An Outline of the Natural History of our Shores

J. Sinel

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AN OUTLINE OF THE NATURAL HISTORY OF OUR SHORES

The Shore. A Typical Rock-pool on the Jersey Coast.

Frontispiece

AN OUTLINE OF

THE NATURAL HISTORY OF OUR SHORES

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WITH CHAPTERS ON COLLECTING AND PRESERVING MARINE SPECIMENS, METHODS OF MICROSCOPIC MOUNTING ETC., AND ON THE MARINE AQUARIUM

Illustrated by One Hundred and Twenty Photographs from Nature and numerous Descriptive Diagrams

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THIS BOOK IS DEDICATED

TO THE LOVING MEMORY OF ONE WHO FOR MANY YEARS WAS MY CONSTANT HELP IN THE PURSUITS WITH WHICH IT DEALS, AND BY WHOSE HANDS MANY OF THE SPECIMENS THEREIN FIGURED WERE PREPARED

AN ARDENT NATURE LOVER, WHO BOWED TO NATURE'S IRREVOCABLE DECREE AT THE CLOSE OF 1904.

TO THE MEMORY OF

MY WIFE

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AN OUTLINE OF THE

NATURAL HISTORY OF OUR SHORES

INTRODUCTORY

HENRY LORD BROUGHAM, in a discourse on the objects and pleasures of science, says:

"In order to fully understand the advantages and pleasures which are derived from an acquaintance with any science, it is necessary to be acquainted with that science.

"It may easily be demonstrated that there is an advantage in learning, both for the usefulness and the pleasure of it. There is something positively agreeable to all men, to all at least whose nature is not most grovelling and base, in gaining knowledge for its own sake.

"When you see anything for the first time you at once derive some gratification from the sight being new; your attention is awakened, and you desire to know more about it. If it be a piece of workmanship—as an instrument, a machine of any kind—you wish to know how it is made, how it works, and of what use it is. If it be an animal you wish to know where it comes from, how it lives, what are its dispositions, and generally its nature and habits.

"You feel this desire, too, without at all considering whether the machine or animal will ever be of the least practical use to you. But you have a curiosity to know all about them because they are new and unknown.

"You accordingly make inquiries; you feel a gratification in getting answers to your questions—that is, in receiving information and in knowing more; you feel that you are better informed than you were before.

"When you see another instrument or animal in some respects like it, but differing in other particulars, you find it pleasing to compare them together, to note where they agree and where they differ.

"Now, all this kind of gratification is of a pure and disinterested nature, and has no reference to any of the common purposes of life, yet it is a pleasure, an enjoyment.

"You are nothing the richer for it, you do not gratify your palate or any other bodily appetite, and yet it is so pleasing that you would give something out of your pocket to obtain it and forego some bodily enjoyment for its sake." [1]

The truth of these words is well demonstrated by the enthusiasm which marks each devotee to science whatever his particular branch may be; whether it is a profession or a pastime it is with him a delight.

But in all these vast realms it seems, to me at least, that the branch which possesses the greatest charm is that which deals with living forms.

Here we see the physical forces—chemistry, etc.—operating not only in modes that we are acquainted with, but in such ways as to present to us the most stupendous of problems—Consciousness.

We note the dawn of this in the simplest protoplasmic speck—this responding to stimulus. We note its advance as complexity of structure advances, up to its culminating point in ourselves.

Then living forms present us with the interesting points of structure in relation to environment. We note how

[1] "Circle of the Sciences."

"Each fashion of life, with reflex forcible action,
Works on the form."[1]

Then we have the enthralling study of development, which shows us that forms which in their adult state appear far as the poles asunder are yet closely related.

But I have not the inclination, even had I the ability, to enter into these deeper depths of the science. This has been, and is being, done by abler hands. The task I am setting myself is a survey of a small portion of Nature's great domain—the natural history of our shores.

The "great wide sea," with its "creeping things innumerable," has always had a special fascination for me. Among its denizens we can most readily study the life cycle, and see the advance from the simple to the complex to the highest advantage.

Moreover, the sea is, upon very good grounds, held to be the birthplace of life: "The nascent goal, from which the drama springs."

But to soar a little less loftily, and come at once to the level of my subject, let me ask: Who is there that does not love the sea-shore; love to wander over shell-strewn sands and weed-draped rocks; to peep into crystal rock pools, where the vegetation is crimson and scarlet, chocolate and emerald? The plants rootless, leafless, and flowerless, but in beauty of form and in delicate tracery outrivalling the choicest products of our hothouses.

Strange little worlds these rock pools, with some animals that look like flowers, and vie in form and colour with the brightest of these, and others that are living miniatures of the dragons of mythology.

There is a charm in this that appeals to all, from the romping school child to the grey-bearded professor.

And yet to how few are the wonders of the shore revealed! I think I am safe in saying that, to three-fourths

[1] Goëthe.

of its visitors, it is just what a well-appointed library would be to a lad who has not learned to read. Such lad would find pleasure in a survey of the bright colourings and gilded bindings, but to him the glories that lie within the close-packed pages would have no existence.

My object in writing this little book is to help to open some of the volumes in this part of *Nature's* library, to assist in deciphering the text, and to point out, as far as I am able, the more readily understood passages.

Therefore to those who, while not prepared to "give up, in short, both business and sport, and give themselves up *tout entier* to philosophy," as did Sir Robert the Good, but who none the less would wish to gain an insight into the life histories, the place in Nature, and the ways and doings of some of the myriad forms that live upon our shores, I venture to address the chapters that follow.

It is only a few forms among these myriads that can be dealt with within the limits of this book, but I trust to be able to say sufficient to create an interest in the subject, and that my effort may prove a stepping-stone to the high-class monographs, each dealing with a particular section, that exist.

A learned writer has recently said that, to the naturalist of old, living things were objects to be collected, named, and classified, while to the modern one they are things to be studied and explained.

If this definition of each is complete, then I think that both ancient and modern fall short of completeness, and, holding that the thing studied and explained should also be collected and classified, I shall devote a not inconsiderable portion of my book to the matter of collection and preservation.

For, even apart from their scientific value, well-preserved specimens form interesting mementoes of days spent on the sea-shore.

In *nomenclature*, when more than one name has been applied to the same organism, I shall employ the one most generally in use, although recent revision may have made alteration; and as to *classification*, I shall simply proceed from the lower to the higher groups, for the subject of strict classification is still somewhat unsettled—some authorities placing as one division, or even as one group, what others consider a *subdivision* of another.

For the details of the subject of classification I shall refer the reader to *The Encyclopædia Britannica*, where the different systems are given in full.

I am writing this on the coast of Jersey, in the Channel Islands, a district proverbially rich in the variety of its marine fauna, although, as far as I can judge, there are very few forms that occur here that do not also occur on the shores of Great Britain in general—the reputation that these islands hold in this respect being simply due to the fact that many diverse geological conditions, each with its accompanying forms of life, are here concentrated into a limited area.

Before me, as I write, stretches the Bay of St Clement, a locality which has been my chief hunting-ground for nearly twoscore years. It is composed as follows:—

First a stretch of fine white sand; then a large expanse of low-lying rocks, plentifully interspersed with rock pools, both deep and shallow; stretches of loose shelly sand; patches, many acres in extent, of *Zostera* or "sea-grass"; and clusters of tall rocks, with their bases densely clothed with Fucus and Laminaria; fallen blocks of stone, here and there bridge dykes and gullies, forming small caves and grottoes — the whole affording, as I have said, a great variety of conditions within easy reach of one another.

It may or may not be the good fortune of my young reader to light upon a similar shore on his next seaside visit, but, of course, one or more of the conditions named will be present, and will have its characteristic inhabitants, unless, indeed, he falls on evil times, and lights on a shore of rolling shingle, for such does not favour much in the way of zoology.

That my young reader has some bent in this direction I take for granted by the fact of his having this book in hand. Let me urge upon him to take up the subject as seriously as circumstances will allow, and I can promise that even a very elementary study of the living forms of our shores will open for him a fount of pleasure—of pleasure that does not pall.

The equipment required is, with perhaps the exception of a microscope, of the most simple and inexpensive kind. Hints on this will be given further on.

CHAPTER I

THE PROTOZOA

THESE are the simplest forms of animal life, each individual consisting of one cell only, a simple speck of that compound which Professor Huxley termed "the Physical basis of life"—*Protoplasm*.

A great number of forms live in fresh water—*e.g.* the so-called *animalculæ* of stagnant pools—but many are marine. Among these is one of comparatively large size easily visible to the unaided eye. It is a globe-shaped organism, transparent as the water in which it lives, with a threadlike process serving as organ of locomotion, termed a *flagellum*. This is *Noctiluca miliaris*. In some parts of our seas it swarms. As its generic name (=Night-light) implies, it is luminous, and contributes in a large measure to the phenomenon of phosphorescence of the sea.

One division of the marine protozoa, termed the *Rhizopoda*, secrete shells either of silica or of carbonate of lime, always of very beautiful patterns. This division embraces two orders, *Radiolaria* and *Foraminifera*. The former, also known as *Polycistina*, has shells of silica, the *Foraminifera*, as a rule, shells of carbonate of lime. As the latter are the more conspicuous, and the most easily obtained and studied, we shall restrict ourselves to these, repairing to a sandy shore for our observations.

The stretch of sand before us, the tide having receded, and the sun partially dried its surface, is seen to present different shades of colour, the whitey-brown tint of quartz

Fig. 1

1. *Lagena vulgaris.*
2. *Lagena gracilis.*
3. *Lagena clavata.*
4. Var. of *Lagena gracilis.*
5. *Lagena striata.*
6. *Lagena striata interupta.*
7. *Lagena striata substriata.*
8. *Lagena vulgaris semistriata.*
9. *Nodosaria radicula.*
10. *Nodosaria radicula*, var.
11. *Dentalina subarcuata.*
12. *Spiroloculina depressa.*
13. *Spiroloculina depressa*, var.
14. *Miliolina seminulum.*
15. *Miliolina seminulum*, var.
16. *Miliolina seminulum*, var.
17. *Miliolina seminulum*, under side.
18. *Miliolina bicornis.*
19. *Spiroculina depressa*, var. rotunda.
20. *Noneonina elegans.*
21. *Noneonina Barleeana.*
22. *Polystomella incerta.*
23. *Polystomella crispa.*
24. *Polystomella umbilicata.*
25. *Plencroplis planatus.*
26. *Nummulina planula.*
27. *Patelina corrugata.*
28. *Noneonina umbilicatula.*
29. *Spirilina margaretifera.*
30. *Cristallaria calcar.*
31. *Bulimina pupaoides.*
32. *Planorbulina vulgaris.*
33. *Bulimina pupaoides*, var. *marginata.*
34. *Bulimina pupaoides*, var. *spinulata.*
35. *Textularia difformis.*
36. *Textularia variabilis.*
37. *Textularia spathulata.*
38. *Bulimina pupaoides*, var.

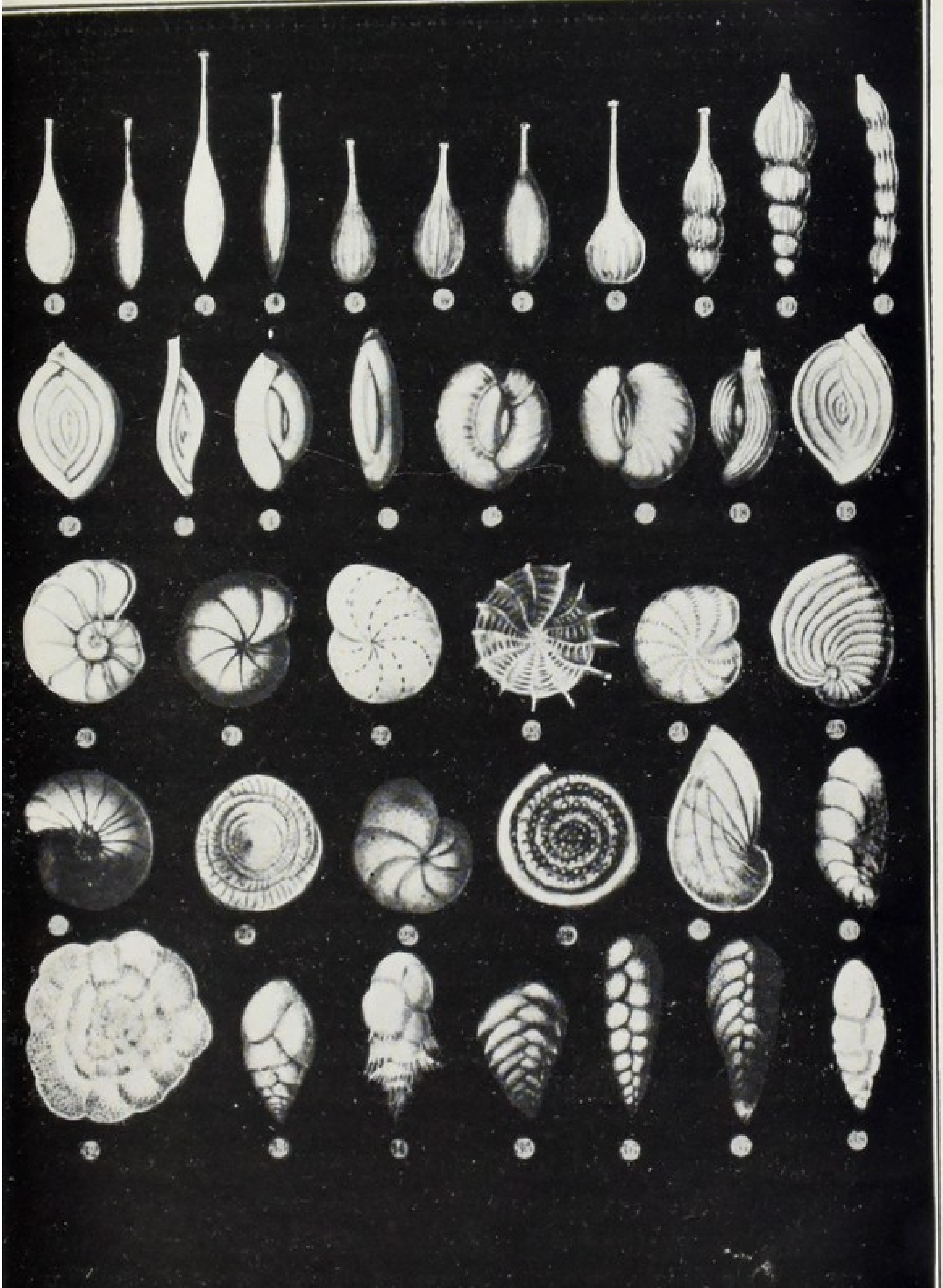


Fig. 1.—Various British Foraminifera

and felspathic sand being here and there marked with patches, some nearly white, others almost black, the result of materials of different specific gravities having been now borne up, now deposited, by currents of air or water, chiefly by the latter.

The dark patches we can dismiss with a short shrift. They are smudges on Nature's fair face made by the hand of man—fine cinder washed in from afar, where some steamer has cast overboard the contents of its ash-pit (unless we are on a shore where titanic iron sand occurs).

The white patches are the object of our quest. A pinch of their constituents examined with a good pocket lens reveals the fact that they are chiefly composed of shells —shells so minute that an ounce by weight will contain some millions of them ; and not only are they interesting, for a history attaches to them, but they are things of most exquisite beauty.

The Plate No. 1 will give an idea of what some of them are like. Among them are miniatures of ancient "Lachrymal vases," soda-water bottles, and cut-glass decanters. Some are like fossil ammonites, others like the productions of some very artistically inclined confectioner. They are in endless variety, and all are girded with beauty. Fig. 2 shows a photograph from nature of few forms.

But these are only the dead shells ; the living members of the tribe are farther afield—some are out on the ocean, many at its surface, others thousands of fathoms down. There are many in the mud and in the rock pools close at hand. But meanwhile let us collect some of these dead ones.

There are several methods of attaining this end. The best one, I find, is to lay a piece of paper—say a newspaper —close to a white patch, and then, with something that will create a stiffish current of air—a lady's fan would be the thing, *par excellence*, if such could be obtained—waft the lightest portion on to the paper, then collect, and pour into any suitable receptacle.

The surface of the sand may also be scraped to the same end, but this plan takes up an unnecessary quantity of sand.

The gathering when brought home must be thoroughly

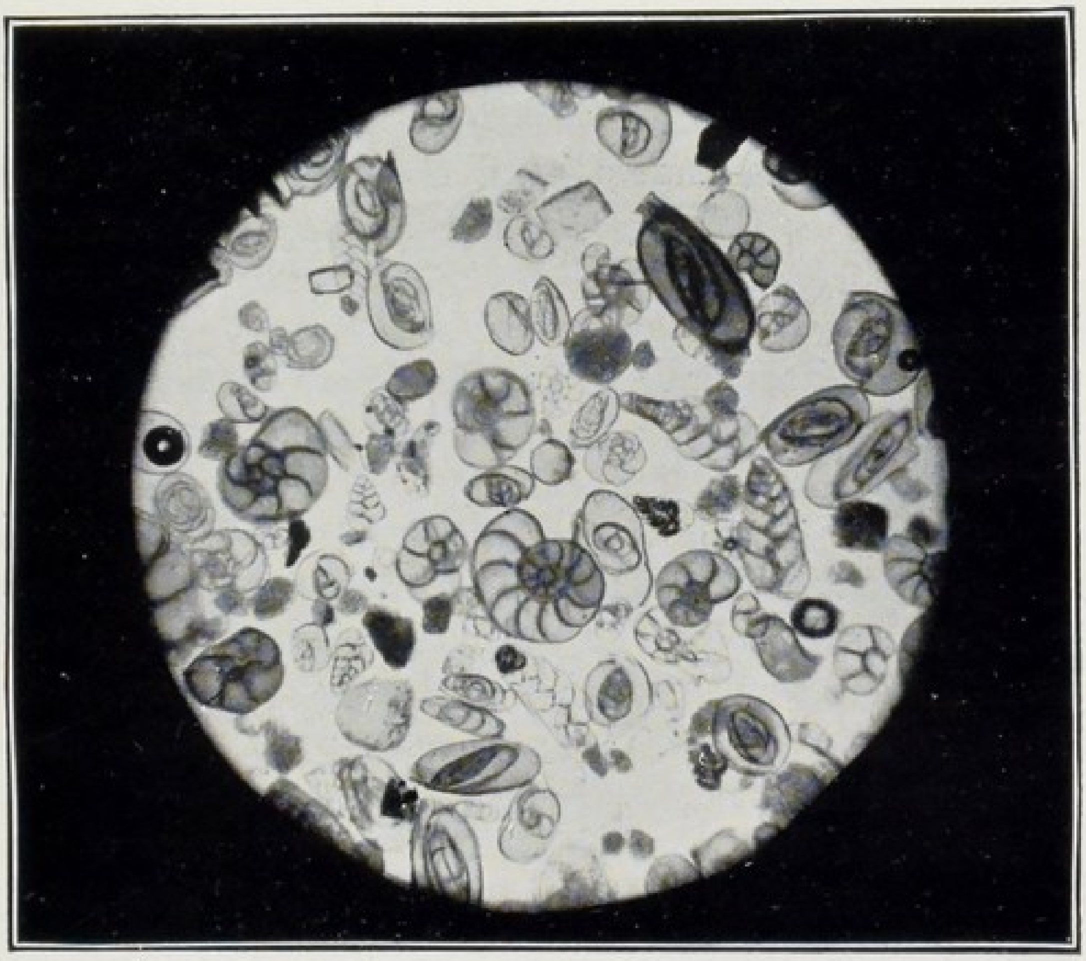


Fig. 2.—Mixed Foraminifera. Photo-micrograph—about 20 diameters

dried on the stove or before the fire, and then when quite cold, not before, it must be tipped, a spoonful at a time, into a basin of cold water, and well stirred with the spoon. The stirring must be considerable, or little bells of air will adhere to sand grains, and cause these to float as well as the little hollow shells we desire. However, the sand will sink and the air-charged shells will float. Now collect and dry these treasures, and put them aside for further manipulation and for microscopic mounting—methods for doing which will be given in the proper place.

Of course, for the appreciation of this particular branch of zoology a microscope is needed, but to the young reader, interested even thus far, the possession of this engine of science cannot be a remote event.

Now who are, or rather who were, in the case of the dead ones, the dwellers in these shells?

Firstly, the name *Foraminifera* changed into familiar English is "door-bearers," and the name is given them, because all, or *nearly* all, the little shells are perforated with minute holes, through which the inmate can protrude long threads of his substance; for his is not of "muscle and nerve miraculously spun," but is, as we have seen, a speck of the glairy white-of-egg-looking substance—*protoplasm*.

And this is how he dines. A morsel suitable for a meal being within reach, some of the threads are extended, and coalesce into a blob. This envelops the morsel, digests and assimilates the good portion, and rejects the remainder. Then, enriched by the meal, the foraminifer withdraws its substance into the shell.

These semi-fluid threads also serve the purpose of locomotion; hence they are termed *Pseudopodia* ("false feet"), and by their extension in one direction and their withdrawal in the other the little animal proceeds.

When an individual has reached size limit some of the extruded protoplasm breaks off, secretes lime from its solution in the sea-water, and becomes a new individual. Thus they multiply.

In speaking of the contents of the cell as a "simple" speck, I say so guardedly, for a living cell is more complex than was formerly supposed, of which more anon.

I said just now that the *Foraminifera* had a history attached to them, and so they have. They are, or are believed to be, the oldest of animal forms; that time was when they were the sole inhabitants of this earth.

(Minute vegetable forms must, however, have preceded them, as the chief distinction between vegetable and animal life is that the former can manufacture protein compounds from the raw elements of earth, while the latter must obtain these already prepared by the action of some other living form.)

And surely enough, in the Laurentian rocks of Canada, the oldest page in Mother Earth's diary that has mention of living things at all, there are records of them, and they must even then have existed in such numbers that their shells have formed vast rocky reefs.

To these early fossil ones geologists have given the name *Eozoon*—the " dawn of life animal."

Then in the ages that have followed they have lived and died in such quantity that it is mostly of their remains that our chalk hills are built, in some places thousands of feet in thickness.

It is also to the existence of these little animals that England owes its classical name—Albion, " the white land "—a title bestowed upon it two thousand years ago by the Gauls, who could see its *Foraminifera*-built cliffs across the Channel.

To see some of the living forms we have choice of two methods. If a deposit of mud from low down in tide range is available, place some of it in a wide-mouthed jam jar with sea-water, shake up well, and then pour off the fine portion. (This is a reversal of the process we employed in getting the dead shells.) The living " forams " are heavier than the mud, and will sink; by repeated washings the water will be clear, and only the clean, gritty particles that were among the mud will remain. Now fill the jar with clean, clear water, and set it aside. In the course of a few hours some of the little creatures will have crawled up the sides of the jar, and can be observed, by means of a pocket lens, extruding and retracting their pseudopodia. They can then be transferred to a slip or to a "Zoophyte trough," and studied under the microscope.

If no mud is available take a few handfuls of sea-weed—preferably coralline—from a rock pool, wash them in the jar, remove the larger scraps, and save the deposit as in the previous case.

It will be noticed that the ammonite and other whorled shelled forams extrude their pseudopodia from the little holes on all sides, but that some forms—*Miliolina*, *Lagena*, etc. (see Fig. 3)—extrude them by one opening.

Allusion to some of the other protozoa will be made in the chapter on collecting.

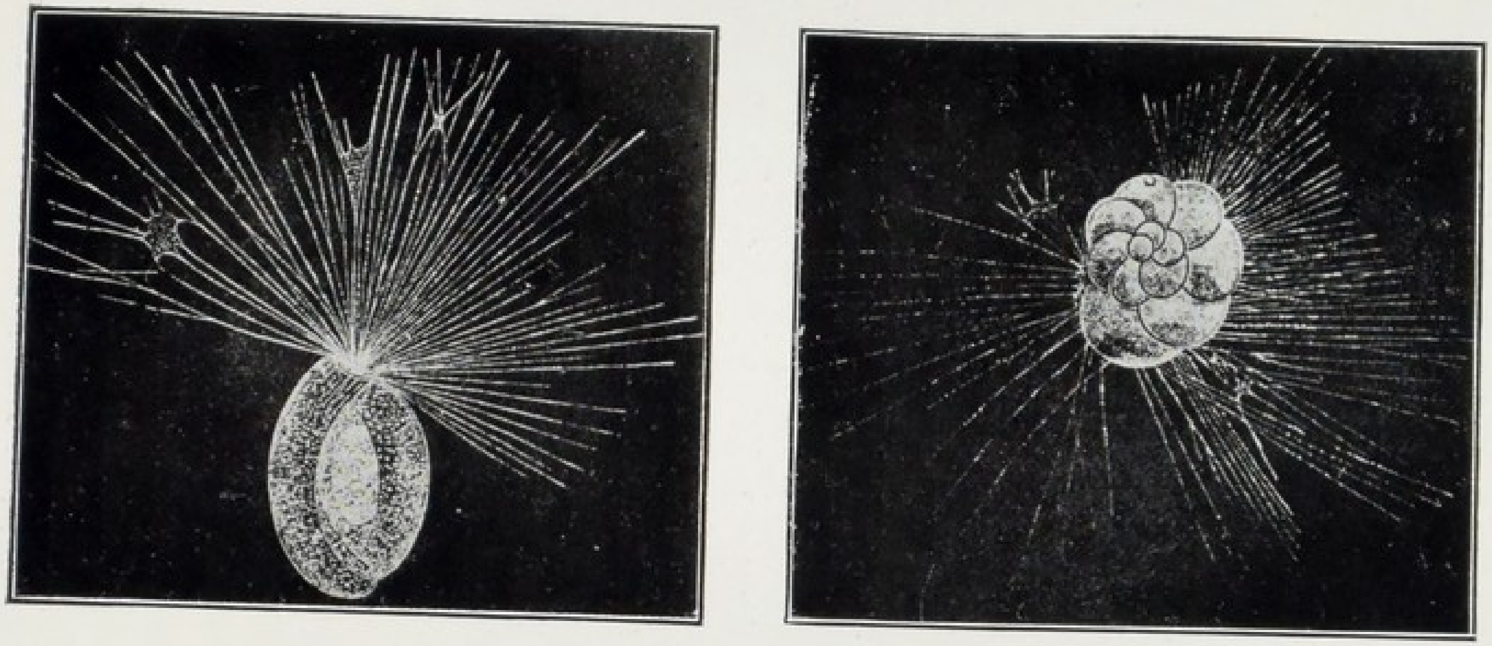


Fig. 3.—*Miliolina* and *Rotalia*, with the pseudopodia extruded

CHAPTER II

PORIFERA

THE next division of the animal kingdom in the ascending scale is represented by the sponges. Here complexity commences, but "tissues," as regards muscle, etc., are not yet apparent, although foreshadowed. Some naturalists do not admit the sponges as a group or *Phylum* by themselves, but include them in the next—viz. in the *Cœlenterata*—but the majority seem to be in favour of keeping them separate

The text-books thus define the *Porifera*: Animals with soft bodies composed of a large number of cells, which cells have the power of amœboid movement.

The structure is supported and maintained in form either by a skeleton of horny fibres, by spicules of carbonate of lime, or by spicules of silica.

The mass is pierced by a vast number of pores (hence *Porifera*, "pore-bearing") opening into a series of canals, which communicate with little hollow chambers—digestive cavities—and each sponge has one or many "exhalent apertures" (*osculæ*).

In adult life they are affixed and plantlike. In early life they are active, and free swimming. They have different methods of reproduction—viz.:

One by budding, by which means the mass extends laterally and in thickness, for except in a few species there is little precise form or size limit. They also reproduce by means of eggs, from which develop free-swimming embryos, which lead a roving life for a brief period, and then settle down, and proceed to extend as above said.

I have observed in one species at least (it occurs in several others) another method of propagation. In *Tethya lyncurium*, at the end of summer, the surface becomes covered with little protuberances, which at length become

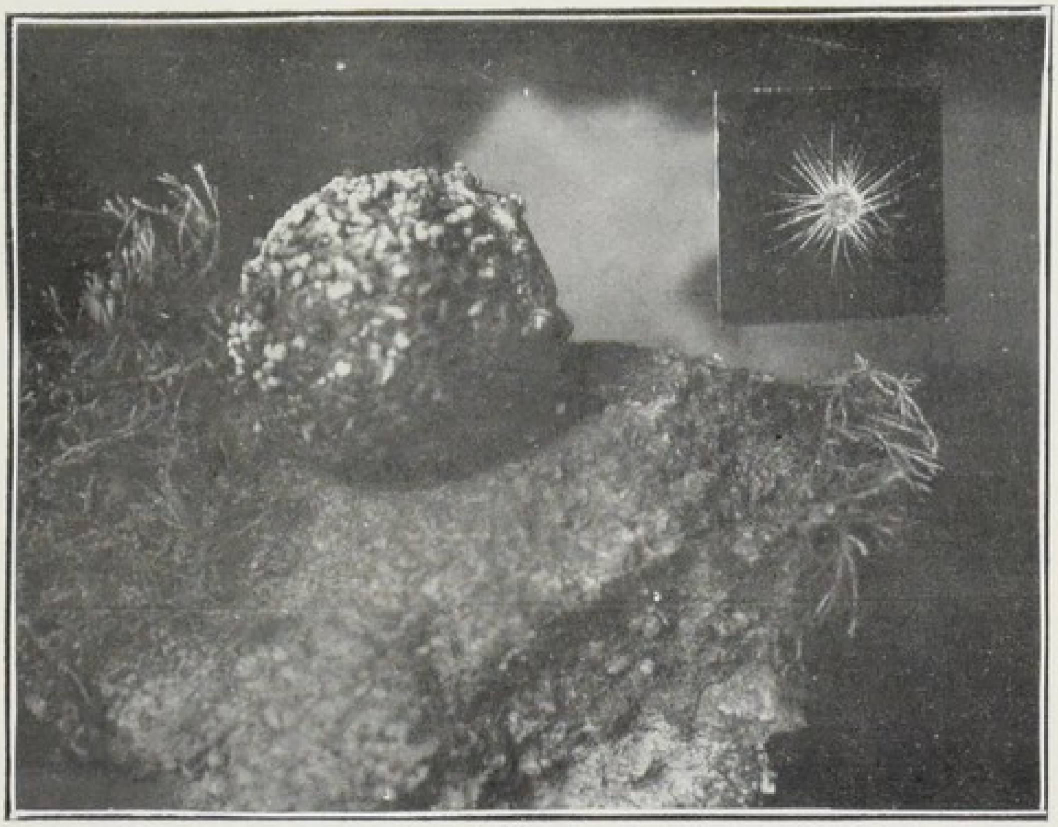


Fig. 4.—*Tethya lyncurium* budding, natural size. Inset, a freed bud enlarged about 6 times

stalked and furnished with a radiating arrangement of spicules; then these break away, and are carried by currents to other localities, where they affix and grow to the form of the parent.

A photograph of one of these sponges, showing this mode of reproduction, is shown in Fig. 4. It is from a living specimen before me as I write.

The sponges are divided into four families as follows:

Myxospongia.—Those in which little or no skeletal support exists. An example on our coasts is the "jelly sponge" (*Halisarca dujardinii*).

Ceratospongia.—Those in which the mass is supported by a network of horny fibres. Example: the ordinary sponges of commerce.

Calcispongia.—Usually small simple forms, in which the support is formed by an arrangement of spicules of carbonate of lime. Example: the common little *Sycandra* and *Grantia* of our shores, shown in Figs. 5 and 6.

Silicispongia.—Those in which the support consists of an arrangement of spicules of *silica* or "flint." Example: the great majority of our local sponges. A very familiar one is *Halichondria* (Fig. 7).

With these details in mind we can proceed with our investigations.

Sponges love shelter, and while a few stunted specimens may be seen attached to rocks and sea-weeds in exposed situations, for the greater variety and more luxuriant growth we must repair to sheltered situations, little caverns and grottos or deep rock crevices. A photograph of a little cave closely lined with a heavy growth of sponges is shown in Fig. 9. This little cave or grotto, one of a vast number on this coast, is not done full justice to in the photo, only the *Halichondrias* showing. The spaces between are covered with a deep crimson form, *Hymeniacidon*, but owing to its colour the plate does not register it, except as dark shades.

Halichondria, or the "crumb of bread sponge," is subject to much variation in its growth. In dark crevices it is almost white, in a sheltered situation with a fair amount of light it is green, and in intermediate situations yellow. Sometimes, where not subject to much wave action, the osculæ are raised to a considerable height. An example of this growth can be seen in the centre of the plate just alluded to. Under other conditions they are even with the

Fig. 5.—*Sycandra ciliata*, growing on coralline
Natural size

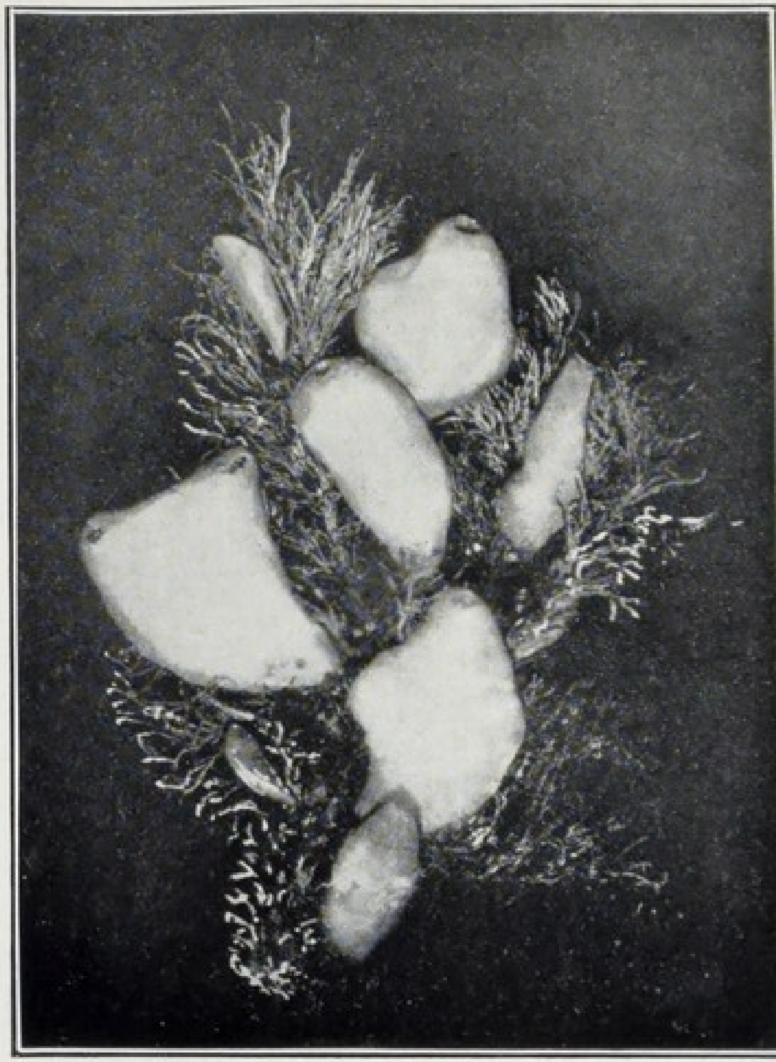


Fig. 6.—*Grantia compressa*, growing on coralline
Natural size

surface. So diverse is the growth that, apart from microscopical examination, the species is often difficult to determine.

It thrives best about the middle zone of tide range, becoming scarce as the limits of both high and low water are reached. In favourable situations it forms large

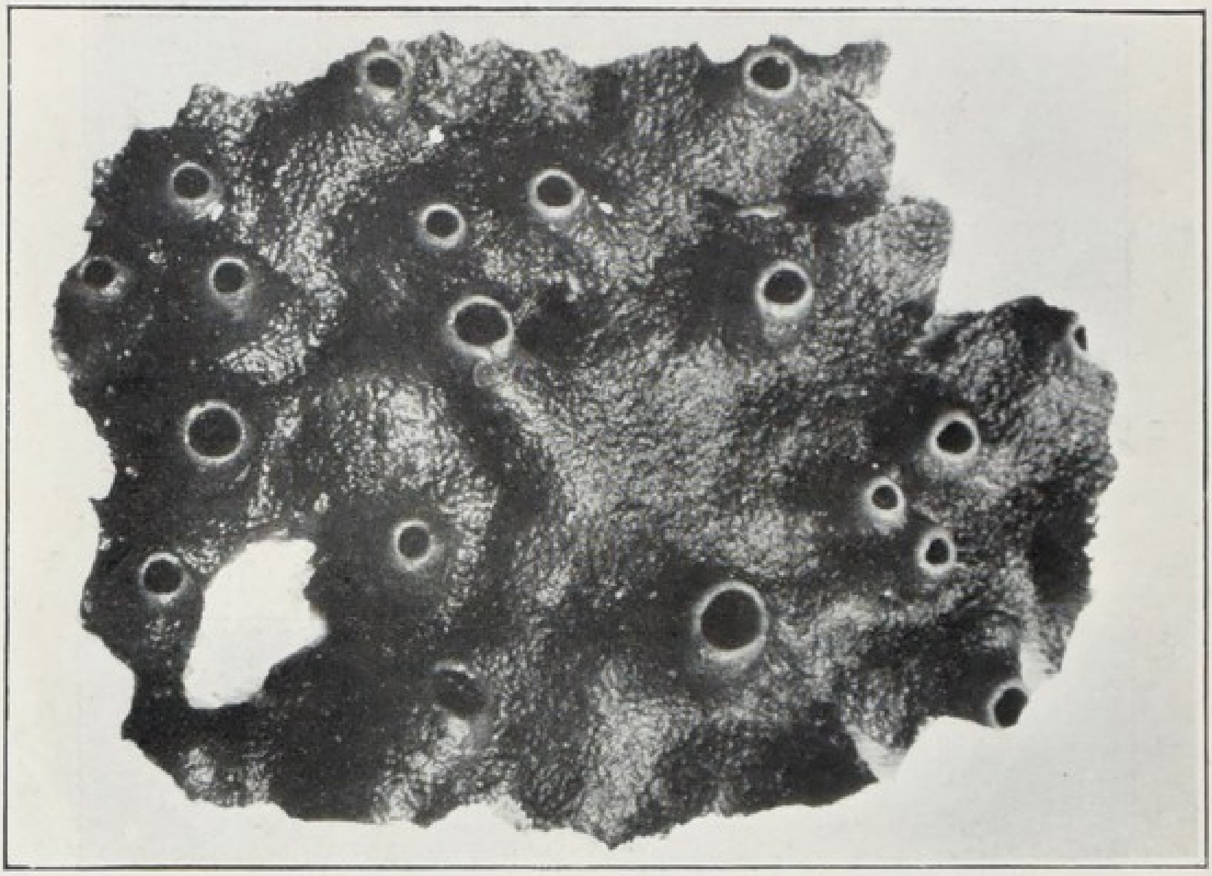


Fig. 7.—*Halichondria panicea*. Natural size

masses, often covering several square feet, and varies in thickness from half-an-inch to two or three inches. In Fig. 7 it is photographed in its actual size as regards osculæ, etc.

In the same localities as this species grows are also found very abundantly large patches of the orange and crimson *Hymeniacidon*, and sometimes some of the branching forms, *Isodictya* and *Chalina*. These grow in the form of slender stems, about the thickness of a pencil, and they creep over the surface of the rock, often crossing, and coalescing in the form of lattice-work. Their colour varies from pale yellow through orange, red, crimson to deep purple, but these are more abundant at a lower zone.

Fig. 8 shows a branching sponge, *Isodictya palmata.*

At all ranges of the tide, where there is shelter, under

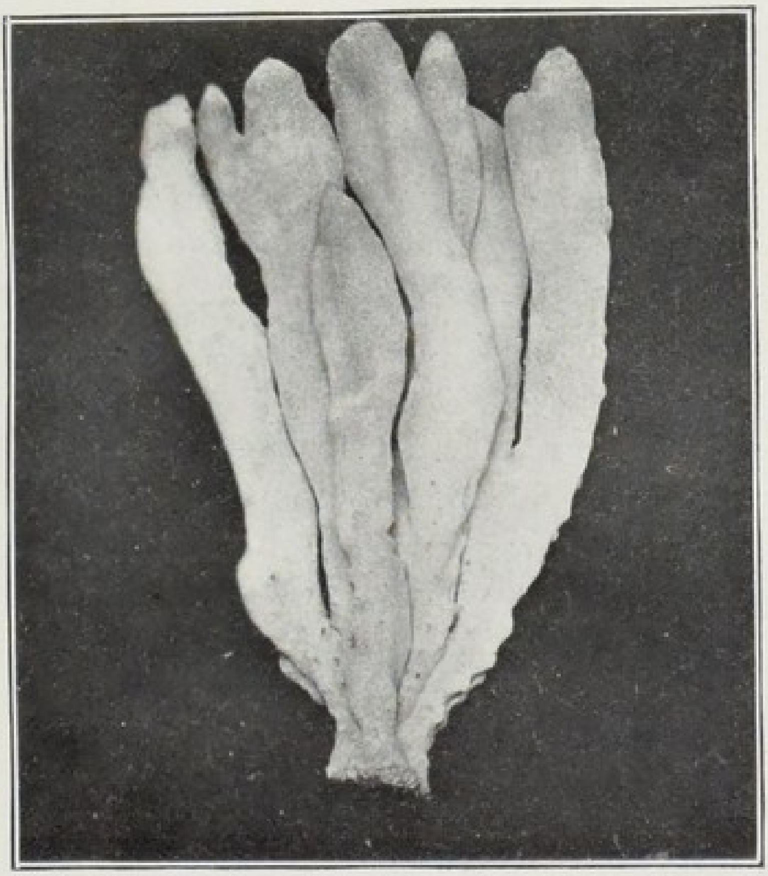


Fig. 8.—*Isodictya palmata.* ½ Natural size

overhanging rocks, and also among the corallines in the pools, will be found the little tassel-like, or rather catkin-like, *Sycandra ciliata.* This is one of the simple sponges, as regards structure. Outwardly it is of the form described, in size it varies from half-an-inch to two inches in height. The spicules project on the whole exterior, giving it a woolly appearance, while at its apex, around its osculum, there is a collar formed of several rows of strong needle-shaped spicules. This collar is under control, the sponge having the power of expanding and closing it. This sponge is the one shown in Fig. 5.

Closely allied to it, and still more abundant, is a flattened leaf-like form, *Grantia compressa* (Fig. 6). Structurally this is much the same, but the spicules do not project beyond the surface, and there is no collar. The large cavity within (when it is submerged and bulges out a little) is often made use of as a shelter for various little crustaceans. One curious little isopod, which will be described in due course, *Anceus maxillaris*, sometimes fairly crowds the cavity.

These two sponges belong to the *Calcispongia*.

Other forms of *Calcispongia* are found in the same localities—one of these, *Leucosolenia botryoides*, forms twisted masses, looking like a tangle of rather abraded white crochet cotton, the osculæ projecting at intervals.

We will take one of these calcisponges as a type for an elementary survey of sponge anatomy, but must first digress a little for an explanation of the term "cell."

Whether or not this term is aptly chosen, it is used by biologists to designate the smallest masses of matter which, singly or collectively, evince that series of phenomena which we term "life."

These cells are minute, some less than a thousandth of an inch in diameter, others just visible to the unaided eye.

They vary in form: some are round, others oval, flattened, star-shaped, etc., according to the tissues which they constitute.

They multiply by division—*i.e.* when one has attained a certain size it divides into two, and so on—and it is by this multiplication of its constituent cells that the growth of an organism, let it be a sponge or a mammal, is effected.

In the vegetable kingdom each cell is usually enclosed by a bounding membrane of a substance rather different to its contents, termed *cellulose*. In the animal kingdom

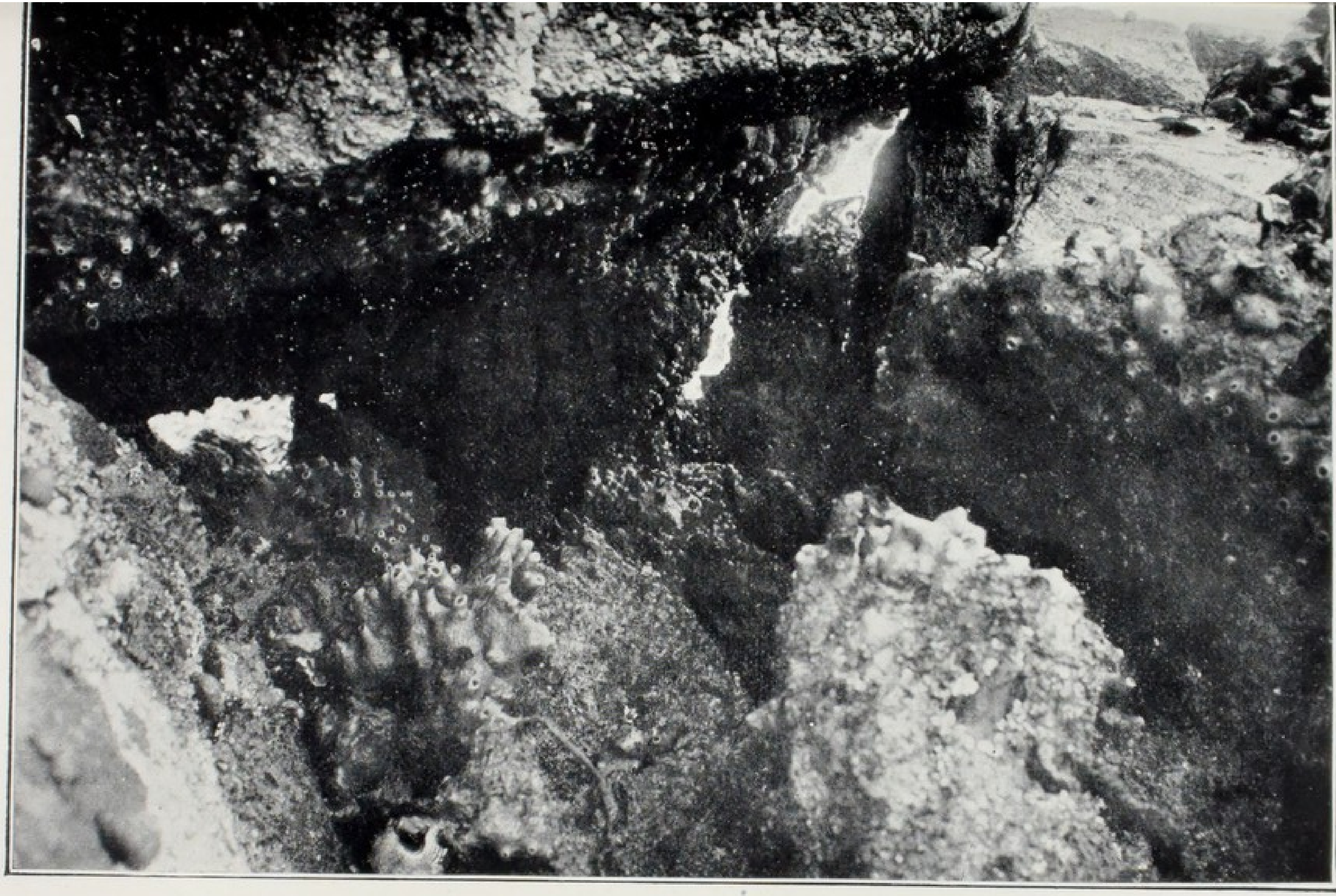


Fig. 9.—*Halichondria* and *Hymeniacidon* growing in a Grotto of Diorite Rock. St Clement's Bay, Jersey

this envelope is absent, and the cell has, at most, a boundary of the same as the contents, only of rather firmer nature.

The contents of the cell are, as I have already said a glairy semi-fluid substance termed *protoplasm*, but it is not homogeneous all through, but is arranged in regular system.

In one part of the cell is a little body termed the *nucleus*, and within this, or adherent to it, a smaller body termed a *nucleolus*. There is also a space, that appears hollow, but which contains a watery fluid, termed the *vacuole*; further, a very delicate network permeates the whole structure.

The lowest organisms, as we have seen, consist of one cell only, and its division is with these not growth, but multiplication.

In the vegetable kingdom a good example of these one-celled organisms is seen in *Protococcus*, the minute plants that appear as a powdery green coating to the trunks of trees, palings, etc., in sheltered situations.

When a cell is about to divide the process commences inside, the nucleus being the first part to divide. As its halves are drawn apart a series of fibres follow the divided portions in a regular pattern, which microscopists term *karyokinetic lines*. Then the cell becomes constricted from without, and becomes *two*.

Some cells have non-retractile filaments, which are termed *cilia* when there are many, or *flagellæ* when there is but one to each cell.

This is a very bare outline of cell structure, but it will serve our present purpose.

In sponges there are, besides the round cells which form the greater part of the mass, others which have a cup-shaped collar, and within this a *flagellum*. These are termed "flagellated cells"; and an "egg" is in the sponge, as in every other living thing, a specially modified cell.

After this little excursion into the fields of biology we shall get back to the more congenial task of observation in the open; and yet I must apologise for still a little further digression, for it is needed for the full understanding of what is before us. We must have a little "animal mechanics."

Fig. 10 is a diagram showing the plan of a *Sycandra*. The small arrows mark the direction of the currents of water. The circular spaces in the wall of the sponge are the

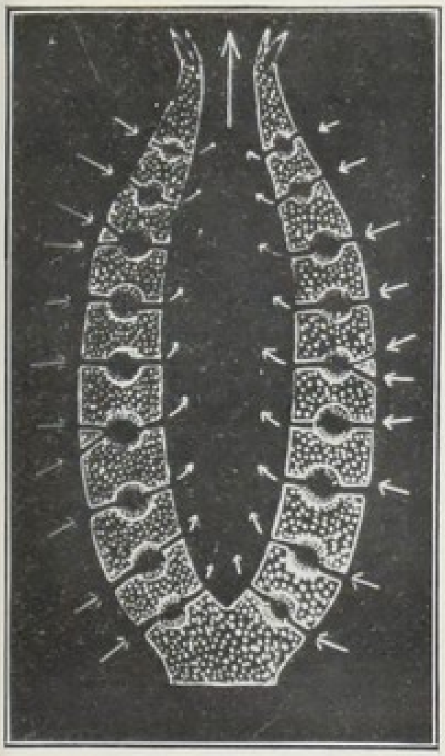


Fig. 10.—Diagram, explaining plan of a *Sycandra*

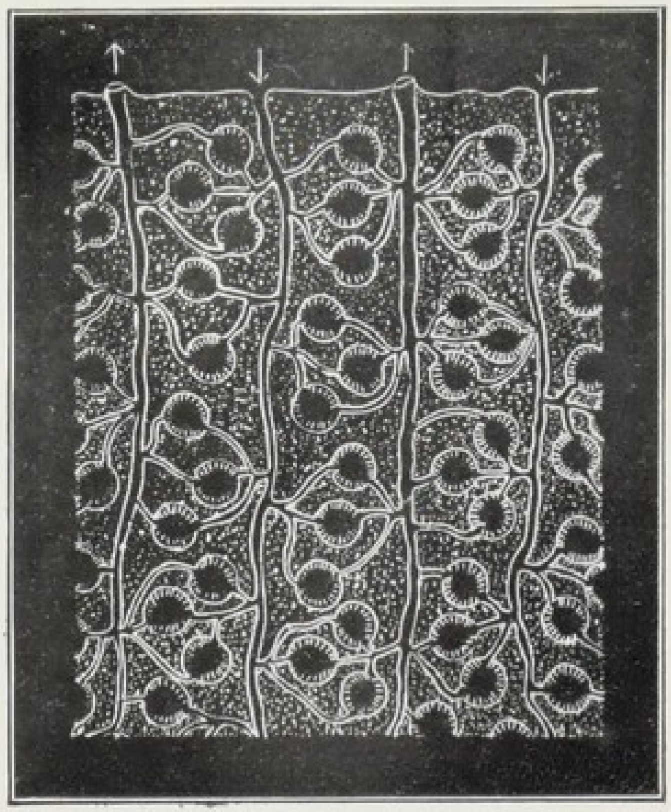


Fig. 11.—Diagram of a complex sponge

chambers lined by flagellate cells, and where digestion and absorption take place. Inside is a cavity, and at the top, marked by a large arrow, is the osculum, by which the water which has served the purpose of respiration, and which has surrendered the food particles which it contained, is forced out.

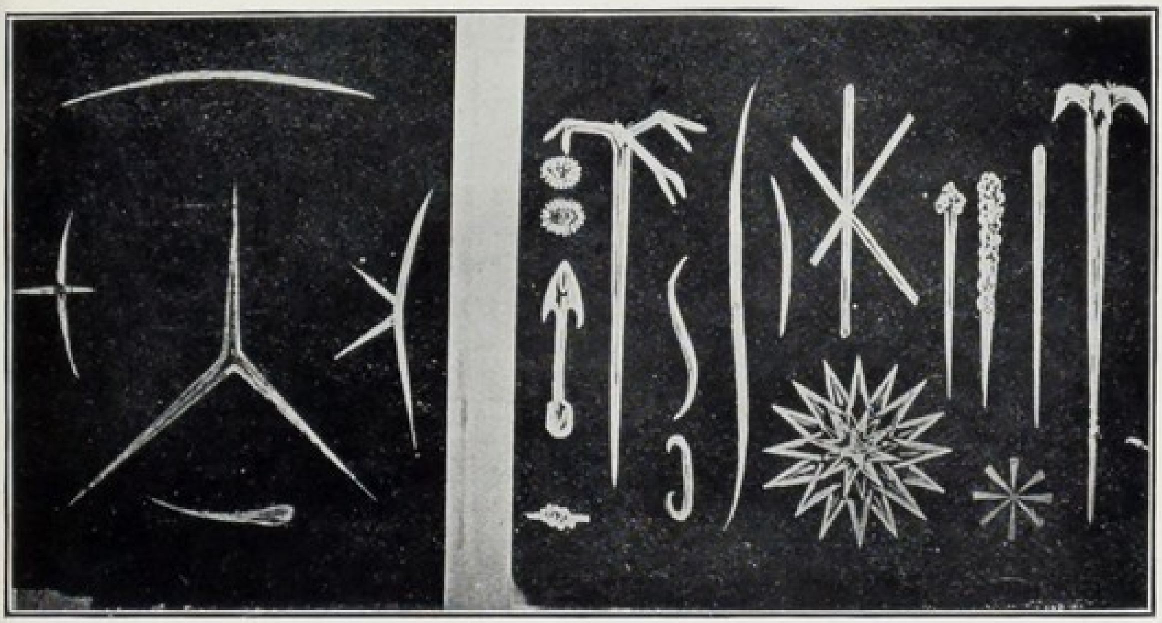
The whiplike threads, *flagellæ*, within the canals and chambers, have a peculiar action: they wave to and fro, but in the outward direction they move *glidingly*, as it were, the curved base going first; then on the reverse stroke they strike boldly, thus causing the current of water to flow always in the same direction—viz. inward.

Now, the simple sponges, as *Sycandra*, do not need to extend laterally, but the form is complete, and size limit is reached, when they are of the form figured; but most other sponges do. A complex sponge, such as *Halichondria*, is, as it were, a fused-together mass of *Sycandra*-like arrangements. The canals, chambers, and cavities become altered in arrangement to meet the shape, the short canals opening into longer ones, which reach the surface, and appear as pores. The inner part of the canals open into cavities, which terminate in the *osculæ*. A glance at Fig. 11 will explain this.

If a piece of healthy living sponge is put in a glass of clear sea-water, and a very little powdered carmine is added, then the currents will become apparent, moving from all sides to the pores, and then, sometimes spasmodically, the expulsion of the water which has travelled through will be seen at the osculæ.

At certain seasons cells which have been modified into eggs and fertilised (both male and female elements are present in each sponge) are ejected with the waste water from the *osculæ*, and develop into little sac-shaped organisms, closely similar to the young of many other animals. These swim freely in the sea for a while, and then, settling down, and affixing to a rock or other object, soon develop into a form like a little *Sycandra*, and then, in the case of more complex sponges, extend, and multiply parts in all directions, until the large mass is built up.

