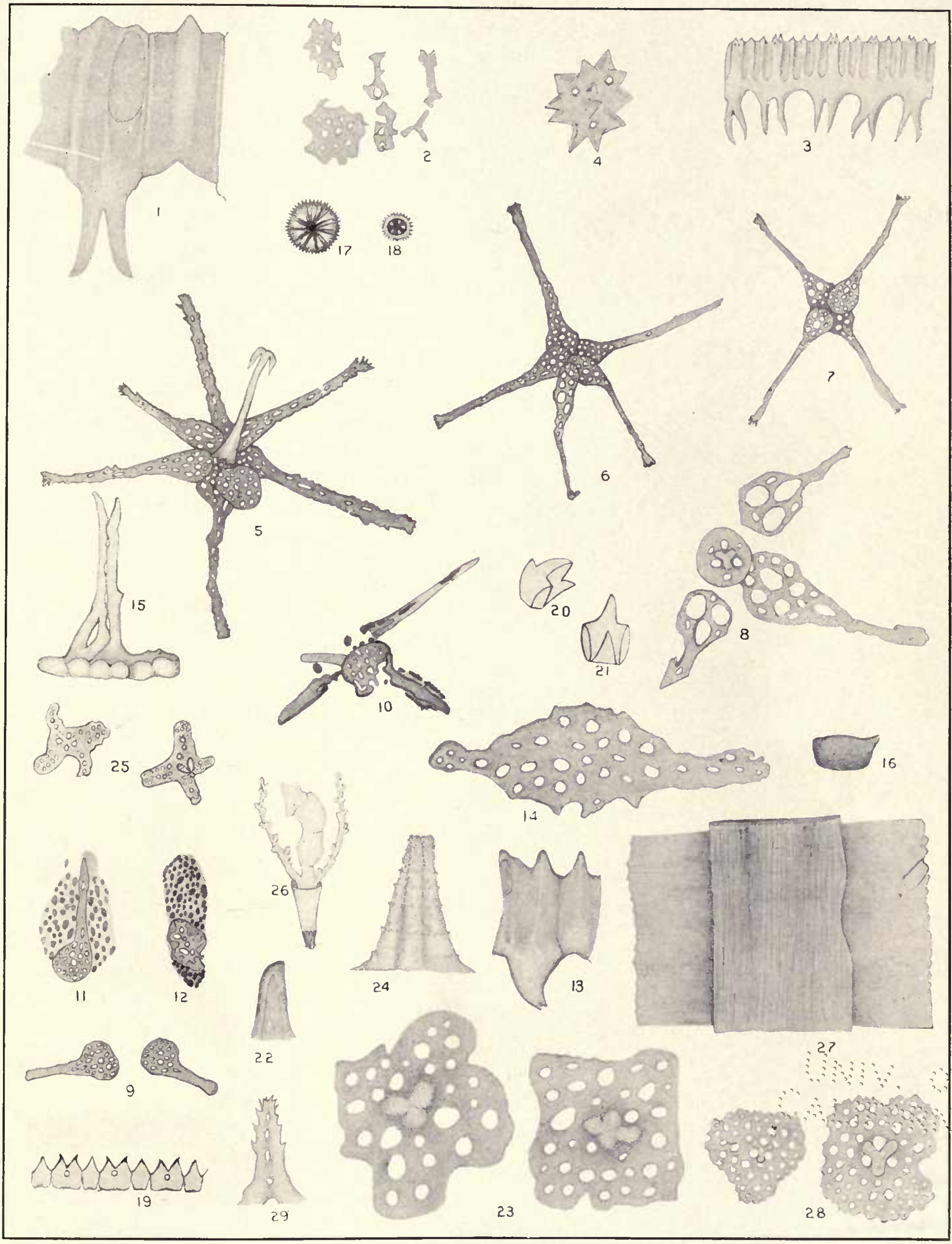
Figure 5. Rosette of 6 plates, with anchor. × 55.
6. Rosette of 5 plates. × 55.
7. Rosette of 4 plates. × 55.
8. Rosette of 3 plates, with broken anchor. × 156.
9. Rosette of 2 plates. × 55.
10. Late remains of a rosette. × 55.
11. Later remains of a rosette. × 55.
12. Last remains of a rosette. × 55.
13. Calcareous ring. × 4.
14. Perforated plate from anterior part of body. × 156.
15. Table seen from side. × 230. (From Ludwig, 1894.)

Figures 16–27. *Eupyrgus scaber* Lütken.

Figure 16. Adult. Natural size.
17. Oral disk with retracted tentacles. × 5.
18. Anal opening, showing anal teeth. × 5.
19. Part of calcareous ring. × 10 (?) (From Semper, 1868.)
20. Interradial piece of calcareous ring from outer side. × 20 (?) (From Semper, 1868.)
21. Interradial piece of calcareous ring from within. × 20 (?) (From Semper, 1868.)
22. Tentacle. × 10.
23. Tables, seen from above. × 125.
24. Spire of table, from side. × 125.
25. Tables, according to Barrett, 1857.
26. Cloaca and respiratory trees. × 10 (?) (From Semper, 1868.)
27. Bit of body-wall, to show simple longitudinal muscle band. × 70.

Figures 28 and 29. *Eupyrgus pacificus* Östergren. × 125. (From Östergren, 1905*b*.)