Now we shall get back to the shore. If the tide has well receded, and there are deep rock crevices or grottos accessible, a search within these will reveal many other kinds of sponges, possibly ridged, snow-white, crisp-feeling lumps of the calcisponge, *Leuconia nivea*; large harsh-feeling masses of a slate-grey one, sometimes as large as a quartern loaf, with the osculæ arranged in lines on its surface—this is *Pachymatisma Johnstonia*; pink or purple ramifying branches of *Isodictya Ingalii*; branches of *Chalina occulata*, with the osculæ arranged along the sides of the branches; perhaps the Tangerine orange, resembling one, *Tethya lyncurium*. If within some dark recess a black India-rubber-like—to both look and touch—one is seen, it is a prize—it is *Dercitus niger*. If harsh, needle-clad, rubbly



From *Calcisponges* From *Silicisponges*

Fig. 12.—Some typical forms of Spicules

branches, about an inch in height, and plentifully coated with oozy mud, are perceived, this is *Raspalia*—also a prize.

All these may look to the novice very uninviting and uninteresting things compared to the pretty shells and the gay sea-weeds strewn around, but I must here tell him that the microscopic preparations of these, which he will soon know how to make, are some of the most exquisitely beautiful, as well as interesting, things of which the mind can conceive.

Fig. 12 shows a few of the forms of spicules that form the skeletal parts of local sponges.

It is a good plan to preserve specimens of all kinds that are met with. Methylated spirit is a good preservative, and wide-mouthed pickle jars, which can be covered with a piece of bladder (damped before tying on), are very readily obtainable.

If, however, a regular study is intended, and it is desired to make preparations, to exhibit the cell structure, etc., which I have described, other methods must be resorted to, full particulars of which will be given later on, but specimens simply preserved in methylated spirit will afford good sections to exhibit the spicular and other arrangements.

Over a hundred species of sponges occur on our coast. The books dealing with these and their distinguishing characters will be named in the bibliography at the end.

CHAPTER III

THE CŒLENTERATA

This word is from two Greek terms, and signifies animals with a "hollow interior." This name is applied to the group we now enter upon on account of their structure, which is that of a sack.

The group includes the sea anemones, the hydroid zoophytes, and jelly-fishes.

The reader may ask: If "hollow interior" is a definition of the group, why are not the sponges, such as the sack-like *Sycandra* just described, classed with them? Well, some authorities do place the sponges in the *cœlenterata*, but the doctors disagree, and it will be safe to do as I have so far done—follow the majority.

The sea anemones are typical of this group, and for this reason, as well as that of their being the most popularly known, we will give them priority.

The common name "Anemone" is given them on account of their bearing some outward appearance to the beautiful flower of our gardens with the same name. Our German friends call them "Sea-rosen," sea-roses; and even our matter-of-fact leaders in science have been put off their guard by beauty, and have termed them the *Anthozoa*, or flower animals.

Before we enter into the subject of their appearance, habits, and doings we must take a glance at their anatomy; and the young reader will do well to bear in mind that this description applies to the *corals* or coral builders as well—

so often alluded to as "Coral Insects." The corals belong to the division *Anthozoa*.

Each consists of a circular column, which is hollow, and has its upper margin fringed with one or more rows of hollow, finger-like tentacles. These tentacles are sometimes short and stout (in *Tealia*, etc.); sometimes long, slender, and "snaky" (in the "snake-locked anemone"—*Anthea*); oftentimes fine and feather-like (in *Dianthus*, etc.). Each of these we shall survey presently.

These tentacles are retractile, and when the column folds inward at the top they are out of sight.

On the upper part of the column, within the rows of tentacles, is the disc; in the centre of this is the mouth, a slitlike opening; and from this, in the inside of the column, but not extending to the bottom, is a membraneous tube, corresponding to an œsophagus, which opens into the cavity below.

From the inner wall of the column, radiating towards the centre, and attached to the œsophagus as far as it reaches, are a number of membraneous partitions, termed *mesenteries*. These divide the column into a number of triangular chambers from top to bottom.

Attached to, and between, these membranes are a number of glands, reproductive and other.

There are no internal organs in the usual sense—neither stomach, intestine, heart, or breathing organs; hence the term *cœlenterata*.

Most species attach themselves by the base of the column to rocks or other objects, but one or two forms live, worm-like, in the sand, from the surface of which they protrude their circle of tentacles (*Peachia*, etc.).

One species on our shores secretes lime from the sea, and builds itself a skeleton around its column, and following the course of its mesenteries, thus constituting itself to all intents and purposes a coral, representing the mighty hosts of its relatives that live in southern seas, and those that lived in the seas which in ages gone covered *these* lands, and which have left their skeletons well preserved in our limestone hills. The name of this one is *Caryophylla*.

What we learned of the structure of cells in the last chapter will help us to understand what follows.

The anemones, like everything else that lives, are made up of cells, as have been described, but in this group—*i.e.* the *Cœlenterates*—there occur cells of a peculiar kind, called *Nematocysts*, which are very complicated bits of mechanism.

Coiled within each of these *Nematocysts* is a fine thread (Gr. *nēma* : a thread ; *cyst* : a cell), which, fine as it is, is hollow, and may be said to be a part of the outer layer of the cell greatly prolonged and invaginated to the interior, like the finger of a glove would be if drawn inward from its tip until it was inside the palm ; only in the cell the finger would be many times longer than the receptacle, and it would have to be coiled to lie within it.

At the base of the thread are several very sharp barbs—*very* sharp they must be, since the entire machine is smaller than a full stop on this page. A little " trigger " acts like the hook on a child's " jack-in-the-box," and keeps thread and barbs packed within (see Fig. 7 in Plate 13).

Now this is what happens. When any little fish, worm, or other wanderer in the sea approaches one of these *cœlenterates*, or rather comes in contact with one, a number of the little triggers are touched, the sting cell suddenly contracts, and shoots out the barbed portion, which penetrates and sticks into the skin of the visitor. The thread, which is so fine that no awl is required for its insertion, follows suit, and at the same time an irritant fluid is injected into the visitor's flesh, causing, to a small animal, paralysis or death, and to a large one considerable local discomfort.

A bather who has collided with a jelly-fish—preferably

Fig. 13.

1. A colony of a *Gymnoblastic* zoophyte. *Coryne vaginata.* Natural size.

2. A colony of a *Gymnoblastic* zoophyte. *Syncoryne exima.* Natural size.

3. A polyp of the latter, much enlarged, to show—*a.* mouth; *b.* tentacles; *c*, *d.* medusids developing.

4. The *Medusid* freed from No. 3 and advanced in growth. About 3 times natural size—*e.* its mouth; *f.* tentacles.

5. *Obelia geniculata.* Natural size.

6. A "stock" of obelia geniculata, much enlarged—*g.* nutrient polyps; *h.* reproductive capsules with young medusids inside; *i.* a freed medusid seen from the side; *k.* a freed medusid seen from beneath; *l.* mouth (in each medusid); *m.* reproductive glands; *n.* the *cœnosarc* (in the stock); *o.* the horny tube.

7. Stinging cells, "Nematocysts." Lower figure with the thread coiled within. Upper figure with the thread shot out—*p.* ordinary cell contents; *q.* nucleus; *r.* the "Trigger"; *s.* barbs; *t.* thread.

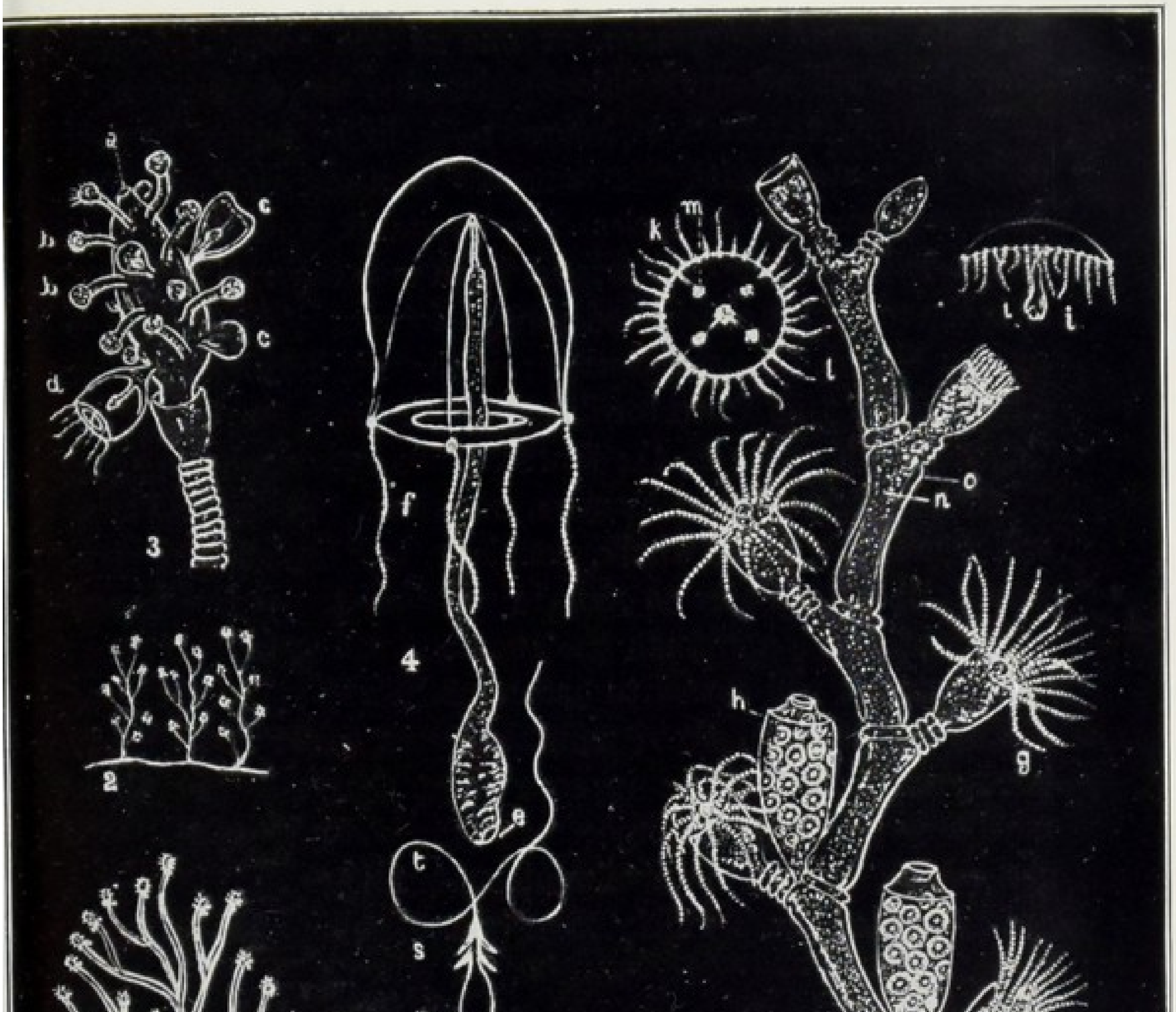


Fig. 13.—Hydroid Zoophytes and their Medusids

C

the one named *Chrysaora*, or one of the colonial forms, *Physalia*—will often graphically describe the experience.

The anemones feed as follows :—A little animal having come in contact with the tentacles is stung and numbed, the neighbouring tentacles close upon it, and it is then thrust *bolus* into the mouth, and down into the cavity below.

If the morsel is considered enough for a meal the tentacles remain closed during digestion ; if there is only enough for a snack it is sent down for digestion all the same, but while the process is going on the tentacles are expanded for more.

Nothing comes amiss to most anemones : the large *Tealia* will swallow a crab, whelk, cockle, a few limpets, or anything else that seems to contain nutriment. If the morsel happens to be larger than the anemone it does not matter : the anemone will *stretch* to accommodate it.

The digestion of these animals seems to be remarkably good ; as a rule, within an hour or so, the shells of crab or whelk, or whatever the object has been, are thrown out from the mouth, cleaned of all valuable material, and the tentacles are expanded more widely than before, calling for the next meal.

Some of the anemones, however, are more dainty ; only small objects—minute crustaceans, fry of fishes, or comminuted material—will suit the taste of the "Plumose anemone" (*Dianthus*), or the "Parasitic" one (*Adamsia*).

Anemones reproduce by two methods : one is by division or "fissure," the other by ordinary sexual method.

In the former case the anemone becomes constricted vertically from disc to base, until on viewing it from above it looks like the figure eight. Usually one of the "halves" is larger than the other. The "mouth" is shared between them, and finally the one becomes truly two, and one of the "halves"—now *one of* "*them*"—moves gently away ; for although anemones are usually *fixed*, they are not immovably so, but can glide along on the "foot," as the base of the column is called, but the movement is too slow to be noticed.

In some species numerous young are developed within the body cavity of the parent, and are ejected from the mouth in the form of the adult, except that the tentacles are less numerous. They then speedily affix themselves to the rock.

Among the species that thus issue their own duplicates are the " Gem anemone " (*Bunodes*) ; the common " Beadlet " (*Actinia*) ; the " Sand anemone " (*Sagartia*), and possibly others—perhaps all—but I have observed the process in those named.

We will survey the species which will most likely be met with on the shore.

The one most in evidence, as it occurs from near high-water level to about the middle zone—rarely below—is the common " Beadlet " (*Actinia mesembryanthemum*). (It has other names, but this is the time-honoured one.)

It is usually of a blood-red colour, although there are some olive-green. When expanded its tentacles form a circle about an inch and a half across, and its column is about an inch in height. When closed, as it is usually seen when the tide is out, unless it happens to be in a pool, it forms a red lump about the size of a walnut.

It has received its popular name, " Beadlet," on account of its possessing a necklace-like row of bright blue beads just below and around its fringe of tentacles. Its scientific name, *Mesembryanthemum*, is, on account of its resemblance to the pretty flower of that name, common in gardens near the coast.

The next in evidence is the " Snake-locked anemone," also called the " Opelet "—the first name on account of its long and slender tentacles, the second because, unlike all its relatives, it rarely closes up. Its best-known scientific name is *Anthea cereus*.

On rocky shores in many places it is so abundant as to carpet the bottom of pools and tapestry their sides. On sunny shores its colour is usually a brilliant grass-green, and the tentacles are tipped with purple. There is a drab variety, usually occurring in shaded places. I have followed authority in saying "variety," for I have had green ones in aquaria which turned into the drab, so it seems that the colour is according to environment. It is a large anemone, the column often three inches each way, and the long tentacles spreading six inches across. Some writers have questioned its power of stinging. If the reader will on the first opportunity touch one with, not the hard skin of his hand, but say his wrist, he will be able to form an opinion. The sting is much as that of the stinging nettle of our roadsides, or perhaps a little less severe.

In exposed rock pools, generally high up, and where there is little or no vegetation, there will frequently be found the "Gem anemone" (*Bunodes gemmacea*). It is a very beautiful little thing, about an inch across the expanded tentacles. Its colour is usually a cross-banding of very delicate tints—pale green, pink, and pearly white, sometimes narrow lines of scarlet coming in between. It well deserves its name.

The large *Tealia crassicornis*, or "Dahlia anemone" as it is called, from its resemblance to that flower, is a common species on most shores. It is the king of its tribe; of large size and gorgeous colouring it is far and away the most striking of the living things of our seas.

An ordinary specimen measures about five inches across its extended tentacles, but I have had specimens eight inches across, the size of an ordinary tea-plate. Its tentacles are short and stout (*Crassicornis*, thick-horn), and they are gracefully tapered. In coloration it is greatly varied; some specimens are uniform crimson—deep and brilliant; others have a crimson disc and snow-white tentacles; some are uniform lilac-coloured, others purple, some various shades of orange; but the most ordinary coloration is the column mottled red and orange, the disc pearly white, and the tentacles cross-banded with red, buff, and white.

For some years I had an aquarium tank in which was a rock about three feet high and the same in breadth. This was covered with *Tealia*, and no flower garden in the height of its glory could compare with this display.

Although this splendid object is common on most of our shores it is very possible that the visitor may fail to see it. It belongs to the lowest zone in tide range (and extends into deep water), and when not expanded is very easily passed over, as it has a very efficient method of concealment. The outside of its column is studded with many little suckers, which hold small stones and bits of shell, so that when it retracts its tentacles and assumes the form of a rounded lump, about the size of an orange, it looks just a part of its surroundings. So that "that man should never trust his eyes who has not learned to look."

At the foot of rocks where there is gravelly surroundings, and in crevices, sometimes in caves and grottos where the light is dim, many a gravelly lump will, if touched with the finger, be found to be yielding. It is a "crass" in mufti; but if in some quiet low-tide pool one or two are seen in full expansion, then I can answer for the statement that they will arrest attention.

One is shown in Fig. 14.

At the other extreme as regards size are the little *Corynactis*. These are about as large as peas. They also are of lovely colours—red, green, white, and magenta. They usually live in colonies. In some places in Cornwall and Devon, in Guernsey, Sark, Herm Island, etc., they are abundant. Strangely enough, in Jersey, so rich in all other kinds, they are exceedingly scarce.

A remarkable form, that has been called the "Parasitic

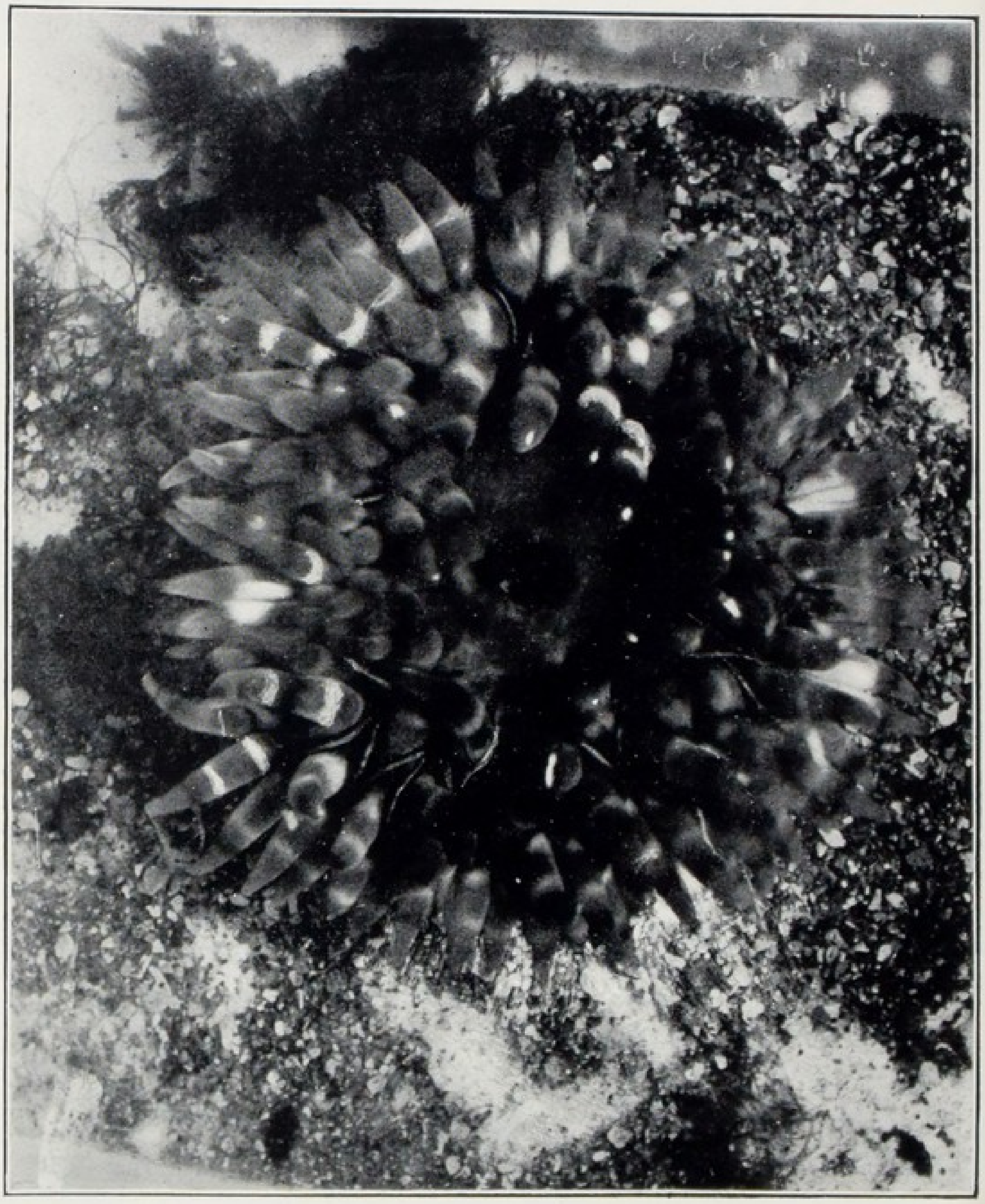


Fig. 14.—*Tealia crassicornis.* ⅗ Natural size

anemone" (*Adamsia parasitica*), is tolerably common. It is usually (not invariably) found attached to a whelk shell which is being tenanted by the common hermit crab (*Pagurus Bernhardus*), but this is a misapplication of the term "parasitic." This only applies in the correct sense to such animals or plants as live upon some other, and at the expense of the latter, for their own ends. The anemone and the crab are "commensals" or messmates, that is all. *Adamsia parasitica* (I dare not alter the name) is a pretty form; the column is about two inches high by one in diameter, and is striped longitudinally with chocolate and white. The tentacles are very fine and fluffy, like a powder-puff. Their colour is either pearly white or a delicate salmon tint.

The advantage this anemone gains by its choice of a dwelling is obvious. It has the means of rapid transit to where food is to be had. The hermit crab being its purveyor, it has gained the use of the crab's eyes, olfactory organs, and legs. When the crab has found something good to eat, and tears this with its pincers, knife-and-fork fashion, many fragments are set free, and the anemone, that prefers, as I have said before, broken-up food, saves the fragments.

The woodcuts that appear in many books—even our high-class ones—which represent this anemone and its congener, are in one respect incorrect. The anemone is always represented as upright—palm-tree-like—on the top of its equipage, as if its chief object were display—or a-ride.

I have kept many hundreds of this queer pair, and handled thousands more, and I may say that this position is rare, and when it occurs is temporary (if it occurs at all). I have invariably found the anemone affixed to the rear of the shell, and in such position that when the hermit is at a meal, or even moving about, the margin of the tentacles just touch the ground, like some patent sweeping machine. It, no doubt, finds this position the best paying one.

This anemone presents a feature that I have not observed in any other. When it is irritated it throws out bundles of white threads, *acontia*, which look like skeins of fine darning cotton. They are thrown out both by the mouth and from conspicuous pores at all parts of its column. These threads when untangled can be drawn out eight or ten inches. Examined under the microscope they are seen to be composed of innumerable spindle-shaped bodies of carbonate of lime embedded in a glutinous matrix. (I think they are some modification of stinging cells, and this may have been investigated and reported, but I have not seen allusion to them.) This anemone has also a very offensive and nauseating odour, a feature I have not observed in any other species.

Now, the advantage that the crab gains from its partnership is not so obvious. It has been said that it is protection from fishes that would grind up the hermit, his protecting borrowed shell, his plan of closing the orifice with his big claw notwithstanding—for fishes with pavement teeth, some of the shark and ray tribe, for instance, could crunch the lot—and that such fishes would not care for the combination of crab and stinging, evil-smelling anemone, but this I am not sure of. The hermit crab is abundantly found in the stomach of dog-fishes and wrasses, that have some plan of snapping him up, unless they catch him when changing his home, which he frequently does.

The anemone, however, benefits obviously, nor is it alone in its appreciation of the hermit crab as a caterer. A fine nereid worm lives within the shell with the hermit, and peeps from the door when a meal is spread. A colony of zoophytes are also usually attached to the shell near its opening, all anxious for the crumbs that fall.

Then another species of anemone has copied the habit of this one (unless it is the other way about). This other anemone is *Adamsia palliata* (the "Cloak anemone"); but, curiously, this one selects another species of hermit crab, the "purple" one, *Pagurus prideauxii*. It has been questioned as to whether this is constant. I do not know, but I have seen no exception. This last-named one is a peculiar anemone. It has no raised column, so that when its tentacles are retracted it is almost flat. Its " foot," instead of being circular, as in all others, is so arranged that it fits around the open end of the shell, in such manner that when both crab and anemone are " extruded " the former appears as if frilled with tentacles, like a lady with an exaggerated feather tippet. *Adamsia palliata* is not frequently found in the littoral zone ; it prefers fairly deep water, and the shell to which it is attached is more often that of a large trochus (*Trochus majus*) than that of the whelk. It *may* be a question of depth of water that determines the different associations mentioned, but a mixture of the two species, each true to its own associate, is not infrequent in the same haul of a dredge in about ten to twenty fathoms of water.

In low-tide situations, chiefly in rock crevices, the beautiful little white *Sagartia nivea*, will be found, and another species, *Sagartia venusta*, with yellow disc and white tentacles—like a field daisy—may be also there, and where there is one there will be many.

On the open sand, especially in proximity to fields of sea-grass, there may be seen, sometimes in large patches, the tentacle-encircled discs of the " Sand anemones " (*Sagartia bellis*). There are many varieties of this, and all are beautiful and curiously marked. A common variety is as if the disc had been ruled crosswise—that is, divided into four sections—and the opposite ones coloured deep purplish chocolate, the two others grey or white. Sometimes all one side is chocolate, the other white ; in others there are many sections, radiating like the spaces between the spokes of a wheel, and these alternately coloured ; others are simply speckled grey, brown, and white. The average size of these is a couple of inches across the expanded portion.

The column is long, and has power of elongation and retraction, no doubt to meet the varying depth of sand which covers the small stone or shell to which the foot is always attached.

Again, in sand, but where this is loose and shelly, there are two peculiar anemones. They are not common, but occur in many localities. The principal one is *Peachia hastata*. It is about four inches long in the column, and the disc and expanded tentacles about one inch across. The tentacles are few, only *twelve*, and they are stout and tapered. The colour is pale pinkish brown, the tentacles being cross-banded with white. It does not attach itself to any object, but lives, wormlike, in the sand, from the surface of which, when the tide covers it, it expands its tentacles. Instead of a flat base to its column, as have other anemones, it terminates in a bluntly tapered point.

Cerianthus is a closely related form, and found in the same localities. This one is still more wormlike in form, being about four inches long, and not much stouter than a pencil. Its colour is creamy white. Both these are rather rare, and they are difficult to find, except to the experienced collector, for when the tide is out the only indication of their presence is a little hole, as if made with the end of a walking-stick, in the sand.

The last anemone I shall mention is the grand "Plumose anemone" (*Dianthus plumosa*). It is fairly common, although not very generally diffused. It is of large size, the column four or five inches high by an inch and a half in diameter. The tentacles, which look like a bunch of well-curled ostrich feathers (hence "*plumosa*"), form a dense tuft, which in well-developed specimens is three or four inches in diameter. The coloration is uniform—white, buff, or a delicate saffron. In some situations it abounds. At the foot of the piles of the pier at Southend-on-Sea I have seen it in immense clusters, and the uninviting masses

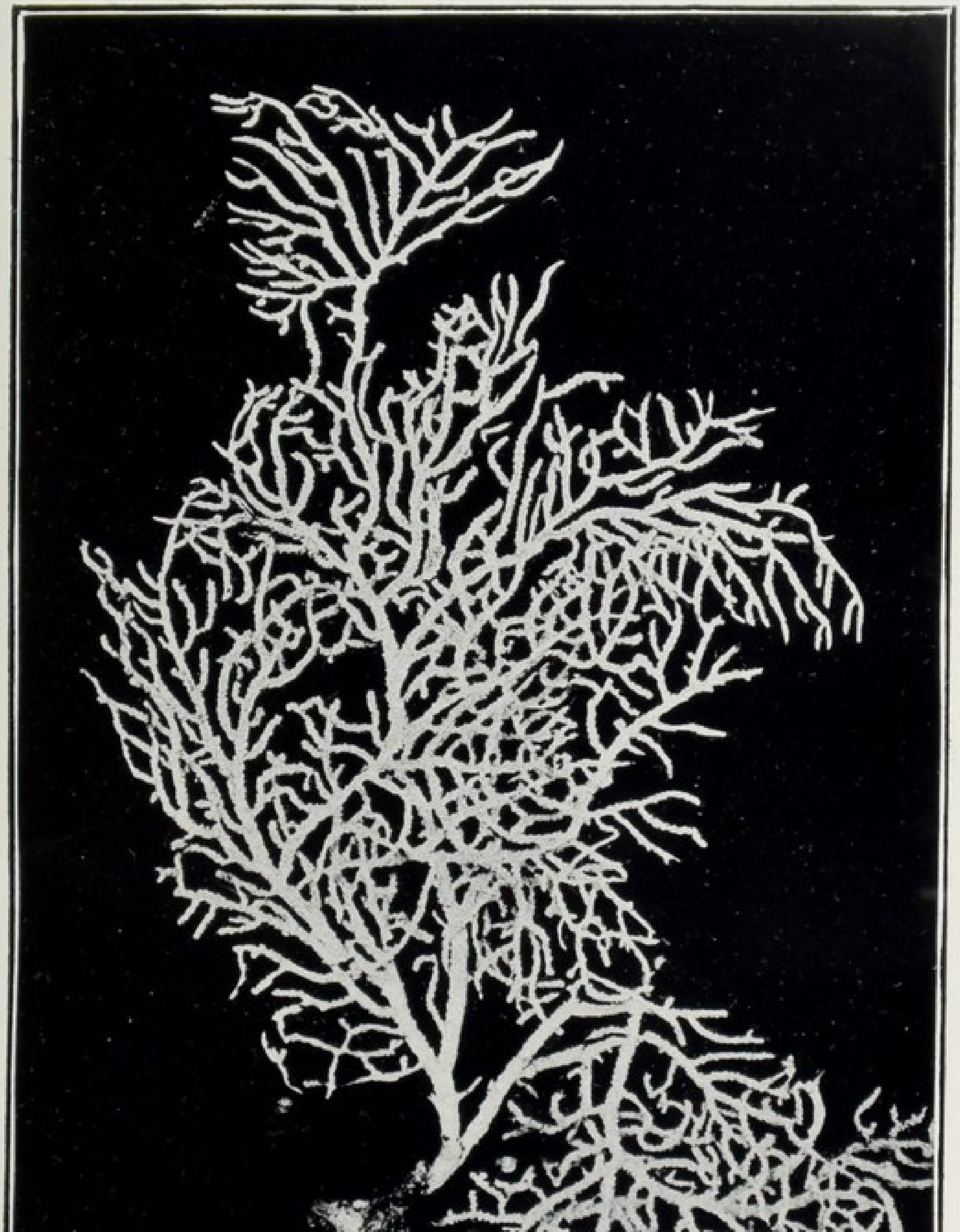


Fig. 15.—*Gorgonia verrucosa*. $\frac{1}{3}$ Natural size

(the individuals being close packed), which hang limp, lax, and motionless from the timbers when the tide is out, are very far from being suggestive of the gorgeous display, the fairy garden, that will be there when the waters have returned.

There are many other species on our shores, but I think I have alluded to the more striking and readily available ones, which is all I seek to do in this book.

Linking the anemones with the compound corals of southern seas, there are several forms on our coast. They are *Gorgonia* and the *Alcyoniums*.

The former is the so-called "Sea-fan," and is a very interesting organism. It does not occur actually on the shore—that is, not between tide marks—and so may be a little out of my province, but it occurs in tolerably shallow water. The specimen photographed (Fig. 15) was taken in the trawl in about twelve fathoms of water on the coast of Guernsey.

Gorgonia verrucosa is the species occurring here. It consists inwardly of a whalebone-like or hornlike axis, branched like a little tree, with a tendency to flatness—*i.e.* the branches are more or less on one plane. Around this axis is a deposit of carbonate of lime (both the material of the axis and the calcareous coating are, of course, secreted by the polypi). The coating is raised into innumerable little prominences (easily seen in the photo), and each of these prominences is a "cup," in which dwells a little eight-tentacled polyp. In anatomy each of these is similar to the anemones described a page or two back. The stock when taken from the sea is of a rich orange colour, and emits a very peculiar, and by no means agreeable, odour, something like iodine. It grows to a height of about two feet, with a lateral extension of somewhat less.

Fig. 16 shows the appearance of a small portion of a branch with the polypi extruded.

On many of our shores the denuded axis of this organism is among the common objects, many persons mistaking it for a branch of heather or of some similar plant, but a small portion placed in the candle flame will reveal its animal

Fig. 16.—A small portion of *Gorgonia verrucosa*, with polypi extruded, enlarged 6 times

origin by the characteristic odour of burning horn—nitrogenous fumes.

The allied forms—that is, *zoologically* allied—although very different in outward appearance, are *Alcyonium digitatum*, familiarly known as "dead man's fingers." This one forms hard nodular masses on many objects—*e.g.* the shells of the oyster and the scallop. In these situations it is a common object on the stalls of the fishmongers. The other is *Alcyonium palmatum*. It is found at low-water adhering to rocks and sea-weeds. In shape it varies considerably, but is usually in ramifying, stag's-hornlike branches, of a grey or pale brown colour, and of a soft, pulpy feel.

Fig. 17 represents a small portion of this latter with the polypi expanded, and Fig. 18 is a micro-photograph of a thin section cut through a small portion, just below the level of the tentacles of the polypi.

The *mesenteries*, described a page or two back, as a

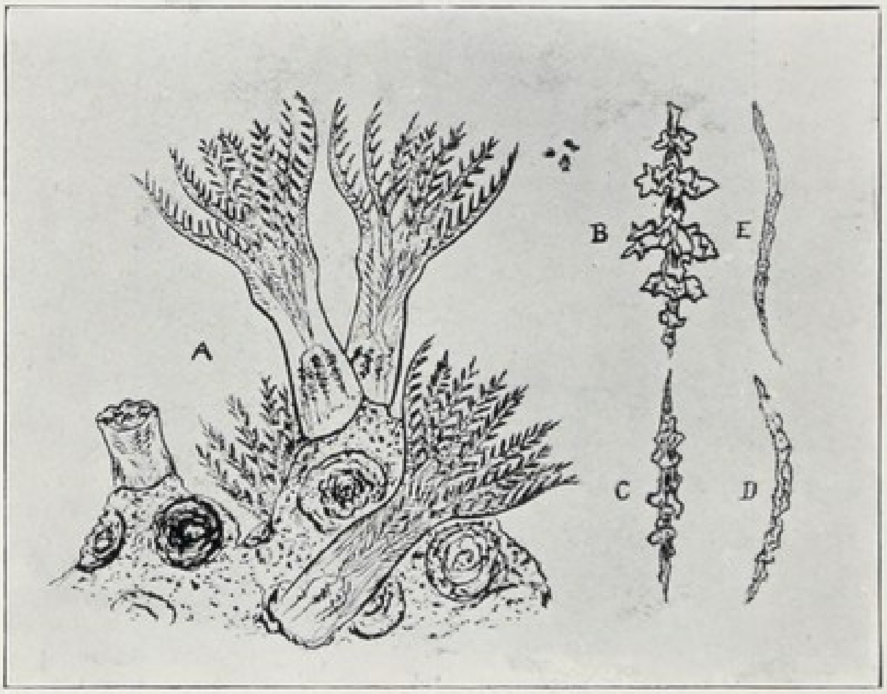


Fig. 17.—Small portion of *Alcyonium digitatum*, with the polypi extruded. About 8 diameters

characteristic of Anthozoan anatomy, are here seen at the part where they radiate from the inner walls of the column to the œsophagus, and in the matrix are seen the spicules of carbonate of lime (shown in larger size in Fig. 17).

These forms are of interest as illustrating the structure of corals ; for it has been shown that all these, even the solid red coral (*Corallium rubrum*) of the Mediterranean, so much used in jewellery, etc., is formed by the fusion of spicules such as those existent in *Alcyonium*.

Hydrozoa.—The next class of cœlenterates we shall survey is that of the *Zoophytes*, or, more properly, *Hydroid zoophytes* or "*Hydrozoa.*" The term "Zoophyte" was bestowed upon them long ago, when it was thought that they were something between plant and animal, but it is retained on account of their branching, plantlike modes of growth.

In anatomy they differ but little from the foregoing, except on one or two points. They form branched colonies, and each individual does not hold a separate entity, but is joined to all the others by what would otherwise be its foot—that is, while each polyp is separate in outward form it is a portion of the general fleshy contents (termed the *Cœnosarc*) of the whole tubular stock, and when one polyp captures prey and digests it the proceeds are for the benefit of the community.

Then they have division of labour: while some are organised for the capture and digestion of food, others are adapted solely for the duties of reproduction—certainly very like the case of a plant, with its separate functions of leaf and flower.

Further, they represent the interesting feature known as the "alternation of generations." The young set free from a reproductive individual are quite unlike the parent. The young are free-swimming, bell-shaped medusids—*Hydro-medusids*, or small jelly-fish. These in turn have sexual reproductive powers, and may give rise either to more medusids like themselves, or more usually to a form which settles down, attaches to some object, buds, and grows plantlike until a branched stock, like the parent; and so the life cycle is repeated.

It is sometimes argued as to which can be termed the "parent"—the branched form or the medusid. This we must leave for others to decide.

This is a brief and, of course, rather incomplete outline of their history; the student will find all details in books devoted to the particular branch.

Naturalists divide the Hydrozoa into two divisions, one of which they term *Gymnoblastic* ("naked bud"), and the other *Calyptoblastic* ("concealed bud").

In the first the little polypi are always exposed, and in the latter they can withdraw into little glassy cups, often in the shape of miniature wine glasses. Both these forms, and explanatory figures of their alternate generations, are shown in Fig. 13.

No. 2 in the figure represents a colony of one of the first division (*Gymnoblastic*). This one is named *Syncoryne eximia.*

No. 3 in the figure shows one of its polypi enlarged about twenty times. A is the mouth, B the tentacles, C C A buds developing towards the *medusid* generation. No. 3 is one of the medusids cast off from the stock. This little medusid bears a name of its own: it is termed *Sarsia.* (One of the tentacles on the polyp shows stinging cells with the threads extruded.)

In this species the "division of labour" above mentioned is performed by different portions of the same polyp, but in most others it is accomplished by separate polypi.

No. 1 is a tuft of another species, which grows larger than the last: it is *Coryne vaginata.* In this one the medusid generation is not cast off from the stock, but performs its functions while remaining attached.

The same figure shows the structure of the *Nematocysts*, or stinging cells, details of which are given in the explanation of the figures.

At extreme low water, and also frequently thrown higher up by storms, may be seen fronds of the great oar-weed, *Laminaria digitata*, on which will be seen growing little upright stems as figured in Fig. 13. They are attached by their base to a creeping stem (*stolon*), which forms a net-

Fig. 18.—Photo-micrograph of a section through a colony of *Alcyonium digitatum*. About 25 diameters

work on the weed. One of these little stems examined

D

in a few drops of sea-water under the microscope, or even with a pocket-lens, will show the details figured on Fig. 5. No. 6 is *Obelia geniculata.* There are other species of *Obelia*, but all show the same structure.

Preparations, mounted for permanency, of some of these stems with the polypi expanded are beautiful and highly valued objects for the microscope. Methods for the achievement of this will be given further on.

Of these Hydroid zoophytes there are a great number on our shores. Some, the *Campanularidæ* (which name signifies " little bells ") form close-set fringes to the leaves of the Zostera, or " sea-grass," and are there seen in millions.

Still more beautiful are the *Plumularidæ* (a " feather "). In these the stem is no longer simply *branched*; it is arranged in pinnate fashion on a mid-rib, like an ostrich feather, or perhaps rather like the frond of a fern ; and the polypi are arranged at regular intervals along each pinna, while between them (in most species) occur curious little bodies termed *Nematophores*, which are polypi of peculiar structure, and the functions of which are not known.

These beautiful forms grow at the sides of rock pools, on sea-weeds, and one beautiful species always selects as its habitat the tips of the leaves of Zostera.

It is very easy to overlook these when collecting, for they are so delicate and transparent that it requires but little to complete their concealment. A bright sunny day is the best for hunting them, for then their presence is often betrayed by their shadows, which are more conspicuous than themselves. A fine robust, although comparatively coarse, form is often cast on shore, nearly always attached to the long stems of the podded weed *Halidrys siliquosa.* This is *Aglaophenia pluma* (Fig. 19). Its colour when living is a golden yellow, but when cast on shore it soon bleaches to white. The reproductive capsules in this one are formed

Fig. 19.—*Aglaophenia pluma* attached to podded weed (*Halidrys siliquosa*)
Natural size

by modified pinnæ, are very conspicuous, and they are termed *Corbulæ* ("little baskets").

So transparent and ethereal are the majority of the Plumularia that to observe them it is necessary at least to place them in a bottle or tube of clear sea-water, and view them against the light.

Plumularia similis is not an uncommon form. It grows to a height of about two inches, usually on stones, or at the sides of rock pools, often very high up in tide range.

There is one representative of the family which is not very obviously plumelike, but it is closely related to *Aglaophenia*. This is *Antennularia antennina*, so named on account of its resemblance to the antennæ or "horns" of a lobster. It grows in erect clumps to a height of about one foot, and may often be seen attached to scallop and oyster shells. In this one the branches are short and bristle-like, arranged around a central axis.

Some Hydroid zoophytes have polypi so small that they cannot be seen by the naked eye; others, such as *Tubularia*, one of the *Gymnoblastic* ones, have polypi nearly as large as a daisy. Some form branches in the shape of a bottle-brush, others are like fans arranged corkscrew-like around an upright stem.

One species of *Sertularia* forms hairlike clumps as large as a football, but all come under the characters above described.

Linking, as it were, these fixed Hydroid zoophytes with the true jelly-fishes—the large familiar forms which have no true branched stock alternate generation—we have an interesting form in *Lucernaria*. Two of these are shown, natural size, in Fig. 20, and one is shown enlarged for details of structure.

The representative of the Lucernarians found on this coast is termed *Haliclystus octoradiatus*. Its actual position in classification is somewhat debated, but it forms, as I have said, a fair link between the Hydroid zoophytes and the true jelly-fishes. It is funnel-shaped, about an inch in height and as much across, and the rim of the funnel is drawn into eight (sometimes, but rarely, ten or twelve) corners, each corner bearing a tassel or tuft of knobbed tentacles, each plentifully armed with sting cells.

The mouth is a square aperture in the centre of the disc,

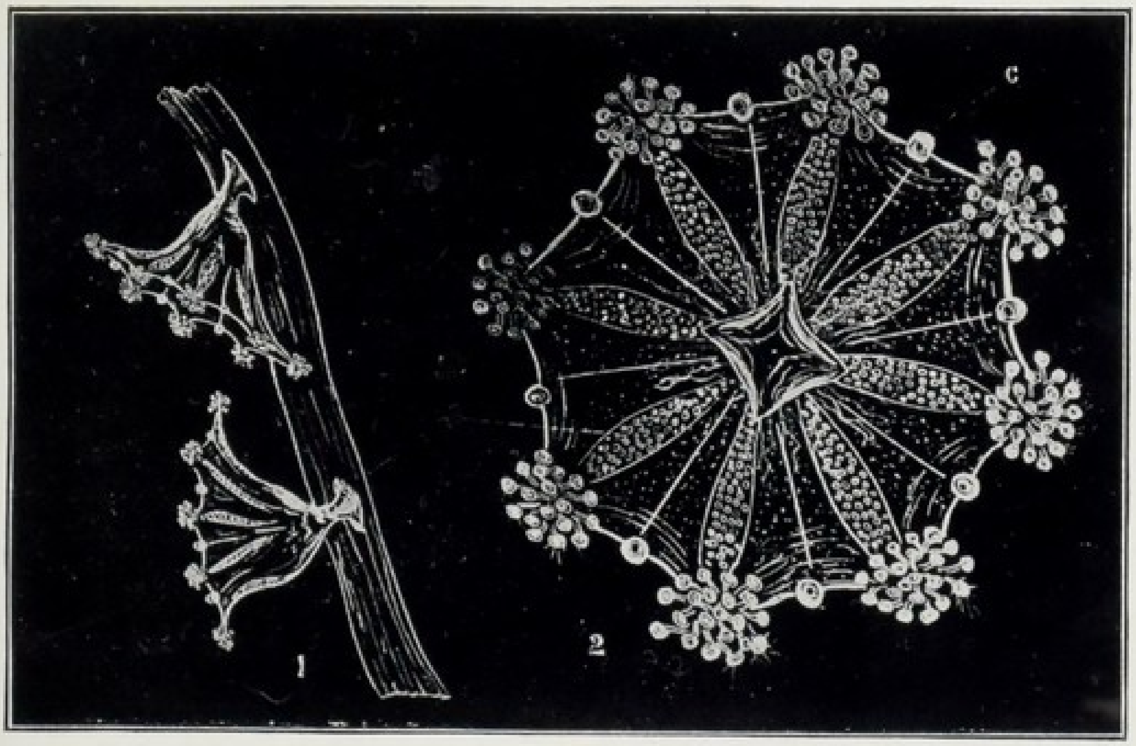


Fig. 20.—*Haliclystus octoradiatus*. 1. Two specimens, natural size 2. One enlarged, about 3 diameters

and the lower end of the funnel is somewhat widened, forming a foot, by which it attaches itself to sea-weeds, etc. (Almost invariably it is attached to the leaves of Zostera.)

From the mouth to the tassels radiate eight strongly marked bands, which at certain times are filled with the reproductive elements, rendering them very conspicuous, the ova especially, which is of a bright red colour.

The colour of *Haliclystus* is usually that of bright new copper with iridescent purple shades; sometimes it is of an olive-green with pink reflections. It is an object of very great beauty, and was termed by the old naturalist Ellis "the lovely Lamp polyp."

In each of the spaces between the tentacles there is a curious little hollow body with an opening on the inner side. These bodies are termed *Colleto-Cystophores*, but their function does not appear to be well known. They cannot be very important, as *Lucernaria* proper, the type of the genus, is without them.

When a leaf of sea-grass with one of these animals attached is taken from the sea the animal only looks like a blob of half-set glue, but as soon as it is dropped into the collector's bottle, into sea-water, it expands into full beauty.

The Jelly-fishes.—We now reach the true *Medusæ*, or "Jelly-fishes" of common parlance—the "Sea blubbers" of the vulgar.

At certain seasons these swarm in our seas, and in those of all warm and temperate zones, often giving a characteristic appearance to the waters in harbours and at the mouth of estuaries.

The "Shore" is not the proper place to look for them with a view to their study, for the cast-up specimens, so frequent everywhere, have always suffered structurally through contact with something harder than themselves, which it is not difficult to find.

Naturalists term these the *Scyphomedusæ*, in contradistinction to the *Hydromedusæ*, those small forms we have glanced at, which are the alternate generation of the Hydroid zoophytes.

They are again divided according to their anatomy, though to the casual observer they are little more than lumps of *Blancmange*. They have sense organs, muscle and nerve, but of an exceedingly primitive kind.

The form most usually found stranded on the shore is the large *Rhizostoma*, as it is firmer than any of the others, and better maintains its integrity under the ordeal (see Fig. 21).

Rhizostoma grows to a large size. I had one brought to me a little while ago which proved a good wheel-barrow

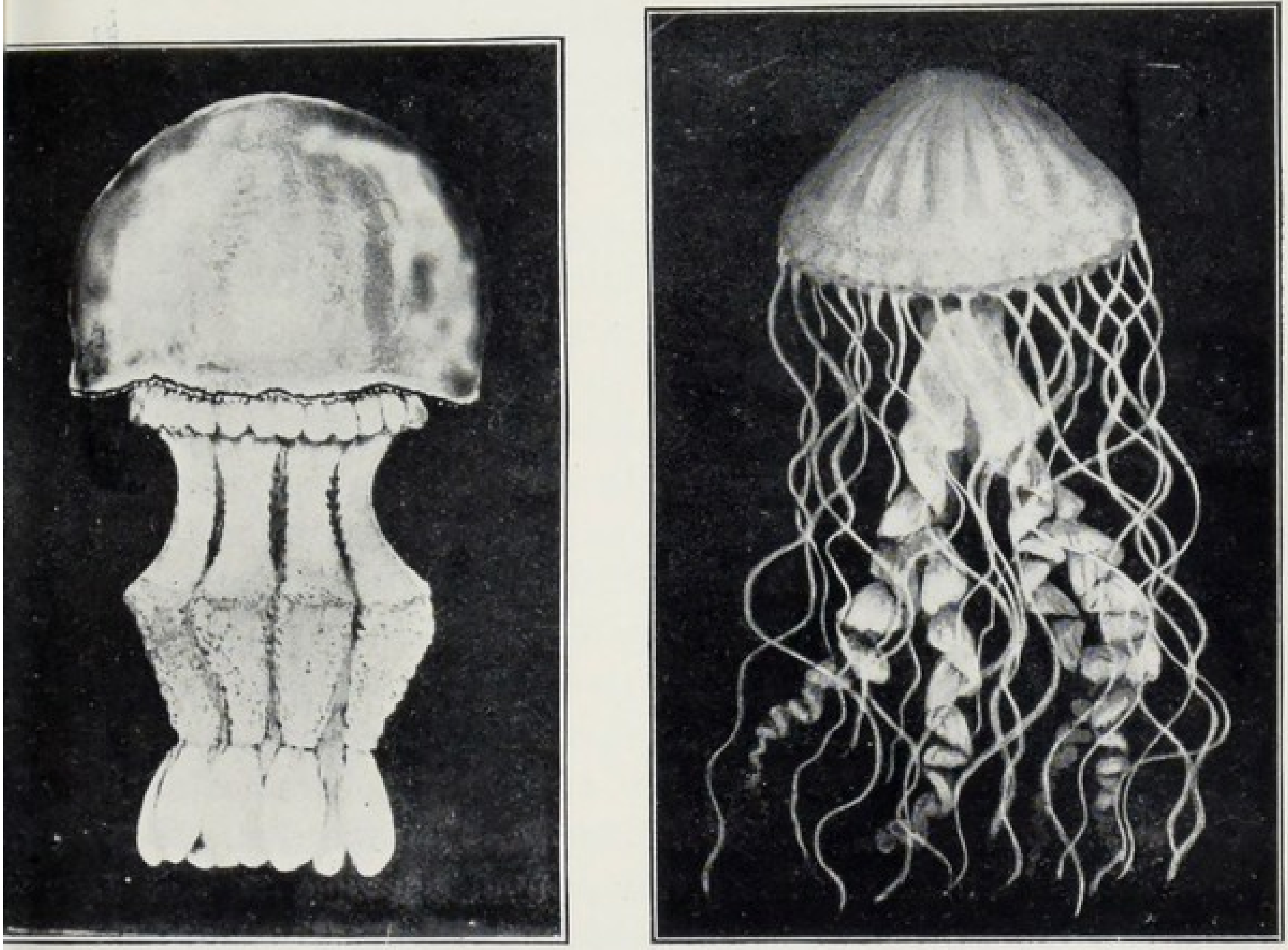


Fig. 21

Rhizostoma. $\frac{1}{6}$ Natural size *Chrysaora.* $\frac{1}{4}$ Natural size

load for a strong man, but the usual size is from six to ten inches across.

The general form of the larger medusæ can be roughly described as a circular disc, umbrella-shaped, the disc partially or entirely closed beneath by a membrane.

Sensory organs, *tentaculocysts*, hang from the margin (they are not present in *Rhizostoma*), while from the centre—long in some species, shorter in others—hangs an appendage termed the manubrium. At the lower end of this is the mouth, and from its sides project, sometimes simple, sometimes complicated and lacelike, what are termed the *Gastric filaments*.

The reproductive organs are on the under side of the umbrella, and within the membrane; below these are four hollows or pockets—" subgenital pits."

This brief review of their general plan will suffice for our purpose.

Aurelia aurita is a very common species. It is rather flat-shaped, and about four to six inches in diameter.

It can be recognised at once, as it floats on the sea, by its having four circular rings (these mark the reproductive glands) of a purple colour, each about the size of a penny piece, and so arranged that their edges touch one another.

The reproduction of *Aurelia* has been well studied, and it gives a key to the reproduction of the others, although the methods are not quite identical.

An egg from the parent develops into a little ciliated embryo, which for a time floats freely in the sea, then settles down upon a rock or a stone and becomes fixed. It grows upward, broadening towards the top. Then sixteen tiny tentacles appear around the edge, so that it looks like a little anemone about one-sixteenth of an inch across. It still grows taller, in shape like a little inverted sugar-loaf. Then a series of constrictions appears on the column (this process is termed *Strobilation*), dividing it into a number of discs, the top ones each having a row of tentacles. The organism is now like a pile of saucers of graduated sizes, the largest at the top. Then the top one breaks away, and is followed at close intervals by the succeeding ones, as each attains the proper size. These little freed discs are termed *Ephyræ*, and they rapidly grow, and assume the characters and functions of the adult *Aurelia*, developing eggs, and repeating the life cycle.

Nor is this all. The original embryo that has settled on the rock may, instead of giving rise to a pile of discs, only grow to a form resembling a little anemone with long slender tentacles, then throw out threads from the sides of its base, which cling to the rock and give rise, at intervals of its length, to fresh buds, which develop to the anemone form—like young strawberry plants on their "runners"—until a vast colony is formed, looking like a patch of white velvet on the rock surface. Then some, or all, of the individuals may take on the process of strobilation, develop into piles of discs, and set free *Ephyræ* in vast numbers, so that an immense number of individuals results from one single egg.

This tremendous method of reproduction accounts for those sometimes mysterious appearances of jelly-fishes in swarms which make the sea look alive with them.

The adults pass a brief, but in the way of reproduction active, existence, and the process is renewed.

Unfavourable circumstances alone keep this multiplication in check, for, as far as is known, nothing preys on the jelly-fishes.

A pretty form, with the disc in radiating segments of pale copper colour and pearly-white, which also sometimes swarms on our coast is *Chrysaora* (see Fig. 21). It has streamers around the mouth margin sometimes nearly a foot in length, and these are pearly white and beautifully frilled. It also has twenty-four long and slender tentacles hanging from the margins of its disc.

The jelly-fishes are all plentifully armed with sting cells, and all (except *Rhizostoma*, which has a modified and almost suppressed mouth arrangement) are predaceous and voracious.

It may have been noticed by the reader that many jelly-fishes give shelter within their "pockets" to other animals—for instance, the great Rhizostoma usually has a set of lodgers, in the way of numbers of young fishes, which make themselves quite at home therein, darting out upon their prey and then back to this peculiar shelter. In some species—*e.g. Pelagia*—these pockets are the constant home of a curious little crustacean, one of the Amphipods, *Hyperia*. How these tenants or lodgers avoid the deadly sting cells, and subsequent attention of their hosts, is difficult to guess.

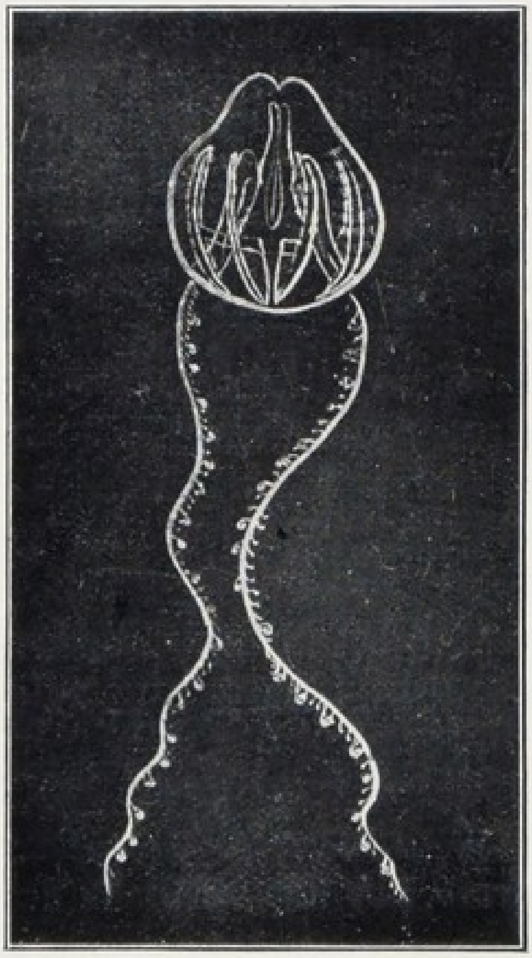


Fig. 22.—*Hormophora pomiformis*
Natural size

In the jelly-fish group, forming a division classed as the *Siphonophora*, are some curious and beautiful organisms. The most abundant is a little apple-shaped one, named *Cydippe pomiformis*, or *Hormophora pomiformis* (Fig. 22). It is about the size of a hazel-nut, with the appearance of glass and the texture of a gooseberry. It has eight bands passing from apex to base, and these bands are crossbanded with rows of cilia, which move almost continuously, with a wavelike movement, causing a play of light and iridescence which is extremely beautiful, the little creature gleaming with rainbow tints.

The bands of cilia are under nervous control, for sometimes one band, then another, may stop and again break into play. It has two long streamers, which are set with little feathery appendages on all their length, and which appendages can be retracted at will into pockets at its sides.

This is one of Mother Nature's gems, more beautiful by far than any of those on which perverted humanity sets its greatest store.

Cydippe is plentiful at the sea surface on all our shores, and may often be found (by the trained eye) in the pools among the rocks.

The *Siphonophora* are without sting cells.

It is curious to note that this class of animals—the jelly-fishes, with muscular and nervous system, sense organs and sexual reproductive system—are from 90 to 98 per cent. *water*.

CHAPTER IV

ECHINODERMATA

We will now consider the star-fishes and their relations—the group *Echinodermata*—" spine-skinned."

They are thus defined: Animals of radial symmetry, usually in five rays, with a firm leathery coating, protected with spines or plates of carbonate of lime, or else (in one division) with a shelly *test* studded with (usually) sharp spines.

They have a perfect digestive system, an organ acting as heart, a nerve system, and a reproductive system, the male and female elements situate in separate individuals. (This last part of the definition applies to the species on our coasts. There are one or two exceptions in exotic species.)

Locomotion is performed by " tube feet " (*Ambulacra*), which are hollow, protrusible processes, exerted or retracted by water pressure, operated by a curious arrangement within the animal, termed the " water vascular system."

At the extremity of the tube feet or *Ambulacra* are little suckers, which give them a hold upon the surface being travelled over.

The tube feet are protruded through openings in the skin or test, which holes are in rows on the sides of radial depressions which are termed " Ambulacral grooves " (see Figs. 24 and 25.

The reproduction is by eggs, these giving rise to free-swimming embryos, which pass through different stages and then settle down to assume the adult form.

The group is placed in five sections, as follows :—

Asteroidea.—The true star-fishes (Figs. 23, etc.), usually five-rayed. (*Solaster* has twelve or more.)

Echinoidea.—The sea-urchins (Figs. 29, etc.).

Holothuroidea.—The sea-cucumbers (Fig. 34).

Crinoidea.—The feather-stars (Fig. 27).

There are about thirty species of Echinoderms on our shores, of which twenty-five or so are to be found in the portion which uncovers by the tide.

There are, however, some species which are confined to our northern coasts, others to the southern, but it is a poor portion of any coast that does not furnish a dozen.

In all rock pools where there are bits of loose stone and gravelly or sandy bottom, with their thread-like rays often tangled in the filamentous algæ, or among the branches of zoophytes and corallines, may be found numbers of the dainty Little Brittle Star (*Amphiura elegans*). This one is about an inch across its extended rays, and the central disc is about the size of a small split pea. Its colour is greyish white, sometimes pink. Closely resembling it are one or two others, just differing in the shape of some of the protecting plates.

In similar situations, but confined to low-tide limit, may often be found the "Thread-rayed star" (*Ophiocoma filiformis*). Its disc is about the size of a threepenny piece, and its rays spread out to cover an area of eight or nine inches. It is considered rare, but the fact is that it is often of the colour of its surroundings and its very slender arms, entangled in masses of *Polyzoa*, etc., render it very inconspicuous.

Still in these situations, but much more abundant in deeper water, is the "Common Brittle Star" (*Ophiothrix fragilis*). This is a very popular form, and is the one usually figured in elementary books of zoology. Its disc is about half-an-inch across, and its rays spread to a compass of about five inches. The rays are beautifully set with radiating spines. Its colour is usually red and white; or red and yellow, the colours arranged in alternate bands across the rays.

A larger species, closely similar in form, is sometimes met with. This is *Ophiothrix niger*. Its colour is nearly black, and the radiating spines of the rays are buff. In the Channel Islands it is common on coralline, or rather *Nullipore* bottom, in ten to fifteen fathoms of water, and is taken in the dredge.

The common "Cross-fish" (*Uraster rubens*), usually taken as the type of the whole class, is frequently cast on shore from deep water, but also lives regularly on shelly gravel bottom and among loose stones. It is about six or seven inches across its rays or "arms." These, unlike the corresponding parts of those we have mentioned, are stout, and form the greater part of the animal's bulk, no definite "disc" being apparent. Its colour is buff, drab, or slaty grey.

The Great Spiny Star-fish (*Uraster glacialis*) bears some resemblance to the last, but is much larger, sometimes twenty to twenty-four inches across its arms. It is strongly armed with stiff spines, the bases of which are surrounded with velvet-like tufts of very fine ones. Its colour is something between a purple and a greyish buff (Fig. 23).

It is found in rocky situations, sometimes squeezed in very unstarlike form in rock crannies. It is frequently taken by fishermen on their lines, having engulfed the bait intended for more marketable denizens of the sea. This species, and the previous one, often cause great havoc in oyster-beds, destroying large numbers of the molluscs.

Their method of devouring the oyster has been much speculated upon, some oyster fishers holding that it inserts the tip of one of its arms between the oyster's valves, and thus keeps them apart while it brings its mouth to bear. It is also said that it injects a fluid which kills the oyster, and that only then does it get to the coveted portion.

I believe the fact is a compromise between the latter and

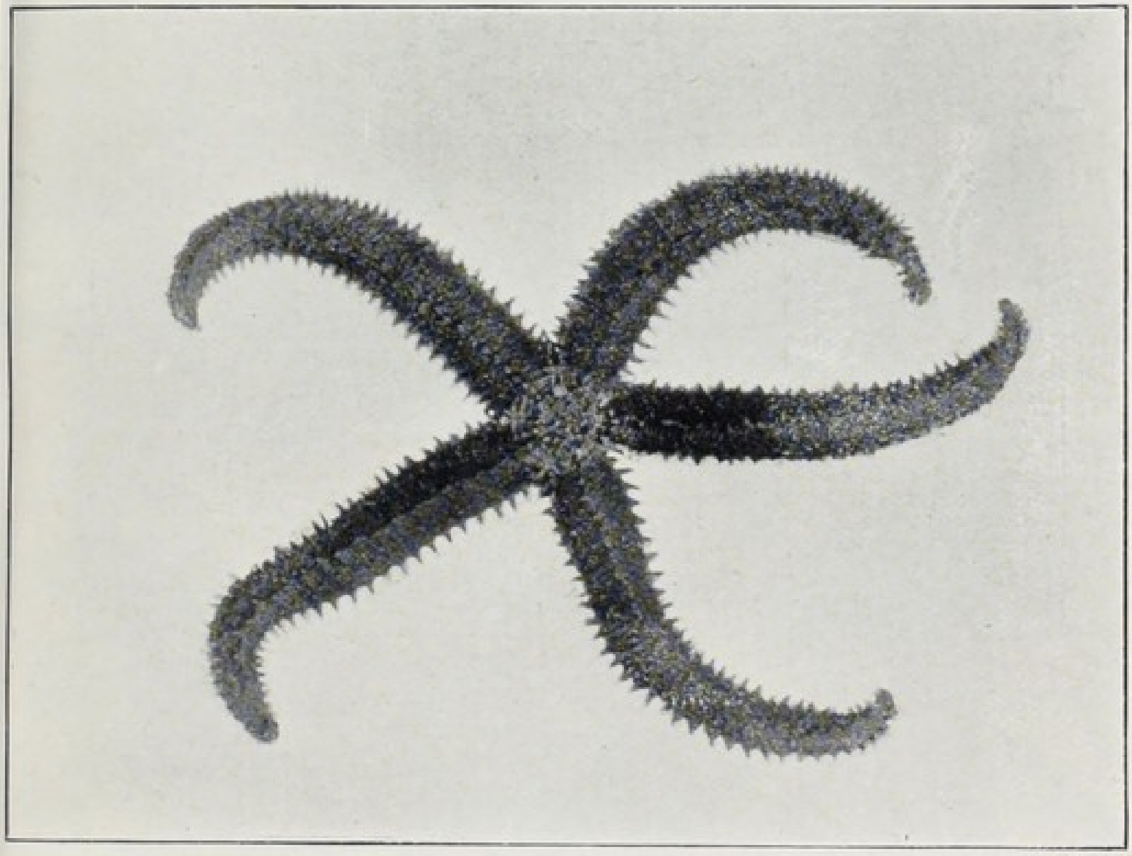


Fig. 23.—*Uraster glacialis.* $\frac{1}{6}$ Natural size

a peculiar faculty that all the star-fishes have of being able to evert their stomachs.

A large star-fish can do this to sufficient extent to envelop a moderate-sized oyster, the digestive fluid then enters between the valves, and digestion and absorption can thus be effected without the oyster, as such, having been within its consumer.

I have not seen star-fish attacking the oyster, but on the shell gravel reaches at Herm Island I have many times found Uraster digesting a *Natica* that was too large to be taken in in this manner.

In rocky situations, and under stones that are not too evenly pressed to the ground, may very commonly be found the little "Cushion Star" (*Asterina gibbosa*). This one is about an inch and a half across. It has no definite

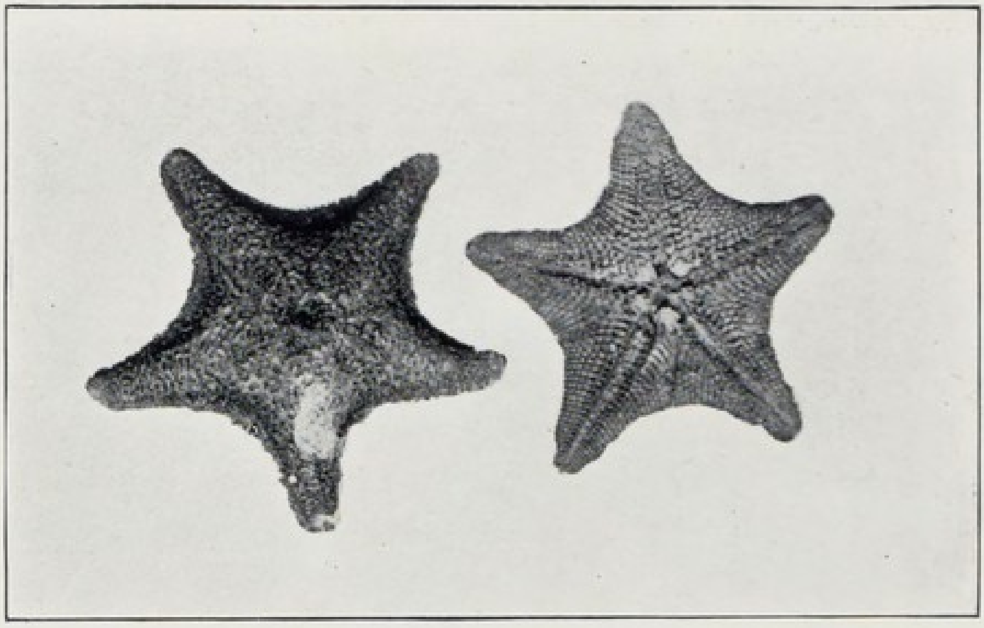
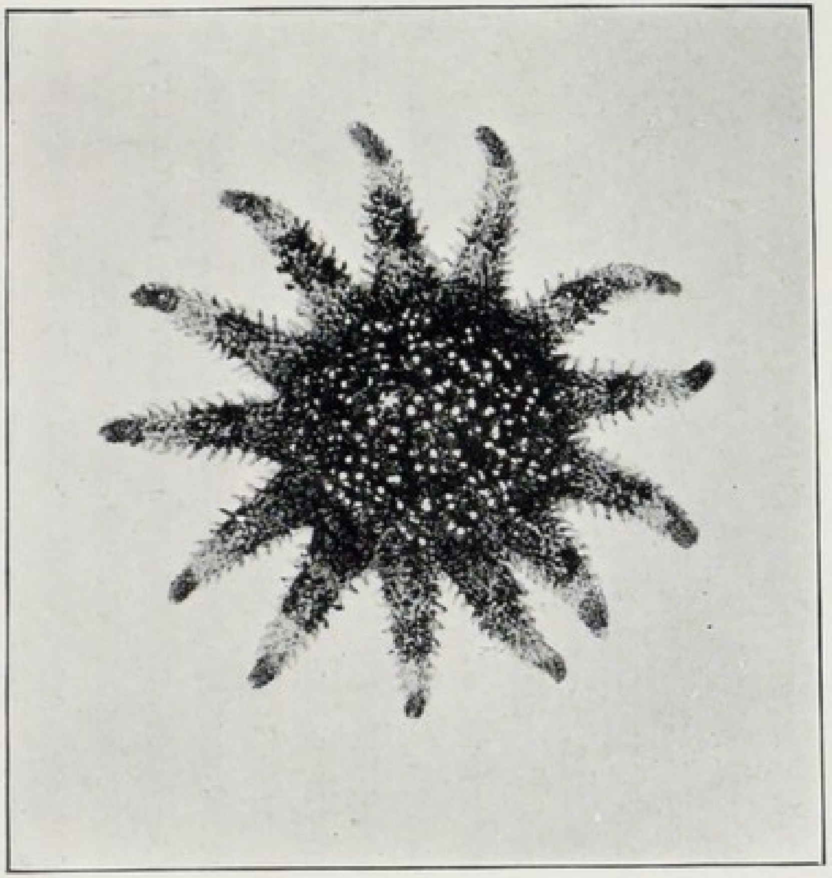


Fig. 24.—*Asterina gibbosa*. Upper and under
Natural size

rays or "arms," only five projecting corners, hence its name of "Cushion" (Fig. 24).

Of much the same shape as *Asterina*, but of very much larger size—often nine inches across—is one of the grandest of the British star-fishes. This is *Goniaster equestris*. It is, when living, of a purplish green colour, and finely set with tubercular processes. It is a northern species, and is not uncommon off Aberdeen. It is properly a rather deep-water form.

The star-fish which attains the greatest size on our shores is *Asterias aurantiaca*. This is of typical star shape. The



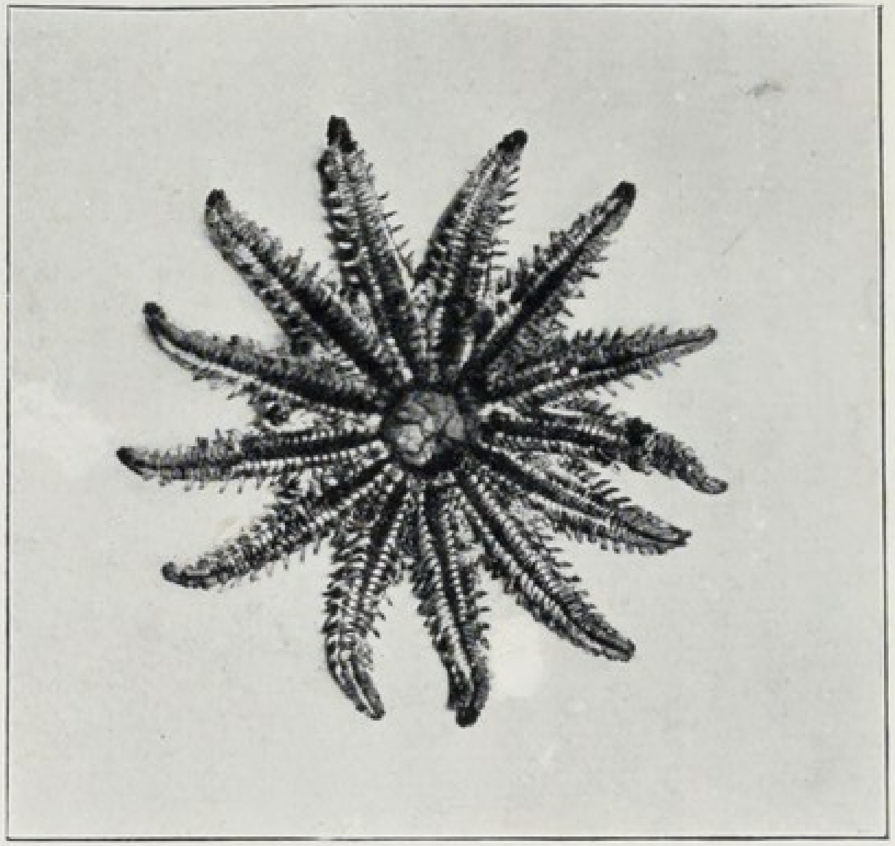


Fig. 25

Solaster papposa. Upper side
½ Natural size

The same specimen. Under side, showing ambulacral grooves arms are flat, and regularly tapered to a point. The upper surface is closely set, pavement-like, with tubercles of small spines, and the rays are bordered with a fringe of long and stouter ones. Its colour is usually an olive-green or olive-brown. Full-grown specimens measure about twenty-six inches across. It is difficult to obtain full-grown specimens entire, as they are only obtainable by dredge or trawl, and, being very fragile, usually fall to pieces in being captured. Only by shore hunting in suitable localities—soft shelly gravel at extreme low-tide limits—can sound specimens be obtained, and these, as far as I have experienced, are never full-grown ones.

Luida fragillissima is another very beautiful British form that often grows to very large size. It occurs in the same localities as the last, and presents the same difficulties, for, as its specific name states, it also is fragile. The number of rays in *Luida* is variable, but usually seven.

Solaster papposa is a striking and beautiful star-fish. It is popularly known as the "Sun Star." It has usually twelve rays, forming a circle. Full-grown specimens measure about seven inches across. The colour is brick-red and white, or brick-red and yellow, arranged in concentric bands around the circle formed by the arms. It is shown in Fig. 25. One is photographed from the under side to show the ambulacral grooves.

Cribella oculata, or *Cribella violacea*, is a fine British star. It is five-rayed, and the rays or arms are rounded. It has no projecting spines, but is closely set with firm-knobbed ones, giving it a rigid, stony feel. It measures about four inches across. Its colour is a beautiful reddish purple on the upper surface, yellow beneath. It lives on rocky shores, and often occurs, where there is fucus, etc., at a comparatively high situation in tide-level.

I am not taking the star-fishes in their proper order, according to the text-books, but as they come to mind, and should properly have placed the two that follow at the commencement of the series.

On sandy bottom, and on muddy ground, from low-tide margin to deep water, are found in number the "Sand Stars." These differ considerably from any of those described. They are firm and fossil-like, having an appearance as if carved out of chalk. They are *Ophiura*

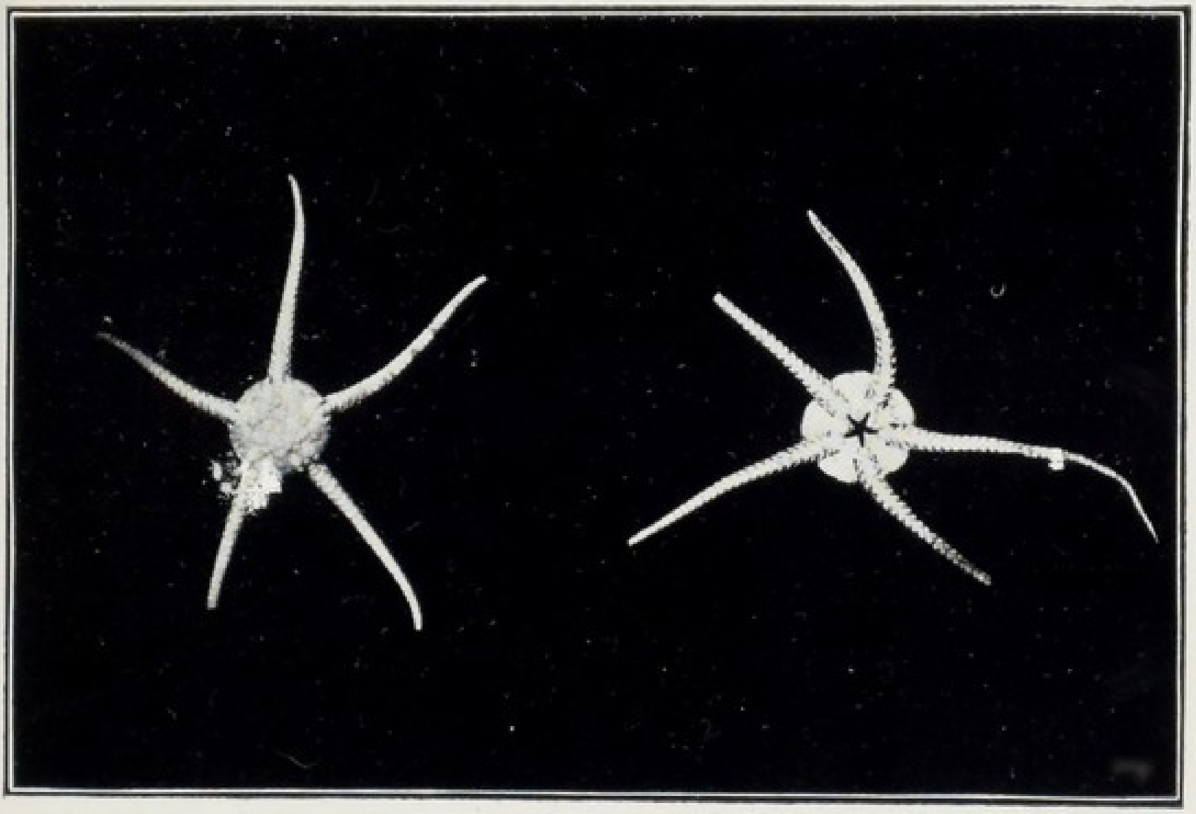


Fig. 26.—*Ophiura albida*. Upper and under sides. Natural size

albida and *Ophiura texturata* (*Ophiura*: "snake tail"). The former measures about three inches across the rays, the central disc being about half-an-inch across. The latter, which closely resembles it, except in the arrangement of the calcareous plates and spines, is about double the size. Their colour is chalky white, with crossbanding on the rays of ash-grey (Fig. 26).

The Crinoidea.—This division, which is formed for the reception of forms which in some respects have affinities with the star-fishes, comprises the so-called "Sea-lilies" of foreign seas and the "Feather Stars."

On our shores it is represented by but one species, the lovely "Rosy Feather Star" (*Antedon rosacea*, or *Comatula rosacea*). It has rays, usually ten in number, which are plumelike, and it has a series of hooked claws around the disc, for fastening to rocks and other objects. It is about four inches across, and is usually of a deep blood-red colour. It is of great interest to the naturalist, as in its young stages it is quite unlike all other Echinoderms.

The young, after their larval free-swimming stage, grow, plantlike, upon a stalk, which is jointed. Then when growth has advanced to a certain point the rayed flower-like top breaks away and becomes of the adult form.

The stalked stage represents an ancient type, which, under the names of Encrenites and "Stone-lilies," are common as fossils in our limestone rocks. In some foreign representatives of the Crinoidea the stalked stage is persistent through life.

These forms must have been very abundant in the seas which once covered what is now our land.

The various stages are represented in Fig. 27.

The Echinoidea, or "Sea-urchins."—The members of this division resemble the star-fishes in general anatomy, although they are of very different outward form.

The structural affinity can be represented by an imaginary experiment. If one of the broad-rayed stars—say one of the "Cushion Stars"—had its projections turned up over the back until the points just touched, and then the edges were fused together, then the once outward enclosed skin be done away with, it will be seen that the five-rayed system would still be maintained, and that the ambulacral grooves, with their tube feet, would now extend vertically up the sides of the now rounded mass. Then we should have a sea-urchin.

Some foreign species of star-fish are thus permanently

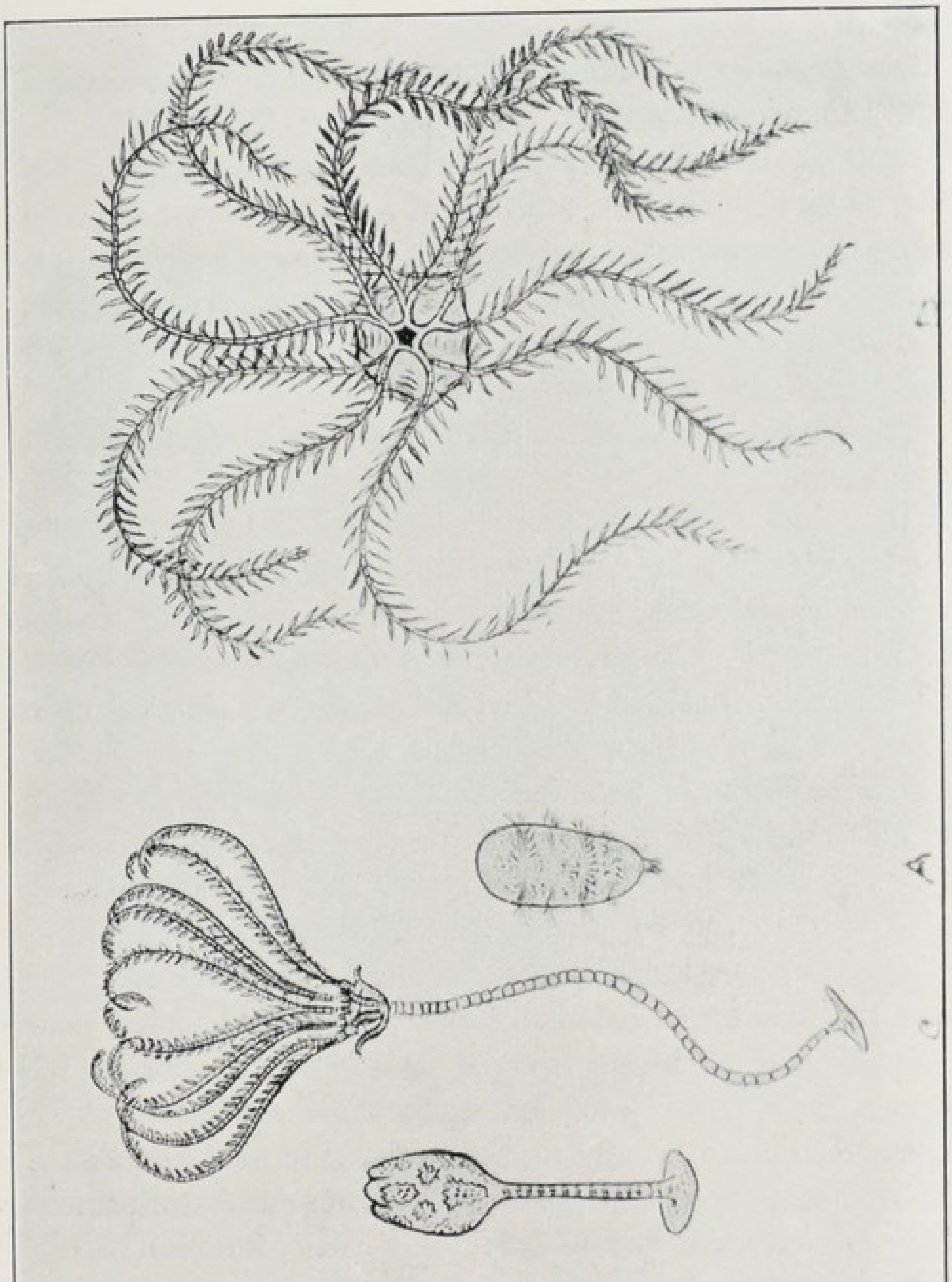


Fig. 27.—The Feather Star. *Antedon rosacea.* *A.* Free-swimming larva and early and advanced stalked stages. Much enlarged. *B.* Adult. Natural size

folded upward, and seem to be a link between the star-fishes and the urchins.

The sea-urchins are more or less globular in shape, although some families, as we shall see, are roughly heart-shaped.

The French naturalists define them as "*Oursins reguliers*" and "*Oursins irreguliers*" (compare Figs. 29 and 31).

Instead of a leathery plate or spine-protected envelope they have a shelly test, built up of a large number of plates, which fit together at the edges in a most beautiful, and always regular, manner and uniform pattern. The five-radiate arrangement is only apparent outwardly by the ambulacral grooves, as stated.

The alimentary canal, and the ducts of the reproductive glands, open, as in the star-fishes, at the top. The shelly plates which edge the grooves are perforated for the extrusion of the tube feet. By these little openings, as well as at base and apex, connection exists between the internal anatomy and a thin membrane which envelops the test. On the shelly plates of the test are arranged in regular order a large number of little protuberances or knobs (see Fig. 28), and these form the base for the sharp spines which radiate on all sides. The spines, which are so well attached that they appear to form a portion of the test, are not so rigidly fixed as they appear, but are movable at the will of their owner, the little knobs and the bases of the spines forming, with the membrane between, a sort of ball-and-socket joint.

Small and curiously shaped three-pointed beaks, like pincers with three jaws, set upon short stalks, occur between the spines, chiefly on the under side near the mouth. These beaks open and shut with a snapping movement. They are termed *pedicillaria,* and their function is not well known.

These *pedicillareæ* exist in the star-fishes as well.

Projectible through a large opening underneath the test are five large teeth, with sharp, enamel-pointed tips. The teeth are made up of a number of plates, and the set is controlled, both for opening and closing, as well as protruding and retracting, by a somewhat complicated muscular arrangement. This apparatus has been termed "Aristotle's lantern." It is shown in the Figure just referred to.

The internal anatomy consists of an alimentary canal, extending from the base of the "Aristotle's lantern" to

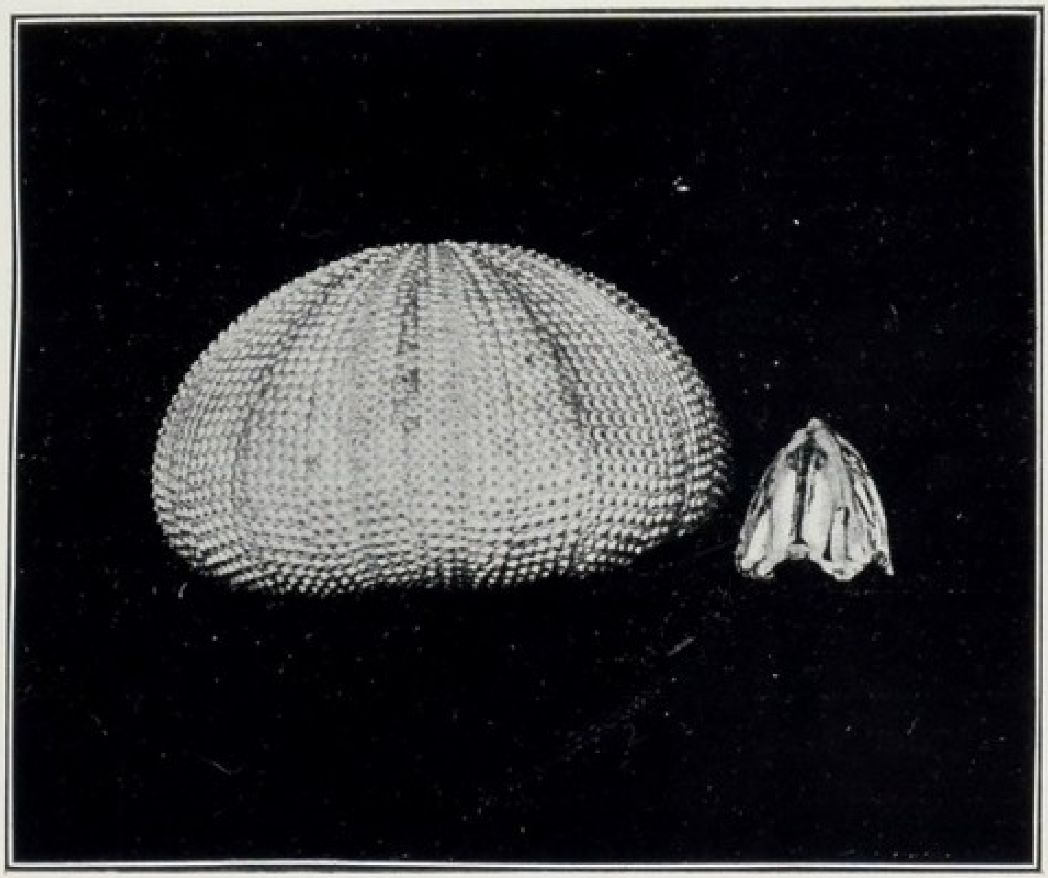


Fig. 28.—Test and teeth of a Sea-urchin. *Sphærechinus brevispinosus.* $\frac{1}{3}$ Natural size

the anal opening at the apex of the test. Five large lobes fill the greater part of the cavity. These are the reproductive glands, and look as if made up of bunches of millet seed. These may contain male or female elements—*i.e.* spermatozoa or ova—but only the microscope can decide which. The sexes, as we have said, are separate.

The products of these glands are expelled through little openings in a set of fine plates immediately surrounding the anal opening at the apex.

The eggs are very minute. When they are expelled (on this coast it is usually in April) they furnish no further appearance than a cloud of a brick-red, or sometimes orange-yellow, coloration to the surrounding water. Millions are set free by one individual.

During the same period—that of sexual maturity—spermatozoids, in a *white* cloud, are set free by the males, and by the mingling of the products in the water fertilisation takes place.

In the case of some of the tube-worms, presently to be described, the same method of fertilisation takes place. Captive specimens have been carefully watched by the writer during this period, and it is curious to note how the individuals of each sex, although far apart, become excited. A sense must exist, which has not yet been defined, and for which I will venture to coin a term. I should call it "*Telethesia*."

The changes that take place after fertilisation are very rapid, within an hour after extrusion an egg becoming a moving embryo.

This process of fertilisation, and the subsequent changes in the egg—one of the most wonderful operations in Nature's laboratory—can be readily observed under the microscope, the elements of the sea-urchin lending themselves to this end more readily than any other subject.

The "water-vascular system" I have mentioned as operating to protrude the tube feet also performs other functions in the animal's economy, but they are not well known.

The water in these vessels has communication with the open sea through some openings in a specially raised and modified plate on one side of the centre, and which is named the *Madreporiform tubercle.* It is conspicuous in a living star-fish and may even be seen in the photograph (Fig. 23), just below the junction of the two arms which are uppermost.

I feel that I must apologise for these repeated deviations into matters more strictly biological than I intended, but these few points are essential for a fair understanding of the

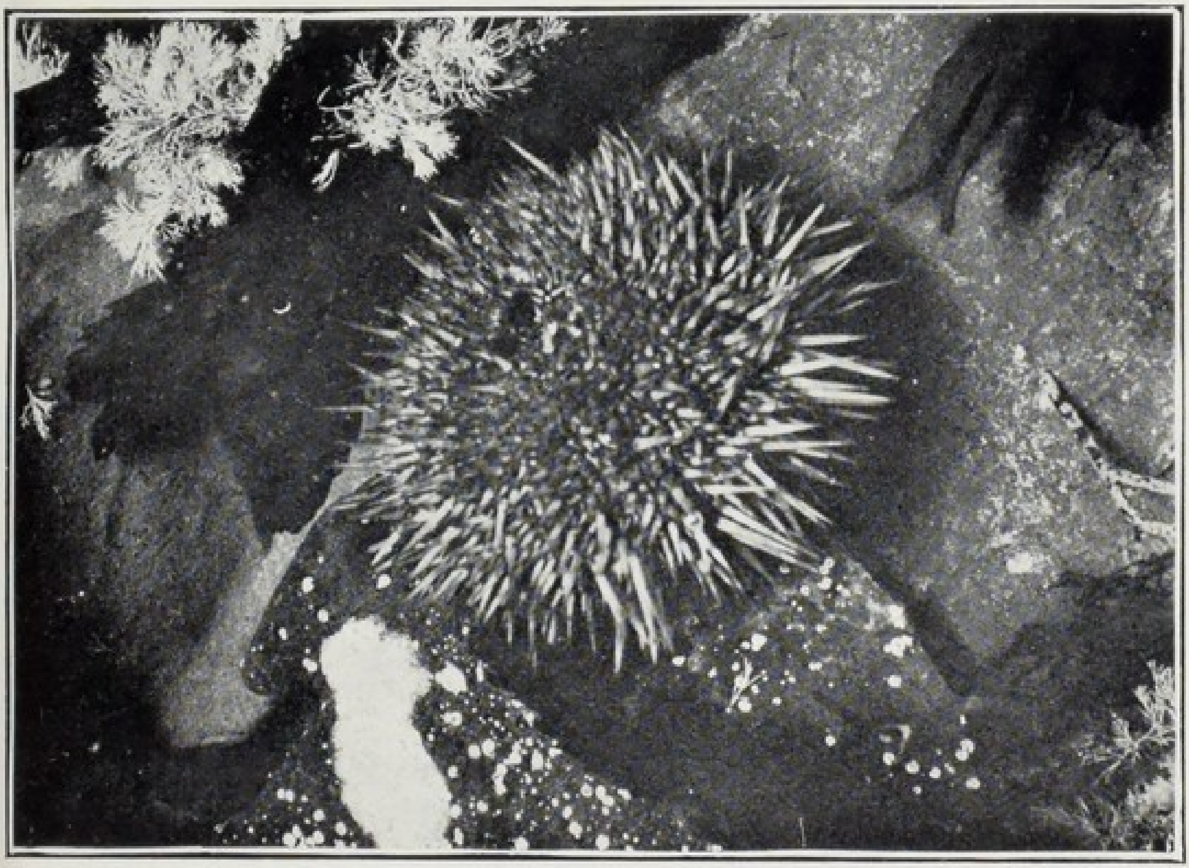


Fig. 29.—*Echinus miliaris*, at home. Natural size

objects we come upon in our researches, and I am writing not for the laboratory but for the seaside observer.

Among the rocks, under boulders, and in crevices, on almost any coast, will be found the common little sea-urchin (*Echinus miliaris*). This little fellow, shown at home in Fig. 29, is about two inches in diameter. The spines are about half-an-inch long, and are usually of a dull green colour with purple tips. The denuded test in this, as in all the others, is of a pink colour.

Still in the littoral zone, and under boulders where there is space, occurs the pretty *Echinus lividus*. It is larger than the last, and is of a more robust structure, the spines stout and very sharp. In colour it varies; some are of uniform deep purple, others of a bright green, and this does not seem to be due to habitat, for both kinds can be hauled out from under the same boulder. This species is shown in Fig. 30. It is said that it excavates for itself hollows in the stone, and it has been speculated upon as to whether it is by a mechanical or a chemical process that it bores. I am not qualified to express an opinion on this matter, for although I have dragged out from their hiding, and examined, some bushels of them I have no evidence of their "boring." The rocks here are granite and diorite, and into *these* I am quite sure that they do *not* bore, although they avail themselves of any existing hollow.

In loose shell gravel and broken stone, sometimes in the littoral but more usually in deeper water, is the large *Echinus esculentus*, used on many parts of the Continent as an article of food, under the name of *Chataigne de mer* ("Sea-chestnut").

This species grows to the size of an ordinary pudding-basin—that is, from four to six inches in diameter. Its colour is usually white, but the spines are rather sparsely distributed, leaving the test visible between, so that a pale pink is the effect. Sometimes the spines are lightly tipped with violet. Closely allied, unless indeed they are but varieties, are *Echinus melo* and *Echinus acutus*. The first of these, as its name implies, is melon-shaped. The latter has a tendency to a conical form. In colour, disposition of spines, etc., they are as the one just described.

A splendid species, found in the Channel Islands—perhaps on the English shore as well, although I have not heard of it—is one termed *Sphærechinus brevispinosus*. It is much more robust than those just described; the spines are short, stout, and very closely set. The test is also much stronger than in the foregoing. It is somewhat depressed in form, and is about five or six inches in diameter. In colour it is usually of a deep and regular purple, but I have had specimens that were pure white.

It rejoices, in the books that have references to it, in no

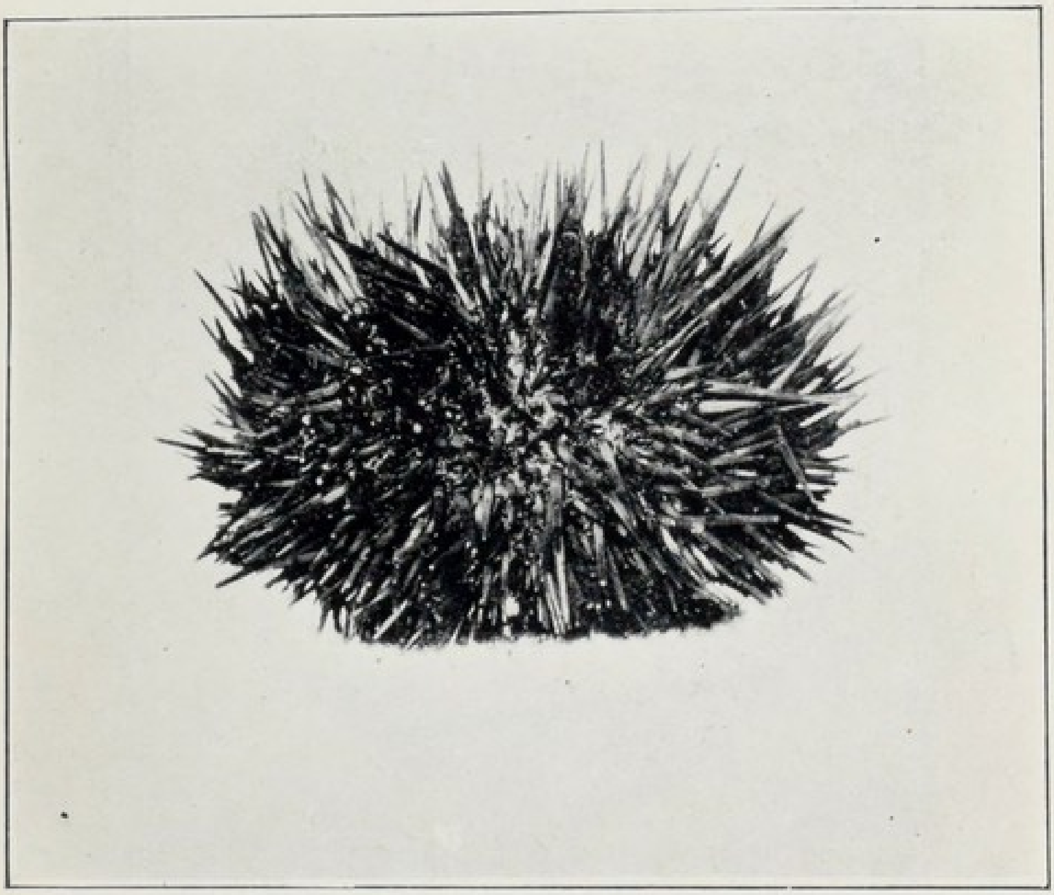


Fig. 30.—*Echinus lividus.* $\frac{3}{4}$ Natural size

less than *sixteen names*, but I have given what seems to be the one first applied to it. It lives in rocky situations at low-tide limit, but is sometimes taken in dredge and trawl when these have worked in stony ground. It is the test of one of these which is shown in Fig. 28.

The Heart-shaped Urchins differ in various respects from the foregoing, chief of which is their outward form.

They are roughly triangular and more or less flattened.

They have no "Aristotle's lantern," but a scoop-like projection of the test on the under side just a little behind their anterior—the wide end.

The spines, instead of being "spine-shaped" and radiating on all sides, are of nearly equal thickness all through,

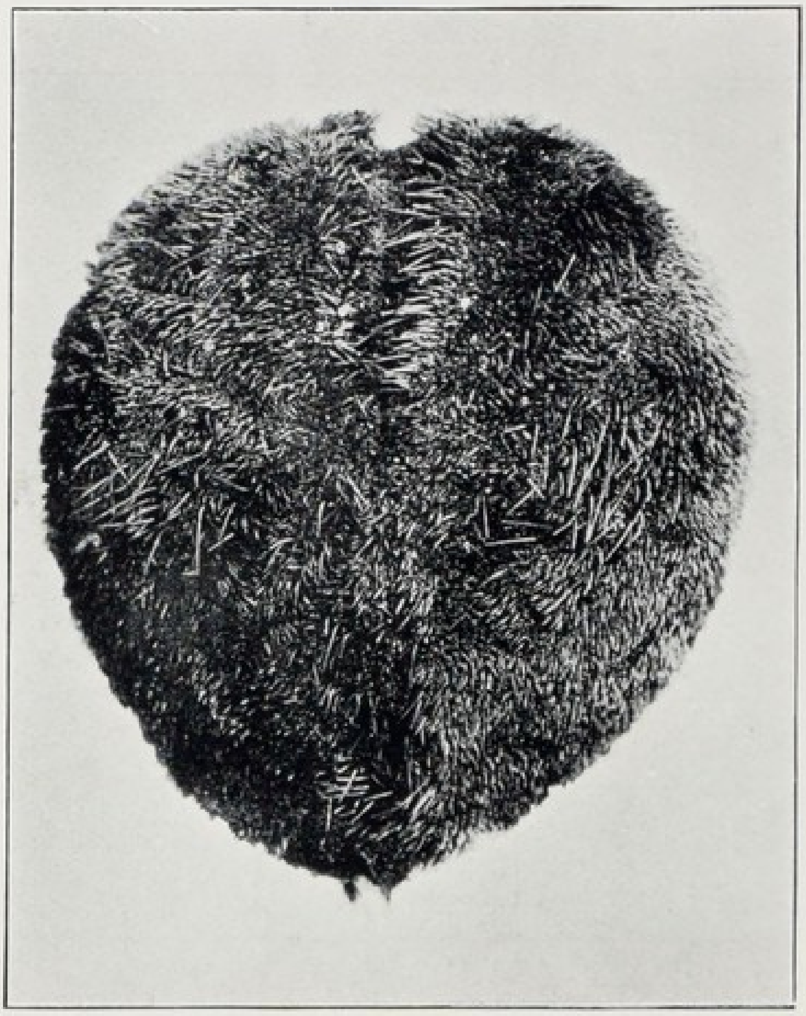


Fig. 31.—*Spatangus purpureus.* ½ Natural size

and they lie pretty well all in one direction—that is, they slope back, like the hair on a terrier dog.

The largest species on our shores is *Spatangus purpureus* (Figs. 31 and 32). It is about six inches in length and four or five in breadth, by about two and a half inches thick in mid body. The colour is purplish brown, and purple (hence "purpureus") seems to pervade the animal throughout: water in which one has been cleaned for preservation looks as if mixed with a purple dye.

This species lives on, or just below, the surface of loose shell gravel, from near low-tide margin to deep water.

On some shores—*e.g.* the shell reaches of Herm Island,

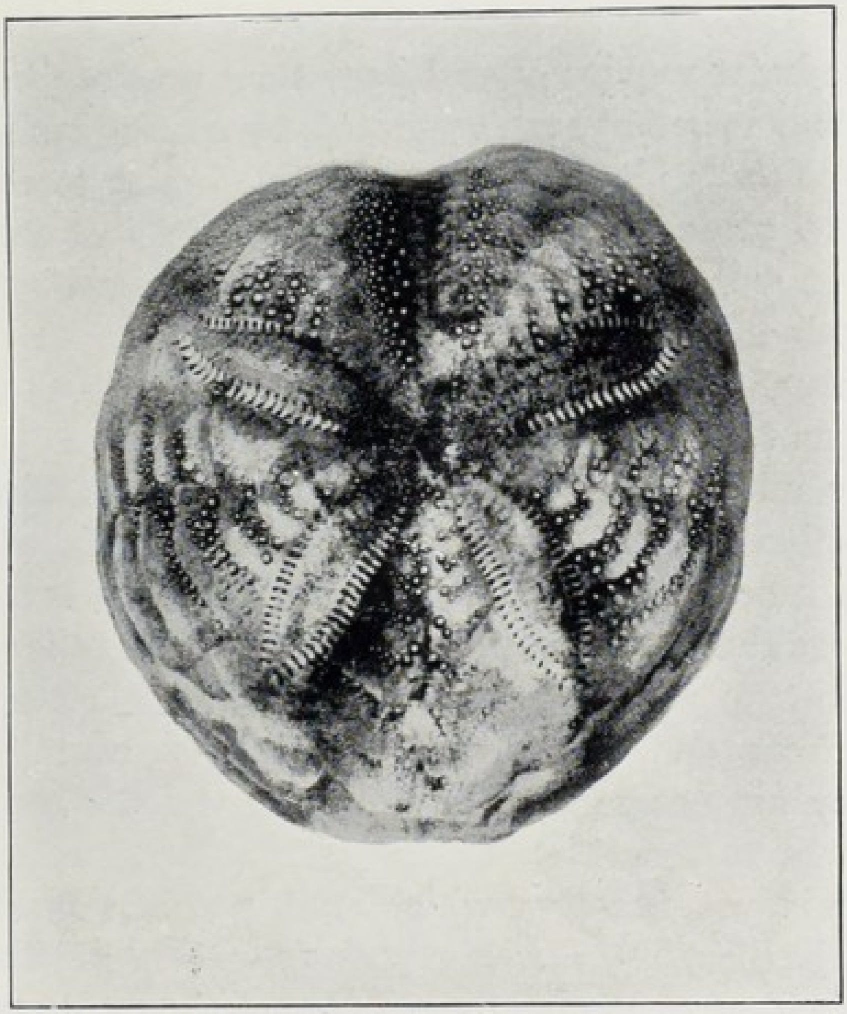


Fig. 32.—Denuded test of *Spatangus purpureus*
½ Natural size

some parts of Grouville Bay, Jersey, etc.—it is very common on that part of the shore laid bare at the period of the equinoctial tides.

Amphidotus cordatus is a smaller species, more abundant than the last, or at least more generally diffused. It is about three inches long by two inches wide, and is rather more elevated in proportion to its size than spatangus. Its colour is usually greyish brown, sometimes buff. Its spines are not so rigid as those of the other heart urchins, but are almost silky.

A rarer species, the "Fiddle Urchin" (*Brissus lyrifer*), is sometimes met with in the littoral, but it belongs to deeper water.

These heart urchins often betray their presence in places where they were not even suspected, by coming out of their hiding below the surface when the tide begins to return.

I have often watched a smooth expanse of flat shell gravel at this period, and seen the surface suddenly rise into little mounds like molehills on all sides. Then from each mound a spatangus or an amphidotus would tumble out, often turning upside down in the process.

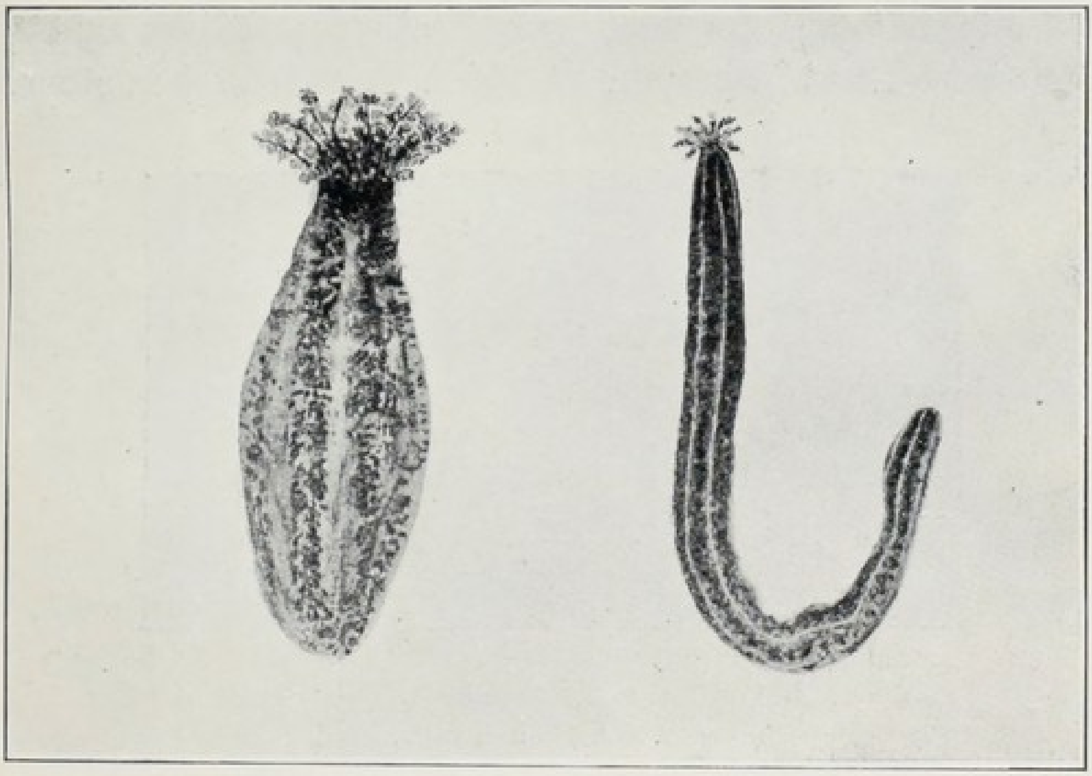
Many other burrowing animals take part in this little resurrection on the turn of the tide—cockles, mactras, various sand crabs—*e.g. Thia polita*, *Portunus marmoreus* (which we shall come to presently), and many other forms. The tide turn gives a good, but very brief, collecting time.

There are one or two other species of heart urchin, but they are too rare to be hoped for by the occasional collector.

There is one, however, which must not be passed over. This is the little "Pea Urchin" (*Echinocyamus pusillus*). It is the smallest of the family, a full-grown one only measuring about half-an-inch in length. Its colour—that is, the colour of its little spines, which look like the pile on furniture velvet—are a deep green. It is found in sandy and muddy localities, usually close to the fields of Zostera. It must abound in some parts of the Channel, for on some shell beaches its little test, denuded and bleached to whiteness, is very abundant.

While the "regular" sea-urchins are predaceous, cutting up and eating any organic substance they light upon, from a growth of small algæ to a dead fish, or even the skin of one of their relatives, the heart urchins scoop up, by means of the projecting lip on the under side of the test, large quantities of sand and mud, for the sake of what organic matter may be mixed with it.

A spangus, opened, will appear to any person not trained to see and trace its anatomy simply a case filled with shell



A B

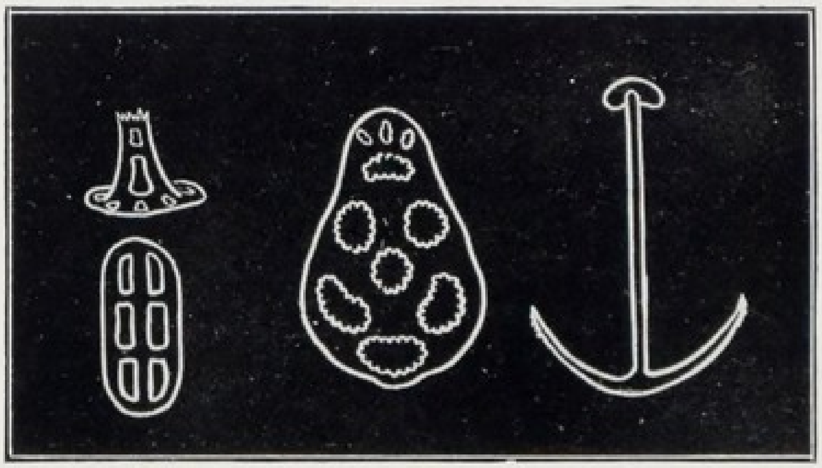
Fig. 33
A. Cucumaria niger. $\frac{2}{3}$ Natural size
B. Synapta tenera. $\frac{2}{3}$ Natural size

gravel, sand, and mud. We now reach the final division of the Echinoderms.

The Holothuroidea. — Of these the common "Sea-cucumber" (I wince each time I have to write these silly and misleading popular names)—however, the "Sea-cucumber" (*Cucumaria vulgaris*) is the type. As its name implies, it is shaped like a small cucumber, with a row of retractile tentacles, which takes the place of rays, around its mouth. The five-part arrangement is still present, being represented in the whole of this division by grooves with rows of suckers along the sides. Like the star-fishes, they are covered with a leathery skin, which is strengthened by calcareous plates embedded in its cuticle (Fig. 34).

The "Trepang," or *Beche de mer*, largely used as an article of food in Eastern countries, is a large species of Holothuria.

The form named, the common one of our coasts, is about five inches long, of a light brown colour, and lives among shell gravel and in ground on which there is broken stone.