Figure 28. Tables from above.
29. Spire of table from side.



MOLPADIIDÆ

PLATE XIII.

MOLPADIIDÆ.

Figures 1–4. *Himasthlephora glauca,* sp. nov.

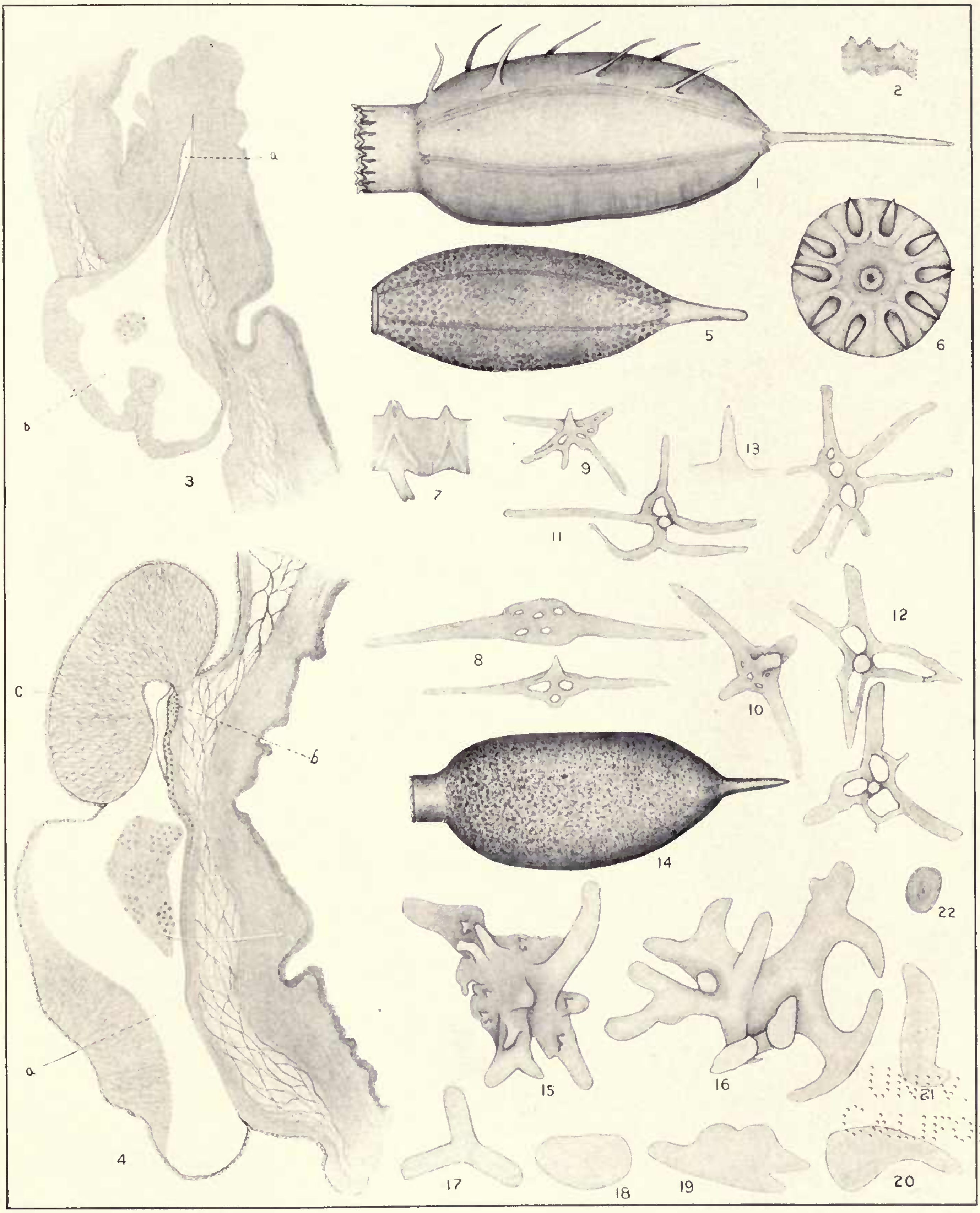
Figure 1. Adult. × 5.
2. Radial and interradial pieces of calcareous ring. × 10.
3. Transverse section of body-wall through base of a dorsal papilla, showing connection between lumen of papilla (*a*) and ampulla (*b*).
4. Transverse section of body-wall, somewhat posterior to preceding, showing ampulla (*a*), radial water-vessel (*b*), and longitudinal muscle (*c*).

Figures 5–13. *Ceraplectana trachyderma,* sp. nov.

Figure 5. Adult. Natural size.
6. Oral disc, showing tentacles. × 4.
7. Radial and interradial pieces of calcareous ring. × 5.
Figures 8–12. Calcareous deposits from skin. × 70.
Figure 13. Spire, seen from side. × 70.

Figures 14–22. *Molpadia amorpha,* sp. nov.

Figure 14. Adult. Natural size.
Figures 15 and 16. Normal tables. × 600.
Figures 17–21. Other calcareous particles from skin. × 600.
Figure 22. Phosphatic deposit. × 156.



MOLPADIIDÆ

INDEX.

Pages on which the descriptive accounts of families, genera and species occur are indicated by black-faced type.