A *B*

Fig. 34.—*A*. Plates of *Cucumaria*. *B*. Plates of *Synapta*. All much magnified

The prettiest species, if the term pretty can be applied to them, is *Cucumaria niger*. It is about three inches long, the body creamy white and the cluster of tentacles black. It lives in rock crevices at extreme low-tide limit, and is not common (see Fig. 33).

The *Synaptidæ* belong to the Holothurians. These are structurally the same, but of more elongated and wormlike form.

Synapta digitata, graphically described by Canon Kingsley in "Glaucus," is the type. It is about five inches long, and about as stout as an ordinary cedar pencil. The tentacles, ten in number, expand to a disc not much larger than the diameter of the body. The five grooves are visible as lines along the sides. The skin is thickly covered with calcareous plates of two forms—one in that of elaborately fretted shields, which are the " supporting plates "—and on each of these is a beautifully symmetrical little anchor (Fig. 34).

If a Synapta is taken with the hand it will be noticed that it clings to the fingers, just like the familiar little plant of our country lanes, the " goosegrass," (*Gallium aperina*), and from like cause—myriads of little hooks; only in Synapta the hooks are the points of the " flukes " of the little anchors.

In different species of Synapta the anchors differ a little in detail. Thus in *Synapta digitata* the points are smooth, while in a small species, abundant here (*Synapta Galliennii*), the points are serrated.

These spicules are favourite objects for the microscope, and preparations of them, often arranged in the form of rosettes (which is questionable taste, and not much commended to the student), are sold at the optician's.

An instructive and beautiful preparation of the skin of Synapta, with the anchors each on its support, can be easily made.

The Synaptidæ burrow in sand and in shell gravel, whence they can be dug with fork or trowel. They live near low-tide limit.

I have not mentioned the beautiful Urchin *Cidaris*, in which clubs take the place of spines, for I have never known it found in the littoral zone, to which I am trying to restrict myself, although I have, I fear, ventured once or twice rather beyond it.

CHAPTER V

VERMES—THE WORMS

THIS is a great and mixed-up group. Formerly the term was used to cover very diverse and anatomically remote animals. For instance, the most unscientific person can, after a moment's consideration, see that such organisms as, say, the tape-worm, in which each division is a separate individual, with its own reproductive organs, the smooth and unsegmented *Nematodes*, such as the intestinal *Ascaris*, etc., and the segmented *Annelids* have not many, if any, points in common. For this complex question I must refer the reader to the recent systems of classification. *The Encyclopædia Britannica* will throw the necessary light upon this matter, and for the present I shall attempt no system, but just glance at the most important and remarkable forms, be they strictly " vermes " or not, that occur on our shores.

About the lowest forms that occur, living *free* on the coast are the *Turbellarians*. These are flat, semi-gelatinous, little organisms that may constantly be seen, half crawling, half gliding on the surface of stones that can be overturned, in all damp situations on the coast, and at all tide levels.

Closely allied to them, however, are some striking forms. These are the *Nemertina*. Like the last, they are unsegmented, and have no appendages in the way of feet and tufts of bristles, so characteristic of the marine annelids proper.

There are a great number of Nemerteans on our shores, and while the majority are rather inconspicuous—little red or yellow fleshy worms, abundant on all sides—yet there are some, as I have said, very striking members in this division. To it belongs the great *Nemertes striata*. This is the form described by Canon Kingsley as "the living fishing line." Specimens ranging from six to ten feet long are common in many localities, and I have known of one over twenty feet in length. In Professor McIntosh's "Monograph of the Worms," published by the Ray Society, there is a life-sized illustration of one in its natural colours, which is over thirty feet in length, but the average size is about seven feet. In specimens of the latter size the thickness is about that of an ordinary penholder. In the specimen figured in the monograph above mentioned, the diameter is about five-eighths of an inch. Its colour is olive-brown, with white lines running longitudinally from end to end.

A beautiful Nemertean is the *Valencia splendida* of Quatrefages. This one grows to a length of about three feet. It is of oval section, about three-eighths of an inch wide, and its colour is a brilliant vermilion. It is frequently found in digging among the roots of Zostera, near low-tide limit.

Mekelia annulata is another beautiful member of the class, sometimes called the "Cross-bearing worm."

It is rather smaller than the last, of deep crimson or sometimes claret colour. It has a white or cream-coloured line running all along the centre of the back, crossed by others at close intervals.

It is not common, but may be found in the same situations as the last. It comes to light, however, more frequently, being sometimes seen twining among sea-weeds, like a boa-constrictor in a tree.

It is exceedingly difficult to preserve sound specimens of *Valencia*, as even on capture it constricts itself and breaks into chunks an inch or two in length. It may, however, be done when proper precautions are taken.

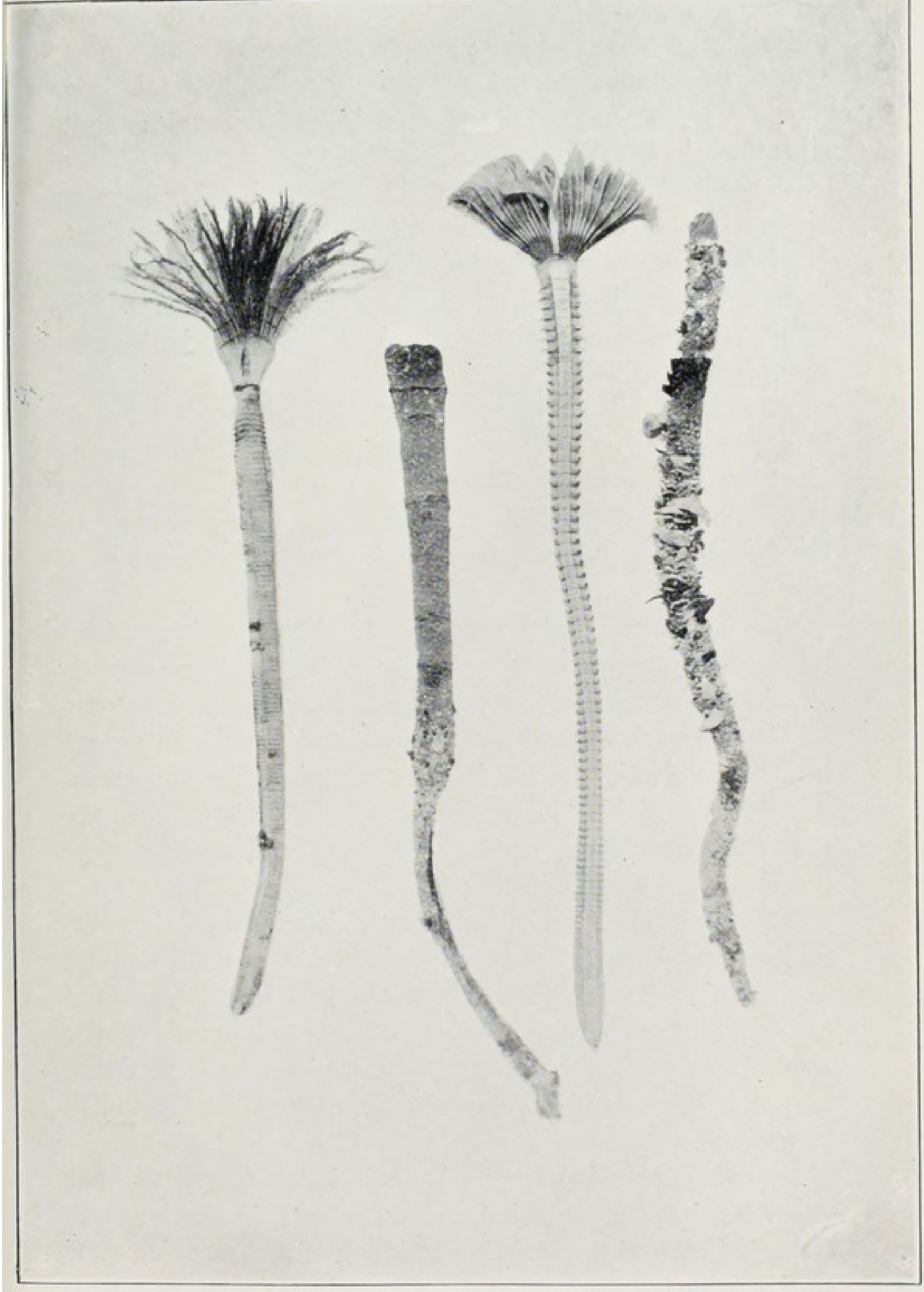
The greater number of marine worms belong to the division *Annelida*, the body being segmented or ringed (*Annulose*). They are by most authorities divided into *Errantia*, those that travel about freely either under or above the ground, and *Sedentaria*, those that build tubes and remain permanently at home (*Tubiculous annelids*), but the distinction is not a very true one, for many of the so-called "Errantia" build tubes; for instance, one with all the characteristics of a roving species, and that can progress rapidly, either crawling or swimming (*Eunice Harassii*), builds a tube and lives in it, until disturbed.

The Great Nemertean (*Borlaisia* or *Nemertes striata*), mentioned above, may live either coiled up, snakelike, under a stone, twine among weeds and stones, or build a tube for a dwelling. I had one a short time back in a tube so hard with cemented-together stone and gravel that a hammer had to be employed to crack the portions that still encircled the worm after it had been put in spirit.

The majority of the annelids have eyes and antennæ, and have appendages along the sides that are of composite structure—one part forming feet, a portion turned up dorsally serving as respiratory organs. These side appendages are set with bunches, often fanlike and resplendent, of bristles. These bristles are of varied form: some in the shape of spears and lances, some barbed like arrows, some straight, and some curved.

The worms bearing these are termed *Chætopoda* (bristle-footed). Some are minute, almost microscopic. Others may be a couple of feet in length, and of proportionate stoutness.

Some (in the *Sedentaria*) have bunches of plumes at the



A B

Fig. 35.—*A*. *Sabella pavonina*, and its tube. *B*. *Sabella arenilega*, and its tube

anterior end which are often of brilliant colours, and open, flowerlike, above the top of the tube dwelling (see Fig. 35). These are beautiful and conspicuous objects in certain situations in low-tide pools.

Many lead an active and roving life, swimming even at the surface of the sea, while others never come to light. Many are clothed with beautiful scales, which are arranged in double row, tile-fashion, along the back (*Polynœ*, *Nykia*, *Sigalion*), and many gleam at night with a bright green phosphorescent light.

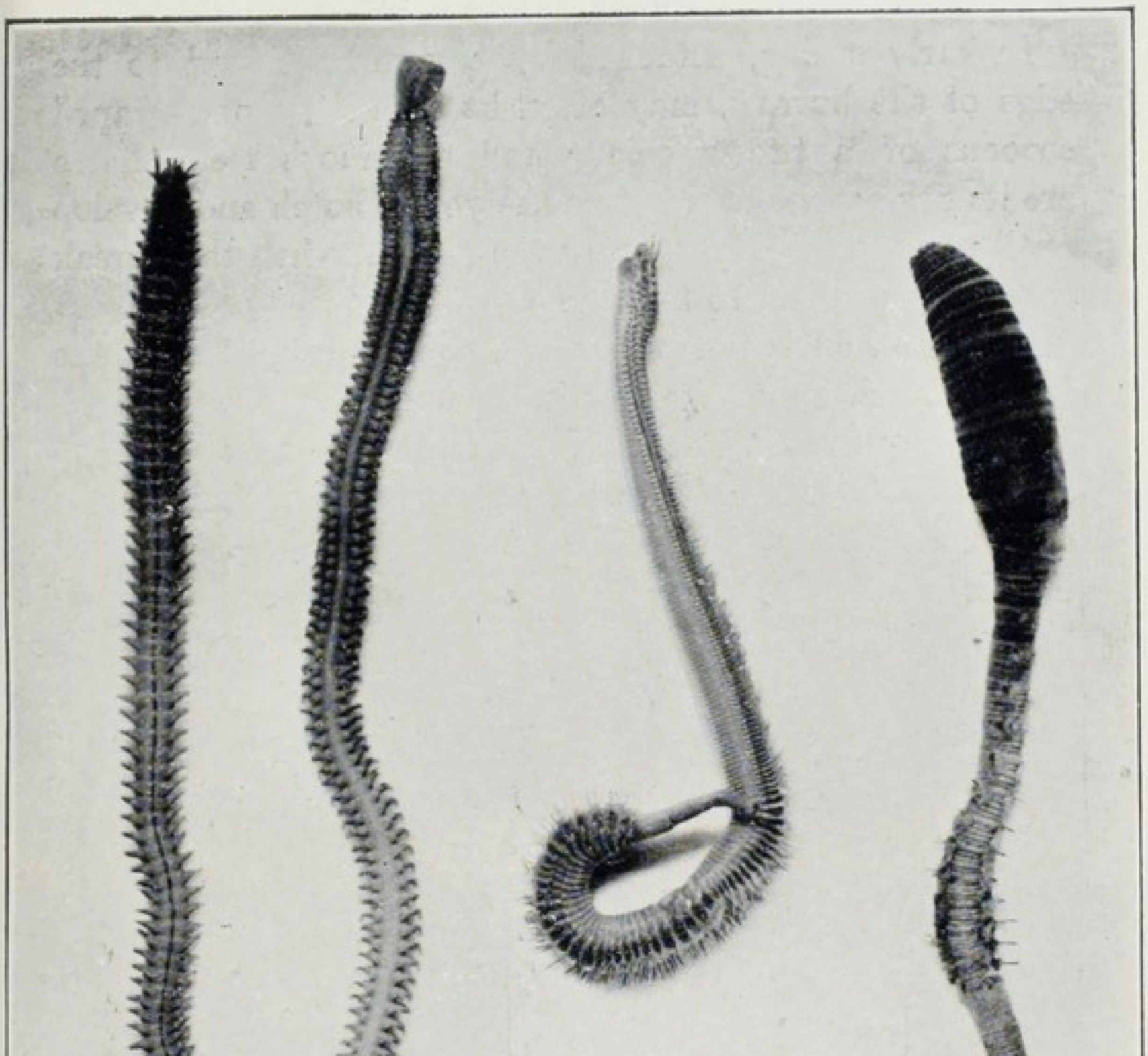
It will be only here and there that we shall take an example, for even a list of their names and a brief description would form a fair volume.

We shall first consider the common "Lug-worm" of the fisherman (*Arenicola marina* or *Arenicola piscatorum*—Fig. 36).

This is very common on all sandy shores, as is manifest by the little towers of "Casts," so called, that are seen on all sides. Arenicola is not a predaceous worm, but only fills its stomach with the soil in which it dwells to absorb whatever organic matter it may contain—like the earthworm of our fields and gardens, and the "Casts" are the sand which has been moulded into form and expelled after transit of the worm's intestine.

The worm itself is buried about nine inches below the surface, and is rarely seen unless it is dug out. There are two openings to its burrow, one marked by the cast and near it a funnel-shaped hole. The anterior end of the worm is towards the latter, its posterior end toward the former. The worm is about six inches long, of a greenish brown colour.

The anterior third of the body is inflated, and without appendages. The remainder of the body is slender, and the middle portion alone is furnished with branchial tufts and bristle-clad feet.



A B C D E

Fig. 36

A. Nereis diversicolor. B. Nephtys margaretacea. C. Marphysa sanguinea. D. Nykia cirrosa. E. Arenicola piscatorum. All $\frac{3}{4}$ natural size

In early spring, attached by a gummy thread to the edge of the burrow, may often be seen little pear-shaped cocoons of a brown colour and gelatinous feel. These are its egg cases, and in these the young hatch and develop until nearly the same form as the parent, when they break away and proceed to burrow.

This method is not common among marine worms, the young much more frequently commencing life as free-swimming, barrel-shaped ciliated embryos—called *Trochospheres*. For example, in the same localities, and also in early spring, may often be seen transparent, green-coloured balls of very tender jelly, each about the size of a gooseberry. These are the egg cases of another worm, usually those of one named *Phyllodoce viridis*, a small and slender one, with a row of leaflike organs on each side, folding over the back.

If one of these cocoons can be found which is beginning to be disintegrated, part of it showing white and ragged, it will repay the interested observer to place it in a bottle of clear sea-water and examine with a pocket lens. It will then be seen that the " blob " itself is colourless, and that the green colour is due to the myriads of little trochospheres which are now breaking away and swimming actively. A bright scarlet spot is apparent on each one of these lively little organisms. These are the eyes.

A splendid worm, which usually heads the list in the annelida, is the so-called " Sea-mouse " (*Aphrodita aculeata*). It is about four inches long by one and a half inches broad, and about an inch in thickness. It is obtusely pointed at each end, less obtusely posteriorly. Its setæ or bristles are of two kinds, one long and silky, the other short, stout, and sharp, of a black or dark brown colour. The fine ones are of resplendent tints, gleaming with all the hues of the peacock's feather. The back is clothed with overlapping scales, which are again covered with a grey coating of fine

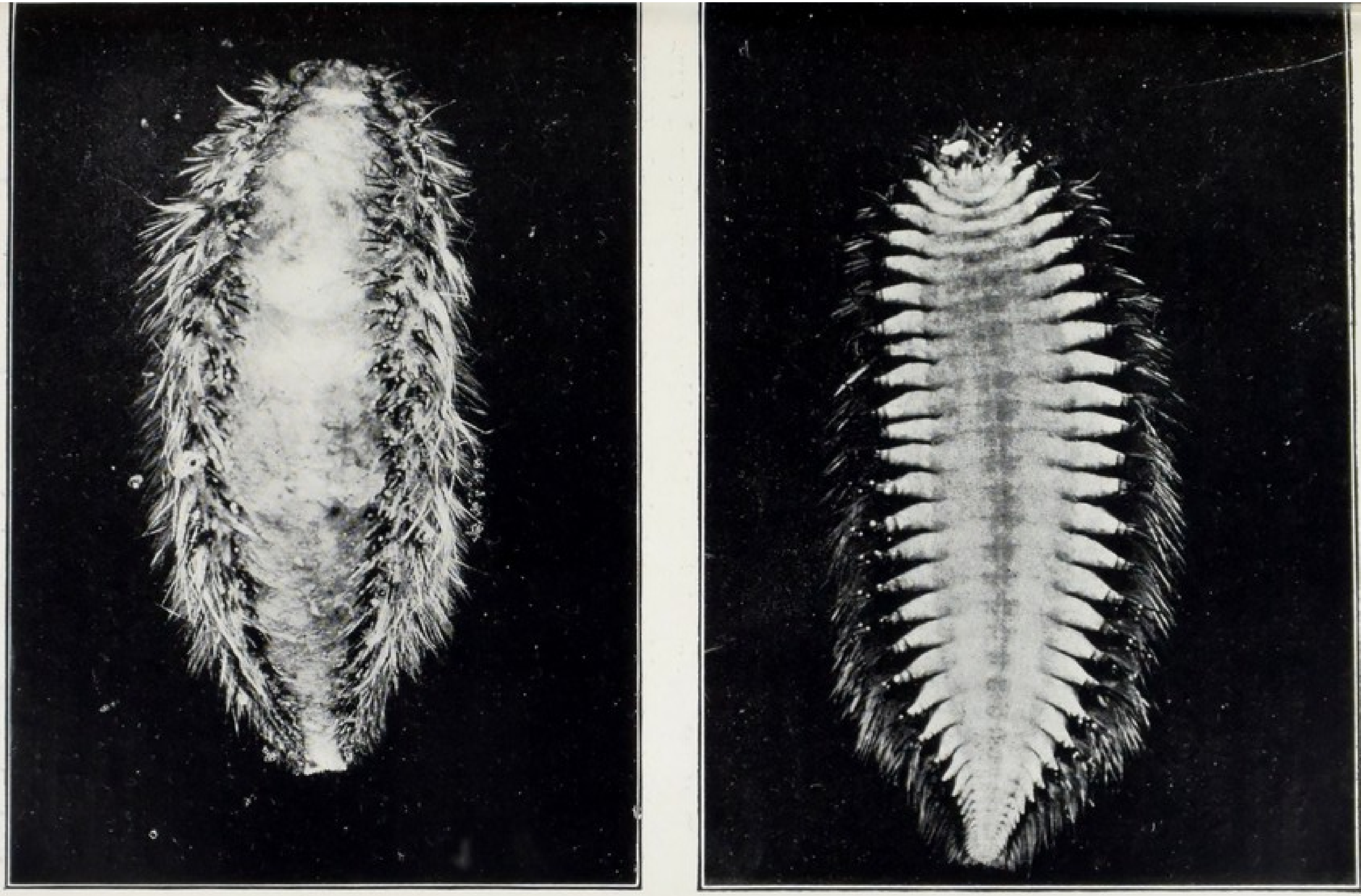


Fig. 37.—*Aphrodita aculeata.* Dorsal and ventral sides. $\frac{3}{4}$ Natural size

bristle matted into a kind of felt. It is shown in two aspects in Fig. 37.

Closely allied to it is another "Sea-mouse" (*Hermione hystrix*). It is of about half the size of the last, and is without the resplendent tints. Its colour is brown, and it is closely set with fascicles of desperate barbed setæ or bristles; each of these is about half-an-inch long, exceedingly sharp, and slightly flattened. Their edges are barbed with many sharp points, slanting backwards, for about half their length. These make formidable weapons, for they are as brittle as glass, and when they enter the skin of whatever animal touches them they break off and leave the barbed portion inserted. Each of these barbed setæ is sheathed between two very limp flat ones, which conceal it, but crumple easily out of the way when the rigid one enters the flesh of its recipient.

Both these species are tolerably common around our coasts, on muddy or partly Zostera-covered ground. They may often be found by seeking in such localities at low-tide limit, but are much more readily obtained by the dredge or trawl.

Closely allied to these are many other worms, all characterised by the two rows of scales on the back. A very common one is *Polynoe propinqua*. It is about an inch and a half long by a quarter of an inch broad, of a red colour, obtuse in front, pointed posteriorly.

It may frequently be seen, on turning over stones, adhering to the stone's under side, and travelling with a wriggling action and great rapidity. One very pretty species is *Nykia cirrosa*. It is larger, and much wider in proportion, than the last, of a cream-colour, or nearly white, and resplendent with pearly tint. This species is figured in Plate 36.

Sigalion boa is, like the Polynoes, etc., scaled down the back, but of more typical worm form, being about five inches long, by a quarter of an inch or a little more in breadth, the scales disposed in double row, as in the shorter species.

There are many allied species, all procurable within the limits of tide range, stony ground at extreme low tide and the edges of Zostera fields being the best hunting grounds for them. One remarkable species may be found by digging in open stretches of shell gravel (*Sigalion arenosa.*) It is of large size, six inches long by about five-eighths of an inch broad. In this one the scales are obscured by their being set with a fine felt arrangement, which holds grains of sand closely and firmly, so that the back is like a piece of coarse glass-paper.

The *Nereids* are another large family. The most familiar example is *Nereis diversicolor*. This worm grows to a length of about nine inches. It takes its name from its varied tints, as it gleams with reflections of red, green, purple, blue, and gold.

The use of these bright colours to an animal that usually keeps hidden has been a puzzle to naturalists, for it is a fairly well-established fact in Nature that strongly marked characters in colour or ornament must be of use to their possessor—for instance, in flowers to attract insects for the transmission of pollen; in sea anemones (probably) to lure little fishes to the larder; in birds, etc., to act, smart necktielike, in entrancing the members of the opposite sex.

In many forms conspicuous colours notify to the enemies of the possessor that the latter is not good to eat, or that it is not safe to try to eat it. To take one example out of hundreds: the common little vermilion and black—or rather *cinnabar* and black—moth, that flits lazily along our footpaths in the day and makes no effort to escape when approached—the "Cinnabar moth"—this flits with impunity where birds abound and is not molested.

If a young and inexperienced bird once tastes one, it perceives a very great nastiness within, and for the future remembers the strongly marked colour, and avoids it, and by that form of hereditary memory that we term "instinct" it becomes natural to avoid these colours.

It has been suggested that Nereis owes its colour to the same end—sign of not being edible. But this is wrong. All fishes consider Nereis particularly good, and fishermen prize Nereis as the best bait for inshore line fishing. They call it "Red Cat-worm," or sometimes "Rag-worm," but the latter term they apply indiscriminately to many other forms—*e.g. Nereine Cirratulus*, etc. etc.

Now let us consider this coloration for a minute. It will be seen, on looking at a specimen, that it is not due to pigments, but that the iridescence is the division of the rays of light through some prismatic arrangement of the worm's cuticle, mother-of-pearllike, and the red flesh of the worm seen through this light-dividing cuticle accounts for the "diversicoloration."

Nereis is a predaceous worm, and is armed with a pair of sharp, hooked jaws, which are set at the sides of a protrusible proboscis, an evertible part of the œsophagus, and any little animal seized by these hooked jaws is drawn within, and landed into the stomach, without the ordinary swallowing process, which entails friction.

Nereis is also rather pugnacious, and never fails to employ these hooked jaws on the fingers of those who intend it no further harm than to thread it with a fish hook.

Nereis lives among loose stones, where these are more or less embedded in clean gravelly ground, at all ranges of the tide.

At certain seasons some members of the Nereis community change their form to some extent. They become shorter and broader, and develop long, silky, swimming bristles along the central part of their bodies. This form is termed the *Heteronereis* stage. In this form the Nereids forsake their burrows, and swim freely in open sea. It is the period of reproduction, but it must also add very considerably to the death rate, for fishes are not averse even to *Heteronereis*.

Nereis is also viviparous. I have not seen the fact recorded, but quite recently, on dissecting specimens, I have found fully developed young, an inch in length, within the parent's body cavity. In this case the Nereis was in its usual, not *Hetero*, form.

Allied to Nereis are many other worms, some of very great beauty. They are *Syllis*, *Psammanthe*, *Ioida*, etc. Most of these are small, and live, mostly free swimming, in open sea. Many are phosphorescent, and contribute in a good measure to sea phosphorescence. Some have, besides the usual sexual system, a reproduction by breakage. In one species this has been carefully studied (*Autolytus prolifer*). In this form, one of the central segments of the body develops eyes, mouth, and antennæ, then this portion (the latter half) breaks off, and is a new individual, while the anterior part proceeds to repair itself, to break off again.

Nephtys margaretacea is cousin to Nereis. It is a large and beautiful worm. As its specific name implies, it is pearly white. It grows to a length of nearly a foot, and lives in rather firm sand, from half-tide to low-tide level. Under the name of " White Cat-worm " it is employed as a bait by fishermen, but it is not so valuable for bait as Nereis. Fishes in aquarium being fed with a mixed diet would eagerly snap up Nereis and others, leaving Nephtys to the last, and often neglecting it altogether. Nephtys has, like Nereis and many others, a protrusible proboscis, but it is not armed in the same strong manner, only a ring of small conical teeth surrounding the mouth.

The largest worm in the class is *Marphysa sanguinea*, the great rock-worm of the fisherman.

This species grows to a length of nearly two feet, and is as stout as a lady's finger. Like Nereis, it gleams with beautiful tints of green, red, and gold. The branchial appendages on each side fold over the back, and are blood-red, hence *sanguinea*. It lives in rock crevices or "cleavage faults," where there is room between these for a deposit of sand and mud. Fishermen obtain it by prising off loose fragments of rock with a crowbar or a pick, but it is also found among loose, sunken stones.

It is a valuable bait. To obtain a specimen entire is a matter of some little difficulty, as it breaks readily, and nine out of ten that are taken bear traces of repair, in the way of new segments at the tail end. The one shown in Plate 36 is really little more than the anterior third of one, and it is in process of adding fresh segments. This is plainly shown in the photo.

Of considerable length—a foot or more—and of nearly uniform thickness all along, nearly round, and of about the diameter of a goose quill, is *Lumbrinereis tricolor*. This species also glows with rainbow colours. It is found in shell gravel, generally among rocks, but sometimes in the open shore near low-tide limit.

Glycera dubia is another large worm, living in the same localities. It is about as stout as a penholder, but tapering gradually to a fine point. It has not the gorgeous tints of its congeners, but is a pale, even brown.

This is a very short list of the Errantia, but it gives the chief types. A gravelly shore, among scattered rocks and Zostera beds, is a prolific hunting ground, and in such localities more species can be obtained in an hour than could be described with the pen in a week.

Now we will pass to those that habitually construct tubes and live in them—the "Tubiculous" worms or *Sedentaria*.

First of these, not by reason of any zoological character, but by reason of its abundance and its beauty, is *Sabella pavonina.* It is about four inches long, and has a cluster of plumes at its anterior end. It builds a tube which, in size and consistency, can be very well likened to a piece of rubber tubing, such as is used for infants' feeding-bottles, grey in colour. This tube is about a foot long, and is usually buried in the sand for rather more than half its length, the free part standing out erect. The base of the tube is always attached to a stone or a bit of shell. The worm is rather flattened in form, and the anterior feet are furnished with hooks, by which the worm travels up and down its tube.

At the head it has a series of narrow plumes. These are so arranged that when the worm protrudes them from the top of its tube they open out into a funnel-shaped flower, about two and a half or three inches across. The plumes are usually about seventy in number. They form rather more than a complete circle, so the end of the row coils inward, in the form a botanist would term "Convolute."

In some specimens these plumes are deep red, in others chocolate, but in the majority they are crossbanded red and pearly white.

They are found low down in tide level, a good spring tide being necessary for their observation, and they live chiefly among the Zostera, or on the edges of the sand, mud, and gravel banks that occur in such neighbourhoods.

In some such situations the visitor may see little forests of these tubes sticking up, best seen by stooping down for a horizontal view. Some of these tubes may be vacant, through the death of the tenant, but the majority will be occupied. The occupied ones can always be identified by their having a drop of water in them, rising in convex form above the end. The empty ones are dry. No worms, of course, will have their plumes expanded where there is no water, but if a pool is at hand there will probably be some in expansion therein.

It is necessary to approach such pools stealthily, for even a slight tremor of the ground will spoil matters. The worm, always suspicious of danger, withdraws very smartly on the least alarm. However, by keeping still and watching, there may be seen first a gradual extrusion of a narrow column, twisted like a bit of stout twine, then a moment's pause and suddenly, like a flower bursting into bloom by magic, the beautiful funnel will appear. This funnel of plumes is never still, but moves gently to and fro, with a semi-rotary movement.

To secure some of these worms for aquarium or for preservation it is necessary to dig the tube out in its entirety, for with danger at hand the worm retires to the remotest end.

In the same localities, and yet more abundant, is *Sabella arenosa* (it has other names, but this is a good old one). This one lives in tubes which are strengthened by the cementing to their outer surfaces of bits of stone and shell. These tubes do not, as a rule, project more than an inch or so above the surface, but they are none the less conspicuous, for they are well outlined. This worm is not so gorgeous as its relative, the plumes being shorter, and arranged in a closer tuft. They are, as a rule, of a pale slate-grey colour, but they are none the less very beautiful, the little ostrich-featherlike arrangement of the pinnæ being regular and perfect.

This species is rather a favourite with some aquarium keepers, as it builds new tubes constantly, the top needing, no doubt through the damage caused by currents in the sea, continual repair, and artistically disposed aquarium keepers furnish it with beads in lieu of gravel, changing the colours from time to time, so that eventually the tube is a work of art, like a beaded slipper.

Around the base of the plumes is a little velvetlike collar, which is the trowel by which the building is effected.

Plate 35 shows one of each of these worms and their tubes. In the right-hand tube there is a worm on the point of expanding, the little twist of plumes projecting from the top.

An allied form (*Sabellaria*) abounds in sheltered situations, forming gravelly tubes, close set together, and cementing the adjacent sand and mud into a concrete.

Not far removed from these are the *Serpulids*. The tubes of these are familiar to everyone who has handled a few shells of oyster or scallop. To these, as well as to nearly any other solid object in the sea, these tubes can be seen attached. Unlike those of the sabellids, which are built of a parchmentlike secretion, or of bits of stone, etc., cemented together, the tubes of the serpulids are solid carbonate of lime, like the shells of molluscs.

Serpula contortuplicata is a familiar example. The tubes, attached by their sides, and often crossing each other or twisted together, may, as I have just said, be seen on nearly all the oyster and scallop shells that come to hand; but not so well known is the little tube builder.

This worm is much on the plan of a sabella, save that a part only of the plumes form the funnel or disc; the others are modified to form a plug, which closes the mouth of the tube when the worm retires within. The worms in this species (which is known to naturalists under a variety of synonyms) are of a pale buff colour, and the plumes and *Operculum*, as the plug is termed, are a bright red.

There are a great many serpulids, one little one, the name of which is *Spirorbis spirillum*, abounds on every coast. In some places the fronds of the fucus, and those of the frilled oar-weed (*Laminaria saccharina*), are studded with them. In this little species the tube is always curled in the form of a small, flattened snail shell. Some of them can be seen adhering to the rock in the photos.

If some of these little ones are placed in a bottle of sea-water, and viewed with a pocket lens, the arrangement of plumes and the operculum, as described, will be readily seen, as the little worm is active, and quickly protrudes when under water.

Another family of the tubiculous worms are the

Terebellidæ.—On many parts of the shore where there is a mixture of sand and gravel, near low-water level, may frequently be seen large patches of what looks like a forest of miniature trees, their trunks and branches coated with sand and gravel. These are the tubes of *Terebella conchilega*, the commonest species.

The tubes are made up, like those of *Sabella arenosa*, of cemented-together fragments of the constituents of the surrounding ground, but they have branched ramifications at the top.

The inmate is a limp and fragile worm, something on the plan of the foregoing, but instead of circlets of plumes it has two bright red tufts, the *branchiæ* or breathing organs, and a large series of threadlike tentacles. In some species these thread tentacles can form a network for more than a foot around the animal. The little branches at the top of the tubes serve to spread these out upon, where they look like the stems of the Lesser Dodder spreading over a furze bush.

I have not seen a description of these threads, but have often examined them, and I make them out to be tubes open all along one side, and the interior to be lined with *cilia*, so that any little organism touching them can be taken in at any point, and then carried by the movement of the cilia to the worm's mouth. One of these worms and its branched tube are shown in Fig. 38.

A large and beautiful Terrebellid is *Amphitrite Edwardsii.*

Although by no means common on our shores, it may occasionally be found on digging among oozy sand and gravel at the edge of Zostera banks, also among loose

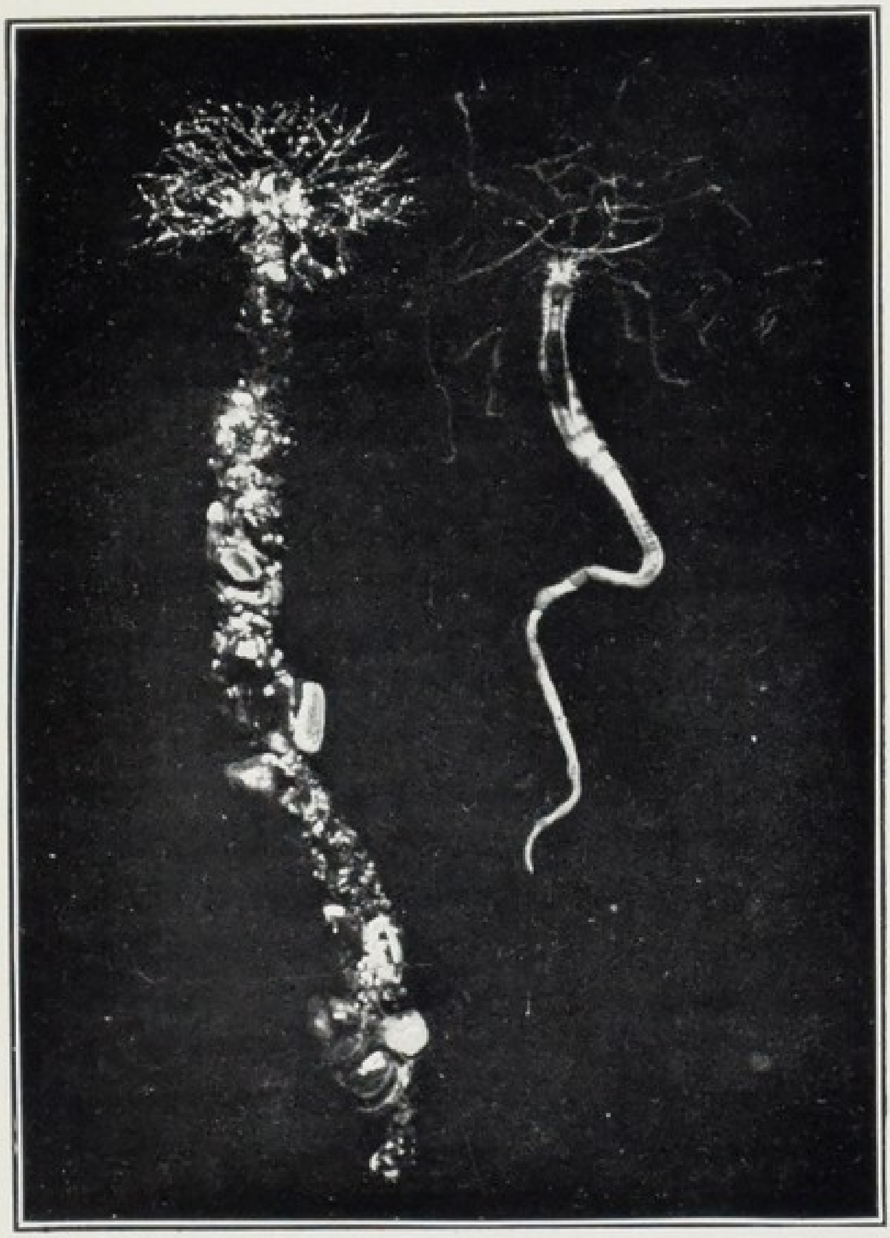


Fig. 38
Terebella conchilega, and its tube. $\frac{2}{3}$ Natural size

stones in rock crevices where there is silt intermixed.

It constructs a tube of very frail consistency, fragments of shell and fine gravel loosely held by a thin mucilage.

The tentacular threads of this worm can be extended to form a circle of two feet or more in diameter.

In colour it is rose-pink, finely dusted with white, as if it had been lightly sprinkled with flour.

It is shown in Fig. 39.

Closely resembling it, and more common, is the large, limp *Terebella nebulosa.*

Among these tubiculous worms there are a great number of small species that are very beautiful—*Dasychone*, about an inch long, forming a parchmentlike tube, the flexible end of which it rolls up when it retreats within, is found in rock fissures and under boulders among sponges and Ascidians. Its plumes are crossbanded chocolate and white.

Othonia Fabricii is a diminutive species, not more than a quarter of an inch long, often abundant among zoophytes and Polyzoa, on the under side of boulders and in rock pools. These two are allied to *Sabella.*

Allied to *Serpula* is a pretty little worm which is very abundant under boulders low down in tide range. This is *Filograna.* Its little limy tubes, not stouter than strong crochet cotton, cross and intertwine among each other so as to form conspicuous white patches in such situations.

In parting company with the worms I shall just mention a very remarkable one. It is a tube builder, and *lives* in its tube, but it has none of the characters of the foregoing. Its name is *Chætopterus variopedatus*—a descriptive name, sure enough—"Bristle-winged and varied-footed." It is one of the most remarkable forms among the worms.

A full-grown specimen is about eight inches long. Its colour is milk-white, except the region of the stomach, which is as a rule dark green (due to the small algæ, etc., on which it feeds).

The mouth is funnel-shaped. The first nine pairs of appendages are stout and conical, their anterior edge set with a number of short, sharp bristles. Dorsal to the last pair of these is a longer pair, modified as feelers, which also are bristled at the ends. Then the three (sometimes only

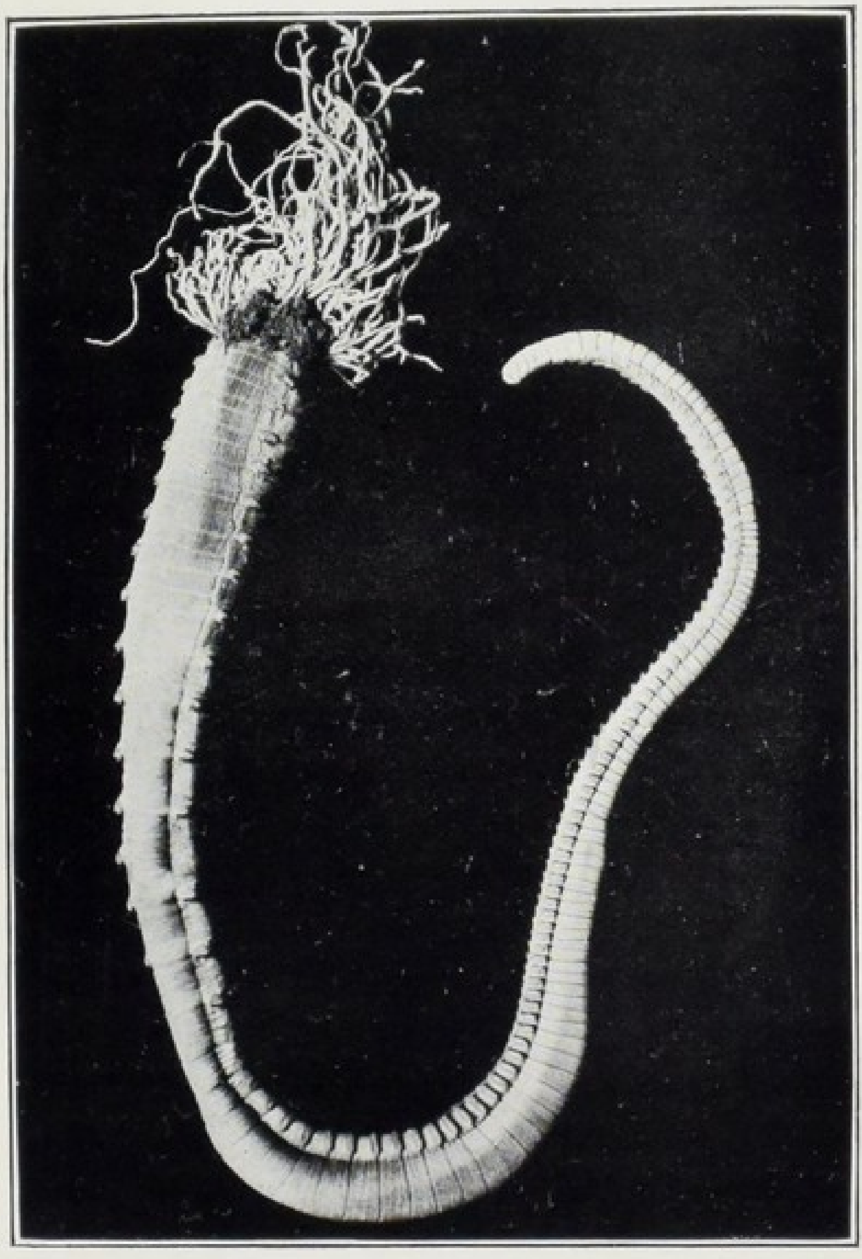


Fig. 39.—*Amphitrite Edwardsii.* $\frac{2}{3}$ Natural size

two) next segments are helmet-shaped, or, better, sun-bonnet-shaped, the flat surface placed anteriorly, the rounded portion posteriorly. These are followed by a number, varying from twenty to forty pairs, of conical feet, each bristled at the ends. Fig. 40 gives a general idea of its appearance, but as the species does not lend itself readily to "posing" the details are not very well seen.

This worm lives in portions of the shore where the ground is a mixture of sand and oozy mud, near the lowest tide zone. It constructs a tube of parchment-like texture, of ample proportions, generally about two feet long, and this tube is buried in the ground in the shape of the letter U, both ends projecting an inch or two above the surface. Often one end of the tube is bifurcate, or even in three branches, as if the original opening had perhaps become blocked, and auxiliary openings, with bits of new tube, added.

Although the worm is not often seen, fragments of these large tubes (they are about three quarters of an inch in diameter) are frequently cast on shore.

This worm has almost invariably a lodger in its tube, one of the beautiful scale-clad worms (*Nykia cirrosa*). The specimen shown in Fig. 36 was taken in the tube of a Chætopterus.

Chætopterus is phosphorescent, and at night a halo of light surrounds its lowly dwelling.

As a subdivision of the worms, although not having many affinities with them, are the so-called "Spoon-worms" (*Sipunculus*, etc.). They belong to a class termed the *Gephyreans*. These are smooth, cylindrical bodied animals, with apparently no sign of life about them.

Some forms are abundant on every shore, even at the highest tide level, where there is a mixture of loose stone and gravel. The most familiar species is *Phascolosoma lævis*. It is about as thick as a porcupine quill, and about four inches long, tapered towards the anterior end, at the centre of which, surrounded by short ciliated tentacles, is the mouth. The body is perfectly smooth, and usually of a straw colour.

A larger species, of stouter build, being about the thickness of an ordinary penholder, is *Phalcolosoma elongata*. Allied to them is a larger, striated, and tubiculated form,

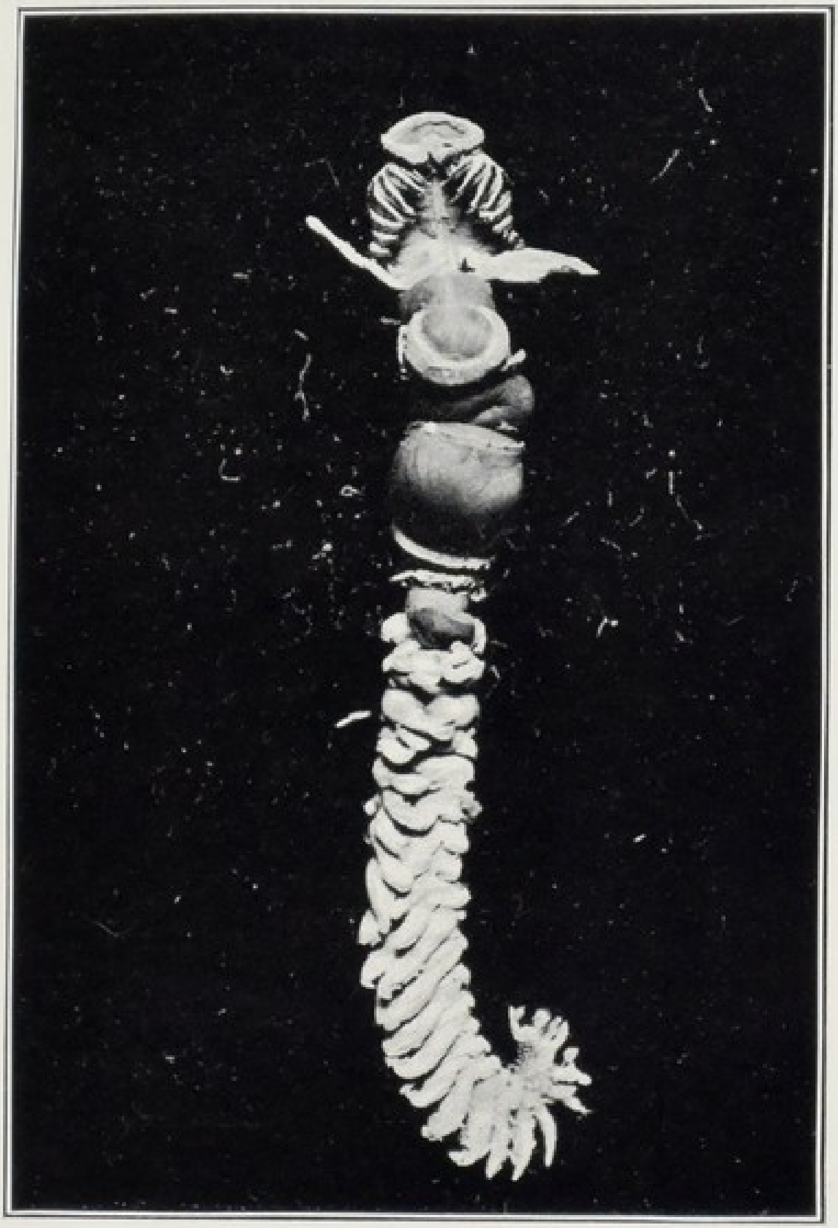


Fig. 40
Chætopterus variopedatus. $\frac{2}{3}$ Natural size

Sipunculus nudus, but this is much less common, and occurs only at the lowest littoral zone. They have been by most authorities placed with the worms on account of some similarity in their development and the presence in some of their genera of a trace of segmentation.

A curious feature in their anatomy is, that the alimentary canal, which is several times the length of the body, is folded to and fro in its length, and then turned into spiral form, like a loosely twisted skein of twine.

CHAPTER VI

THE POLYZOA, OR BRYOZOA

THIS group has been sent from pillar to post by different authorities, some of the older zoologists placing them with the zoophytes. Others have classed them, together with, as we shall presently see, totally different groups of animals —viz. the *Tunicata* and *Brachiopoda*,—forming a large group, which they termed *Molluscoidea*, which is undoubtedly a mistake, for later researches have shown characters in the included forms which prove them to be very diverse indeed.

In fact, the *Tunicata* or Ascidians are now advanced to the same *Phylum* as the vertebrates; and this not from fancy, but from prolonged and careful study of their embryology and their affinities.

The *Polyzoa* seem to be very nearly related to the worms.

They are thus defined: Animals of small size, usually united in colonies, living within a structure which, like the zoophytes, they build up, and which is termed a *Polypary*. This structure is of horny or limy substance, and often of exquisitely beautiful design.

The animals have a retractile crown of ciliated tentacles. They have an alimentary canal, and a simple nerve system. There is an immense number of species, and they abound on all our shores.

Flustra foliacea, or common "Sea-mat," which looks like a bunch of rather crisp fucus, is a very familiar example, seen washed up on every shore where the waves have brought things from their home in deeper water.

On looking closely at the surface of one of these "Sea-mats" it will be noticed that it is a network of little cells

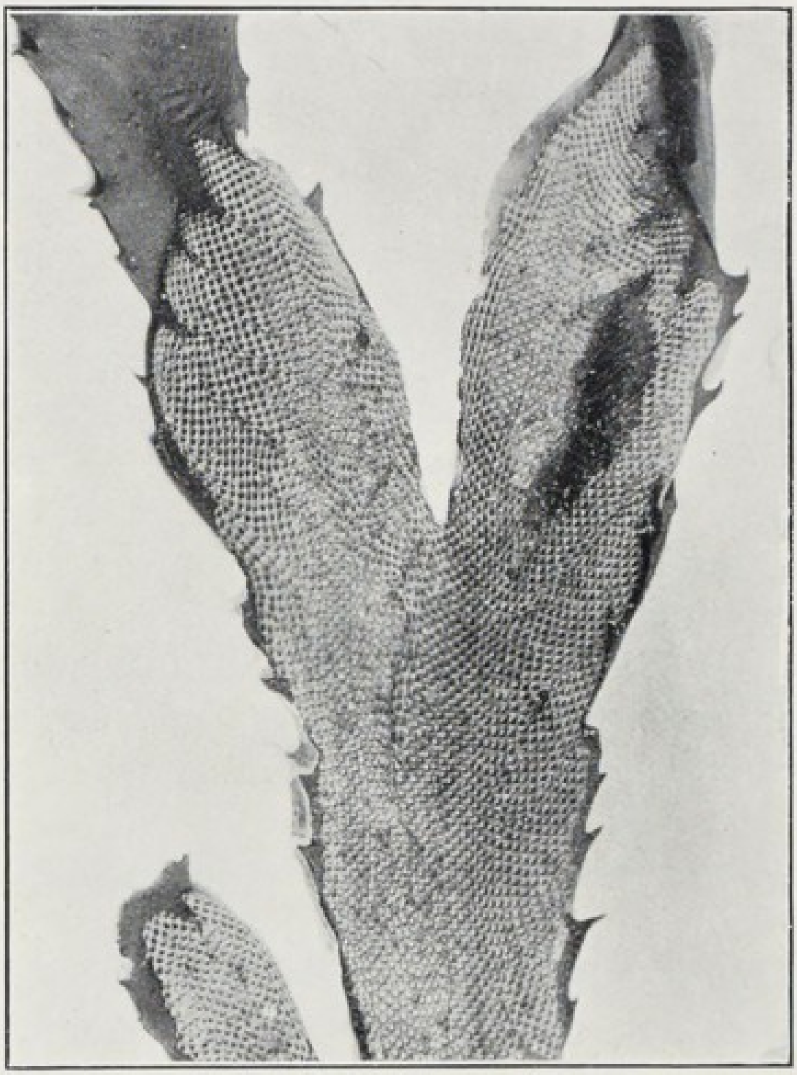


Fig. 41.—*Membranipora membranacea.* Coating fucus. Very slightly enlarged

(not cells in the biological sense, which we have roughly studied, but in the sense of little dwelling places).

Each of these little cells is the home of one individual.

On the surface of rocks, where these are submerged, on the under side of stones in pools, coating the stems of sea-weeds, and on pretty well every fragment of shell which has not been subject to attrition, will be seen representatives of the group.

Fig. 41 shows a frond of fucus which is encrusted with a growth of one of these forms, a very common one (*Membranipora membranacea*), and Fig. 42 shows a small portion of the same enlarged.

There are thin membraneous ones, like the above, and there are also massive stony forms, in which the polypidom is strongly calcified.

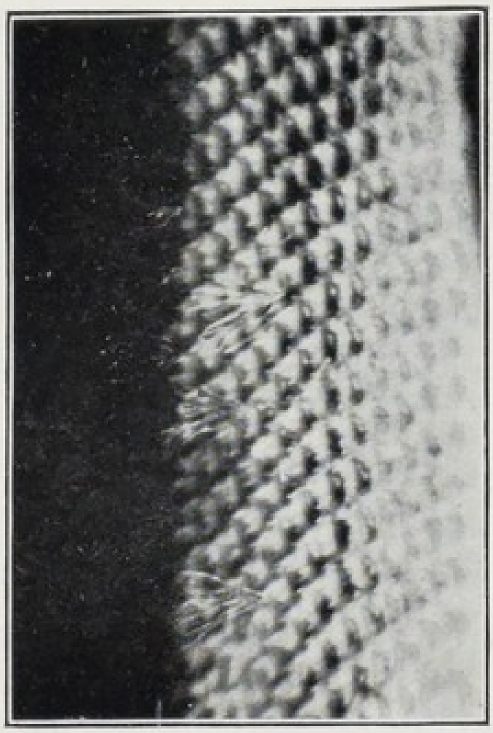


Fig. 42.—A small portion of *Membranipora membranacea*, as seen with pocket lens

Nearly every stone among sea-weed and in rocky places will, on being turned over, reveal pink-coloured patches that, on a close examination, show the cellular structure as described. These are named *Lichenopora*, from their resemblance to growths of some of our familiar lichens.

Very abundant are little circular patches about a quarter of an inch in diameter, and in which the cells are tubular, radiating from the centre. This is *Lichenopora hispida*.

Some form very large masses, with rigid leaflike ramifications, forming as it were a huge honeycombed structure, the millions of little builders occupying the sides of its walls. This form may frequently be seen attached to large shells, or may form masses, eighteen inches or more in area and a foot high, attached to some point on gravelly bottom. This is *Lepralia foliacea* (Fig. 43).

From the under side of boulders near low water-level hang tufts of the branched forms in abundance, *Crisia*, *Scrupocellaria*, etc.

Fringing nearly every bit of red sea-weed (the *Rhodosperms*) that is washed up on the shore are the beautiful little "Snake's-head Polypi" (*Ætea*), and curls of pearly white *Crisia eburnea*, the beauty of which can be seen with a pocket lens of even moderate power.

Over two hundred and fifty species are figured and de-

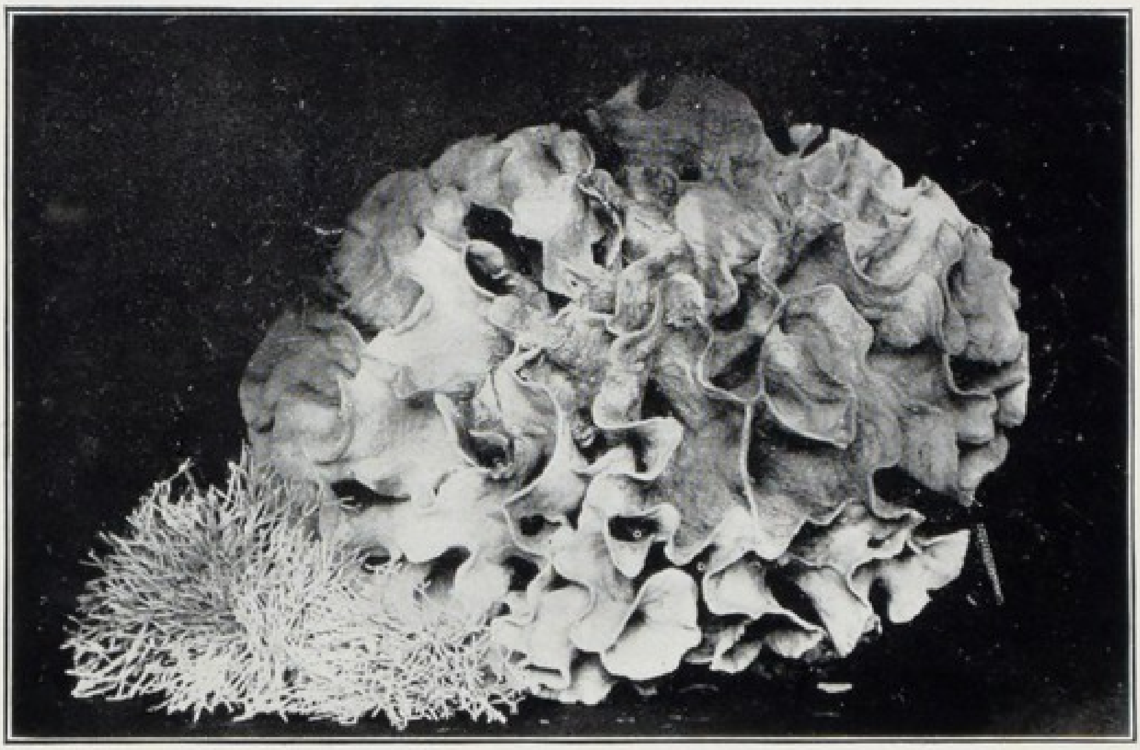


Fig. 43.—*Lepralia foliacea.* $\frac{1}{5}$ Natural size

scribed in Hinck's monograph of the "British Polyzoa," one volume being restricted to plates of the different kinds.

In one species (at least) there is a very curious arrangement. Between the little chambers that contain the animals are processes that look just like miniature vultures' heads, and the curved beaks open and shut constantly, with a snapping movement. The function of these is obscure.

Darwin, in his "Voyage of the *Beagle*," mentions seeing these in the Falkland Islands; on, he says, "a *Crisia*." I have only seen them here on the Archimedian-screwlike *Tubulipora*, a form common in rocky places well down in tide range.

I shall not proceed with this group any further, as all that could be written within my limits would be but a fraction of what is to be learned about them. The interested reader I shall refer to the work I have just mentioned—*and to the shore* itself.

CHAPTER VII

THE CRUSTACEA

ALTHOUGH these are next in the ascending scale the jump seems a big one. We now encounter high organisation, and for the first time—to our senses—the manifestation of conscious intelligence.

The crustacea are differently divided by different authorities, but most place them as follows :—

1. *Epizoa.*—Small crustaceans of parasitic habit, of which *Lernea*, a parasite of the sprat, is the type. (This definition is poor, as many of the higher divisions are also parasitic.)

2. *Cirripedia.*—The ship-barnacle and its allies.

3. *Entomostraca.*—Small crustaceans, of which the " Water-flea " of our ponds and ditches is the type.

4. *Malacostraca.* — All the others—viz. the sand-hoppers, gammarids, shrimps, lobsters, and crabs.

The first division we will pass over, there is nothing in it of interest except to the specialist, and proceed to the *Cirripedia.*

The " Ship-barnacle " (*Lepas anatifera*) is of very great interest, and we shall consider it at some length.

The photograph (Fig. 44) gives a good idea of its outward form.

The place in nature of this curious crustacean was formerly a matter of great perplexity. Some of the old writers thought it was a *bird* !—or at least a developmental stage of one—viz. the *Bernicle goose.* In fact, its scientific

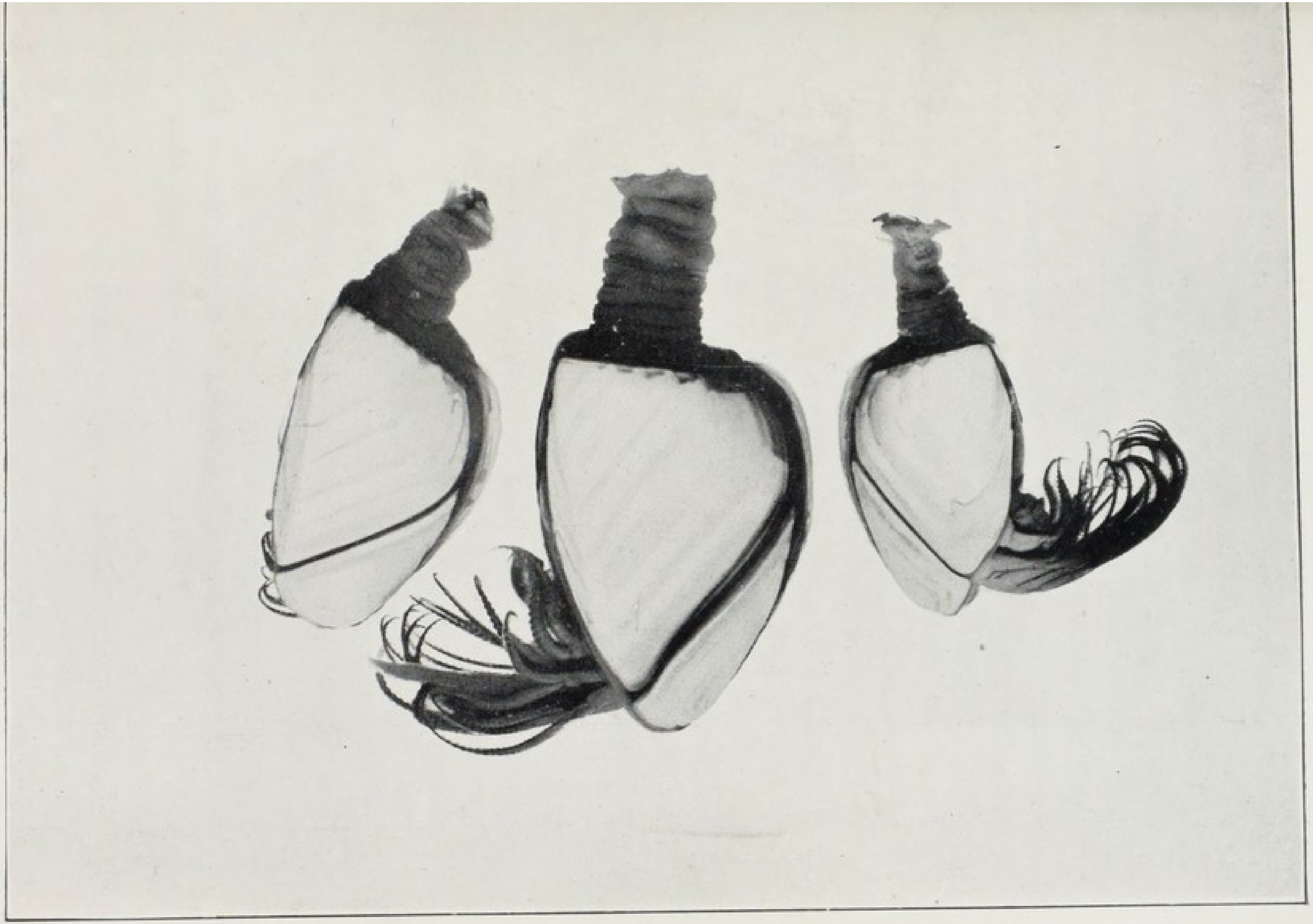


Fig. 44.—*Lepas anatifera* (ship-barnacle). Natural size

name, *Anatifera* ("goose producing" or "bearing"), is a survival of the old belief.

I could give some humorous quotations from the ancient naturalists (Gerald, Sir John Maundeville, and others), but they would serve no useful purpose, and we must, at least, try to think charitably of these old writers, and remember that while "Errors which we spurn to-day were the truths of long ago"—it is possible that some of our "truths" will prove to be error presently, although I am optimistic enough to believe that, in *natural science*, at least, we now stand upon a pretty firm rock.

The embryology of the ship-barnacle has now been watched and studied, even by the least among the disciples of natural history, and its place in nature is well decided.

To understand it fairly we must trace its life history.

From an egg cast from (or hatched within) the parent, issues a little free-swimming organism termed a *Nauplius*, or, better, the "*Nauplius stage*" of the barnacle.

This is a minute, shield-shaped thing, about the size of a small pin's head. It feeds voraciously, changes its coat repeatedly, and makes some structural changes at each moult—*e.g.* it develops more legs, and then a *pair* of eyes, alongside of an original *one*. It travels rapidly through the water, back downward, with little jerky movements.

(This "Nauplius stage" is not confined to the Cirripedes, some other crustaceans develop in a similar way, among them a large prawn, *Peneas*.)

After a few moults it makes an important change. It quits the Nauplius form, and develops two little concave valves, like mussel shells, one on each side of its body, and between which it can withdraw its legs.

It now closely resembles a crustacean of the next division, the Entomostraca.

In fact, it is very like the *Cypris* of our ditches, and is said to be in the "Cypris stage."

Its antennæ or horns become provided with suckers, and with a gland that supplies a kind of glue.

It leaves off feeding for a while, and by means of its suckers attaches itself to some object, preferably a bit of floating wood. (It has a reserve store of nourishment, in the form of oil globules.)

The little shells now fall off, and are lost, while the portion of its head just behind the antennæ develops enormously, and the front part of the antennæ has the holding power of its suckers augmented by a supply of the "glue."

The front part of the head still grows, until by-and-by this becomes the huge, semi-membraneous, semi-aqueous, "stalk" which, in bulk, is more (as a rule) than the rest of its anatomy.

Some have stalks a foot or more in length and half or five-eighths of an inch in diameter, others have but short ones. The specimens photographed are entire, and are "short stalked."

The legs become modified into many-jointed, feather-shaped (*Cirripedial*) appendages, the office of which now is, as Professor Huxley said, "to kick the food into the mouth."

A set of shells, five in number, and beautifully hinged together, protect the internal anatomy, and the ship-barnacle is complete.

(An error very common among fishermen and other sea-farers is that the barnacle "bores holes in timber." It does not do so, only attaches itself; but logs, etc., on which it is found affixed, are as a rule seen to be bored, but this is by the mollusc *Teredo*, usually called the "Ship-worm.")

Sketches of the Nauplius and Cypris stages of Lepas are shown in Fig. 45.

Allied to Lepas is a very similar form, in which the shells are replaced by membraneous flaps. This is *Conchoderma*.

It is sometimes found at low water, living in rock crevices, among nullipores, etc.

The common little "Acorn-barnacles," that coat the rocks in every situation, from the sun-scorched ranges at high-tide level to deep water, and that are also attached to stones, shells, the backs of crabs, and everything else that has a surface, also belong to the *Cirripedia*.

Many young visitors (and, I am afraid, some of their

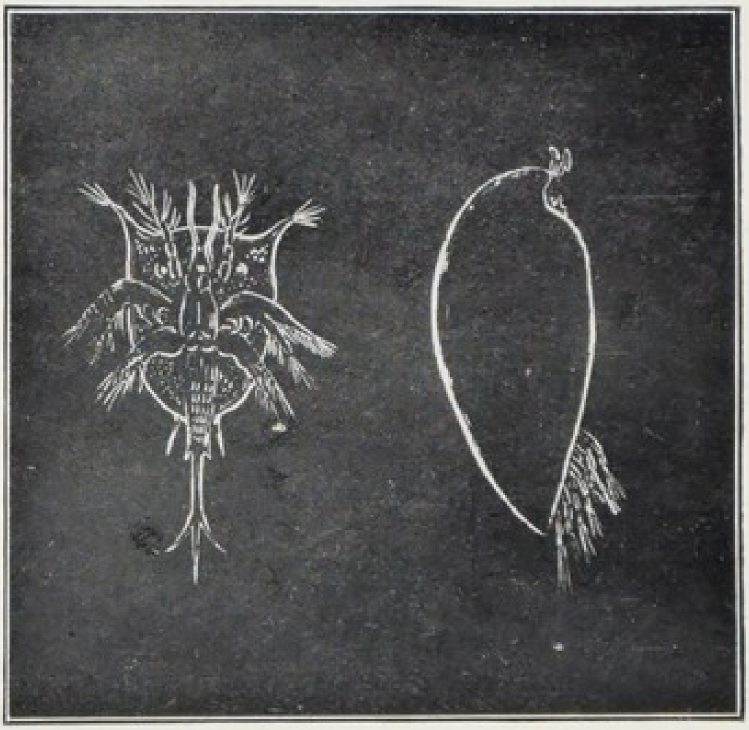


Fig. 45.—*Nauplius* and *Cypris* of ship-barnacle
Much enlarged

seniors) to the shore mistake these little things for young limpets with the tops of their shells rubbed off.

However different these may appear outwardly their interior anatomy and their development is the same as that of the ship-barnacle. The differences are that the "stalk" is suppressed, and replaced by a shelly disc, and that the outer shells are modified into a pyramidal form. On looking at a specimen from the top the movable valves, like those of Lepas, are easily seen.

Very often the visitor to the shore may, when sitting quietly on a rock, have noticed a peculiar little rasping noise, very difficult to locate. This is caused by the myriads of little valves of the acorn-barnacles rubbing against the firmly fixed portion of the shell, as the little inmate, perhaps anxious for a turn of the tide, moves uneasily within its home.

If a piece of stone or a shell bearing a few specimens is placed in a bottle of sea-water, and looked at against the light, the beautiful little "feather feet" will be seen to protrude and begin their operation.

An idea of how abundant these barnacles are can be seen by glancing at the rocks in Fig. 93, just below the octopus. Myriads of the Nauplius and Cypris stages of these occur on the surface of the sea during the summer months, and very frequently a muslin net drawn through the water will be lined with the cast skins of the feather feet, these retaining the beautiful structure of joints and bristles in perfection.

There are several species on our shores. The common one is *Balanus balanoides*.

Fig. 46 shows a number that are attached to the back of a crab, and their "feather feet" can be seen extruded.

There are many other representatives of the Cirripedia, but we shall just glance at one more. It is such as to upset all our ideas of what constitutes "resemblance." This is *Sacculina carcini*. It is a Cirripede "of every grace, of every virtue shorn." One that by the habit of parasitism and the disuse of parts has degenerated into little more than a sack.

It has no feet nor shell, simply a membraneous bag about the size of a hazel nut, and a series of threads like an unravelled bit of string.

It attaches itself when in the Cypris stage to the end of the alimentary canal of a crab, where it remains through life, sending its branching threads into the innermost parts of the unlucky crab's anatomy whence it derives its nourishment.

The baglike body is often little more than a mass of eggs, or *Naupli*, ready to commence their career.

The "Cypris" of this species, once that stage is reached,

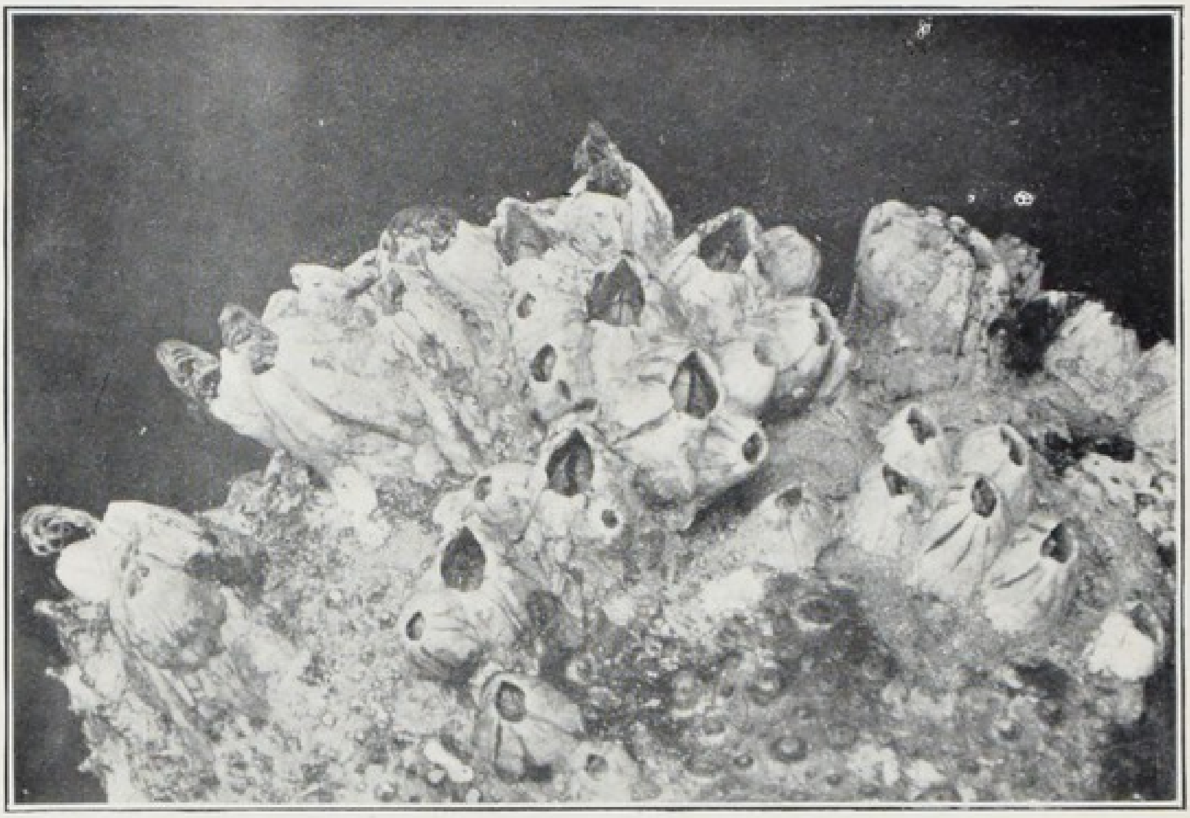


Fig. 46.—*Acorn barnacles* on the back of a large spider crab
Natural size

swims the sea, prospecting, not for a log of timber, but for a crab, upon which it can quarter itself for life.

Comparatively few, however, can find a host in proper time, and the majority of the brood come to an untimely end.

The Entomostraca.—These are crustaceans, usually of small size, although the "Great King Crab" (*Limulus*) of American coasts is by many placed with them.

The *Trilobites* that figured in the earlier history of the race are also supposed to have belonged to them, but of the species now living in British seas all are small —from microscopic dimensions to half-an-inch in length, and the latter size is reached by one or two species only.

They are divided into series according to their plan of structure, the first of which is the *Copepoda*. The representatives of this division have a segmented body, with the anterior part covered with an oval shield, like the carapace of the lobster, etc., a projecting jointed tail, and feet adapted for swimming only.

The common little *Cyclops* is always selected to figure as the type.

The *Ostracoda* have the body enclosed in a bivalve shell (like the Cypris of the Cirripedes), and seven pairs of legs, adapted for either swimming or walking. The body is not segmented.

The division termed the *Caligidæ* includes the so-called "Fish Lice." The curious and, under the microscope, beautiful *Argulus foliaceus* of the pike, etc., is the type. An examination of any rough scaled sea fish, bass, wrasse etc., will usually reveal a number of these. They are of flattened form, oval, broad end in front, and run or glide nimbly over the scales of their host.

A species (if a true Entomostracan) the female of which is the largest on our shores, is *Chondracanthus zei*. It is nearly always present on the gills of the "John Dory" (*Zeus faber*), from which host its specific name is taken. The male is microscopic.

Some of the *Entomostraca* gleam with iridescent tints. This feature is strongly marked in a large Copepod (*Anomalocera Patersonii*). A large foreign species (*Sapphirina fulvescens*) is resplendent.

The Copepods and Ostracods are abundant at the surface of our seas, and on warm summer nights, when the surface is unrippled, often give a tremulous appearance to the water, as if it were being peppered.

The Malacostraca.—This section is so very extensive, and comprises so many diverse forms, that, although I have said I would follow no systematic arrangement, it will be necessary to attend to at least the "sub-orders," and I shall take them as given in Claus ("Text-book of Zoology"). I know the system is open to some objection—and so, in degree, are all others—but doctrinal points need not delay us, and an enumeration of the characters that divide the "sub-orders," "families," etc., would do so to great extent.

It will be sufficient to say that the *Malacostraca* are divided into two great sub-divisions, generally spoken of as the "Sessile-eyed Crustaceans" (*Edriophthalmata*) and the "Stalk-eyed Crustaceans" (*Podophthalmata*), characters obvious to the wayfaring man—the first division having immovable eyes, little, or not, raised above the surrounding shell, and the latter having the eyes on stalks, as in the lobster, prawn, etc.

The first sub-order of the "Sessile-eyed" is the *Amphipoda.* These have different forms of legs—viz. some for walking, and others for swimming, and for jumping. The eggs are developed in a brood sac, placed under some large projecting plates formed by the first body segments.

The young of some species when first hatched follow the parent in a little shoal, returning to the shelter of the shield plates, like chicks beneath the mother's wings, when danger threatens.

A common example of the Amphipods is the "sand-hopper" (*Talitrus locusta*), which abounds on all sandy shores.

This species can hardly be said to be "marine"—"maritime" would be better—for it lives buried (by day) in the sand just *above* high-water level, where only the dampness can reach it.

If kept submerged it will drown, and it may often be noticed that at the time of very high spring tides the sand-hoppers forsake their territory and swarm upon the fields, rocks, roads, and even into the houses near the shore. It seems to be a form which is, in the course of generations, gradually forsaking the sea, to become a land-dweller.

At a somewhat lower level—that is, where the tide covers—under stones, and under heaps of decaying sea-weed, may always be seen in swarms the "Shore-hopper" (*Oschestia littorina*). These two forms, *Talitrus* and *Orchestia*, are classed as the *Saltatoria* (jumpers), all the other Amphipods are swimmers (*Natatoria*).

At the same zone as the last named, but also extending to low-tide level, under stones and sea-weeds, in great colonies, live the Gammarids. (The type of the Gammarids is the common "fresh-water shrimp" of our brooks (*Gammarus neglecta*.) The common marine form is *Gammarus marinus*. Its colour is olive-green, although individuals that have lately changed their shell are pale brown. The females are about twice the size of the males, as is the case with all the Amphipoda, and a few of the Macrura.

Under stones, lower down in the tide range, may be seen the bright pink *Mœra grossimana*.

Another one met with in the same places is *Dexamine spinosa*. It has a strong, sharp, projecting point on the edge of each of its segments, so that when it rolls up, as it always does when at rest, it has the appearance of a little circular saw. Its colour is white, delicately spotted with pink.

In cracks of rocks in dry situations, where sand has filtered in between, is a curious form, in which the antennæ are modified into grasping organs—an unusual modification. This is *Corophium longicorne*. Its colour is porcelain-white.

Another bores into wood when such has been in the water some time—*e.g.* in the piles of piers, diving stages, etc. This is *Chelura terebrans*. It is a beautiful little crustacean, about a quarter of an inch long, of a rose-pink colour, spotted with white. It has a curious paddlelike projection on the tail, and other decorative appendages, the purpose of which is not easy to determine.

It usually works at wood tunnelling, with a partner termed the "Gribble." (This last belongs to the next sub-order—viz. the Isopoda.) The combined labours of these two little crustaceans have cost governments many thousands of pounds.

A list of all the species of our Amphipoda would be wearisome, so I have just named the few that are most usually met with in the littoral.

Nearly all the Natatorial ones come to the surface of the sea at night, and their capture is readily effected by the tow net, in which connection we will revert to them. Allied to the Amphipoda, and by most authorities classed with them, are some peculiar little crustaceans (*Caprella*), popularly known as the "Skeleton Shrimps," a designation that well suits them. They are from half to three quarters of an inch in length, very slender, with large heads and very stout, club-shaped claws, which are fixed near the head. The central body segments are without legs. The last segments of the body only are furnished with them, and with these they clasp the objects on which they are found—chiefly zoophytes and the branches of Polyzoa. Attached firmly by these legs of the anterior extremity they raise the body vertically, much after the manner of some caterpillars (the *Geometers*), and present a most grotesque appearance.

In the female a pair of appendages develop on the central segments. These are convex outwardly, concave within, and fit edge to edge, forming a little sac, in which the young develop, just as in the "Opossum Shrimps" (*Mysis*), which we shall consider presently.

The species represented on our coast are *Caprella linearis*, in which the body is uniformly linear, and *Caprella acanthifera*, in which each segment of the body is produced into a point on the dorsal aspect.

They are very pugnacious, and the males fight desperately.

The Isopoda ("Equal-footed").—This sub-order has for its type the common wood-louse of our gardens. It also is very strongly represented on our shores. The most familiar example on the coast is *Lygia oceanica*. This is about an inch and a half long by half-an-inch wide, and rather flat. The colour is green, with black and white spots and mottlings. It is very abundant, and at dusk can be seen scuttling rapidly over rocks and sea-walls just above high-tide margin. This, like the sand-hopper, seems to be a marine form taking to a land existence.

In the cracks of rocks in places which the tide covers, and also under loose stones in rocky hollows, but still high up in tide range, may be seen, often in great colonies, a form which rolls itself up into a ball, like the "pill wood-louse" of our gardens. This is *Sphæroma serratum*. It is about half-an-inch long, by nearly as much in width and very convex. Its colour varies: some are red, others yellow, white, and green, but the majority are speckled pink and white.

There are several species of *Sphæroma*, and other genera closely allied to them. *Nicea bidentata* is a common little one in dry places and is remarkable for two spinous processes on one of its segments which projects when it rolls itself up.

Some of the Isopoda are parasitic on fishes, others on crustaceans (see Fig. 47).

The large *Æga*, about the size of a cockchafer, attacks the cod chiefly. A beautiful species, of rather smaller size, is named *Anilocra Mediterranea*. This one is common in the Channel Islands, and is parasitic on one of the wrasses (*Acantholabrus exoleta*) always fastening at the same spot, near the eye. Male and female are usually found together.

One species, about an inch long, and of cylindrical form, very narrow for its length, is *Conilera cylindracea*. This one attacks the whiting and bass.

Two very common species of large size—that is, from one to one and a half inches long—are *Idotea tricuspidata* and *Idotea linearis*, the latter of peculiar centipedelike form.

These are abundant on sandy shores, and are constantly

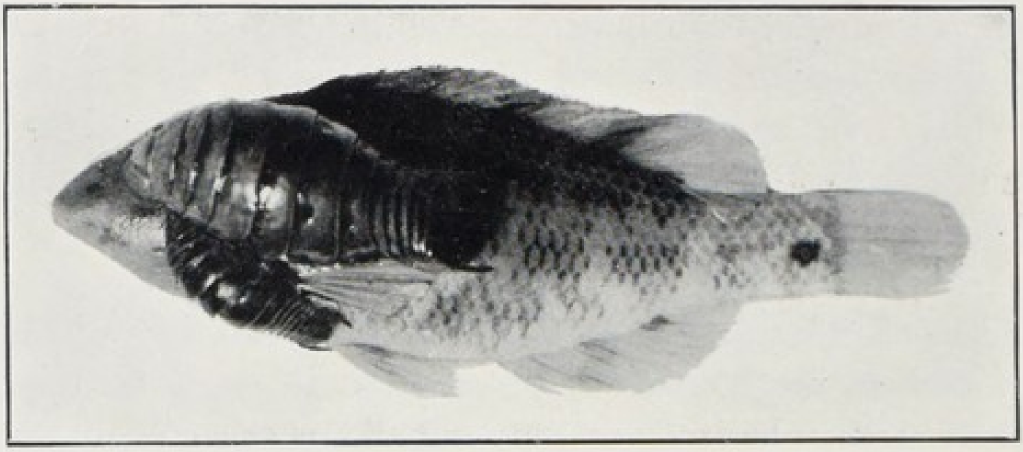


Fig. 47.—*Isopod Crustaceans. Anilocra Mediterranea*, attacking a young rock-fish. Natural size. (Small specimen, *male*; large one, *female*)

taken in the shrimp net. They swim freely at night, and are invariably part of the spoils of the tow net.

Some are of resplendent colours. The little *Dyamene rubra* and others are very beautiful. Some are bright scarlet, some blue, others variegated red and white, while their shells are delicately sculptured.

Eurydice pulchra, as its name implies, is a beautiful form, cream-coloured, with black dots. This little fellow often sticks to the skin of bathers and bites them severely. It is about a quarter of an inch long.

Some, on the other hand, are far from beautiful. One species (*Bopyrus squillarum*) has all but lost every vestige of legs, and every other organ, except the digestive and reproductive parts. It has also lost all symmetry, and is contorted to suit the position it has elected to occupy for life. This is parasitic on the gills of the prawn, just beneath the side of the carapace, which it causes to bulge out in a wartlike process about the size of a pea. This description applies to the *female*.

The male is symmetrical, and can swim at sea, although he is usually found with his consort, but the male is easily overlooked, as he is almost microscopic in size.

The little "Gribble" (*Limnoria lignorum*) is about a quarter of an inch long, broad for its length, and mottled yellow and black. It bores into timber, and is the ally of *Chelura terebrans*, already mentioned.

Some small species are frequently found in the osculæ of sponges; and in the little hollow sacklike *Sycandra compressa* are often found the pretty *Anceus maxillaris*, the male of which has a very large head and a formidable pair of serrated jaws, looking like some dentist's uncanny instrument. The female is of a bright azure blue.

Some figures of the chief types in these orders are given in Fig. 48.

Somewhere between the crustaceans just dealt with and the higher division—the "stalk-eyed"—there is a curious form, named *Nebalia*. It has stalked eyes like the following, but the body is segmented all along, instead of having the first segments fused together into a carapace, but then again it has a carapace in the way of an enveloping shield, which covers the anterior segments. It has characters belonging to the *Entomostraca*, and to the two divisions of the *Malacostraca*. In fact it appears to be a survival of an ancient type, which had the rudiments of the characters which now appear in strong differentiation in the different divisions. A "group," of which it is the only occupant, has been termed the *Leptostraca*. The one species, *Nebalia*

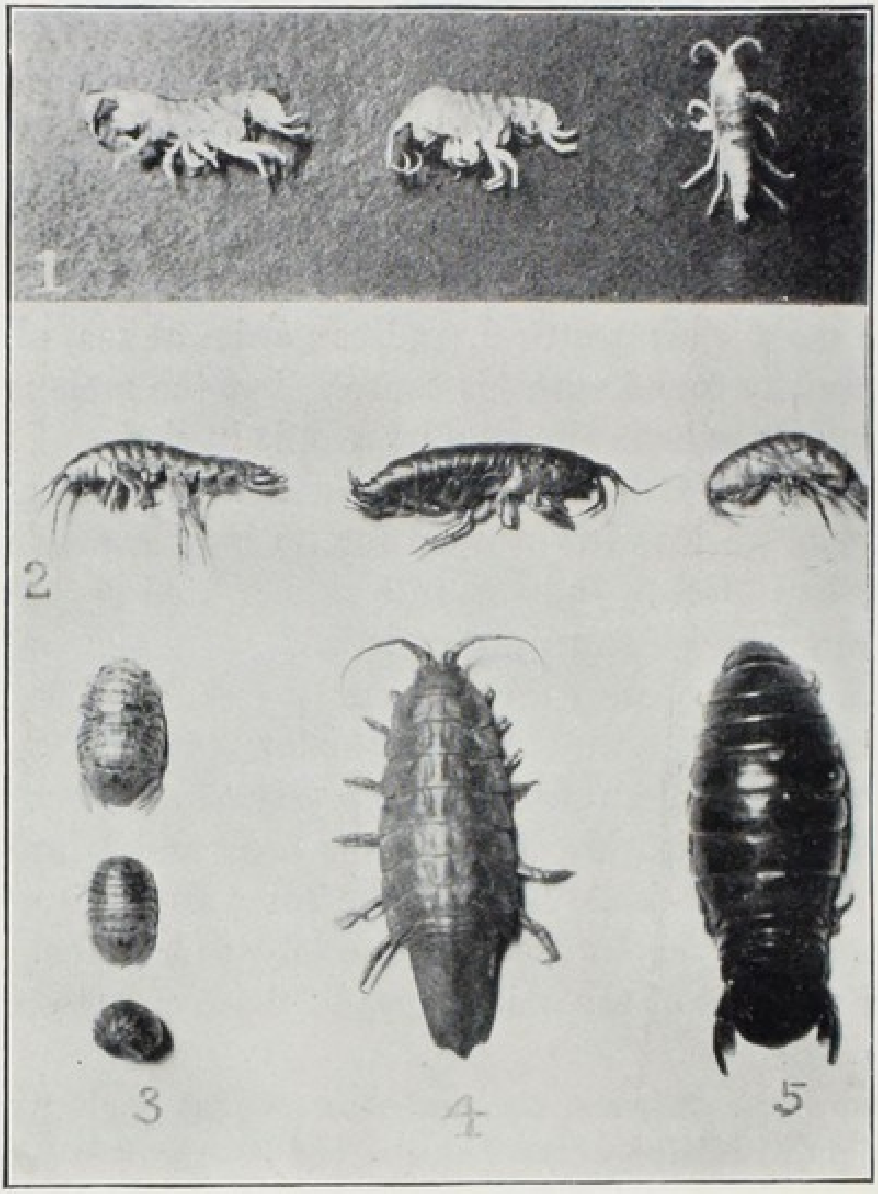


Fig. 48.—*Amphipoda* and *Isopoda*. 1. *Talitrus locusta*; 2. *Orchestia littoralis*; 3. *Sphæroma serratum*; 4. *Idotea tricuspidata*; 5. *Anilocra Mediterranea*. All natural size

bipes (or *Nebalia Geoffroyi*) is common on our shores. It is an oval bodied, laterally flattened little animal, about half-an-inch long, and of a polished ivory-white colour, with bright red eyes.

It may be found by turning over stones under which there is decaying sea-weed, and it seems to revel in these malodorous conditions, conditions that would be speedily fatal to any other of the denizens of the sea.

It swims awkwardly, and yet rapidly, on its side.

The Macrura (" Long-tailed " crustaceans).—In the preceding two true divisions of the crustacea—viz. the *Amphipoda* and *Isopoda*—it will be seen, on looking at a specimen (or at Fig. 48), that the body is pretty uniformly divided into a number of segments, from head to tail, and that there is no " fusion " or joining of any of these to form what is known as the dorsal shield or carapace. (The carapace-looking structure in the Leptostracan (*Nebalia*) is of different origin, and the segmentation is within it.) But in the *Macrura* we have the fusion of the majority of the segments (on their dorsal side) to form the carapace. As a rule fourteen segments are so joined, and six are free to form the flexible abdomen and tail, while each segment, fused or free, bears two pairs of appendages, legs, or their modifications, antennæ, eyes, foot-jaws, etc.

The young emerge from the egg in a form not quite like the parent, and have to undergo a change or two before the adult form is reached.

The *Macrura* are divided into a number of sub-divisions and families—*Astacidæ*, the lobsters: *Palæmonidæ*, the prawns; *Crangonidæ*, the shrimps, etc.—which we will not trouble about at present, but take the most familiar examples first.

Homarus vulgaris, the common lobster (Fig. 49).—This is abundant on all our shores. A full-grown male measures about fifteen inches from rostrum to tail. The female is rather shorter, and broader in the segmented part—*i.e.* the abdomen.

The young, on quitting the egg, are nearly of the form of the parent. They escape from the eggs while these are still attached to the "swimmarets" (the oarlike appendages of the abdominal segments), and for a few hours are weak, and lie helplessly on the sea-bottom, but soon gather

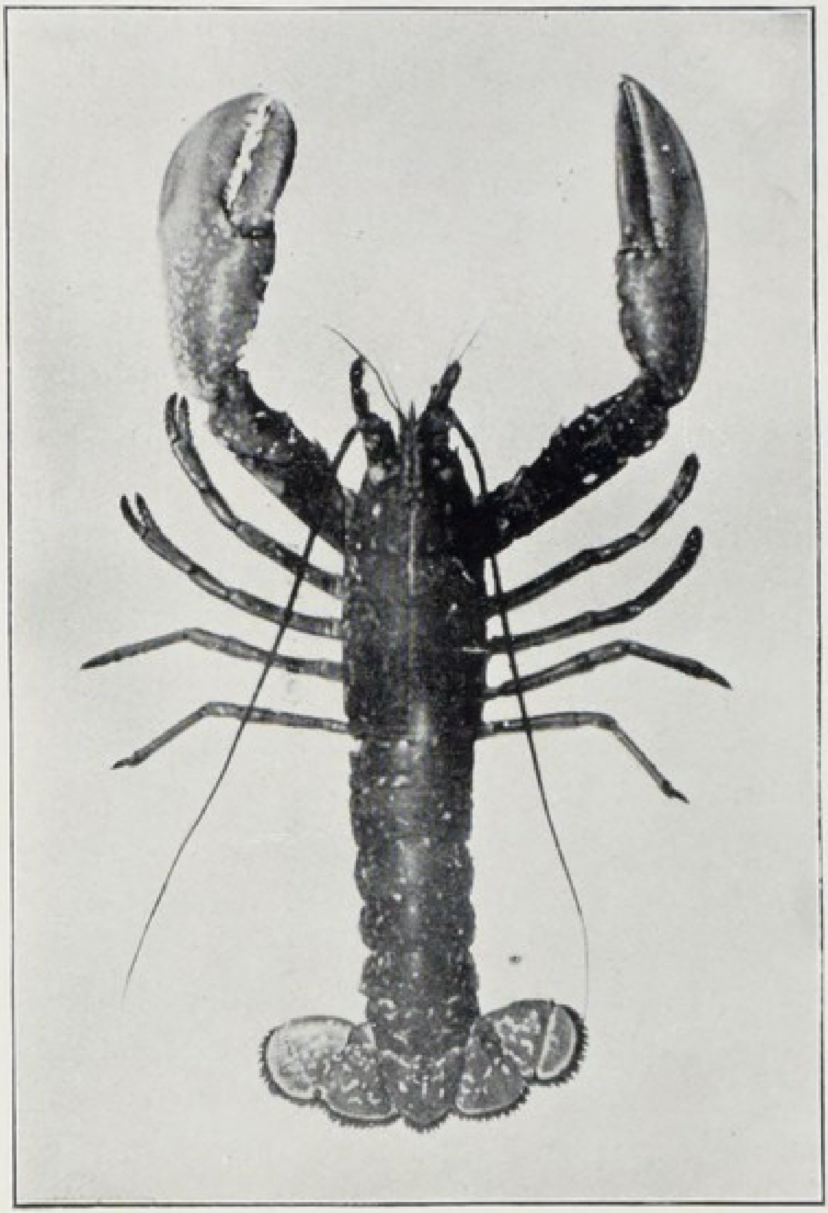


Fig. 49.—The Common Lobster. *Homarus vulgaris*
$\frac{1}{5}$ Natural size

strength and swim away nimbly. (There are from thirty to thirty-five thousand in one brood.) They swim freely in open sea for about twenty-five days (during which their numbers are very much reduced, for they are much esteemed by everything in the sea which has a mouth). They are very voracious little things, and attack animals larger than themselves. They are also inclined to cannibalism.

Then, when about an inch long, they take to bottom, and have the form and habits of the parent, hiding in rock crevices and under stones. The first year the shell is cast several times, as growth advances. Then for three or four years once a year, less frequently after that. The full size is attained when they are from five to seven years old. A specimen which has reached size-limit can be easily recognised by its having the claws and walking feet abraded and worn, and having barnacles and serpulæ attached to the shell, showing that it has not been lately renewed. The shell-casting, or "Ecdysis," as it is termed, is a very interesting process, and will be referred to in the section on the *Brachyura*.

The lobster affords a considerable fishery, both at home and abroad. It is mostly taken here in baited wicker traps, called "lobster pots"; in the big fisheries of Newfoundland, etc., in cages made of wooden laths, about five feet long by three feet high and three feet wide, with two "free admittance—no exit" openings at each end. (The wicker "pots" have but one, this at the top.)

The lobster, where numerous in shallow waters, is also lured from its hiding and speared.

On all rocky shores specimens may be taken in rock crannies and under boulders, in the lower part of the littoral.

(The anatomy of the lobster is extremely interesting, and the young naturalist will do well to study it—Huxley's classical work, "The Crayfish," for his guide.)

The nearest ally to the lobster is the fresh-water "crayfish," but in marine forms its allies are not very familiar to most persons, although they are fairly common.

The first of these is *Axius stirhynchus*. This is very like the lobster in shape. The male is about three and a half inches long. The female is larger—about four, or four and a quarter. The colour is bright rose-pink. It burrows in sand and gravel, in among loose stones, and is very rarely seen except by excavating for it, the open end of its burrow giving the indication of its hiding-place. It is one of the so-called "Burrowing-prawns." A glance at the Photo 50 will show that it is a burrower. When the limbs are held in close to the body the outline at once suggests that of a very different animal of like habit—the common *mole* of our land.

The female at the time of reproduction carries a number of large eggs, of a bright golden yellow, attached to her swimmarets, but these are not in such large numbers as in the lobster—four or five hundred being considered an ample responsibility.

Resembling *Axius* in general aspect, but broader and shorter, and having the "Rostrum" or anterior part of the carapace large, flat, and ridged, instead of small and conical, is *Gebia deltura*. Its colour is pale pink. It burrows in among the roots of the sea grass at low-tide level.

Callianassa subterranea is a very remarkable crustacean, still a burrower, making long galleries in sandy places, or sometimes availing itself of the holes made by other animals.

It is about four inches long, with one very large claw, peculiarly hinged, the "hand" part (*Carpopodite*) being attached to the portion behind it (the *Meropodite*) by a hinge the full width of both parts—*i.e.* it is not contracted into a "wrist," as in most other crustaceans.

The other claw is also long, but very narrow and feeble. The large claw may be either right or left. Except the claws, the front part of the carapace, the walking legs, and the tail plates, it has no "shell" proper, but is soft and membraneous. Its colour is a porcelain-white, except for a blush of pink and yellow, due to internal tissues, which shows through the membraneous abdomen. I shall

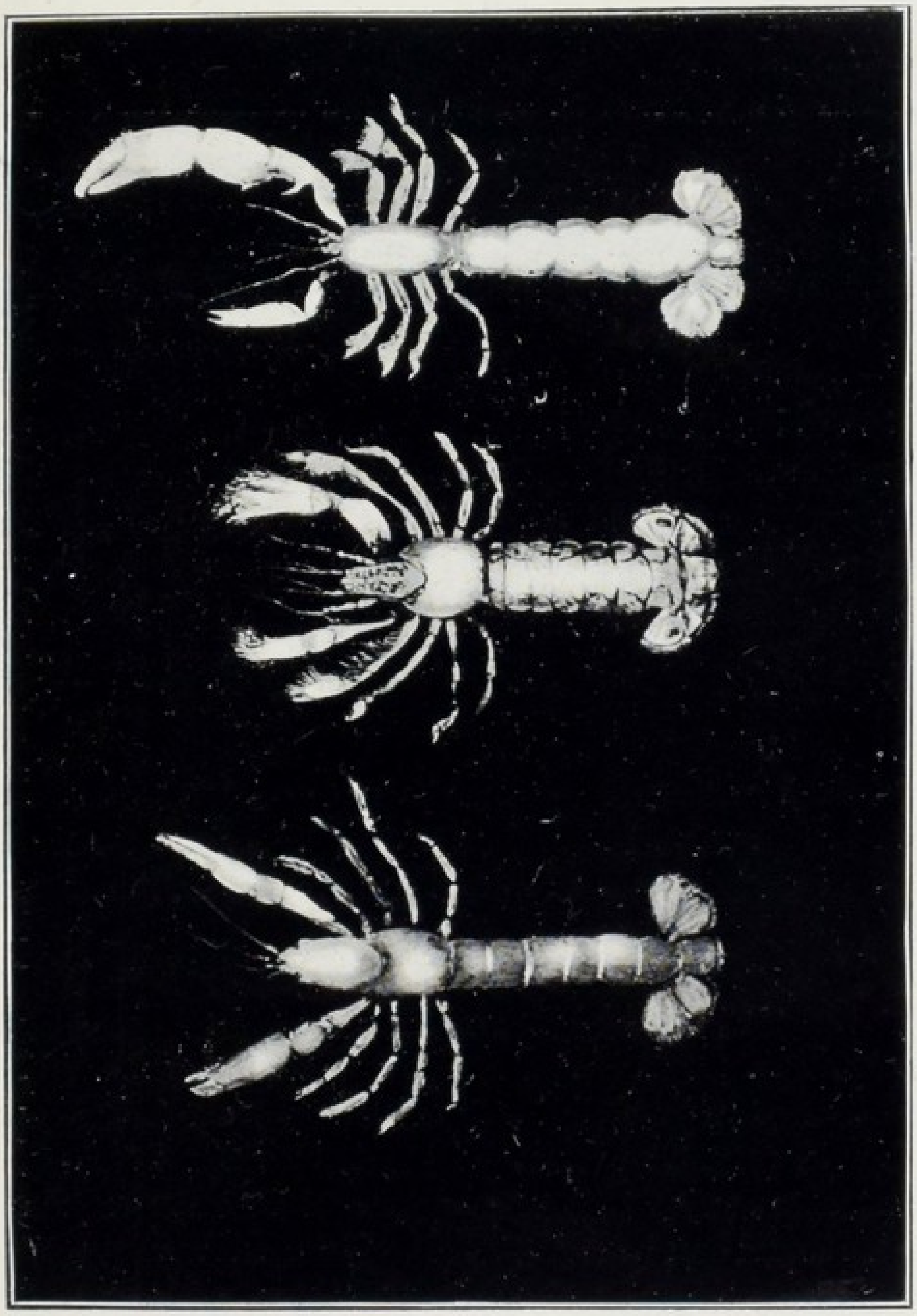


Fig. 50.—The "Burrowing Prawns." 1. *Axius stirhynchus*; 2. *Gebia deltura*; 3. *Callianassa subterranea*. $\frac{2}{3}$ Natural size

refer to it in the next division in discussing the affinities of the hermit crabs.

It is tolerably common in the lower zones of the shore, but owing to its fossorial habit it is not often seen. Its eyes, as in those of all the burrowing crustaceans, except one (*Squilla*), are very small.

Athanas nitiscens is one of a family named the *Alphœdæ*, but still closely allied to the lobster.

This crustacean is a little model, like a miniature lobster. The full-grown male is about an inch long, the colour a deep bottle-green, with a line of pale green down the back and some white dots on the sides. The claws are delicately formed, symmetrical, and beautiful. Specimens that have lately renewed their shells are of a pale brown.

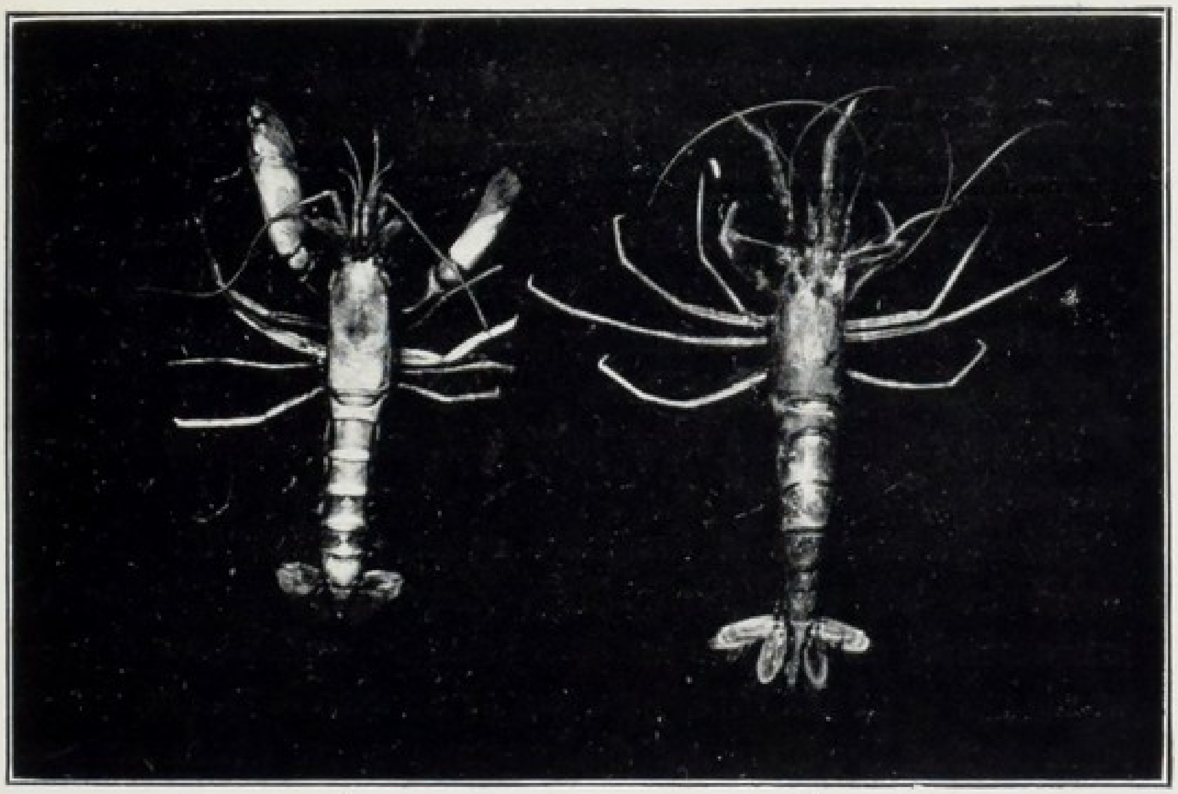
It lives in little colonies of three or four to a dozen, under stones on shelly bottom, where the stone does not rest evenly on the ground but allows a little pool to remain. It is only found at extreme low-tide level.

In the same family is a crustacean which is rather startling by its brilliancy, and its peculiar habit of making a loud clicking noise. This is *Alpheus ruber* (Fig. 51). It is of lobsterlike form, about two inches long. Its colour is a brilliant scarlet, except for the large claw, which has a dash of purple. It is firm shelled and brilliant, the shell, both in texture and colour, suggestive of ordinary red sealing-wax.

The large claw has a peculiar structure: the movable finger, instead of rising vertically from the other, pincer-like, spreads out laterally, and, catching in a little nick, is held there while the closing muscles put strain on it; then it is released with a snap, and striking on a little plate adapted to receive the impact produces a loud "click."

This sound can be exactly imitated by smartly and forcibly striking the palm of one hand with two fingers of the other. The sound can be heard from many yards' distance, even on a windy day on the shore, and, coming from rock crannies, and from under boulders, it is next to impossible to locate its direction.

I have not heard of its being recorded from the coast of England, but it is found in all the Channel Islands, although not commonly. There is a question as to whether this English Channel species is *Alpheus ruber* or a relative, *Alpheus megacheles*, but if the specific name (*ruber*) means "red," as it is supposed to, I shall hold to the name I have



A B

Fig. 51.—*A. Alpheus ruber*; *B. Nika edulis.* $\frac{2}{3}$ Natural size

given; other distinctive characters (plates projecting over eyes, etc.) seem to be hazy and variable.

Nika edulis (Fig. 51) is placed in the same family as the two last, but does not bear much resemblance to either. It is more shrimp-like. It is about the size of an ordinary prawn, of milk-white colour, and not so firm in the shell as the forms just named.

One of the legs, usually on the left side, has a peculiar structure: it is double, and can so fold in upon itself that the additional portion is not perceptible. The joint which *seems* the termination of the leg has also a claw, and is complete without the "extra"; this extension is thin, and very flexible, having twenty or more joints, and it is furnished with a delicate pair of pincers. These are no doubt very useful to the possessor, enabling it to reach distant morsels without the trouble of moving. A similar appendage to the human arm would be of service in various professions.

This crustacean is tolerably common under partly raised stones in gravelly places; much the same in habit as *Athanas*, just described.

Its eyes are large, and at night glow with a bright red tint.

It is a very remarkable thing in an aquarium, these red gleaming eyes being strikingly conspicuous when it is too dark to distinguish any form.

We may now get to some more familiar forms, the *Palæmonidæ* or " Prawns."

Palæmon serratus is the most common example. It is about three and a half inches long. The *rostrum* (or "sword") is beautifully serrated on the upper margin, and is curved upwards; it is about three quarters of an inch long, and projects beyond the little flat shelly prominences which are so conspicuous in all the prawns, the *squames* of the antennæ.

This elongated sword affords a ready method of distinguishing this species from the next, which in all other respects closely resembles it.

It is taken in rocky situations, either in rock pools or at tide margin, by means of the circular hand net. It is also taken in baited wicker traps in deep water.

Palæmon squilla.—This is not quite so common as the last. It is shorter, and for its length somewhat stouter. The rostrum is broader and shorter than in the last; it does not project beyond the squames of the antennæ nor curve upwards.

This species is found in the same situations as the last, but occurs higher up in tide level. In fact, the two species occur in exactly inverse proportions as regards tide range: *Palæmon squilla* being very scarce low down, where its larger relative becomes more abundant.

Those who only know the prawns in the "cooked" condition can form but a small idea of their beauty when

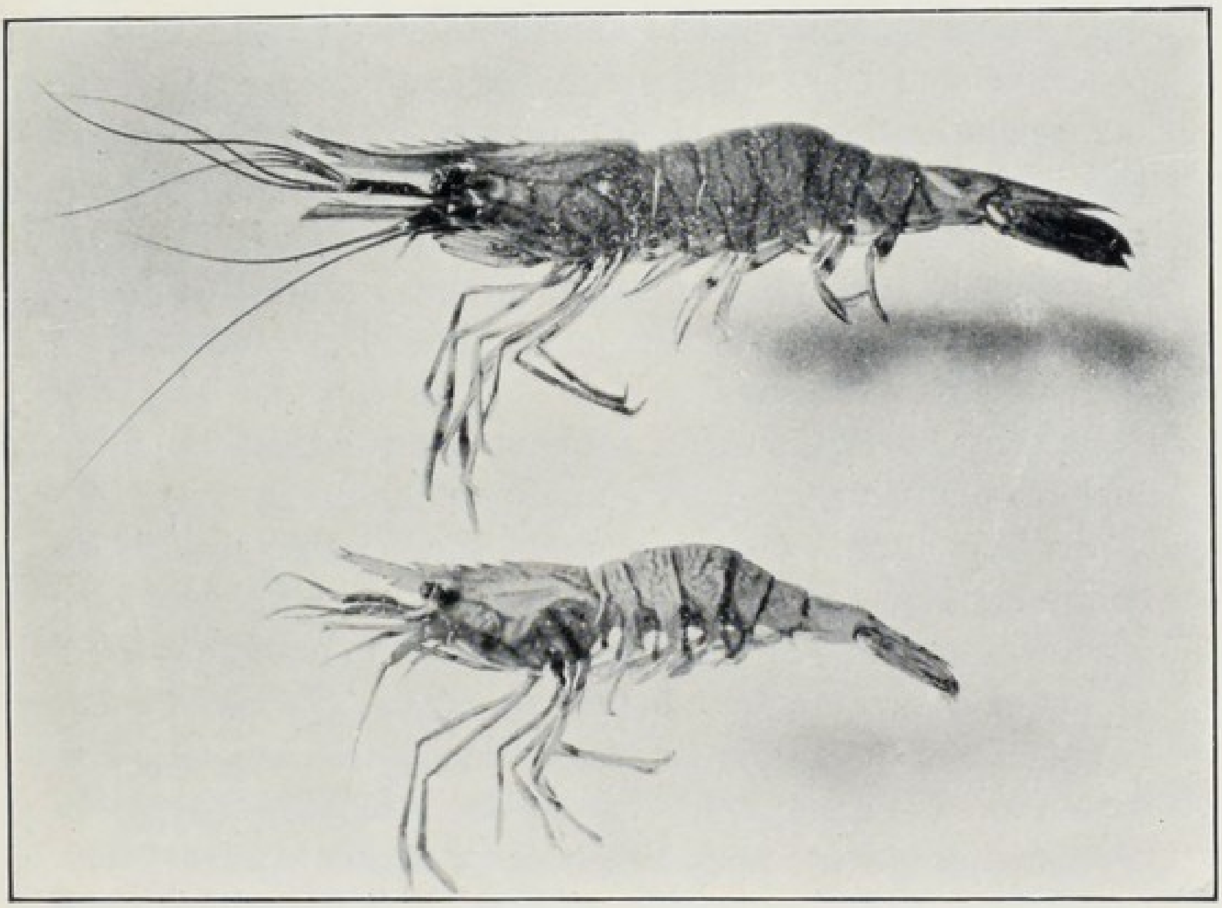


Fig. 52.—*A. Palæmon serratus*; *B. Palæmon squilla.* $\frac{2}{3}$ Natural size

living. They are of a translucent grey tint, striped transversely with waved lines of deep olive-green and purple. Their lovely tints and graceful movements make them very desirable objects for the aquarium (see Fig. 52).

Palæmon varians is a smaller species, closely allied to the last, but only found where the water is of low density—estuaries of rivers and brackish water ditches where high spring tides have access. It is abundant in the Thames.

Pandalus annulicornis is a beautiful species, and largely fished for market. It is of a size intermediate between the two first named, and can be told at a glance by the red and white banded antennæ.

Pasiphea sivado is a curious form, allied to the prawns. It is of about the length of *Palæmon serratus*, but compressed laterally, nearly to flatness.

It does not occur in the Channel Islands, nor have I seen one alive, but I have had specimens from Weymouth.

Lysmata seticaudata is a beautiful crustacean, about three inches long, with short, arched rostrum, and the prawn's graceful outline. It is banded longitudinally and transversely with pink, giving it a chequered appearance. It is really a Mediterranean form, but I have taken it on the east coat of Jersey.

Still in the *Palæmonidæ* we have a number of exquisite little forms, very common on rocky shores. They are the genus *Hippolyte*, better known as "Æsop's Prawns." The commonest species is *Hippolyte varians*. In shape it is like the ordinary prawn, only more "humped" at that part of the abdomen where it bends in under.

It is about an inch in length. The colours vary with the surroundings—green, red, brown—and it has the power of changing from the one to the other within a remarkably short time. Specimens of a brilliant green placed with red sea-weeds in a vessel of water will assume the red colour of their surroundings, even the brightest red of the *Rhodospermæ*, within an hour.

Red specimens placed amid green weeds change rather more rapidly, but quite as completely, to bright green.

How the change is effected is not known.

It is usually supposed that, in the very well-known accommodation of colour to surrounding—as, for instance, the changes of the octopus to brown, grey, etc., as it travels over different ground, or the more familiar (and much exaggerated) adaptability of the chameleon to surroundings—the influence of light is necessary; that what the animal *sees* acts on its nerve system, and indirectly controls the pigment supply to the vessels beneath the transparent cuticle. But, strangely enough, in *Hippolyte* the change takes place in the *absence* of light—or, at least, of light as we know it.

Specimens placed in vessels of water with weeds in contrast to themselves, at *night*, and shut in a close cupboard, had changed their colours before morning. It might be suggested that they feed upon the weeds, and that the change of colour is due to food; but such is not the case, they do not eat the sea-weeds, nor do these give out a coloration. This change is a problem which seems likely to remain such.[1]

There is one of the mysids, named *Mysis chæmaleon*, which is written of as having this faculty, but this is an error. The mysids have *no colour*, evident as such, only the translucent grey, with black pigment spots. I fear that this mysis has been confounded with the long and slender *Hippolyte* (*virbius*) *viridis* which it somewhat resembles, and I regret to see this mistake repeated in such a magnificent book as Wallace's "Darwinism."

The next is *Hippolyte fascigera*. This is the smallest of the genus, being but three quarters of an inch in length. I have never noticed colour change in this one, but it imitates its habitat in a wonderful manner.

It lives among the purple corallines, and a clump of this plant held against the light shows the nodular arrangement of the stems and the clubbed tips of the branchlets, with, of course, clear spaces between them.

Hippolyte fascigera has a transparent body, set with dashes and dots of purple in such a way that it is possible

[1] I have recently had specimens change from brown to green, in a *white* dish, with no stimulating colour present.

to have a dozen specimens perched on a branch of coralline in a tumbler of water, and, unless they move, only a well-trained eye will detect one.

This species is set with curious little branched hairs, of microscopic size, on different parts of the body, their position very erratic, sometimes springing from an eye, from the tail, the sides, or legs. It has been suggested that they are sensory organs, also that they are due to a more complete adaptation in the way of "mimicry," but no theory seems to account at all well for them.

Hippolyte cranchii.—This is somewhat larger than the last, very robust, with short, arched, and strongly serrated rostrum. It is less frequently found than the others; in fact, it is considered a rare species.

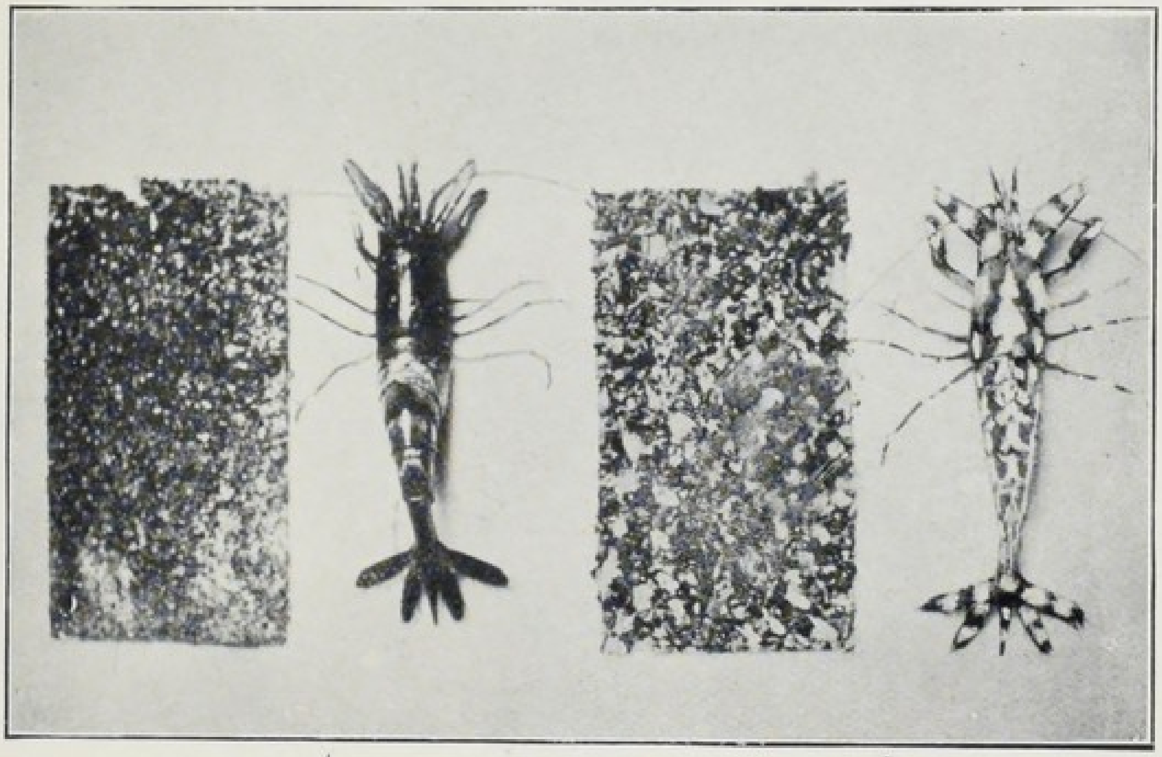
Hippolyte viridis (or *Virbius viridis*) is a slender form about an inch and a half long, with a simple, sharp, and prominent rostrum. When taken amongst sea-grass its colour is always bright green, but when amongst fucus or other dark weeds its colour is brown, so that its specific name must not be considered as distinguishing.

It no doubt has the colour adaptations of *varians*, but I have not experimented on this one.

The Crangonidæ or "Shrimps" (all the smaller prawns, as well as the Crangons, come under the name "Shrimp" in the *fish-markets*)—The familiar species is *Crangon vulgaris*. This abounds in all our sandy bays and estuaries. Its form is "squat," and evenly tapered from head to tail. The legs are shorter (more as in the insects) than those of the prawns, and the rostrum, so conspicuous in the latter, is represented by a little scalelike plate.

Its colour is a minute speckling of black on a buff or whity brown ground, in imitation of the sand on which it lives, and from which it seldom rises, for it has not the swimming power of the prawns.

I have taken specimens on a rocky part of the coast where the bottom was a rather fine gravel composed of crystals of black hornblende and whitish felspar (the rocks around being a gabbro). In these specimens the markings consisted of dots and dashes of black on a white ground, in imitation of the gravel, only that the markings were symmetrically disposed, right and left (see Fig. 53).



A B

Fig. 53.—*Crangon vulgaris*. *A*. Type, and a portion of sand bottom; *B*. Variety marked to imitate diorite gravel, portion of gravel bottom also shown. $\frac{2}{3}$ Natural size

Crangon trispinorus is a smaller species, about an inch long. It is distinguished by the presence of three sharp spines on the front of the carapace. It lives in gravelly situations. Its colours are as those of the common form.

Crangon sculptus is a very beautiful little shrimp, about the size of the last. This has the whole of the shell incised in regular pattern. It is rare. This also lives in gravelly situations.

Crangon fasciata.—The "Banded Shrimp" is a robust little fellow, about an inch long, and it narrows very suddenly just before the tail.

It has two wide black bands across the abdomen, and in

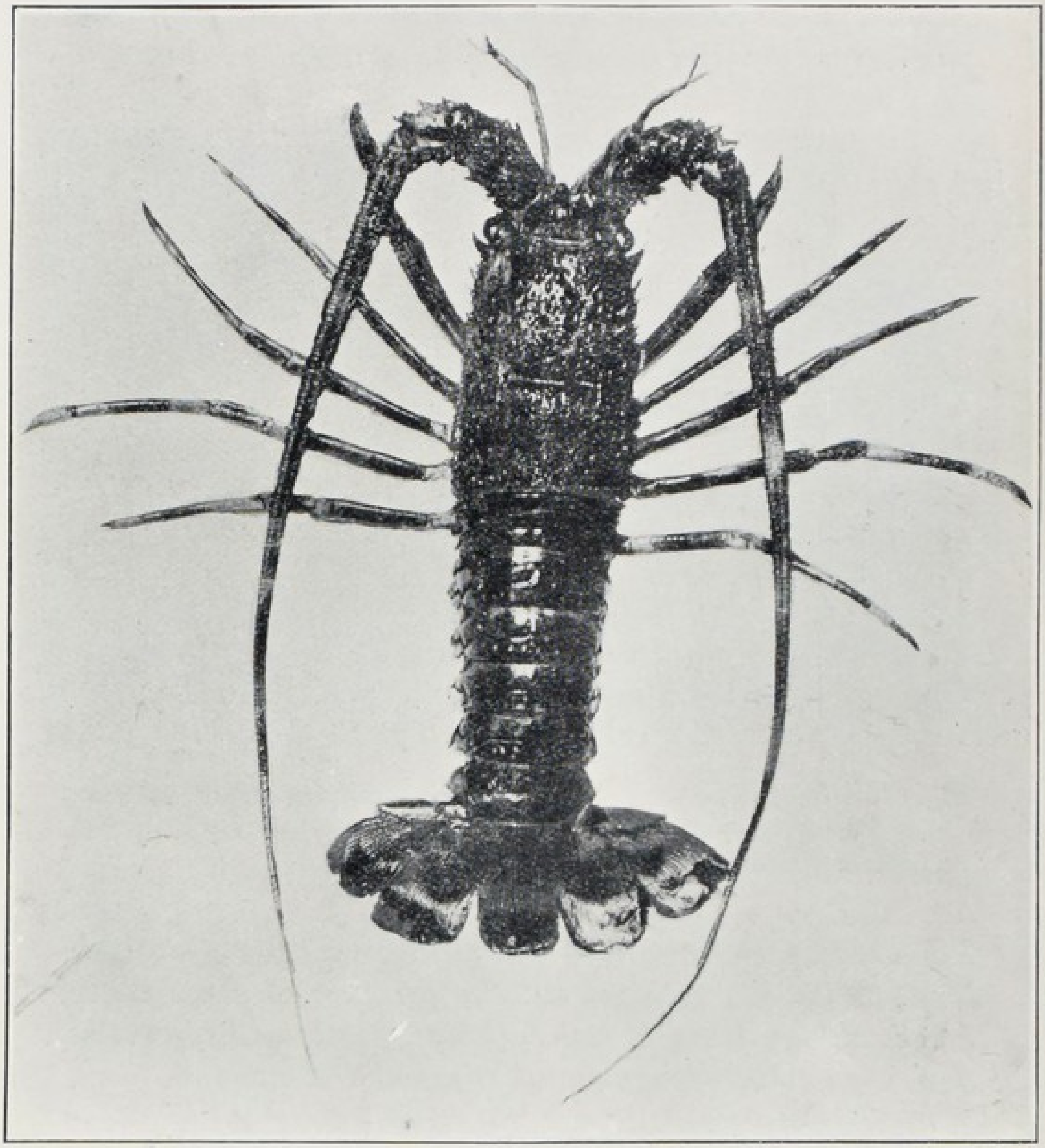


Fig. 54.—The "Crawfish." *Palinurus quadricornis.* 1/6 Natural size

some specimens the head is black. It is not common, but is not so rare as *sculptus*.

The Palinuridæ.—Of this splendid family we have but two representatives on the British shores or in the Channel. They are characterised by a rough spiny armour; the abdomen is broad, and the tail fins fleshy, only the portions near the hinges being calcified.

There are no "claws," in the regular way, only the movable finger (*Dactylopodite*) being developed. The prominence on the large part of the limb (the *Carpopodite*), which in most other genera forms the "fixed" part of the pincers, is represented only by a sharp spine, against which the finger closes—a rather severe pinching apparatus, none the less.

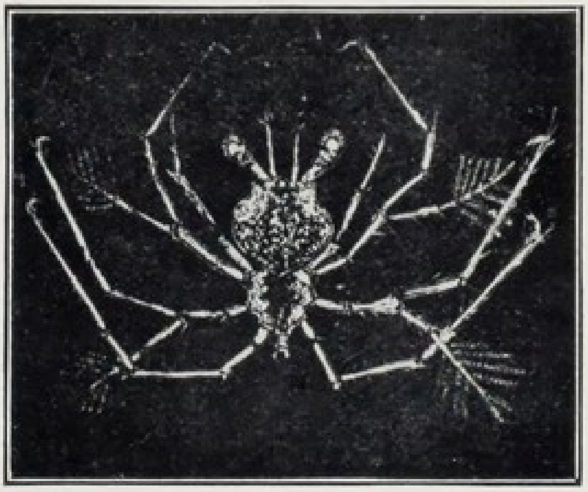


Fig. 55.—*Phyllosoma* stage of Craw-fish. Somewhat enlarged

The young emerge in a curious form, termed a *Phyllosoma*. These are transparent, flat, leaflike organisms, about half-an-inch across when a few days old. They have long, slender limbs, with branchial appendages.

Before their life history was known these *Phyllosomæ* were termed "Glass Crabs" (see Fig. 55).

The best-known example is *Palinurus quadricornis*, the "craw-fish" of our markets. This is without exception the grandest of the British crustaceans (Fig. 54).

A full-grown specimen (male) measures about twenty inches from rostrum to tail, and has a girth of eighteen or twenty inches.

The antennæ are stout and long (up to twenty-four inches), ridged, and thickly set with sharp spines. The colour is a marbling or mottling of red and orange.

The craw-fish is a "sound-emitting crustacean" (this and *Alpheus* the only two British examples). The appliance for this consists of horny plates on the sides of the rostrum and a polished surface to the large basal joint of the antennæ, which lie close against the rostrum. When the antennæ are moved the friction causes a loud grunting sound. (This can be exactly imitated by drawing an office ruler across a bit of india-rubber, holding the latter on a table to act as sounding board.) I have on two occasions, when boating on the coast of Sark, heard this grunting, and, coming from several fathoms under water, it seems very mysterious and "uncanny." It can always be heard when fishermen are bringing in their catch of this crustacean.

The other representative of the family is not so well known: it is *Scyllarus arctus* (Fig. 56). (It has other names, but this is the best known.) This crustacean is about five inches long, and one and a half or so in breadth across the carapace. It resembles *Palinurus* in many respects, but differs greatly in others, the most marked difference being in the antennæ. These are short, flat, orbicular, or rather leaflike, organs with strongly serrated edges. Its colour is deep chocolate-brown, the shell is closely and finely sculptured, and the depressions are black, while a scarlet band marks each joint in the abdomen. The eyes are black, set on scarlet stalks, these closely resembling the little scarlet and black beans (*Abrus*) often seen in bottles among the chimney ornaments in the homes of seafaring men.

I have not heard of this species being taken on the English coast, except one or two examples in Cornwall, but it occurs in all the Channel Islands, although I must say that I have had but two specimens, in Jersey. In Guernsey it is frequently taken, and there known to the fishermen as the "Square-faced Lobster."

A curious type of crustacea exists in the *Stomapoda* ("mouth-footed"), the local representative of which is *Squilla desmarestii*. This is about four inches long and three quarters of an inch wide. It is flat, and the

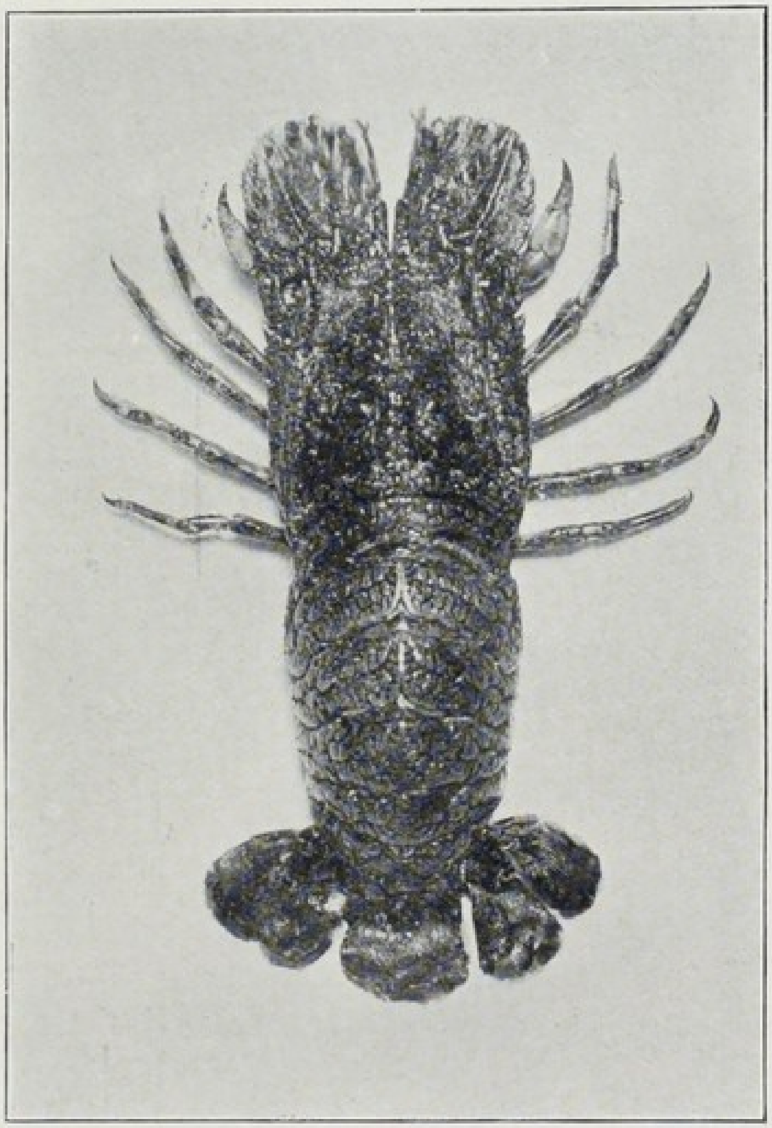


Fig. 56.—*Scyllarus arctus*. $\frac{2}{3}$ Natural size

abdomen widens posteriorly. It is shown in Fig. 57, and the photo of the under side shows the curious arrangement of the anterior feet which gives the name to the division.

It is nominally rare in these latitudes, but this is only owing to its habits. It burrows deeply below the roots of the Zostera at, and beyond, low-tide margin, so that it is pretty well safe from dredge, trawl, or hands.

On one occasion, when a storm, occurring at the time of

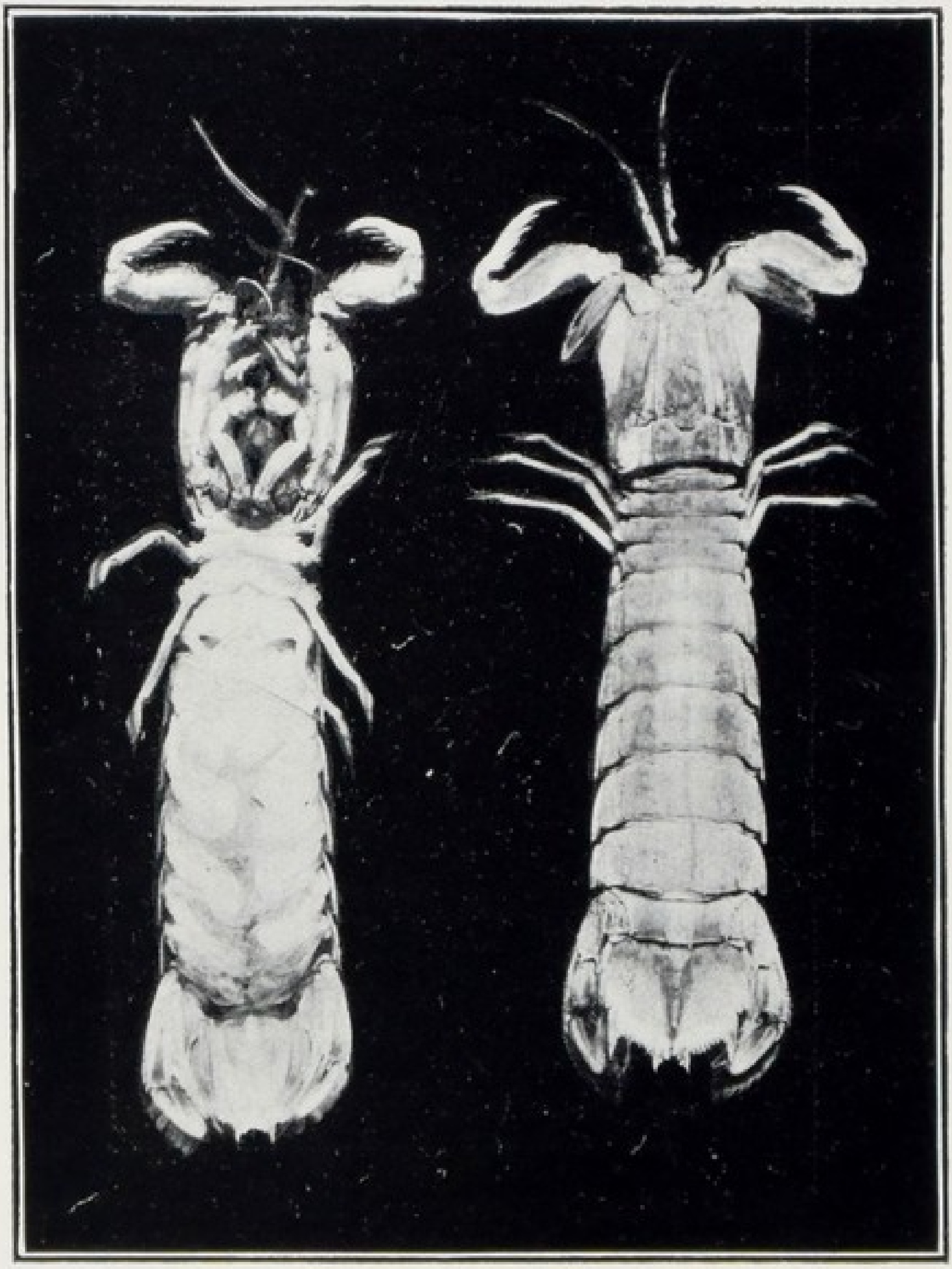


Fig. 57.—*Squilla Desmarestii.* $\frac{2}{3}$ Natural size

a very low spring tide, tore up a large expanse of Zostera beds, squillas were washed on shore on the east coast of Jersey by thousands. (This was in 1881.) Better known than squilla are the *Mysidæ* (or "Opossum Shrimps," or "Fairy Shrimps," as they are often called).

These popular names are very well applied. The first is from the female having a little "brood sac" formed by a peculiar modification of the first pair of swimmarets, in which the young develop until they are nearly of the form of the parent. (A similar arrangement obtains in a totally different class of crustaceans—viz. in *Caprella*.)

The name "Fairy Shrimp" is from their beautiful, almost ethereal, appearance. They are mostly of a translucency which is nearly as clear as the water in which they live, the only coloration being a dorsal row of star-shaped spots of dark pigment. The commonest species is *Mysis chæmaleon*. This is about an inch and a half long, very slender. It is the darkest coloured one, being a faint grey, sometimes inclined to buff.

Mysis Griffithsæ (Bell) is about the same size, but almost crystal clear. There are several other species on our coast, but the nomenclature is so varied and constantly altered that it is difficult to attempt a list. One little species, however, must be alluded to. This is, according to the latest nomenclature, *Mysis* (or *Schizomysis*) *ornata*. It is about half-an-inch long. This one is very abundant in the Channel Islands, and in Jersey its capture is a subject of legislation. It is largely used there as a ground bait in several methods of sea-fishing—*e.g.* in angling for mullet, and in using the "lift net."

The little mysis is caught in quantities by means of large hand nets, salted, and packed in pans.

Many of the poorer fishermen make a part of their none too heavy incomes by this fishery. They collect these mysids, and sell them to anglers at about two shillings per gallon. This compost of pickled specimens is locally known as "Chevrin."

In use it is thrown, a small quantity at a time, in some spot selected by the angler, free from tide run, and mullet and other fish, sniffing the none too agreeable (at least to us) substance from afar, flock to the source of supply, where daintily bait-tipped hooks compete with the "Chevrin" for attention.

A small group of crustaceans which seems to have no abiding city in classification may be introduced here. This is the *Cumacea*.

These are small, elongated forms, the carapace nearly circular and about the size of a large pin's head (common or workbox pin). The tail is slender, about half-an-inch long, and of equal thickness all along.

They are ivory-white. Several species are found on our shores, mostly swimming at the sea surface. Reference will be made to them later on in dealing with the use of the tow net.

The *Anomoura* ("Irregular-tailed").—This division of the crustacea is always described as "transitional between the *Macrura* and the *Brachyura*" ("long-tailed" and "short-tailed" crustaceans), a definition which I so strongly resent that I shall use this opportunity to raise objections to it.

The Anomoura comprises the Hermit Crab, the Galatheas and Porcelain Crabs, the "Stone Crab," and *Dromia*. The type is the common hermit crab.

Pagurus Bernhardus (Fig 58).—This is superlatively abundant on all our shores. A full-grown male measures about three inches in length by three quarters of an inch across the back. Its colour is pale red, one claw always, the right in this genus (no rule obtains in ordinary crustaceans), is much larger than the other. The abdomen is not calcified, but is simply *membraneous* (in some foreign species there are calcified plates marking each segment). The sides of the carapace which cover the gills are also simply membraneous. The last somite or joint, the true "tail," is, however, calcified.

The two last pairs of "walking" legs are aborted in size and form, and are turned up, folded on themselves, over the back. The large claw at the "wrist" bends, hingelike, in

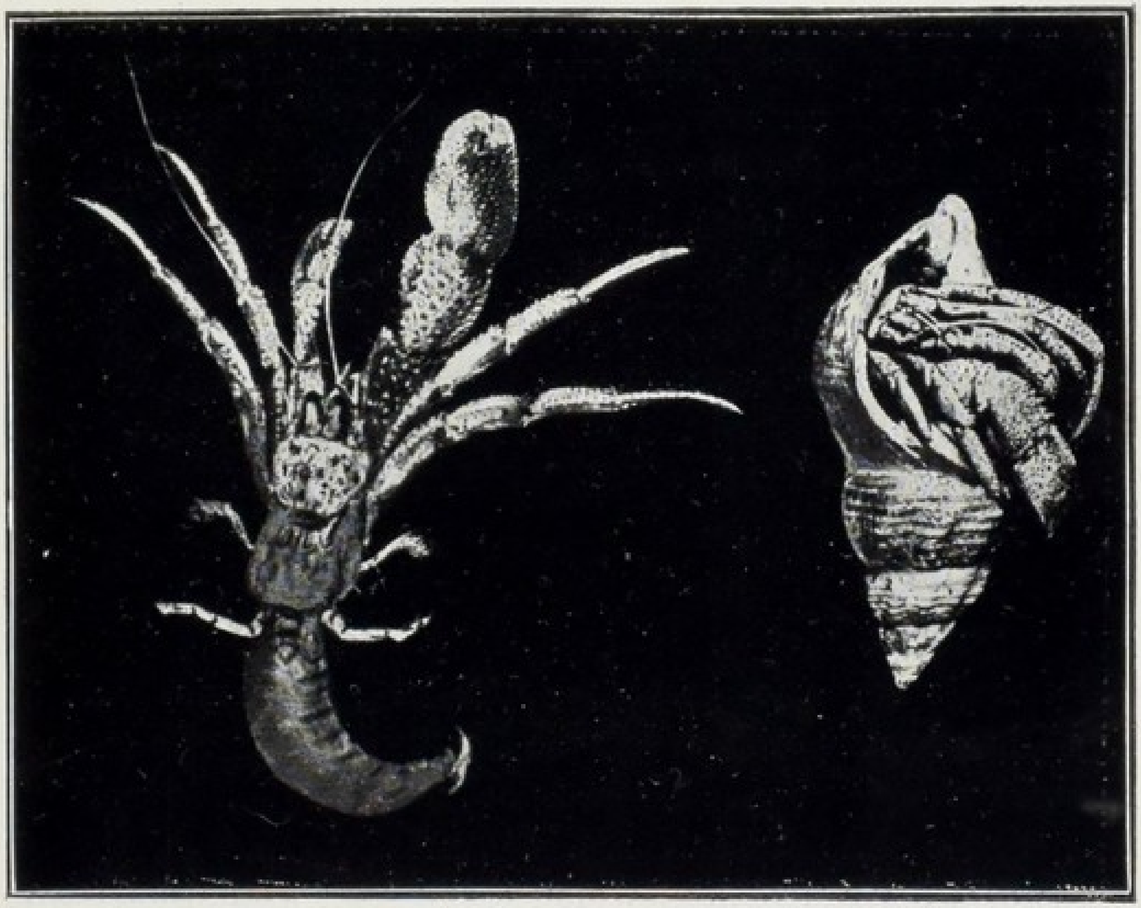


Fig. 58.—The Common Hermit Crab. *Pagurus Bernhardus.* $\frac{2}{3}$ Natural size. Right-hand one ensconced in whelk shell; left-hand one extracted.

a *lateral* direction only; other crustaceans move their claws from this joint in an *upward* and *inward* direction. The abdomen is curled towards the right, so as to fit into the whorl of the shell which the crab makes its home, and the side appendages of the tail or "tail fins," are developed on one side into a hooklike arrangement, so as to hold on to the central part (the *columnella*) of the shell. The termination of the tail (or telson) is jointed, *across* and in median line, which is not usual in ordinary crustaceans.

(I must ask my reader to bear in mind these little details.)

When first the hermit crab develops from the egg it is bilaterally *symmetrical*, like a little shrimp; in fact, it is a little *Macruran*, and it swims freely at the sea surface. Then, when about a quarter of an inch in length, it seeks a shelter, and generally finds one in the cast skin (or "shell") of some small crustacean. (I usually find it inserting its abdomen into the broken cast shell of some amphipod, which, by its lightness, is floating on the sea.)

Soon it sinks to bottom, and seeks some little univalve shell, at first a diminutive one. (This day I have found one in a *Rissoa*, a microscopic shell.) When it has grown too big for this habitation it seeks a larger one, and is frequent in the common "Periwinkle." Finally the shell of the whelk alone will suit it.

Possibly this is what has fixed its size limit: we having no larger univalve shells in sufficient number to furnish tenements for the great number of applicants, and a shell-less hermit crab, unless he has some little advantage in being tougher than his mates, or has some plan of tucking his tender abdomen into security, must perish.

The two pairs of legs which serve for locomotion (two pairs are out of use within the shell) are very largely developed, through their increased use in having to drag about a borrowed shell, and usually an additional burden in the way of an anemone (see Chapter III.).

The hermit crabs are very pugnacious—that is why they are sometimes called "Soldier Crabs"—and fight tremendously. The object of each one's contention being generally the house of his neighbour; and the efforts to pull each other out of house and home is constant.

When one has succeeded in evicting another he slips at once from his own dwelling into the vacated one, the evicted tenant as quickly making it a matter of exchange.

Then the trouble begins again, the new house does not suit, and there is a fight for a return to the original state of affairs. I have kept these crabs, fifty at a time, and always saw trouble on the way. (With a little care these crabs thrive well in aquaria.)

Not so common, but still pretty numerous on our coast, is "the Purple Hermit Crab" (*Pagurus prideauxii*). It is not quite so large as the foregoing, and the shell of a large trochus is usually sufficient accommodation. It frequents deeper water, although pretty constant on the shore. Its claws are not quite so rugose as those of the common species, and the colour is a beautiful pale purple. The anemone that accompanies this one is a different species to that which accompanies the last-named (see "Anemones," Chapter III.).

The "Woolly Hermit" (*Pagurus cuanensis*) is far less common than either of the preceding. It is also smaller, about half the size. It is thickly covered with a coating of hairs, which, examined closely, are seen to be club-shaped, and thick end outwards. These hairs, and their form, serve to hold a plentiful supply of mud or ooze, which helps to conceal their owner. It usually occupies the shell of the murex or the dog whelk, and is found in the neighbourhood of rocks on oozy ground. It is rather rare.

A very small species, not more than half-an-inch long, is sometimes met with on the shore, more often in dredgings. This is *Pagurus Herdmanii*. It is a pretty little thing, with chubby, knob-shaped claws, very smooth, and of ivory whiteness. It is somewhat rare.

Next to the hermits are the "Scaly Lobsters" or "Squat Lobsters" (the *Galatheas*—Fig. 59). They are, as their popular name implies, somewhat on the outlines of the lobster, but more flattened, and the carapace is ridged transversely, scalelike. But their relation to the hermit crabs is at once seen in several details. The hindermost pair of legs is aborted, doubled up, and folded over the back. The under side of the abdomen is membraneous,

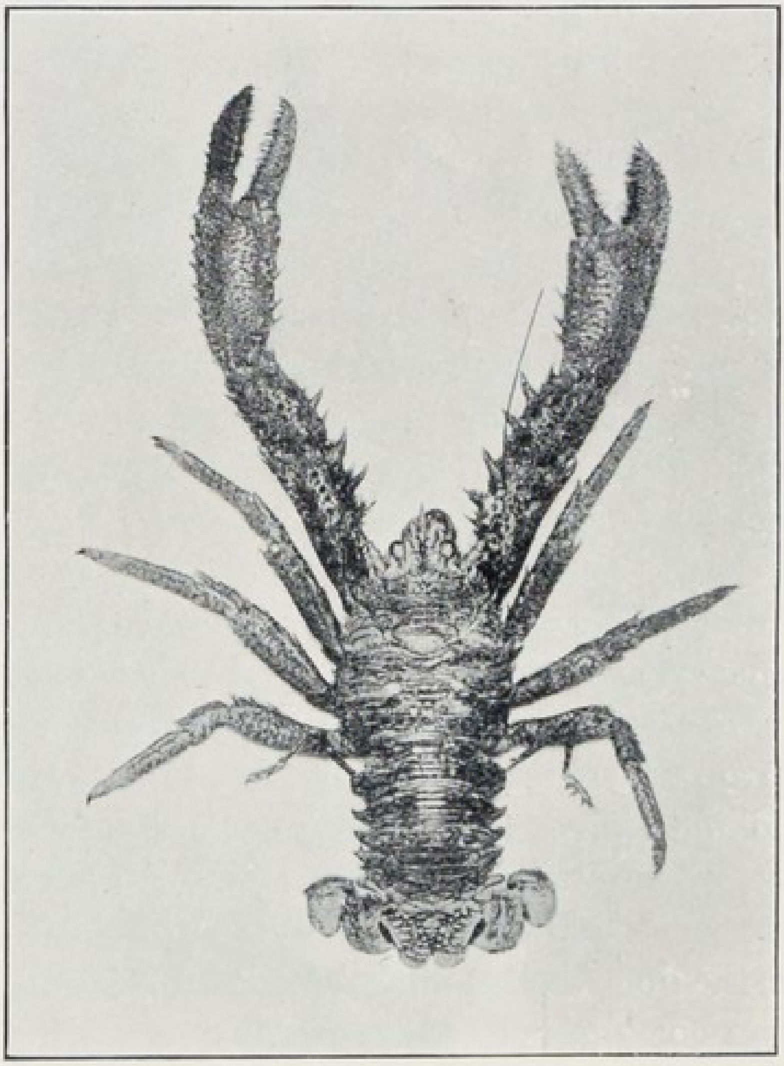


Fig. 59.—*Galathea strigosa*. $\frac{1}{3}$ Natural size

and an examination of the last segment of the abdomen —that is, the "tail"—will show that this is not quite on the plan of that of the lobster, the "telson" or terminal portion being hinged across, and also longitudinally downwards, from that hinge. The large side "fins" are not round, but hooklike, all these points being as in the hermit crab. There are some other points of similarity, but these will be sufficient for our purpose.

The common species on our coast is *Galathea squamifera*. The male is about three inches long by one broad. The claws are long and flat, and beautifully decorated with tubercles and sharp spines. The female is shorter and broader, and the claws are less developed.

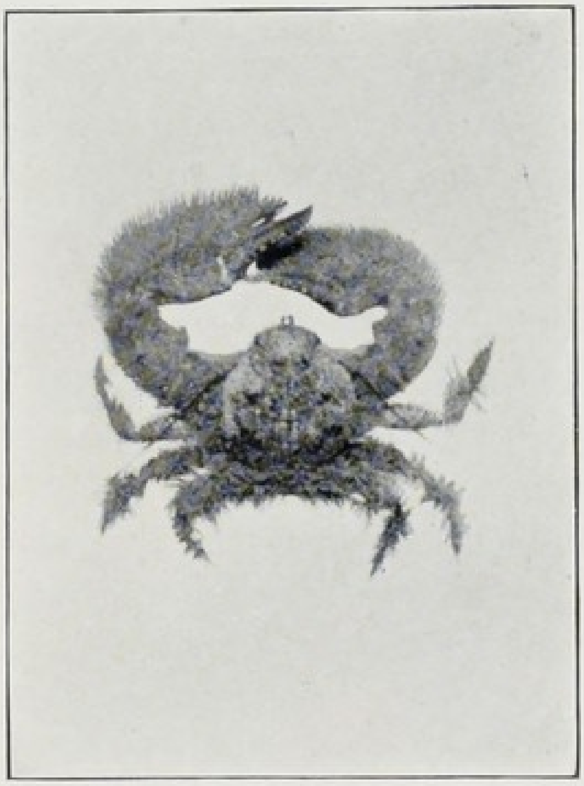


Fig. 60.—*Porcellana platycheles*
Natural size

The shell is highly polished, and ridged transversely, as we have seen. The colour is a dark brown.

It is tolerably common under stones at low-tide level in rocky places.

Galathea strigosa is a gorgeous crustacean, much larger than the last, being about five inches long and about one and a half wide. Its colour is bright red, and the transverse grooves deep blue.

This is found in the same localities as the last, but only rarely, as it really belongs to deep water. It is not infrequently taken in the traps set to catch prawns.

Other species are *Galathea media* and *Galathea nexa*. These are small, and found only in deep water.

The next division of the Anomoura is the *Porcellanidæ* (or "Porcelain Crabs"). The most familiar example is *Porcellana platycheles* (or "Broad Claw"—Fig. 60). This is very abundant under stones from near high-water mark to the lowest zone. The upper surface and all the limbs are thickly covered with a velvetlike coating of hairs, long and fringelike at the outer edge of the claws. It will be noticed that the movable finger of the claws is so shaped that when the crab draws its claws towards the body they fit exactly to the front of the carapace, so that when legs and all are closed in the crab is a circular disc about the size of a penny. The hairs hold mud and ooze, and thus covered it easily escapes detection, even when it leaves its hiding-place and perches against the side of a rock.

We have but two representatives of the genus, the other is the little *Porcellana longicornis*, about as big as a split pea. This one is not velvet coated, but smooth and bright. In colour it varies much: red, brown, white, or green; sometimes mottled with all these colours. It is still more abundant than the last, and found in similar localities.

An examination of the tail of these two last species will show that it is still on the hermit type, only that the side fins are reduced to microscopic dimensions, the porcelain crabs having assumed the general form of the *Brachyura*.

In these, as well as in the species which follows, the vestigiary hind legs are not always visible outwardly, as they have an adaptation for packing them under the hinder edge of the carapace.

Most striking of all the Anomoura is "the Great Stone Crab" (*Lithodes maia*—Fig. 61). At a casual glance the non-naturalistic observer would easily mistake it for the "Great Spider Crab" (*Maia squinado*). A full-grown male measures about seven inches across the carapace, and has a spread of limb about twenty inches. The colour is pink, with a purple shade.

On looking at the under side of a Lithodes, it will be noticed that the abdomen is membraneous, except for some triangular shelly plates (as in some foreign hermit crabs), marking each segment, and that the segments do not follow in line, gradually diminishing in size, as in the true "crabs," but that they run down one side and up the other, following the curve seen in the abdomen of the hermit crab, and that the telson or last segment is touching the first, a true hermit crab tail, only here tucked in under and touch-

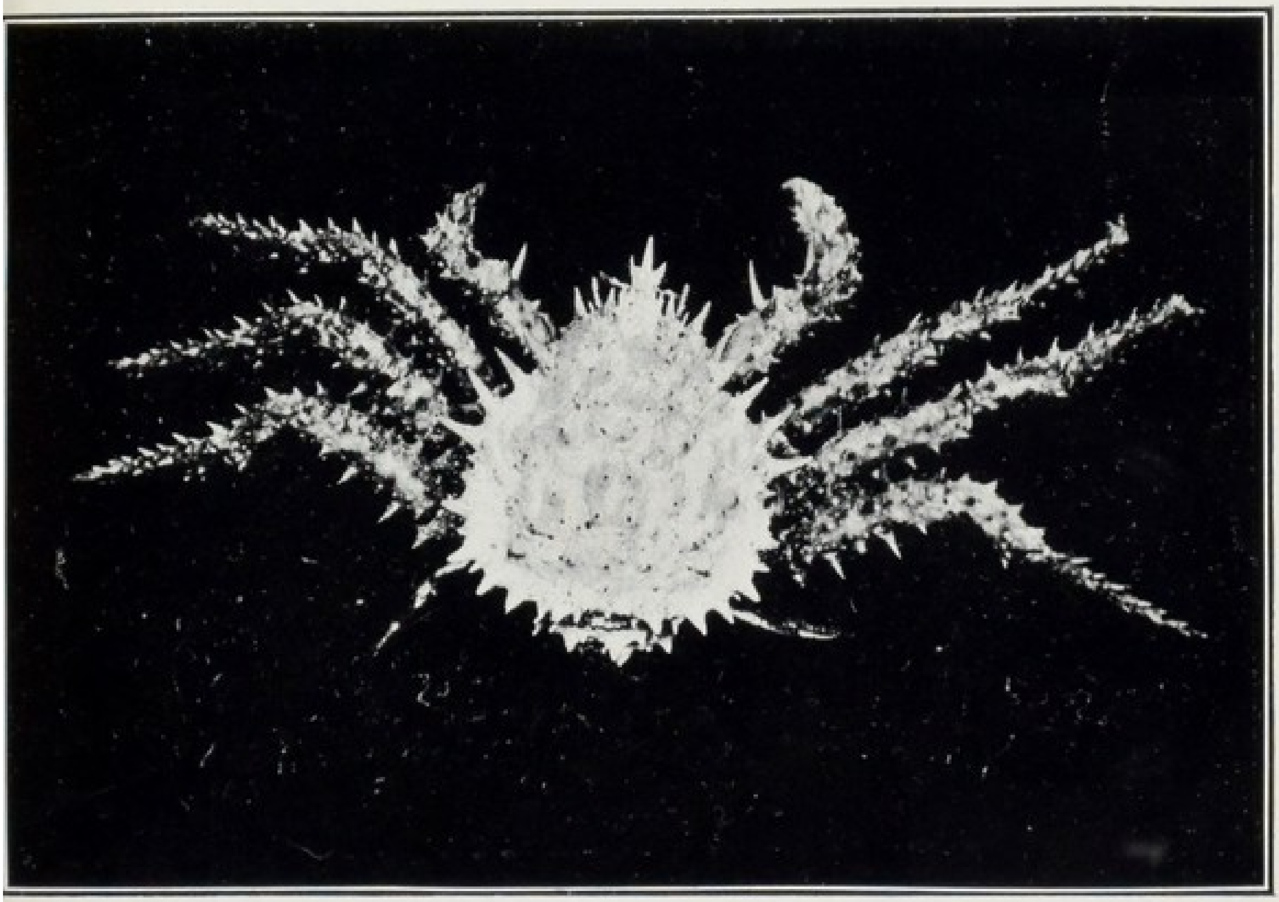


Fig. 61.—Great Stone Crab. *Lithodes maia.* $\frac{1}{5}$ Natural size

ing the sides, now joined with a thin membrane. These peculiarities are best seen in the female.

Last of the Anomoura, and, I think, a doubtful member of the order, is *Dromia vulgaris* ("The Sleeping Crab" —Fig. 62). This is a very peculiar crab. The body is of a roughly oval form, very convex, and knobbed or "knolled", with large bosses. It is thickly clothed with close-set short hairs, wears a regular velvet coat, only the tips of the claws, which are porcelainlike and of a pink colour, projecting, like the tips of fingers from mittens, and the sharp nail on each leg being bare.

The last pair of legs is smaller than the others, but not altered in form, as those of all the preceding, and these are carried turned up over the back of the carapace. Its colour is an even shade of grey or "mouse colour."

When the crab is at rest, and it usually is, all the limbs

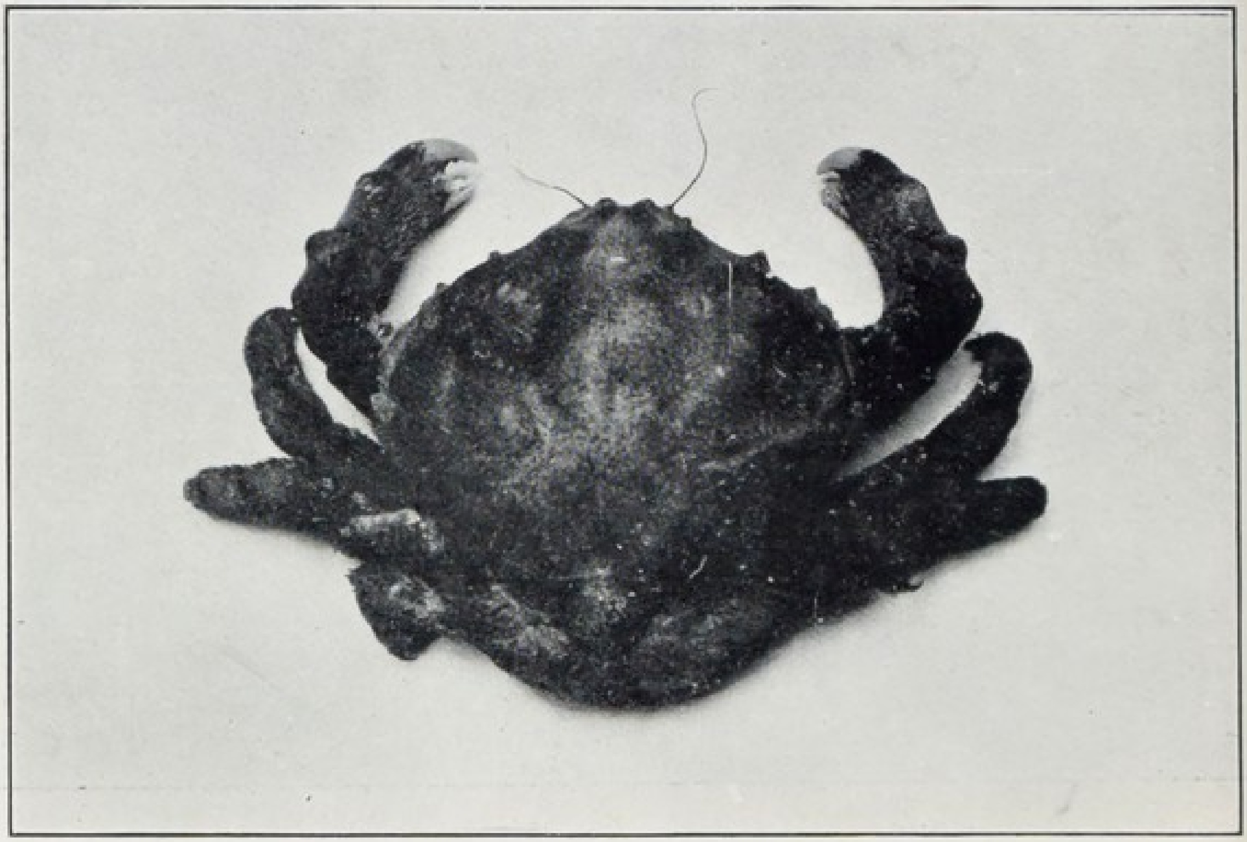


Fig. 62.—*Dromia vulgaris*. ½ Natural size

are packed close to the body, and they are so shaped that they fit each other closely, giving the crab the appearance of a large potato wrapped in velvet. It usually holds some object, generally a sponge, upon its back by means of the sharp, hooked nails of the short pair of legs (none of the preceding have a nail on the abortive legs). Frequently the sponge so held becomes attached to the carapace and grows there.

The size of the male is about three and a half inches broad by two and a quarter in each other direction. It lives on muddy ground, and is not often taken on shores, but is pretty frequently taken by dredge and trawl.

Let us now digress a little, and wander into the fields of deduction, to ascertain, if possible, the place in nature of this division "Anomoura."

Let us go back to *Callianassa* (p. 129), and note its structure, and habit of now and then utilising the burrow of a worm or other animal to protect its tender parts, then postulating tentatively some ancestral form of Callianassa that could not always find burrows to let when it was on ground too hard to tunnel. The next best accommodation they would find would be empty univalve shells. They would force themselves into these. Those that managed this best would have a chance in life, and would transmit to their offspring their plasticity. They would gradually modify their form to suit the new conditions.

"Each fashion of life with reflex forcible action would act on the form," and in the course of time the "Hermit" type would be reached, for the telson would at first bend, then become hinged. The legs that protruded would become large and strong by use, and by having a shell to drag about. Then some of the hermits, yielding to further developments of conditions, would find, no doubt with "Hobson's choice," that a tucking under of the tail and a development of defensive spines, etc., would enable them to live on. Thus the *Lithodes* and *Galathea*, etc., types would be arrived at. So that the anomoura would seem to be, not a form transitional between the long and short tailed crustaceans but a strangely erratic offshoot of the former.

I set this out at length in an illustrated article in *Life Lore* for August 1889, but am told that the same conclusion has been arrived at by some naturalist who has also published the results of his observations. This publication I have not seen, and do not know whether it is antecedent or subsequent to the date above named.

In this, *Dromia* has also been rightly placed with the *Brachyura*—forming a division.

The Brachyura (short-tailed or true crabs).—Before we enter into the consideration of the different species of those that are found on our shores it will be well to survey their development, and the changes which they undergo before they reach the adult form, changes which may almost be likened to the "larva," "pupa," and "imago" stages of insects.

We will take the common shore crab for an example.

At certain seasons, attached to the swimmarets of the female (the swimmarets are the oarlike appendages on the under side of the abdomen, strongly developed in the prawn, lobster, etc., and aborted or modified in the short-tailed crabs), are a large number of eggs, attached also to each other in little clusters by fine threads, the result of the coagulation of a gummy substance which is extruded with them.

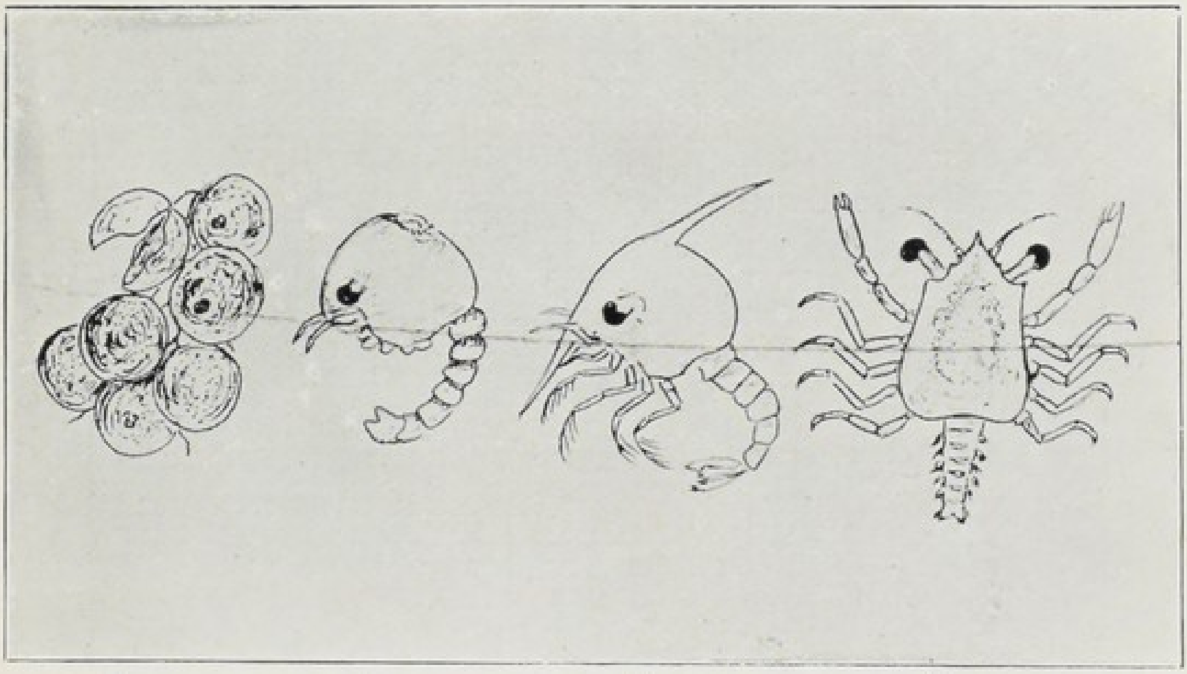
Hatching takes place while the eggs are attached, and the young crabs, in form quite unlike the parent, roll helplessly on the sea bottom for a little while, but they rapidly gain strength, and after a few tentative efforts rise, and swim nimbly away, with little spasmodic jerks.

Little folds of membrane on their back and at their anterior end are pressed from within until they form long spine-like processes and the young (a *Zoea*, it is called) is of the form shown in Fig. 63. It swims nimbly in the sea, usually near the surface, in this form for two or three weeks, feeds greedily and changes its coat repeatedly. Then after a time its spines disappear and it resembles a crustacean of the *Macruran* or long-tailed type, such as the lobster, etc., only it is broader in proportion.

It has exchanged its swimming feet for claws and walking legs, and is now of the form termed a *Megalope*. But it still swims in the open, only it begins to frequent the bottom a little.

Finally it tucks its tail beneath the body and assumes the *Brachyuran* or "short-tailed" true "crab" form (Fig. 64). Its size during these changes ranges from a small o to a capital O in this type.

All the *Brachyura* pass through these stages, only some



A B C D

Fig. 63. — Development of Shore Crab. *A*. Eggs with enclosed larvæ; *B*. just hatched Zoea; *C*. Zoea, 2 to 15 days or so; *D*. *Megalope* stage. *A*, *B*, and *C*, about 20 diameters; *D*, about 10 diameters

differences in slight structural detail marking the different species.

In the *Macrura* (prawn, lobster, etc.) there are not so many changes, the young of these emerging from the egg more or less on the plan of the parent, modification of the various appendages only being needed to complete the form.

There are, however, some exceptions, *e.g.*—in the "craw-fish" (*Palinurus*), etc.—as we have seen.

While on the subject of "Morphology" (study of form) we had better glance over another important matter in crab life. This is the moulting, or change of shell—*Ecdysis* is the term used to express it.

While encased in its firm shell a crab is not seen to *grow*—the shell is a "fixed quantity"—but the crab is growing

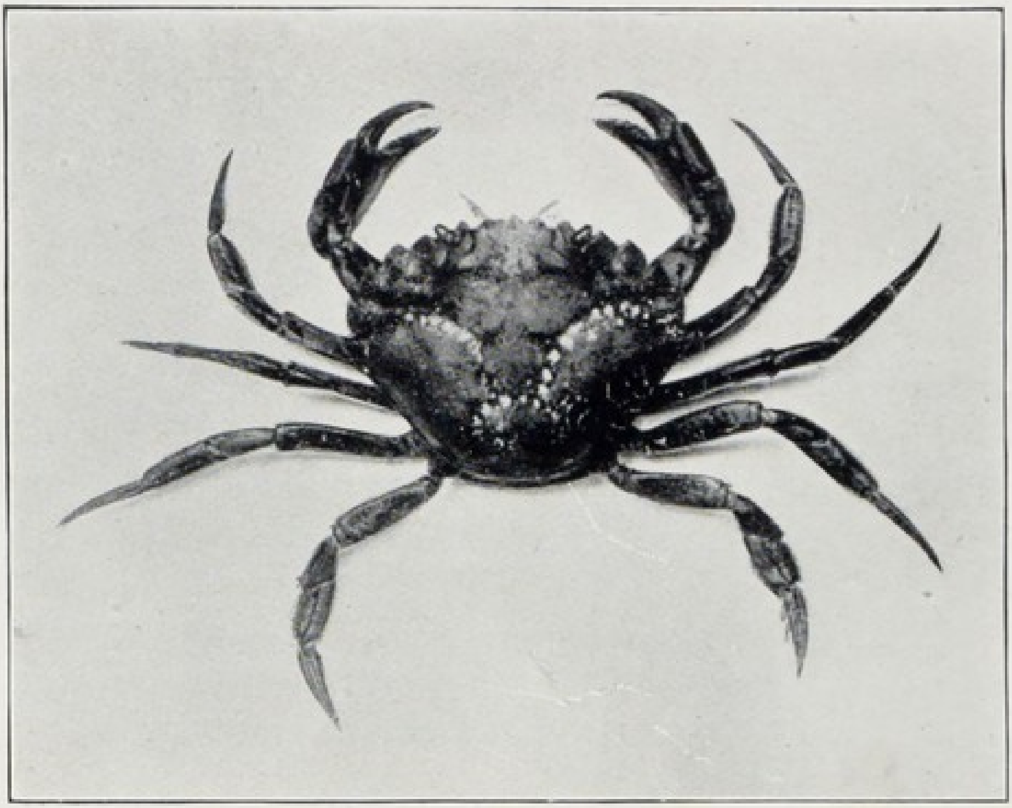


Fig. 64.—Common Shore Crab. $\frac{2}{3}$ Natural size

within, in a state of compression, until, by-and-by, the situation becomes awkward and something must be done. The shell opens at the joint between the carapace and the abdomen or "tail," and the crab, covered only with a leathery skin, and elastic as a bag of jelly, withdraws from its tight jacket, and is about one third larger than this old garment. It seeks a place of shelter, for it is aware of its vulnerability, and remains there, still *growing*, for a day or two, until the cuticle of its skin shall have secreted lime and become a casing in which its owner can face the dangers of the open world once more.

This Ecdysis presents many interesting points. Not only is the external and visible portion—shell of back, tail, legs, antennæ, and eyes—cast off, but with this, and all without severance, the internal shelly parts as well. The covering of the gills, the complicated honeycomblike structure termed the "Endophragmal System," the lining of the stomach, with its internal "teeth" and the blade-like processes which act as tendons in each joint—all are cast, and in the same position as they occupied in life. This is a puzzle in animal mechanics too long to explain here, but which a little thought will show is not so very difficult to unravel, bearing in mind, as a clue, that the internal parts are, as it were, *inward folds* of the outside.

One more curious feature in Ecdysis. If a crab has, some time prior to the process, lost a leg or two, an eye or claw, the emerging form has these in perfection. (This quite independent of the frequent process of the replacement of lost limbs from a bud which appears on the scar.) If a limb gets broken off *just before* the moult I do not know what happens. This I have not seen, and in this book I am nowhere *quoting*, only telling of what I have observed.

Let us get back to the shore crab (*Carcinus mœnas*). We have seen him a *Zoea*, then a *Megalope*, now he has assumed the form of his parents, and is living at the sea-bottom.

This species abounds on all our shores, living from high-water mark to nearly, but not quite, the lowest zone—that is, it is strictly a "littoral" species.

The adult male is about two and a half inches across the back. Its colour is usually olive-green; in some localities it is bright green; in others brownish red, but shades of green are the most frequent. A line of white spots marks the groove, which relates to inward anatomy, and shows in the form of a crown.

But the young crab, after quitting the *Megalope* form, does not take on these colours, but presents features I have nowhere seen commented upon. It mimics its surroundings, like many other things in nature. Those whose lot has fallen on sandy ground are *grey*, or finely

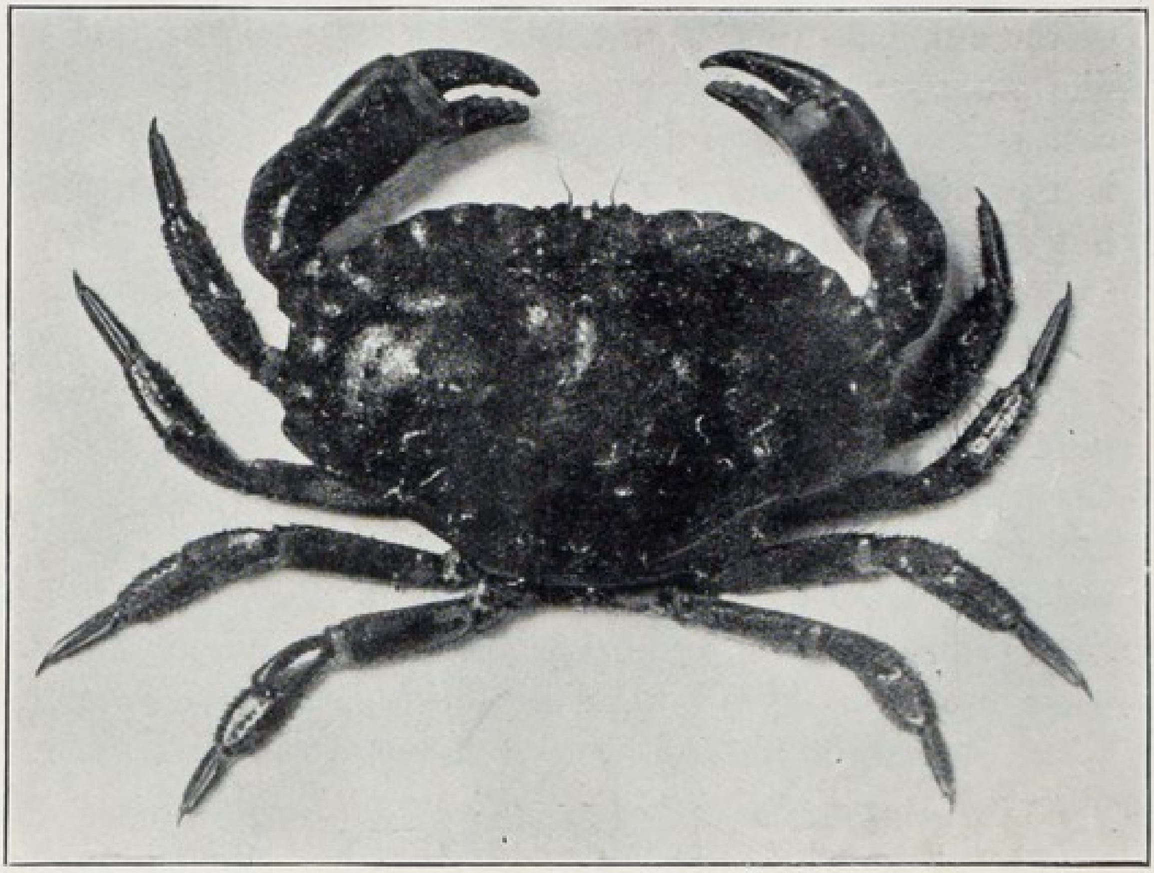


Fig. 65.—Great Edible Crab. *Cancer pagurus.* $\frac{1}{3}$ Adult size

speckled black, buff, and white, usually with a triangular patch in front, broad end between the eyes—this patch *white.* But on other kinds of ground its colours are not the same.

Just in front of me is an area of gravelly bottom, near high-water line. It is composed of fragments of red felspar, white quartz, and black hornblende. The little crabs that are running about on it are spotted and squared, in *red*, *white*, and *black*. There is very great diversity in the arrangement of these colours, in fact *some* few specimens are nearly all over one of these colours, but the great majority are spotted.

Unlike the adults, which seek concealment during the day, these little fellows, from a quarter to half an inch across, scamper about even in full sunshine, although there are enemies about—gulls, curlews, and ring-plovers.

They take on the adult form and seek refuge when they

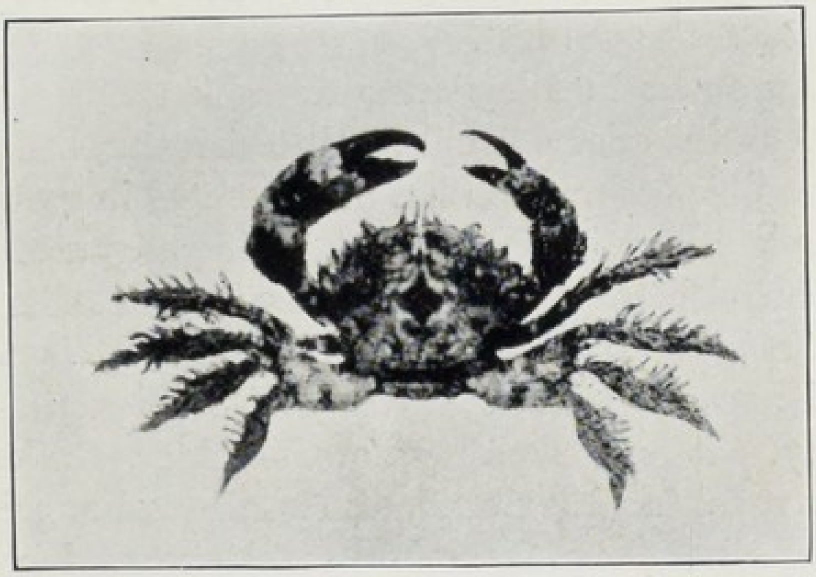


Fig. 66.—*Pilumnus hirtellus*. Natural size

are about three quarters of an inch across, about one year old.

The next crab in evidence is *Cancer pagurus* (Fig. 65—the "Great Edible Crab") but only the young ones, up to three or four inches broad, live in the littoral zone. The adults are far away, in deep water.

The male grows to a large size, sometimes a foot across the carapace, and the claws in the male are hugely developed. The female is smaller, more convex, and less powerfully armed, and the abdomen or "tail" is, as in all crustaceans, broader.

When first the young have quitted the megalope form they are white, but soon take on the characteristic red brown of the adult.

Adult females come to shore from the deep water at the "spawning" time (generally October), and may then often be found partially buried in shell gravel, chiefly near rocks.

Closely resembling the edible crab in general outline and in colour, in fact, in every way except in size, *convexity* of the back, and the possession of some stiff hairs on the carapace, is a splendid little fellow named *Pilumnus hirtellus*. It is shown of its natural size (Fig. 66). It frequents the same localities as the last.

Another genus that has some resemblance to the edible crab is *Xantho*. Some people, even fishermen, believe that it is the edible crab, which has been stunted in growth, and become old and wrinkled without having advanced in size. The French fishermen term it "*Le Crabe Druine*" and "*Le Vieux Crabe*" ("withered" and "old"). It is a robust form, the species termed *Xantho florida* (Figs. 67 and 68) especially. It is brownish yellow in colour, the carapace strongly rugose and knobbed, also more quadrangular than in the species above named. Its claws are largely developed, and have tremendous pinching power (this last is strongly impressed upon me). The size of the adult male is about three inches across.

Xantho rivulosa is less "fossil-looking," smaller, less convex and rugose, and the colour is cream-yellow, with purple marbling. Both these species occur under stones, in rocky situations, rather low down in tide range. Neither is common, but yet cannot be said to be rare.

The so-called "Swimming Crabs" (*Portunidæ*) are represented on our shores by numerous species.

The one usually taken as the type is *Portunus puber*, the "Velvet Fiddler," the "Lady Crab," etc. (Fig. 69), of different districts.

It is a beautiful crustacean, of graceful and decided form,

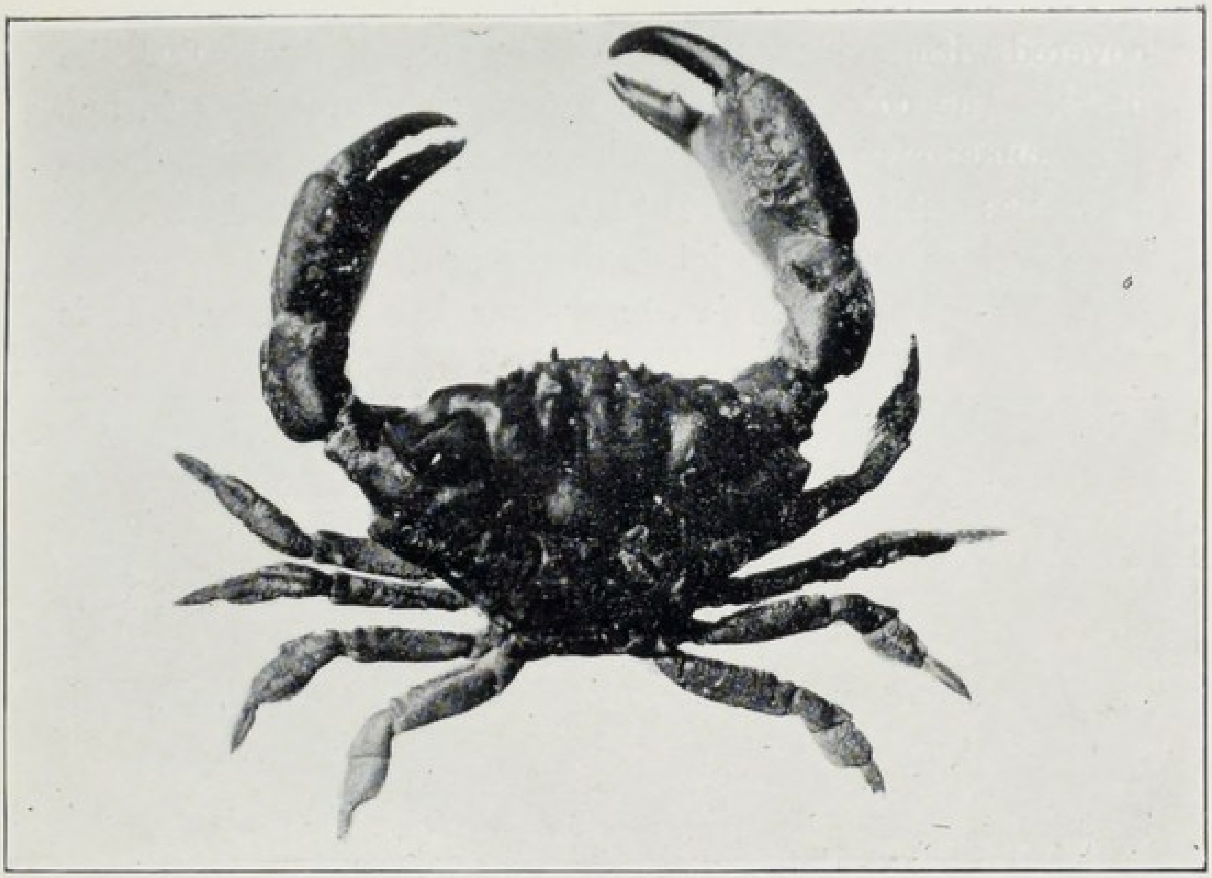


Fig. 67.—*Xantho florida.* Male. $\frac{2}{3}$ Natural size

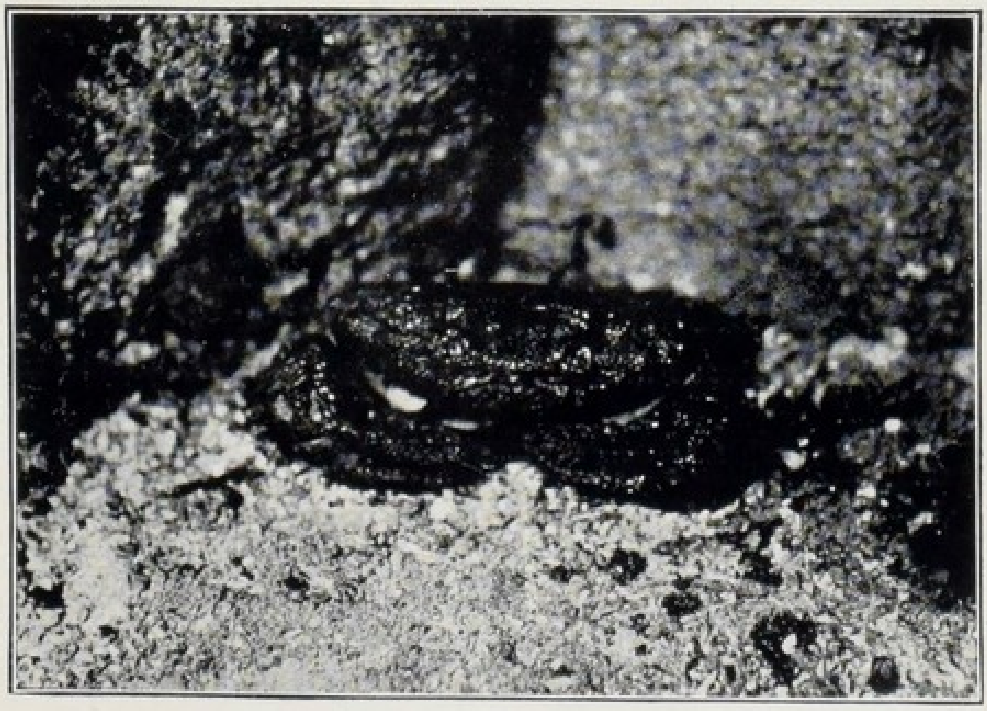


Fig. 68.—*Xantho florida.* Female, at home. $\frac{2}{3}$ Natural size

covered with a close, although thin, coat of fine, velvetlike hairs. The colour is purple brown as a groundwork, but the numerous projecting ridges, tubercles, and spinous processes with which it is plentifully beset, are dark blue. Scarlet lines mark the joints in the armour.

A full-grown male is about four inches across. It is

Fig. 69.—"Velvet Fiddler." *Portunus puber.* $\frac{1}{3}$ Natural size

active and pugnacious, fighting furiously when on the point of being captured.

The French fishermen call it "*Le Crabe Enragé*," which term reads freely as it stands, in English, and this well describes its temperament.

The shell is not so solid as in those we have been surveying: the latter depend chiefly on their defensive armour for protection, but Portunus trusts to his weapons, and his skill in their use.

Closely allied, but of smaller size, and less velvety, the shell finely sculptured with waved lines, and of uniform red colour, is *Portunus corrugatus*.

Portunus depurator and *Portunus holsatus* resemble these, but are of rather smaller size than the last, and are not of striking colours, being simply of a yellowish brown.

Portunus marmoreus is a beautiful representative of this genus. It is about as large as the last—that is, about two and a half inches across the back. It is on the same lines of structure, but is of a cream-colour, with a marbling of light purple. It is rather rare.

Portunus arctuatus, about an inch across, is told at a glance, by its having the front of the carapace, the part between the eyes, in smooth arched form ; the others are in several angles, and spined. Its colour is yellowish, with a black and white chequering on the first ring of the abdomen.

Portunus pusillus, the pigmy of the race, is about three-quarters of an inch across. Its colour is reddish brown. The two first named of this genus are found, the first commonly, the latter rarely, under stones in rocky places. All the others frequent open ground in shell-gravel bottom, and bury just beneath the surface for concealment.

Allied to this genus is *Portumnus variegatus*. This one is of different outline, being a little longer than broad. It is about an inch across. The colour is yellowish white, sometimes pure white, finely speckled with black. It frequents sandy shores, and is not common.

Last of the swimming crabs, and in fact the only one that does swim, in the sense of leaving ground and travelling any distance through water, is *Polybius Henslowii* (Fig. 70). This is a beautiful form, with a circular carapace, very flat and smooth, about two inches in diameter.

The colour in Channel Island specimens is dark slate-blue, with iridescent reflections, very like what is termed "smoked mother-of-pearl." I have not seen specimens from more northern districts, but am told that they are pink or pinkish brown.

Museum specimens do not retain the colour properly, so I have not been able to compare rightly.

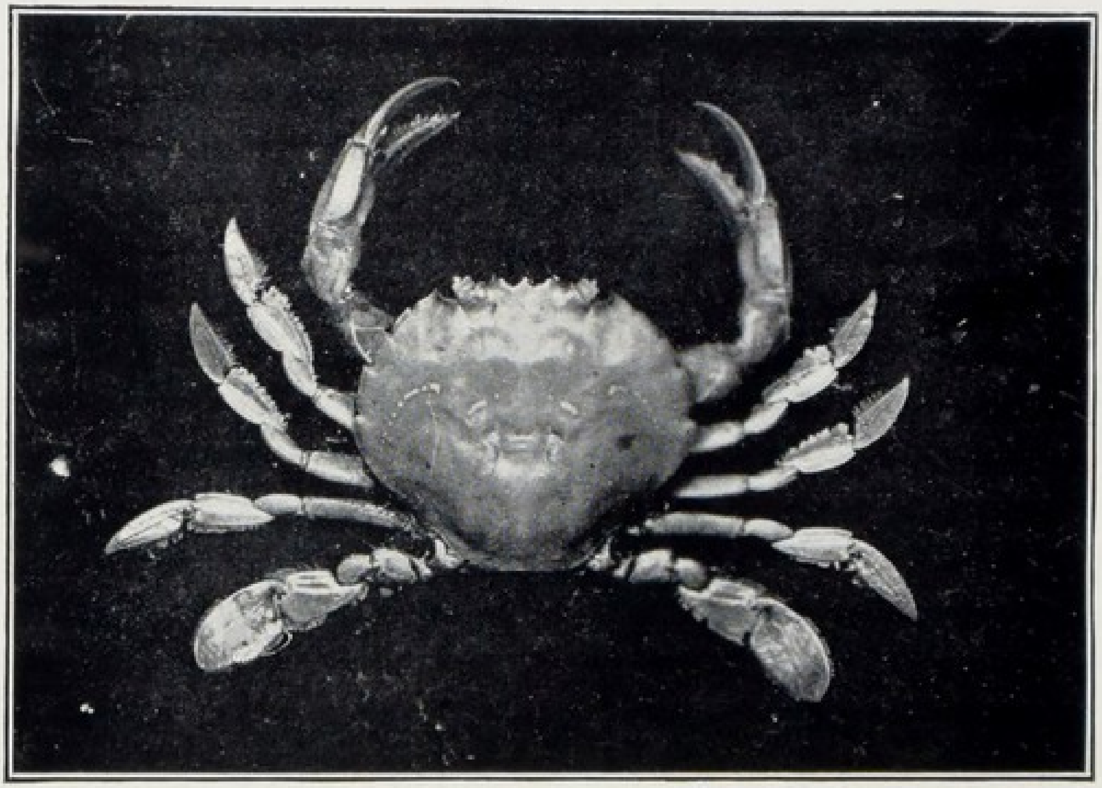


Fig. 70.—*Polybius Henslowii.* ⅔ Natural size

This one has the two posterior pairs of legs flattened out into oval-bladed paddles. The preceding species have only the last pair so modified, and in much less degree.

This species is often taken in mackerel nets, and is frequently found stranded on the shore.

There is a beautiful little crab which is often classed with the *Portunidæ*, but which is without their most characteristic feature—the flattened feet—and whose general outline is more nearly that of the common shore crab.

It is named *Pirimela denticulata.* It measures about half-an-inch across the back, and the sides and front of its carapace are armed with strong and sharp denticulations (hence its specific name). Its colour is olive-green, with

Fig. 71.—*Corystes cassivelaunus.* Male. $\frac{2}{3}$ Natural size

red and white markings. It is considered very rare, but this is owing to its habits ; for, as a matter of fact, it is fairly numerous. It buries itself just below the surface of shell gravel, where there is such in crevices at the foot of rocks at the lowest tide zone, and here, of course, readily escapes detection, except by the experienced shore hunter.

A little group of crabs that live on open shores and bury in the sand for protection is named the *Corystidæ*.

Its representative is *Corystes cassivelaunus*, sometimes called the "Masked Crab" (Fig. 71).

This species has an oval body, about an inch broad, and about the same in thickness, and about one and a half inches long—an unusual proportion in the short-tailed crabs. It has long, straight, feathery antennæ. In the male the claws are long and straight, in the female shorter and incurved. Its colour is greyish white. It may often be found buried in the sand, with just its antennæ and claw tips projecting.

Fig. 72
Thia polita. $\frac{2}{3}$ Natural size

Atelicyclus heterodon is a species with a circular shell, about an inch and a half in diameter. The edges of the carapace are strongly toothed, and this part, as well as the limbs, is furnished with hairs. The colour is pink. It is less common than the preceding.

The most curious and beautiful of these sand crabs is *Thia polita* (Fig. 72). This crab, which is only an inch across the carapace, is ivory-white, delicately spotted with pink. The shell is highly polished. Its shape is peculiar: the shell of the carapace being rounded in one direction only, from side to side.

It has, I believe, no popular name, beyond the precincts of this household, where the junior members have termed it the "Thumb-nail Crab," a name which well describes its form.

The arched front of the carapace has a projecting and even fringe of fine silky hairs, of a golden yellow.

Its habitat is fine white sand at extreme low-tide level, where it may be discovered by watching the first return of the tide, when it issues from its hiding.

The angular crab (*Gonoplax angulata*), of red colour and quadrangular body, belongs to this family, but is not

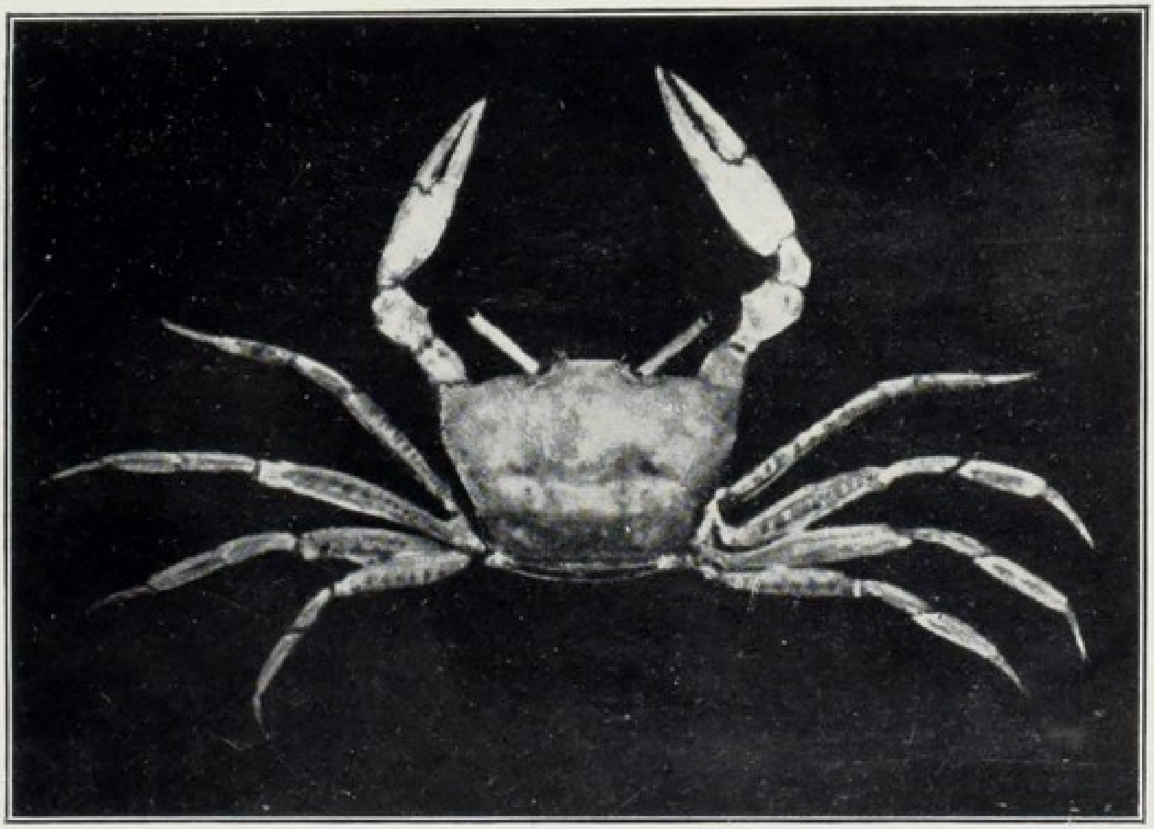


Fig. 73.—*Gonoplax angulata*. ⅔ Natural size

common, at least on this shore, as I have seen but two specimens (Fig. 73).

I am taking the crabs in irregular order as regards the usual routine, but have not pledged myself to system; in fact, those which follow are usually placed at the beginning of the list. These are the "Spider Crabs." They (in Claus) constitute the family *Oxyrhyncha* (not *Oxyrhynchus*, which is a family of fishes). They are so termed on account of their having a sharp, beaklike process in front, either single or forked (Gr., "acute," "beak"). They are divided into the *Leptopodiadæ* (slender-legged) and the *Maidæ*. Let us take first the *Maidæ*. The largest and best known of these is the common "Spider Crab" (*Maia squinado*). The full-grown male is seven or eight inches across the carapace, which is rounded in all directions except towards the front, which assumes a conical outline. The claws in the male are very long, and these and the legs cover an expanse of twenty-four inches. The female is smaller, and the claws much less developed.

The carapace is thickly studded with stout spines and rounded tubercles, and both carapace and limbs (not the claws) are densely covered with short, sharp bristles, mostly in the form of hooks. The fingers of the claws are smooth and rounded (without serrations, as in all other crustaceans). The colour is reddish brown with a shade of purple. (The bristles in adult males are usually rubbed off.)

It is very abundant on all our shores. In the winter it frequents deep water, but in April and May it comes in-shore, chiefly in such places as are covered with sea-grass, among the luxuriant growths of which it conceals itself during the day.

On the Continent and in the Channel Islands this species is largely used as food; tons at a time may frequently be seen in the Jersey markets.

They are taken in baited wicker "pots," also on the shore, by a method that perhaps will not commend itself to the sea-side visitor. The shore fisher walks, barefooted, in the shallows, and gropes with his toes for his coveted crabs, the presence of which is ascertained usually by a puncture of the fisher's skin by the sharp spines. The crab is a passive resister, and never attempts defence after the manner of crabs in general.

The females and young males are usually thickly covered with scraps of sea-weed caught in the hooklike bristles, and the question has often been discussed as to whether these are hooked on by accident, or purposely placed by the crab.

The answer is by both methods. As the crab crawls among weeds, bits, of course, do get hooked on, but there is constant attention on its part to the completeness of this disguise, and the tips of the claws are nearly always busy picking up and attaching fragments, and this is done with much care and deliberation.

It may have been noticed, or may henceforth be, that in this family the claws are so curved that their tips can reach any part of the back, this affording an accomplishment not possessed by any other crustaceans.

In the absence of sea-weeds these crabs bury in shell-gravel or loose shingle, to the level of the edge of the carapace, then pile material on their backs.

Captive specimens in the aquarium of the Biological Station at Jersey were very amusing in this respect. The bottom of their tank was shingle, into which they would half bury themselves. Then, carefully, a claw would reach out for a little pebble, which would be placed on the back, the spines keeping it from slipping, then there would be a pause, to ascertain if all was right ; if the stone slipped a little it was gently pushed or lightly tapped until it was safe ; then more stones would be added, until a pile a couple of inches each way was formed. Then, as a rule, the lot would topple over, and the work would recommence with a display of very enviable patience.

The crab's attempts to keep the body perfectly steady while the claws were at work were exceedingly ludicrous. This species is shown in Figs. 74 and 75.

Closely allied to *Maia* is the " Four-horned Spider Crab " (*Pisa tetraodon*—Figs. 76 and 77). This is smaller, more rounded, and less spiny. The male is about an inch and a half across. The claws are largely developed in the male,

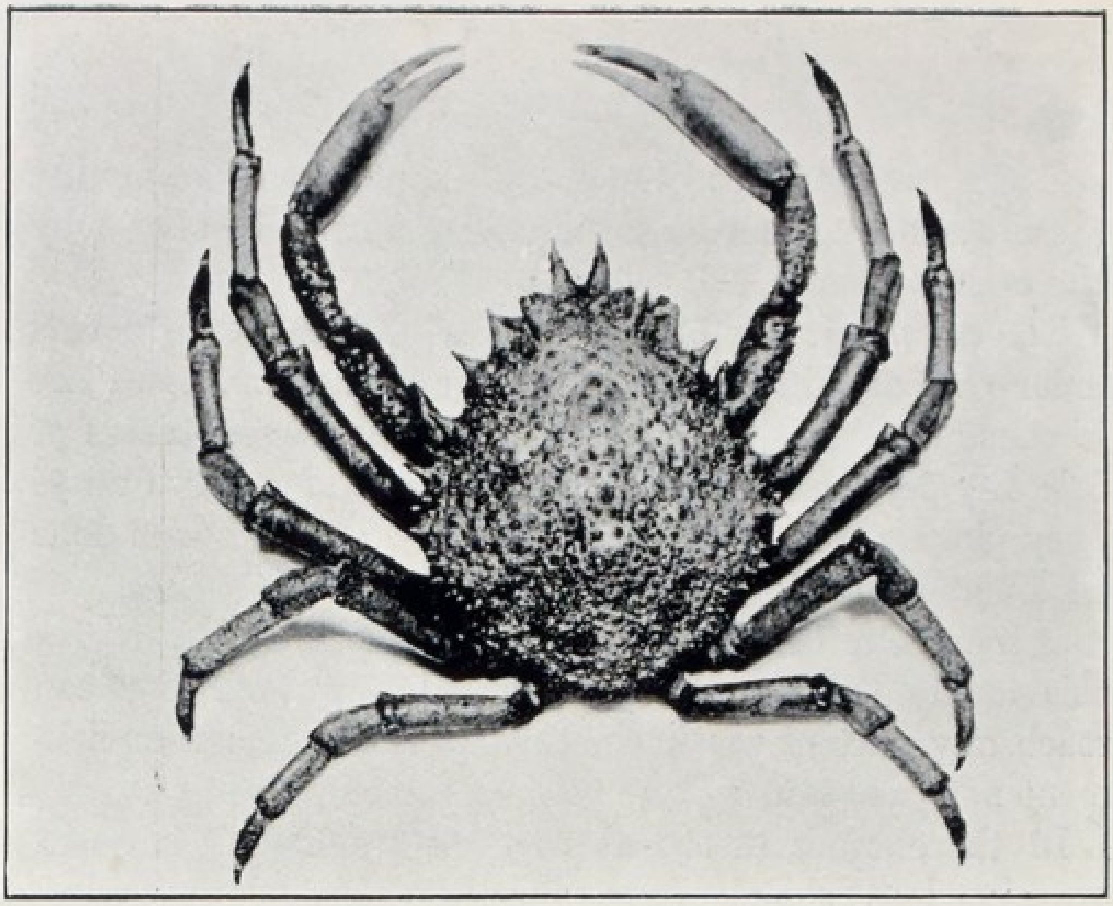


Fig. 74.—Adult Male. *Maia squinado.* $\frac{1}{5}$ Natural size

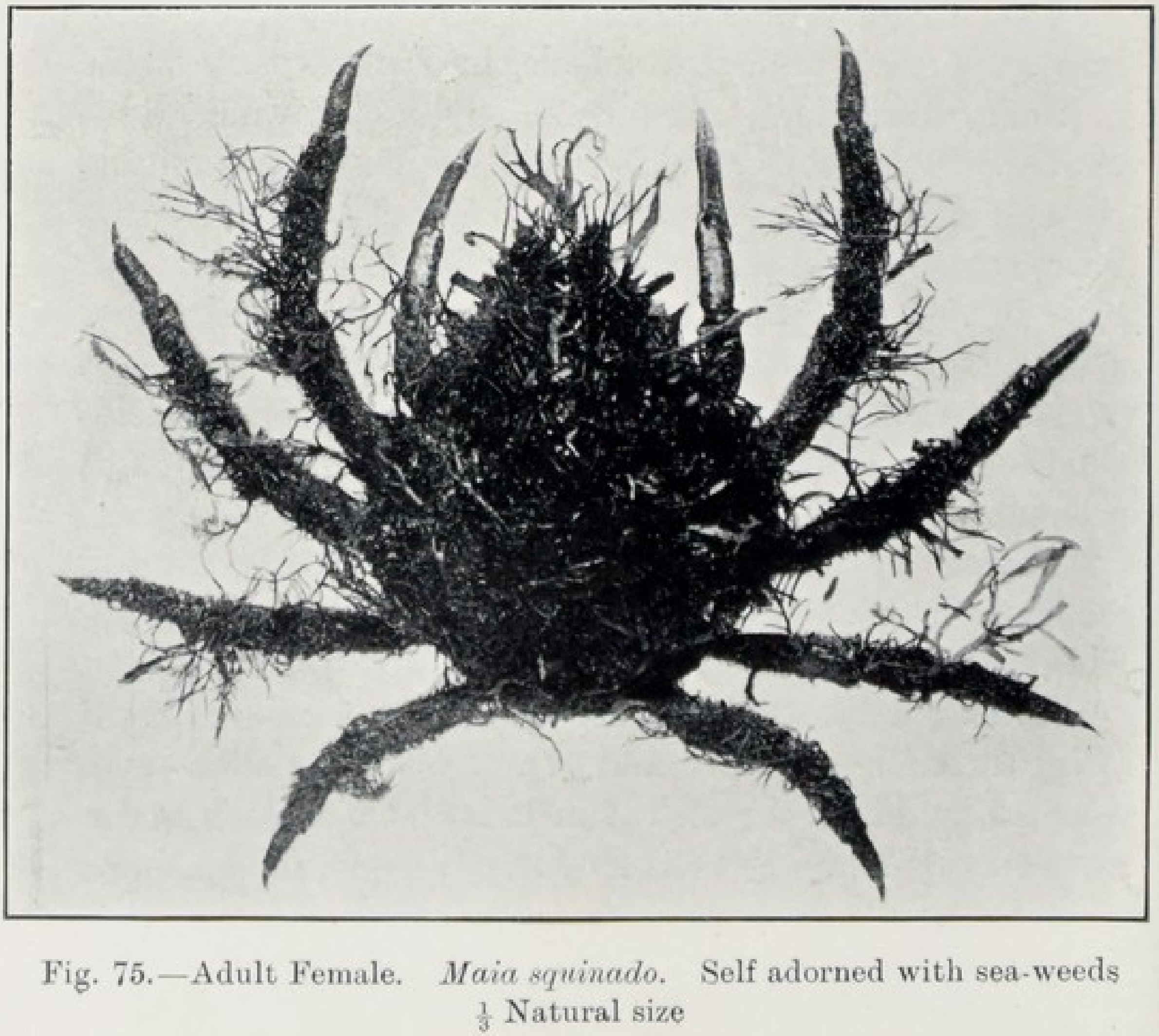


Fig. 75.—Adult Female. *Maia squinado.* Self adorned with sea-weeds $\frac{1}{3}$ Natural size

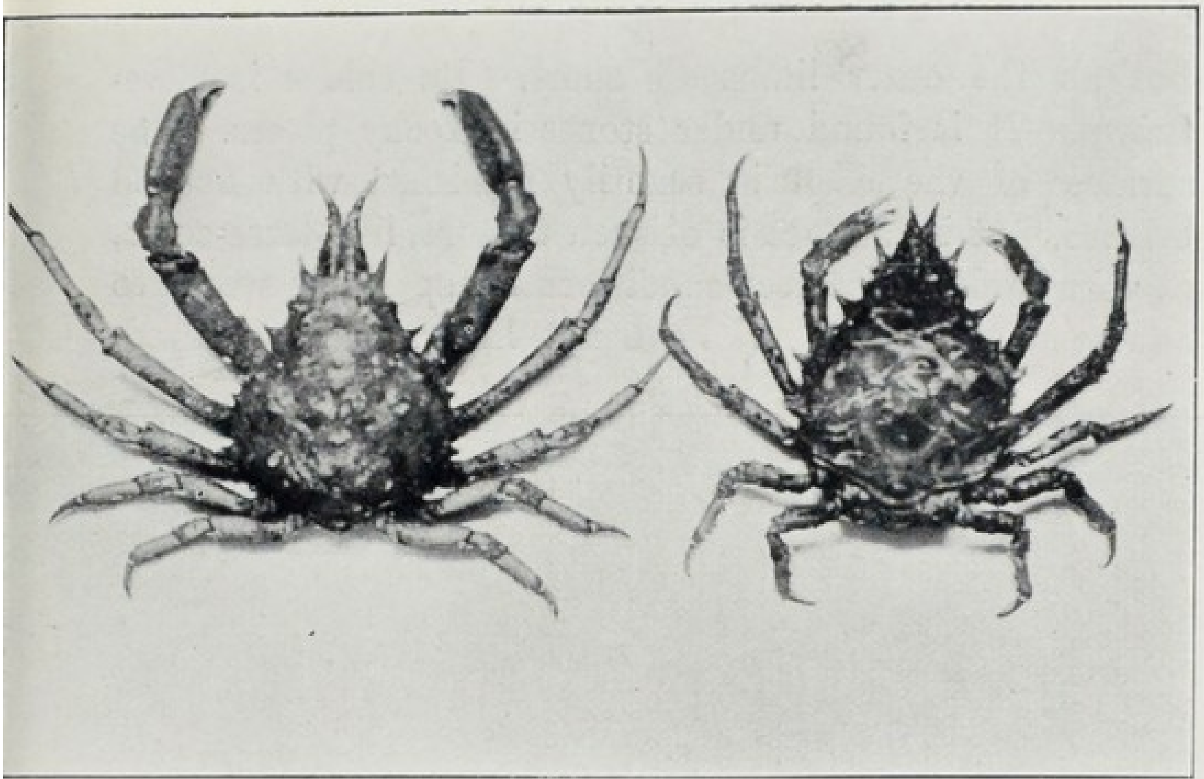


Fig. 76.—*Pisa tetraodon.* Male and Female. ½ Natural size

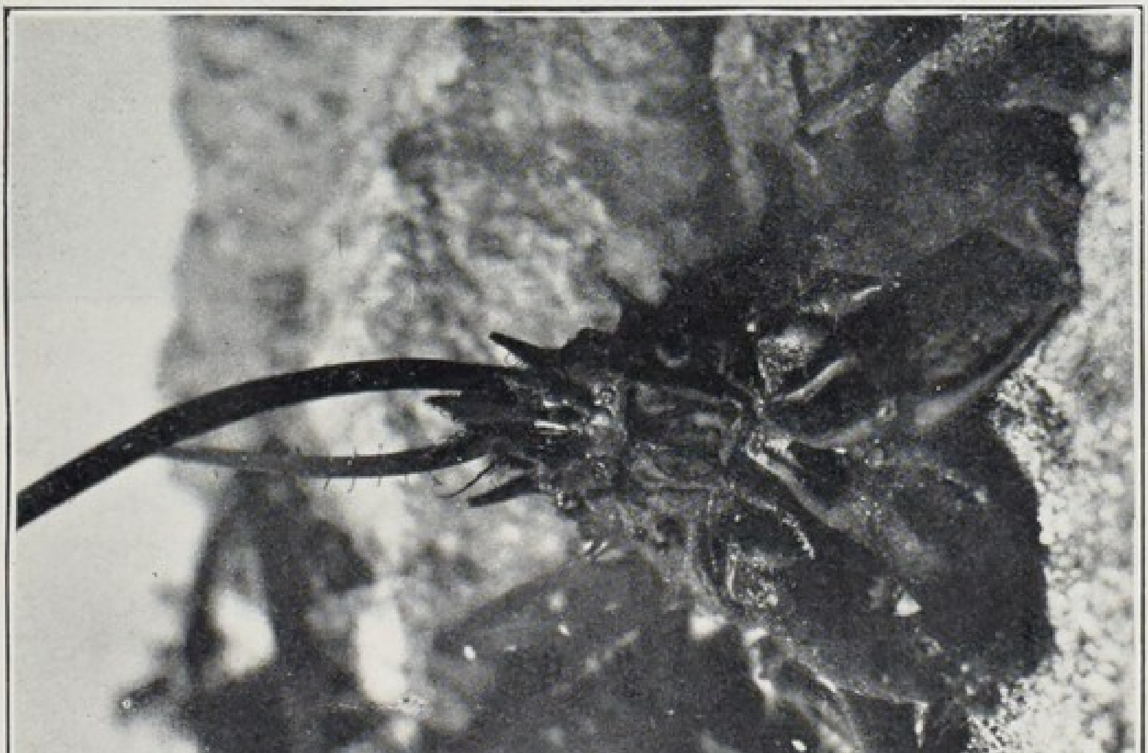


Fig. 77.—An Adult Male, *Pisa tetraodon*, that has fixed two blades of Zostera to its rostrum, and is sitting in the open. Natural size

but all the other limbs are short. Its colour is olive-brown. It is found under stones in rocky places. The surface of the shell is scantily furnished with hooked bristles, but its surface is of such texture, like terra-cotta, as to afford the correct conditions for spores of weeds to adhere and develop. (I have not known this observed,

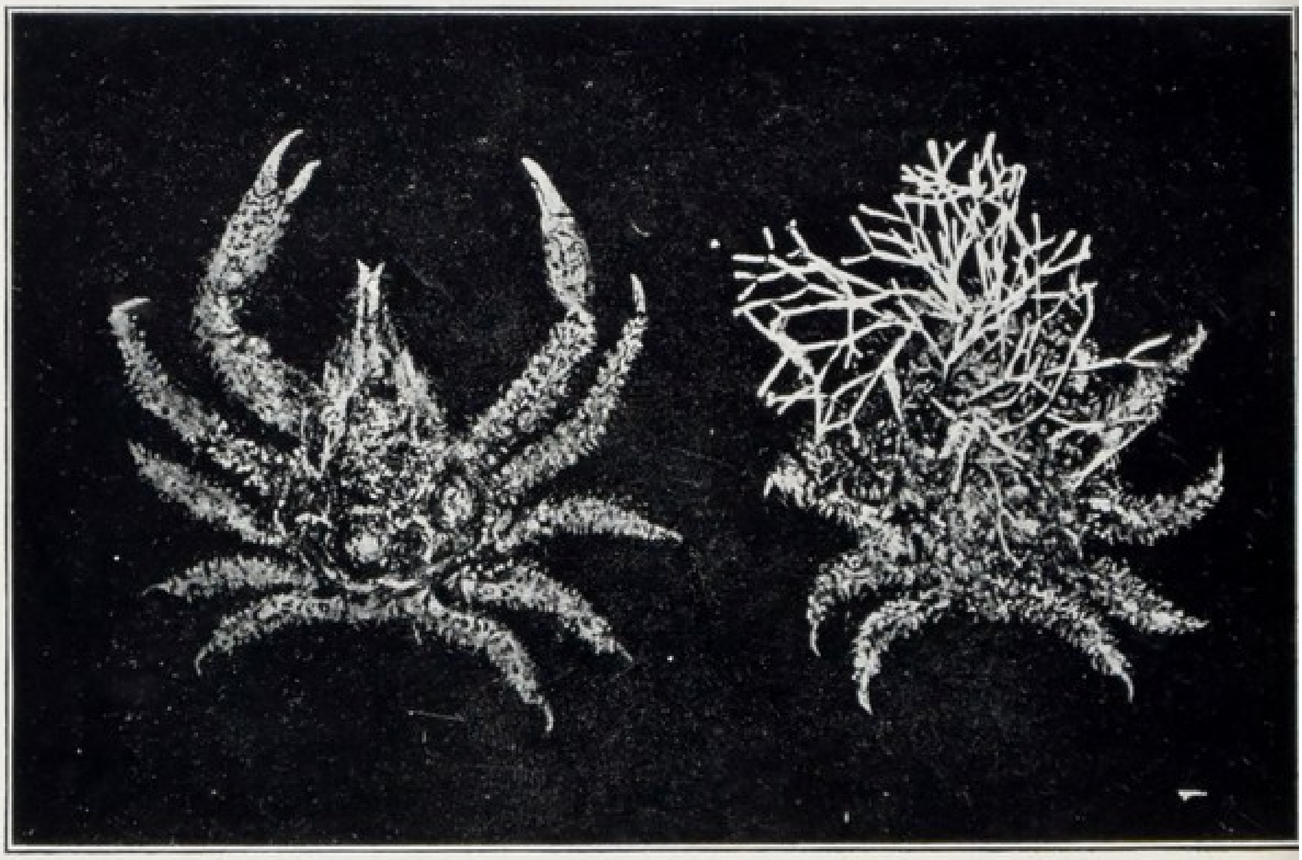


Fig. 78.—*Pisa Gibbsii*. Male and Female. The latter is decorated with branches of Polyzoa. Natural size

but the same thing obtains in another genus (*Inachus*), which does not decorate itself, but upon which sponges, ascidians, etc., are always found growing.)

Pisa Gibbsii (Fig. 78) is a species that is often found in the littoral, in the same situations as the last—viz. under stones in rocky districts—although it pertains to deeper water. It has a general resemblance to the last, but is more angular, and the back is covered with a fine coating of short hairs, very closely set, looking exactly like a good quality thick-piled velvet. The back is also raised into a number of conelike processes, touching at their bases, in symmetrical pattern. It is a very beautiful crab. The usual colour is a light brown or buff, but I have had specimens of a uniform deep crimson.

Still in the *Maidæ* are two forms found in deep water, rarely on shore. These are *Hyas araneus* and *Hyas-coarctatus*. These are without hairs, and the spinous processes are fewer. The lateral spines are flat, and projecting forward. The first-named is about two inches across the back, the last is about half this size. They are of brick-red colour.

Eurynome aspera is a peculiar member of the same family. It is only about half-an-inch across, without hairs or spines, but very angular, and closely tuberculated, as if it were built up of grains of gravel cemented together. Its colour is grey, with red dots. It is found among corallines low down in the littoral, and in deep water.

The "slender-legged" forms (*Leptopodiadæ*) are represented on our shores by several species; *Stenorhynchus rostratus* is the best-known one. In this the body is triangular, about three-quarters of an inch long; the limbs very long and slender; the rostrum prolonged into a simple sharp point, and the limbs very long and slender. The crab with legs extended measures about four inches across. *Stenorhynchus phalangium*, like the above, but with a shorter and more obtusely pointed beak, is equally common.

A species which is considered rare, but which here is far more abundant than either of the foregoing, is *Stenorhynchus Egyptius* (Fig. 79). This is a beautiful form, very delicately fashioned, and with the rostrum long, down curved, and in two parts, which terminate in front in one sharp point. This one is plentifully covered with hooked hairs, and works continuously at trimming itself. It is very interesting to watch this operation. The tips of the claws are small and delicately pointed, and with these little bits of weed are gently picked up and carefully set in position; never more gracefully did taper fingers affix a

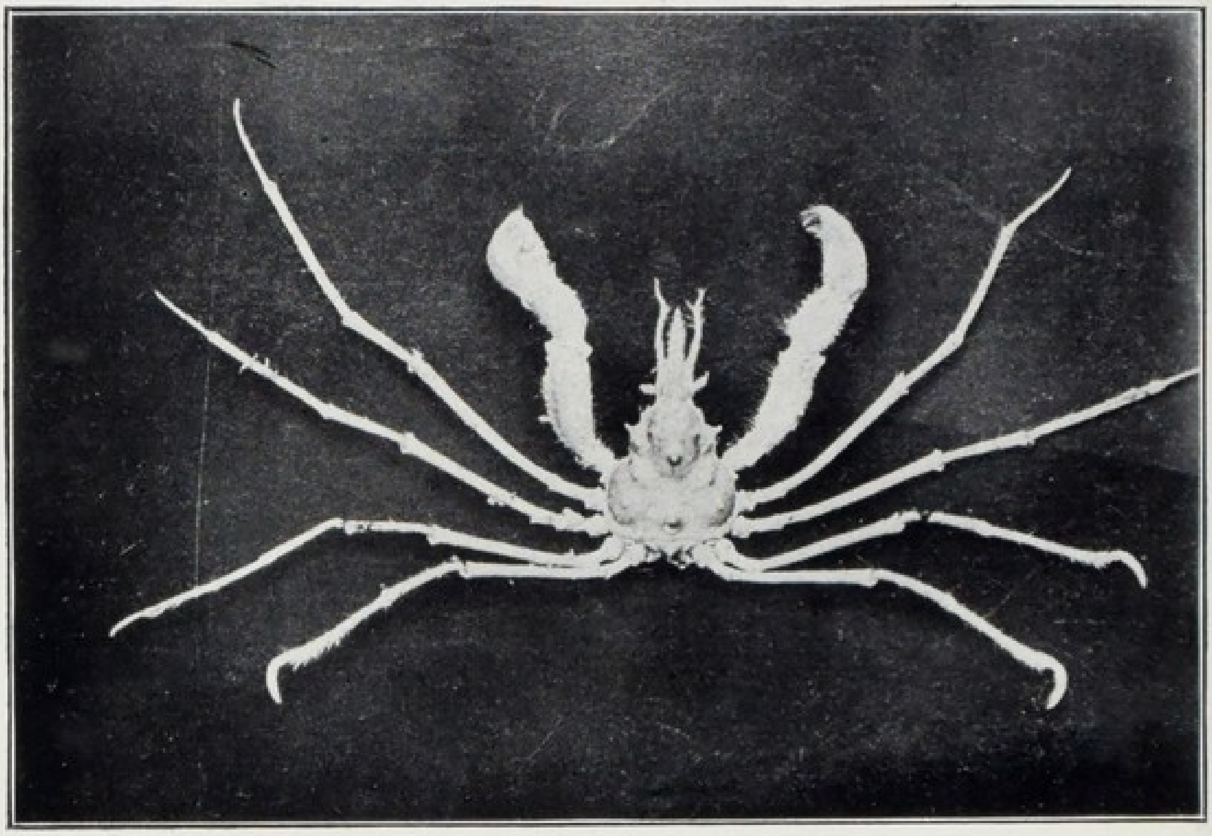


Fig. 79.—*Stenorhynchus Egyptius.* Natural size

flower in their fair owner's hair than this little crab's claws arrange their owner's toilet.

Oftentimes I have noticed one or two of these crabs fully stretched out in some gravel-bottomed pool among the Zostera beds in full sunshine, and had to look closely to see that they were not tufts of one of the red sea-weeds (see Fig. 80).

One splendid little species is *Acheus cranchii.* It is of very peculiar habit. A glance at Fig. 81 will show that its hinder legs are furnished with large, hooked tips; by these it adheres

Fig. 80.—*Stenorhynchus Egyptius.* Female, self decorated with red sea-weed. $\frac{3}{4}$ Natural size

Fig. 81.—*Acheus cranchii.* Sea-weed decked and denuded (Same specimen). Natural size

to weeds, sponges, or ascidians that are on the under side of overhanging blocks of stone, or the roofs of little caverns, and thus hangs, head downwards. In this position, and in such localities, when it is densely covered with weeds, which it attaches to its hooks, it is not easily discovered. It is no doubt owing to this very effective concealment that it is written of as "very rare." In the arrangement of the hooked bristles there is regular system, and on each side of a little groove that runs lengthwise on the rostrum or "beak," they are set in a row, with their points facing those on the opposite side, so as to hold a bunch of seaweed directly in front. This is the case with all the *Leptopodiadæ*.

In the photo (Fig. 81) an acheus in full decoration is shown, just as it was taken, and the same specimen stripped of his upholstery.

Allied to the foregoing is the genus *Inachus* (Fig. 82). These are larger bodied crabs, but with still the same general outline (only broader). These have no hooks, but have that peculiar "pottery" surface to the shell which affords a good base for sponges, etc., with which they are invariably covered.

It is to this genus that the world's largest crab belongs—viz. the *Inachus giganteus* of Japan, which has a stretch of legs of ten or twelve feet.

The species on our shore are *Inachus dorsettensis*, *Inachus dorynchus*, and *Inachus leptochirus*. These resemble each other, except in points which could not be elucidated without diagrams. The last-named can, however, be readily identified by its having a little pearly tubercle on the under side. All these are found at extreme low water, at the base of rocks.

The little "Nut Crabs," somewhat resemble these, except in length of leg, for here the very extreme, shortness, is the case. These belong to the family *Leucosidæ*. They are very beautiful little crabs, with nearly quadrangular bodies (set with the angles towards head and tail). They are about half-an-inch across, and of a delicate pink colour.

Our local species are *Ebalia tuberosa*, *Ebalia tumifacta* and *Ebalia cranchii*—the last-named rare. They are to be found on shelly gravel and amid the "nullipore" corallines at extremely low spring tides.

The Pinnotheridæ ("Pea Crabs").—Two species of this

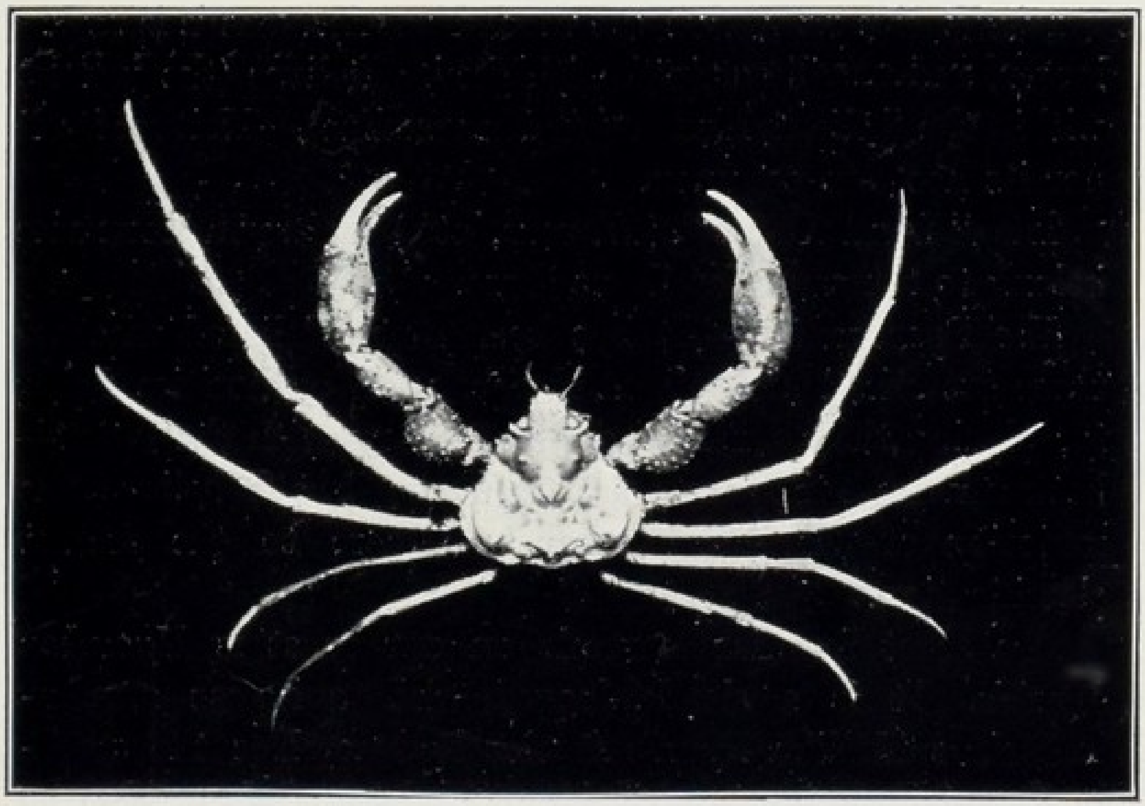


Fig. 82.—*Inachus dorsettensis*. Male. ⅔ Natural size

curious little crustacean occur on our coast. They live in a sort of commensal manner, within the shells of living bivalve molluscs, nestling between the mantle and the gills.

The most familiar example is *Pinnotheres pisum*. It is frequently found in the oyster.

The female is the larger, about the size of a good marrowfat pea. It is more frequently met with than the male, as the latter is of roaming habit.

In the female the carapace, in fact, all the body, except the limbs, is membraneous. The colour is milk-white, sometimes with a tinge of pink.

The male is smaller and less rotund, being in size and shape very much like a lentil, and its shell is firm and polished.

It is sometimes taken, with the female, within the oyster, but is more successfully hunted for among the refuse of the oyster fisher's dredge.

Pinnotheres veterum is the second species. This is rather larger, and usually striped with grey. It lives (the female) within the "Giant Mussel" (*Pinna marina*). Neither itself nor its host are common.

The "Land Crabs" (*Grapsus*, etc.) of warm countries belong to the same family as these.

The Pycnogonidæ.—It has been much debated whether these are *crustaceans* or *arachnids*, some authorities being for placing them with the former, others with the latter—between the mites and the spiders; but I believe the majority of English naturalists adhere to the former classification.

The most familiar example on our coast is *Nymphon gracilis*. It is a slender-legged, and quite as slender-bodied, spiderlike form. It closely resembles the small-bodied and long-legged spider (*Pholcus phalangoides*) so common in outhouses, only that the body is still more reduced.

This family of crustaceans have a curious anatomy: the body offering so little accommodation within, part of the alimentary canal, and also part of the reproductive system, has to occupy space in the legs.

In most other crustaceans the eggs after extrusion are carried by the female, attached to her swimmarets or within a brood pouch, as we have seen some pages back, but in the *Picnogons* the male relieves his mate of her burden, and by means of a pair of specially modified legs carries the egg clusters until the young emerge; in this respect imitating the example of some of our fishes, the *Syngnathidæ* (or " Pipe-fishes "), and some of the toads of foreign lands.

The male Nymphon can very frequently be found with this precious burden. It is common among weeds in rock pools in the upper parts of the littoral.

There are other species on our shore closely allied—*e.g.* *Pallene brevirostris*, *Phoxichilidium coccineum*, *Phoxichilus spinosus*, etc. All these are on about the same lines as the above, but hardly so slender. These are found in similar localities, but usually lower down in the littoral.

Picnogonum littorale is, however, of very different build. This one is stout limbed, and has a firm, hard shell, apparently built up of blocks like a bit of mosaic work. It is taken on shelly and stony ground low down on the shore. It is also often attached to the bodies of cetaceans (porpoise, dolphin, and whale), and is commonly confounded with the " Whale-louse," *Cyamus*—an amphipod.

Nymphon is shown of the natural size in Fig. 83.

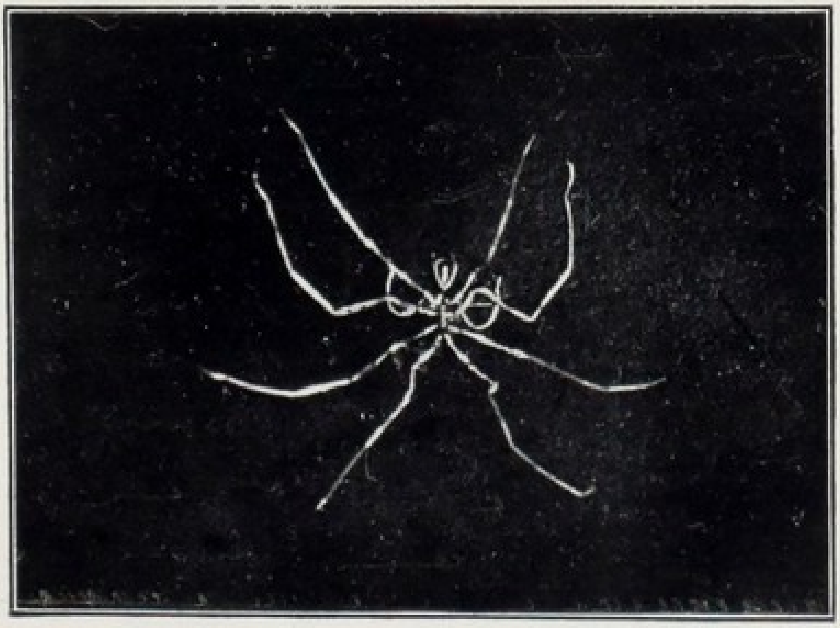


Fig. 83.—*Nymphon gracile*. Male. Natural size

CHAPTER VIII

THE MARINE INSECTA, ARACHNIDA, AND MYRIOPODA

DOWN among the rock pools seems hardly a promising hunting ground for the entomologist, and yet there are not a few insects that live in the sea.

To draw a clear line of demarcation between those that are truly *marine* and those that occupy the strip of shore just above high water, and sometimes are submerged, is rather difficult; but in this chapter I shall deal with those that are nearly constantly submerged, and that are found in the lowest parts of the littoral, treating of the others in a separate chapter, "The Fauna of the *Maritime* Zone."

Commonest of those that I consider truly marine are the little black "Spring-tails," representatives of which family (*Poduridæ*) are frequently seen among old books, running a little way over a page and then springing several inches.

This marine form (*Podura marina*) is about an eighth of an inch in length. It lives in the cleavage cracks of rocks, from near high-tide mark to about half-tide level, and is sometimes so abundant that colonies of it look like patches of black velvet, sometimes four or five inches across.

There are several other species allied to these, that live isolated, and are often seen even at the lowest tidal zone, but they do not appear to have been studied.

In the same situations—viz. in cleavage cracks, and under stones that are partly bedded in gritty ooze—are several species of *Coleoptera*.

The best known of these is *Æpus marinus*. This pretty little beetle is rather over an eighth of an inch in length, and is of a pale bronze colour.

Another is *Æpus Robinii*. It is somewhat larger, nearly a quarter of an inch in length, and of a metallic, bottle-green colour. It is considered rather rare, but on this coast, at least, it is as frequent as the former.

There are several other species of marine beetles, but I have not seen these. The Rev. Canon Fowler records one (*Micraymma brevipenne*) taken far below high-tide level, at Ventnor, Isle of Wight; also *Diglossa mersa*, under shingle, local and rare, but found at Southend, Sheppey, Weymouth, Tenby, etc.; and *Phytosus spinifer*, under weeds, etc., below high-tide level.

Perhaps the most interesting of the marine insects is one belonging to the *Hemiptera*, and which is named *Æpophilus Bonnairii*.

For some years a specimen of this was in the British Museum, with no data beyond the name of the discoverer, and the locality—*Cornwall*.

Then I believe I was the next to come upon this species. From time to time, while collecting sponges, etc., I had found this, to me incomprehensible, insect, and had sent many specimens to entomological friends without being able to obtain information.

Then one day, while among the rocks with Dr René Koehler, of the Academy of Science of Nancy, I called his attention to some specimens. He at once recognised it, collected a good many, and published an illustrated paper on it in the Proceedings of the Academy of Science of Paris.

It is about a quarter of an inch in length, and in form and colour closely resembles a much too familiar Hemipteron—named (in science) *Acanthia lectularia*. It lives under stones, and in the roofs of little caverns, among the sponges and ascidians that crowd those places. It occurs from near high-water level to the lowest zone in tide range. It runs swiftly, and is not easy to capture.

It is a mystery how these marine insects live, for they cannot rise to sea surface, and have no means of securing a stock of air, as do water spiders ; and *Æpophilus*, at least, lives in places that do not uncover more than once or twice in the year.

This insect is fairly common in Jersey, less common in the other Channel Islands. It is found in Cornwall, and most likely on all our shores, although it has not been widely recorded.

The visitor to the low-tide zones must frequently have noticed swarms of small flies hovering over the water surface, and in little caves and rock clefts, and wondered what became of them when the tide returned.

These are dipterous flies, named *Clunio marinus*. Their larval stages are passed under water, and their lease of life, when once the perfect stage is reached, is very brief—most likely only about six hours. There is a second species recorded (*Clunio bicolor*), but it only differs from the former in microscopical detail.

The *Marine Arachnida* are represented by several forms.

Firstly the *Pseudo scorpions*. Of these one species (*Obisium marinum*) has long been known. A second species was discovered by myself in 1889, or I had better say I was in the *joint* discovery, for, by a strange coincidence, when I announced the discovery in *Nature* it was also announced from France (Boulogne), and this on the same day, September 29th.

The mites (*Acarina*) are represented by several species, ranging from high-tide level to many fathoms deep, but I do not know if they have been listed.

Of the *Aranea* (or true "Spiders") we have at least one species, although I think the only record of it is mine. A specimen was found by my wife in a tuft of coralline, at extreme low tide, in St Clement's Bay. It was identified for me by the arachnologist of the British Museum, in which institution the specimen now is.

The *Myriopoda* (Millepedes, etc.) are represented by three species of *Geophilus* (one of which is my record). They are about two inches long, and live in rock crevices at all ranges of the tide. They resemble the common land form, but are darker in colour, and have fewer legs. The land species (*Geophilus maxillaris* and *Geophilus electricus*) have fifty-five and seventy-four pairs respectively, the marine ones about forty.

The forms named in this chapter present an interesting problem. They are land animals taking to a life in the sea, in reversal of the grand march, which has been from sea to land.

There is much scope for research for the young naturalist among the dwellers of the rock crannies between tide marks.

Among the rocks and stones at that part of the shore which is not covered by the tide there is another interesting fauna, and a chapter will be devoted to it later on.

CHAPTER IX

THE MOLLUSCA

We now enter into a division of the animal kingdom which is more popular than those we have so far dealt with; the "shell-bearing" section of it, at least, having been the subject of the collector's attention for centuries.

Although we have a goodly number of molluscs that are terrestrial or lacustrine the vast majority are marine.

The popular divisions are as follows:—

Bivalves.—Those with a double shell. Example: oyster, cockle, etc.

Univalves.—Single shells. Example: whelk, etc.

Nudibranchi.—Those with no outward shell.

Cuttle-fishes. Example: octopus, squid, etc.

But this is misleading. For instance, some of the so-called "bivalves" are "multivalves"—pholas, teredo, etc.—while "univalve" might or might not cover those that have an internal shell, such as the sea-hare, the squid, and so forth.

So, without going into full scientific arrangement, such as "sub-class," "order," "sub-order," etc., we shall take them in the large divisions, or "classes," or, as occasion compels, "sub-classes."

The Lamellibranchiata (Fig. 84).—These are laterally compressed molluscs, with the shell in two parts, joining by a non-calcified portion forming a hinge or "ligament." The animal within is symmetrical, and its back is against the hinge of the shell. There is no distinct head; when sense organs are present (*e.g.* the eyes in pecten) they are borne on some other part of the body. The body is enclosed in a fleshy envelope, the "mantle." The gills are large and flat.

Some have a protrusible "foot," which serves for locomotion—*e.g.* cockle. In others the foot is suppressed—*e.g.* oyster. The shell is closed by adductor muscles firmly attached to the inside of each valve.

Just within the dorsal edge of the valves there is a set of "teeth," which interlock when the shell is closed and prevent lateral slipping of the valves.

In some forms—*e.g.* in *Mactra*—there is a little projection of the shell inwards, and upon this the ligament or hinge is fixed. It is in the form of a little pad or cushion, of a consistency like firm india-rubber. When the valves are pulled close it is compressed, and when the tension on the muscles is removed it reasserts itself, and forces the valves apart.

In others—*e.g.* in the cockle—the mechanism is reversed. The ligament is strap-shaped, and on the outside of the shell. The inner margins of the latter, near the hinge, are rounded, so that when the valves are closed the ligament is stretched. Its contraction when the pull of the muscles is released reopens the shell ; so that the animal only uses exertion in closing : the opening process is mechanical.

Within the body are two chambers, one lying on the lower side and one on the upper. They join at the anterior end of the animal, and present two openings, close to one another, at the posterior one.

These chambers are richly lined with ciliated cells, the cilia of which, by their movement, cause a steady flow of water into the lower chamber, round the anterior end, and into the upper one, and then out by the upper opening.

These openings are termed—the lower one the "in-

Fig. 84

1. *Anomia ephippium.*
2. *Ostrea edulis.*
3. *Pecten maximus.*
4. *Lima hians* (v. *tenera*).
5. *Modiolus.*
6. *Mytilus barbatus.*
7. *Pectunculus glycemeris.*
8. *Loripes lactea.*
9. *Gallimma Turtonii.*
10. *Cardium edule.*
11. *Cardium echinatum.*
12. *Venus verrucosa.*
13. *Venus fasciata.*
14. *Tapes virgineus.*
15. *Venus exoleta.*
16. *Tellina crassa.*
17. *Psammobia vespertina.*
18. *Pandora inequivalvis.*
19. *Donax politus.*
20. *Mactra glauca.*
21. *Lutraria elliptica.*
22. *Solen ensis.*

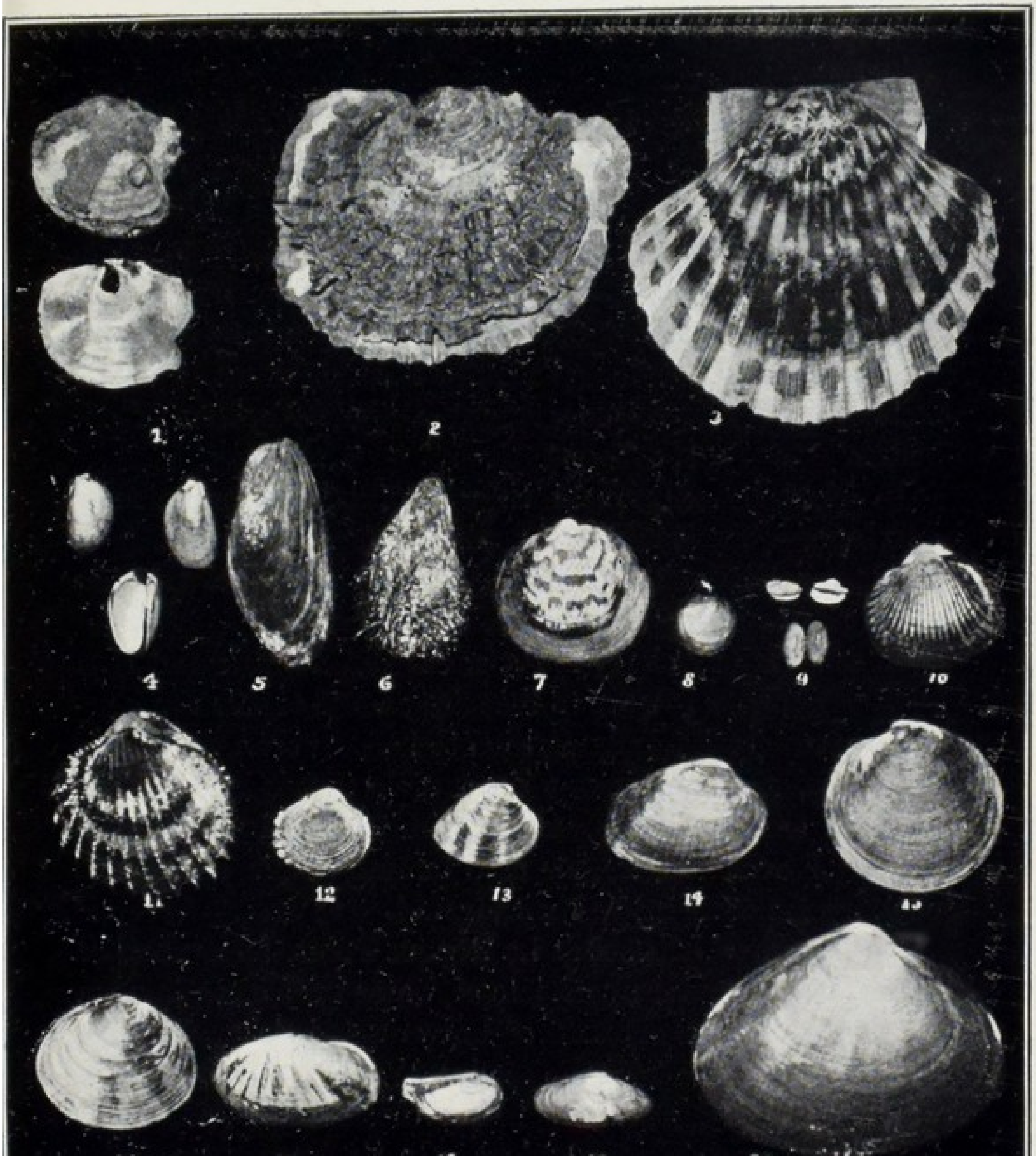


Fig. 84.—Types of Lamellibranchiata

halant" aperture, and the upper one the "exhalant" aperture.

In such forms as close the shell completely—that is, with the entire margins of the valves in contact, as in the cockle, oyster, etc.—these apertures are simply fringed slits in the mantle, but in such forms as *Mya*, *Lutraria*, etc. (the so-called "Gapers"), where there is a bending out of the valves at the posterior end, the apertures are in the form of long tubes, "syphons," sometimes separate and sometimes joined side to side, giving a figure 8 section if cut across.

In some lamellibranchi these syphons are enormously developed—for instance, in *Teredo* (the "Ship-worm") they form the bulk of the animal's anatomy, and this has given rise to its popular name.

In such forms as bury in the sand—*e.g.* *Lutraria* and *Mya*—these syphons project to the surface, and enable the functions of respiration and nutrition to be carried on while their owner is out of harm's way six or eight inches below. The syphons are to a large extent retractile, and the lightest touch, or even the tremor of a footfall (while the tide is out), causes their instant withdrawal.

On the gravel beaches at La Rocque Point, Jersey, and at Herm Island, numbers of jets of water may often be seen thrown up by the syphons of Lutraria and Solen, thus betraying the presence of the molluscs.

The water, in thus circulating through the chambers, performs a variety of functions. In its passage from the lower to the upper chamber it has to pass the mouth. Here two little flaps (*labial palps*) arrest and carry into the stomach any nutrient particles which it may hold in suspension.

In the breeding season the spermatozoids which have been set free in the water by the males are brought into contact with the ovaries of the females, and fertilise the ova.

Then on its exit the water carries with it the waste products of digestion, and eggs, or embryos, as the case may be.

Thus, except that larger particles can be taken in, a lamellibranch mollusc lives and reproduces very much in the same way as a sponge (the reproduction or extension by budding in the latter, of course, excepted). The most familiar example is the common oyster (*Ostrea edulis*).

This is found on all our shores, but more especially where the bottom is of such character as to afford points of attachment for the embryo oysters when once they settle, the conditions being clean, gritty substances, such as sharp gravel or broken shell. (This will be best understood a little farther on, when we get to the question of its reproduction.)

The form of the oyster is too well known to require description. It will just suffice to say that the flat valve is the right side of the animal and the convex one the left, for the oyster, like the large "Pecten," and one other of our lamellibranchi (*Pandora*), is "inequivalved," so that if an oyster is held hinge uppermost, and the flat shell to our right, the "inhalant and exhalant apertures" are towards us, the mouth on the further side.

The reproductive glands, both male and female, are represented in each individual, but do not mature at the same time. Thus an oyster may function as female one year and as male the following, or maintain the one function for several successive years.

When the eggs have been fertilised, in the manner we have just observed, they, after the usual process of segmentation of the yolk, give rise to little ciliated embryos, termed *Trochospheres*. These are accommodated within the parent, in a special pocket arrangement. If an oyster is opened when it contains these trochospheres it appears to the unaided eye as if partly filled with a milky fluid, and is said by the oyster dealers to be "sick."

These embryos are about $\frac{1}{150}$ of an inch in size, and their number within one oyster is from one to two millions.

As they increase in size they begin to show the dark line of the alimentary canal, and also develop a little transparent shell, which has both valves convex. From within the gaping edges of the shell extend two flaps, which are fringed with cilia at their edges. The little oyster is now in the *veliger* stage, and, in the language of the trade, they form "black spat." Then when they are sufficiently advanced they are shot forth in clouds into the open sea. By means of their cilia they swim nimbly and beautifully, the hinged side of the shell downwards, at all depths.

They continue in this *veliger* stage for from fifteen to twenty-five days, and then settle down, and affix themselves to some object; but only a very small percentage have the opportunity of so settling, for from the moment they are cast upon the world the slaughter of the innocents begins.

"Nature red in tooth and claw" is still more red in ciliated tentacle, sting cell, and suctorial mouth, and their comrades in the world of waters—jelly-fishes, from the size of a pin's point upwards, pelagic worms, crustaceans, larval fishes, and a host of other forms—feed upon them, and only a few survive. If it were not so, within a very few years the world itself would not contain them.

Those that so far have escaped disaster affix themselves, at first by means of their little flaps, then by the secretion of lime, to any suitable surface.

The surface, as we have said, must be clean and, preferably, gritty, although they will affix to wood, but where there is mud or a layer of silt upon the objects they cannot affix, and so perish. When first they can be seen by the naked eye in the fixed condition they appear as if they had but one valve, forming a little pearly boss, about the tenth of an inch in diameter.

The shell which is outward is the flat one, and if they have fixed to a large stone or the surface of a rock the whole of the convex shell becomes firmly cemented down, so that its convexity cannot be seen outwardly.

By many fishermen those so fixed are supposed to be of a different species, and are by them called "Rock Oysters."

Those that are dredged up loose from the bottom—that is, those that we see in commerce—are such as affixed to small objects at the bottom, and in which the convex shell, not being applied to a flat surface, has developed its convex form.

The object to which the *veliger* fixed itself can frequently be seen in the adult oyster, close to the hinge on the convex side. It is usually a small stone or a fragment of shell.

In oyster-fishing districts it is customary to strew the bottom with broken shell to try and induce a "fall of spat." This is termed "cultching" the bottom.

This "fixing" on the part of the young oyster has enabled the formation of the large and important industry of "oyster culture."

In many districts, especially on the coasts of Brittany, where there is suitable locality, such as a fairly land-locked bay, or, in default of such, in enclosed areas, ordinary roofing tiles are coated with a friable cement made of clay and sand with a little lime or cement. These prepared tiles are arranged in stacks, with their concave sides downwards, in such way as to form nests of little tunnels, and then breeding oysters are strewed around. The *veligers* affix chiefly to the under side of these tiles, in numbers varying from units to hundreds on each.

As soon as the breeding time is over these tiles are taken into sheds, where women and boys scrape off the cement, together with the young oysters. This is termed the process of "*detrogage.*"

The little oysters are then washed and placed in cases, which have bottoms of coarse wire gauze raised about six inches from the bottom. The cases are six inches deep, and a lid, also of wire gauze, protects them from enemies.

The cases are placed in such position that they uncover at least a day or two each fortnight to allow of examination. At first eight or ten thousand are placed in each case. Then, as growth advances, they are thinned, and extra cases brought into service.

Fig. 85 shows an arrangement of these rearing cases on the coast of Jersey. Here they are in an enclosed area, and their submergence can be controlled by means of some large sluice gates, the supports of which can be seen in the photo, in the distance on the right.

Growth is rapid, and the first year the "spat" or "brood" oysters will have reached the size of a two-shilling piece. Growth takes place chiefly in the summer, when a layer of new shell appears around the margin, so that the age of an oyster can be readily ascertained by counting these layers, which are, as a rule, distinctively marked.

When the oysters have reached a size of two and a half or three inches across they are taken from the cases, and sold by the breeders to the "planters," who place them on such grounds as will best fatten them for market. The chief grounds on our coast are thus "layered" with artificially reared oysters, for the conditions under which oysters best fatten are not those in which the delicate little veligers best develop, and it is only occasionally that in such "fattening grounds" there occurs a "fall of spat."

The oyster becomes of marketable size when three to four years old, and its age limit is probably from fifteen to twenty years.

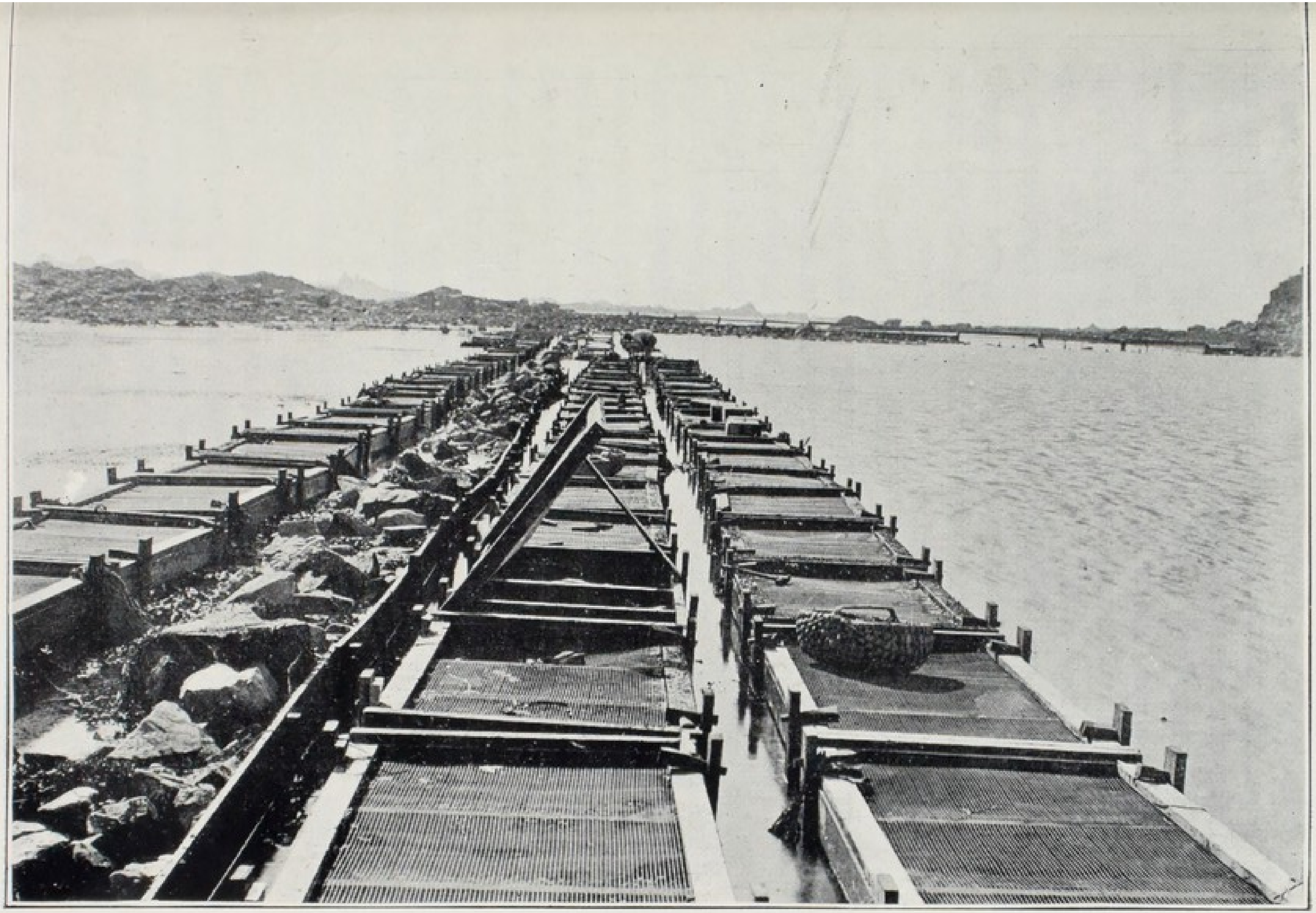


Fig. 85.—An Oyster rearing plant on the coast of Jersey. Each case is 6 ft. long by 3 ft. wide, and 6 ins. deep

N

Its food in a state of nature consists of the spores of sea-weeds, minute, floating plants, and the embryos and larvæ of marine animals.

In "layerings" near populous towns, in the estuaries of rivers, etc., its menu is unavoidably more varied.

The above description applies to our common round oyster (*Ostrea edulis*). In the mussel-shaped or "American" oyster (*Ostrea virginea*) the reproduction is different, the fertilisation of the eggs, and subsequent development of the young, taking place in the water, and not within the parent.

Anomia ephippium (the "Saddle Oyster").—This is often mistaken by many for the young of the edible oyster, which it somewhat resembles in general outline.

The shell in this genus is thin, and irregularly waved, with pearly tints. It is very common, and is frequently attached to the shells of ordinary oysters, also to the large pecten. It is found at extreme low water, but is more usually taken with the dredge. Its method of attachment is peculiar. The lower shell is perforated near the hinge, and a solid little block of carbonate of lime, in the form of a collar stud, is there secreted, one end firmly fixed to such object as forms the base of attachment, the other within the mollusc, so that the latter can be moved about, as if on a ball-and-socket hinge. It is about two inches across when full grown.

A second species (*A. patelliformis*) is found on our coasts, but not so frequently as the former.

Pecten maximus (the "Common Scallop").—This is common all around our shores, from the lower littoral zone to deep water, wherever the bottom is suitable; rough, gravelly ground, clean sand, and Zostera fields being its usual habitats.

The pectens are not fixed, but have power of a certain amount of locomotion. This is effected by the alternate opening and smart closing of the shell, this causing a rapid expulsion of water, which, reacting on the pecten, drives it backwards. The edges of the mantle are fringed, and bear well-developed eyes, usually sixty or seventy in number. These may be seen when the shell is slightly opened, as a double row of brilliant green beads, about the size of a small pin's head. Microscopic sections of these eyes show a very high development. The shell is beautifully convoluted, in radiating, fanlike pattern. The valves are unequal, the right one being flat, the left convex. Full-grown specimens measures five inches across.

Other species are :

Pecten opercularis (the "Queen Scallop").—This one is equally common, and occurs in "beds" close inshore and extending to deep water. Both valves are convex, and more finely convoluted than in the last. It measures two inches in diameter.

Pecten varius.—This is a smaller species, about an inch across, both valves equal, but the wide, hinged portion, which in the foregoing is straight, is developed more strongly on one side (see Photo). The colours in this species are very varied and beautiful. Specimens occur of a pure white, others lemon-coloured, crimson, brown, but the majority are mottled red and white.

This one attaches, by a little bunch of horny fibre, the *byssus*, to stones or to others of its kind, forming bunches. It is sometimes dredged for market. There are several other species on our shores—*e.g. Pecten pusio*, *P. tigrinus*, etc., but these are rare.

Allied to the pectens are :

Lima hians.—This is a very beautiful form ; the shells are elongated, finely convoluted, and pure white. The mantle is divided at its edges into a long fringe, which can be extended considerably beyond the margins of the shell. These fringes are of bright colour, usually bright red and orange. This species swims rapidly by the alternate opening and closing of the shell, and as it thus progresses through the water the fringe forms a series of brilliant streamers. It lives in colonies, building a "nest" of agglutinated grains of sand and gravel, under boulders, where there are pools remaining when the tide is out. When the nest is disturbed its inmates issue forth, and are not easy to capture, as they dash about the pool.

I have kept these in aquaria, and they are very beautiful subjects for this. The shell is about three quarters of an inch long.

The species shown in the Figure is variety *tenera*, which is the only one found in the Channel Islands.

Other species are *L. subauriculata* and *L. Loscombii*, the last rare, but all are found between tide-marks on rocky coasts.

Mytilus edulis (the "Common Mussel").—This abounds wherever there are suitable localities: muddy flats, and fairly quiet waters, sheltered bays, estuaries, harbours, etc. It attaches by a *byssus*, often forming large clusters. It can live under conditions of impurity which would be fatal to most other molluscs, and as it is largely used as food, especially by the poorer people, gatherings from unwholesome districts have often caused serious illness.

Mytilus angulata (the "Hoof Mussel") closely resembles the latter, but is more angular, and wider in proportion to its length. It is found solitary, firmly attached, and often wedged in rock crevices and on barren shores, nearly up to the highest tide level.

Mytilus modiolus.—This is a large species, frequenting deeper water, and not so common as the former.

Mytilus barbatus (the "Bearded Mussel").—This species is considered rare, but is none the less tolerably common on rocky shores. It is of smaller size and flatter form than the common mussel, and the anterior sides of the shell are furnished with stiff, branched hairs or bristles. It lives, firmly fixed, in rock crevices at extreme low water, among sponges, etc., and the hairs retaining a layer of mud and silt help to conceal it.

There are several other species, some of which live embedded within the cartilaginous tests of large ascidians. These are of small size—half to one inch in length.

Nucula nitida and *Nucula nucleus* (the "Nut Shells"), solid-looking, strongly angular little bivales, are common all around our shores, on muddy and fine sandy bottom.

Pectunculus glycemeris (the "Marbled Cockle").—This is a nearly orbicular, very solid shelled bivalve, found abundantly in shelly gravel all around the coasts. It is about an inch and a half across, the colour pale buff, with wavy red markings.

This mollusc has the power of leaping (which is common to all the "cockles") very highly developed. By the smart projection of its foot against the ground it can throw itself a distance of five or six yards.

I remember that once, when a lad, I was sand-eeling by moonlight on the large shell-gravel reaches of the eastern coast of Jersey, when splashes in the water in front of me, and presently a knock on the back, made me think I was being pelted. My consternation was great, as there was not any person in sight, and it was some time before I discovered the cause. This was *Pectunculus* emerging from the gravel, and leaping seawards to meet the now incoming tide. They were jumping thus in hundreds.

Arca lactea and *Arca tetragona* (the "Box Shells") are strongly angular bivalves, from half to one inch across. They live at low water, where there is broken stone mixed with gravel. They must abound in some parts of the Channel, for the well-known shell beach of Herm Island is mainly composed of their valves.

A form almost too rare to be mentioned in an "outline " of our marine zoology, but which calls for attention on account of its remarkable habit, is *Galeomma Turtonii*. This little bivalve mollusc, unlike all its relatives, has more or less the habit of a *gastropod*. It opens its valves right and left, and crawls, or at least, adheres (for I have not seen it progress) to the rocks, with its foot. It is pure white, and about three-quarters of an inch in length.

A list of all our shells would be of no interest to the general reader, and the conchologist has, of course, his text-books.

There are about one hundred and forty species of bivalves on our shores and in the British Channel.

Allied to the lamellibranchi, but possessing but one valve, in the form of a bent tube of elongated, conical form, and open at both ends, is an order of molluscs termed the *Solenoconchia*. It is represented on our shores by two species, well known as the "Tusk Shells" (see Fig.). These live, buried in the sand at extreme low water, on pretty well all our shores. The species found here are *Dentalium entalis* and *Dentalium tarentinum*.

The Gastropoda (Fig. 86).—These are thus defined: Molluscs, with distinct head often bearing tentacles, a ventral, muscular foot, and undivided mantle, which usually secretes a shell, simple and platelike, conical, or spirally twisted (Claus).

They have also a chitinous ribbon set with sharp teeth, which lies in the floor of the mouth. It is termed the *radula*, or the "tongue," also, erroneously, the "palate." It serves the purpose of rasping or breaking up the food of the mollusc.

In some of the carnivorous forms it serves as a boring instrument. By the recurving of its end a number of the sharp, siliceous teeth are set in such position that by a semi-rotary movement the hardest shells can be pierced.

This arrangement also occurs in the *Cephalopoda*. Hence these and the gastropods are often classed together, under the title *Odontophora*, or tooth-bearers. The most remarkable of the gastropods are the *Chitons*. These have the shell in eight parts, arranged on the dorsal side in such way that the pointed, posterior edge of each overlaps the one behind. When detached from the rock or stone on which they are found they roll up, armadillolike.

The species on our shores is *Chiton fascicularis*. This is about an inch long by five-eighths of an inch wide, of a greyish brown colour, and has tufts of light-coloured bristles along the sides.

Chiton discrepans (Fig. 87).—Somewhat resembling the last, but of larger size, reaching two inches in length by one in breadth. Its colour is mottled greyish brown and white. I believe it is rare on the English coasts, but is very common in the Channel Islands.

Chiton cancellatus.—About three-quarters of an inch long, prettily marbled with grey brown and white, but subject to much variation in colour, often mottled with red and grey.

Chiton cinereus. About half-an-inch long, slate-grey, but also varied in colour and marking. This is the commonest species.

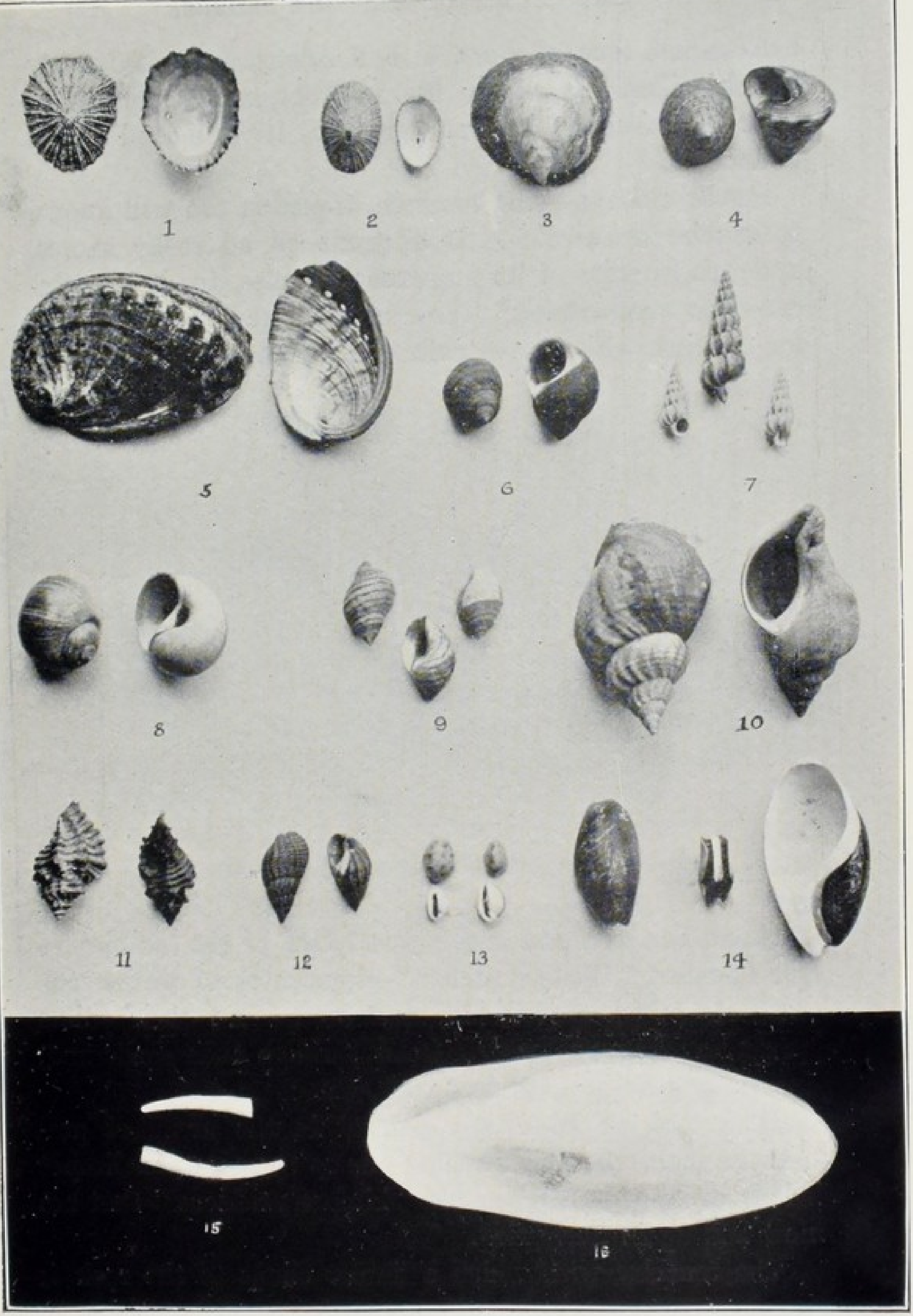
Chiton marginatus, *Chiton lævis*, *Chiton debilis*, are all closely allied.

Chiton ruber is a beautiful form about three-quarters of an inch long, and of brilliant red. All these are found under loose stones in rock pools.

Chiton scabridus.—This is a species much prized by collectors, as it is supposed to be rare. As a matter of fact it is not rare, but its habitat is a strange one. It lives on the under side of stones which are deeply set in firm, muddy sand, in conditions which do not seem conducive to health or to a decent food supply. It is a small species, about

Fig. 86

1. *Patella vulgata.*
2. *Fissurella græca.*
3. *Capulus hungaricus.*
4. *Trochus zizyphinus.*
5. *Haliotis tuberculata.*
6. *Littorina littorea.*
7. *Scalaria commaris.*
8. *Natica nitida.*
9. *Purpura lapillus.*
10. *Buccinum undatum.*
11. *Murex erinaceus.*
12. *Nassa incrassata*
13. *Cypræa europea.*
14. *Scaphander lignarius*, and its shelly gizard.
15. *Dentalium.*
16. *Sepia officinalis.*



½ Fig. 86.—Types of Gastropod Shells, etc.

half-an-inch long at most, of buff colour, and with nearly parallel sides. It can be known from small examples of somewhat similar form and colour by its being red on the under side.

Patella vulgata.—The common limpet is too well known to require description. It abounds on all rocky shores, and this in spite of its numerous enemies, for it is persecuted to vast extent. They are collected by the bushel for cooking. Fishermen collect them and string them on

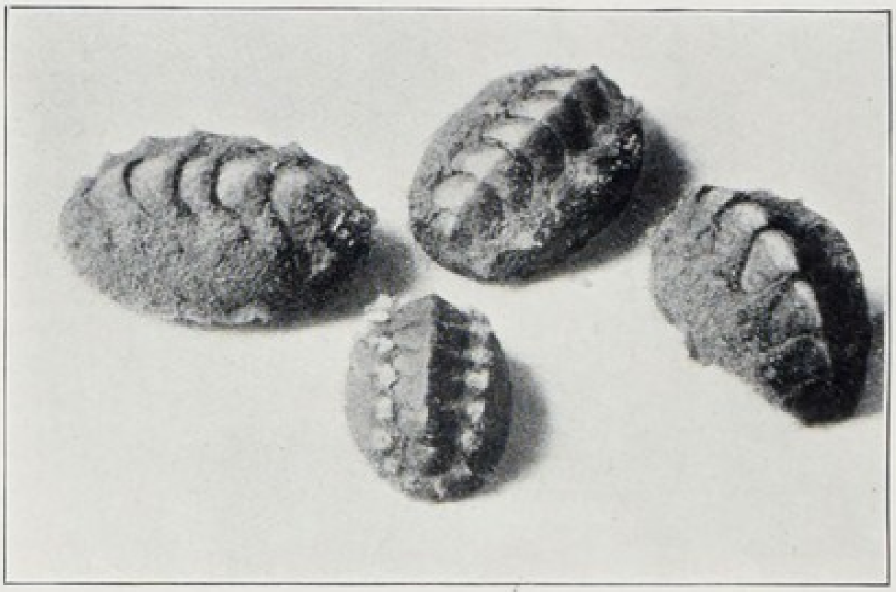


Fig. 87.—*Chiton discrepans.* $\frac{2}{3}$ Natural size

wires to bait fish and crab traps. One of the sea birds—the so-called "Oyster Catcher"—knocks them off the rock with its punch-shaped bill, and scoops out their edible parts, and dog whelks drill holes through their shells and, inserting their protrusible mouth, eat them out.

It formed an important element in the menu of prehistoric man, when his dwelling was on the coast, for limpet shells are abundant in the old "kitchen middens" that are now and again unearthed.

The tenacity with which a limpet clings to the rock is a matter of proverb, but the actual force has not hitherto, I believe, been given, so the following experiment, tried by myself, with the assistance of a friend, may not be without interest.

Small holes were drilled on each side of the shells of many limpets, at Green Island, Jersey. A steel clip with sliding bar was then attached, and a vertical pull made with a spring balance, the latter having an adjustment to register the maximum reach of the indicator.

It was found that limpets with the base one inch and a quarter by one inch—that is, giving an area of somewhat less than a square inch—came off at a pull of *seventy pounds* ! Larger and smaller examples at the same proportion—that is, that the force by which they hold is nearly five times what would be the case if they held by suction only. Whether the rock was smooth (water-worn basalt) or somewhat rough (disintegrating granite) made no difference whatever.

There are no perceptible grasping arrangements which might cling to minute pores in the stone, so it is a puzzle how they do hold. It is possibly as glue holds to polished glass—a point in mechanics which has not yet been defined.

The young of the limpet emerge, in the form of little disc-shaped, ciliated embryos, in the months of December and January. They do not appear to swim freely, but progress on the surface of the rock by the movements of their cilia.

There are several varieties, but the only well-marked one is variety *Athletica*, one in which the shell is ridged from apex to base. This is the one shown in the Figure.

Helcion pellucidum is closely allied to the common limpet, but is of smoother outline, and the shell is more horny-looking, of pale reddish brown colour. It is found among the roots of the oar-weeds (*Laminaria*) ; it feeds on this plant, eating its way upwards into the stalk.

In the summer months its young may be seen in numbers on *Laminaria digitata*. They are not quite like the adult in form, but more like one valve of a mussel shell. They are of a lovely, iridescent blue colour. Allied to the limpets are the so-called "Split Limpet" (*Emarginula fissura*), found among stones at low water on rocky shores, and *Capulus hungaricus* (the "Night Cap"). This remarkable form (shown in Photo) is, however, rarely found in the littoral. It lives on coralline ground a few fathoms deep.

Calyptræa chinensis (the "Chinaman's Hat"), a curious, flat, limpetlike, little form, with a ridge inside, as if seeking to approach a whorled shell, is very common attached to pebbles and smooth stones at low water in gravelly and coralline grounds.

Haliotis tuberculata (the "Ormer").—This is about the largest of our gastropods. Full-grown examples are about four inches in length by two and a half in breadth. The beautifully iridescent shells are well-known and popular objects, being frequently used as trays for knick-knacks, and also used for inlaid "papier-mache" work.

The ormer seems to reach its northernmost limit in the Channel Islands, and here, and on the opposite coast of France, it is very abundant, and is largely fished for market.

In the markets of Jersey and Guernsey, at the time of the spring tides, it may frequently be seen in tons at a time. It is largely esteemed for table, and the taste is not a recently acquired one, for an old writer, whose name I forget, says of it: "The epicure would think his palat in paradis if he could always regale it with such delicat Ambrosia."

I can quite endorse his sentiment, although I am not qualified to verify his comparison.

The ormer lives under large stones and boulders, at the lowest tide zone, chiefly where there is Laminaria.

Allied to the ormer, but easily mistaken for a limpet by the inexperienced, is *Fissurella græca* (or the "Keyhole Limpet").

This resembles the limpet in general outline, although rather more parallel-sided, and there is an opening at the apex of the shell for the entrance of water to the gills.

The *Trochi* are represented on our shores by eleven species, and many varieties of these.

The most familiar is the purple "Top Shell" (*Trochus zizyphinus*). This is the most beautiful of the genus, being fairly large, about an inch in height, sharply conical, and beautifully ridged and striated with alternate red and blue bands. It is very common at low water on rocky shores, preferring grottoes and fissures at the base of high rocks.

Trochus magus is our largest representative of the genus. It is of more squat form than the last-named, and subject to much variation in colour. It is very abundant in some localities, preferring bottom, near low-water mark, where there is a mixture of gravel and small stones.

The forms that are found in such localities are usually the largest, and are elevated. Specimens that are dredged in deeper water are of more depressed form, usually of smaller size, and of brighter colouring—chocolate and white, bright red and white, etc.

The pretty little *Trochus striatus*, in general outline like *T. zizyphinus*, but taller in proportion, is common on the leaves of Zostera at low water. The little scarlet-tipped *Trochus exasperatus*, so much prized by collectors, lives in the same locality, but among the small, loose stones.

Trochus lineatus abounds in the Channel Islands, and is common on most rocky shores, living high up on rocks nearly to high-tide level. In the Channel Islands, and on the opposite coast of France, it is largely gathered, and sold in the markets as the "Grey Winkle."

Phasianella pulla.—This beautiful little mollusc, with a foreign air about it, is local: in some places it abounds, and upon other shores, apparently offering the same conditions, it is not to be found at all. It lives on gravelly bottom, and among small stones at extreme low water. It is the only gastropod we have which develops a shelly operculum.

The operculi of larger specimens form a domestic surgical appliance in old-fashioned homes, where they are known as " Eye Stones," and are used for removing foreign objects, dust or grit, that have got into the eyes.

The *Rissoas* are a group of beautiful little molluscs. We have about twenty-five species on our shores.

Rissoa striata is our commonest species, a little burly, strongly-ridged shell about a fifth of an inch in height. The Rissoas live on the under side of stones, from high-water line to the extreme lowest.

Littorina littorea (the " Common Winkle ").—This is, as is well known, a very abundant species, many hundreds of tons being gathered yearly for market, but it is local, and, strangely enough, is far from common in the Channel Islands.

Littorina obtusata is a common and pretty shell. As its name implies, it is not so conical as its relatives, but is smooth and rounded. It is subject to much variation in colour, ranging from nearly black to pure white. A bright uniform yellow variety is quite an article of trade with enterprising children in Herm, who collect and sell them at so much a quart, to fancy box makers.

Littorina rudis is familiar to every visitor to the shore. This little winkle is interesting as living in situations where, for sometimes weeks together, it is only reached by the spray of the sea. Some naturalists hold that it is a mollusc following in the footsteps of the sand-hopper, etc. —gradually forsaking its ocean home and endeavouring to qualify for a terrestrial life. It is found of all colours, red, white, yellow, etc., and banded with these colours.

Natica catena and *Natica alderi* (the "Sea Snails").—These beautiful, large, white and pink molluscs live on most of our shores where there is soft shell sand, from low-tide level to some fathoms deep.

Curious biscuitlike cakes of sand, very firm and yet elastic, often puzzle the sea-side visitor. These are the egg cases of Natica, embedded and protected by this agglutination of sand grains.

Purpura lapillus (the "Dog Whelk") is familiar to every sea-side visitor. It lives near high-tide level, on nearly dry rocks, and does not extend to the lower zone. It lives chiefly on the limpet, drilling smooth, round holes at one side of the shell near the apex, and then, inserting its proboscislike mouth, feeds upon the unlucky, living limpet. If a dog whelk is seen perched upon a limpet, and it is carefully lifted off, the process of drilling will be seen either in operation or just completed. Dead limpet shells strewn around show by the holes the extent of the dog whelk's ravages. It also feeds upon the common little trochus (*T. umbilicatus*), but does not trouble to drill the shell of this, simply turning the trochus over and sucking him out by the opening of the shell.

The egg cases of *Purpura lapillus* are curious and conspicuous objects in rock crevices and attached to stones near high-water line. Fig. 88 shows a colony of these egg cases.

Murex erinaceus (the "Rock Winkle") is another mollusc borer, and is the plague of the oyster grower. This lives at a lower zone than the dog whelk, chiefly on rocky, but also on stony and gravelly, ground..

If the flat side of a few oysters is examined, on the smooth part near the hinge smooth, round holes, the attempts of this mollusc to get to the inside, may often be seen. (Other forms bore the oyster—viz. a certain worm (*Leucodore*) and a sponge (*Clione*)—but the holes made by murex are cleaner and more decided than those made by the latter.)

The little purple rock winkle (*Murex corallinus*) is a

Fig. 88.—*Purpura lapillus*, and its egg cases
Natural size

beautiful little mollusc, with strongly-ridged purple shell and a scarlet foot.

This, and a form that somewhat resembles it (*Lachesis minima*), may be found under loose stones in rocky places, from half to low tide level.

Nassa reticulata is another borer. This one lives in sandy and gravelly sand, and is very abundant. It bores chiefly into the cockle, but also attacks the young oyster. It is also a great pest to ground-line fishermen, clearing the baits from their hooks within a very short time of their having placed them.

The egg cases of Nassa are very curious and beautiful

Fig. 89.—*Nassa reticulata*, with its egg cases attached to fucus. Natural size

objects. They are in the form of little flat vases, and are always arranged in symmetrical order. Each case contains from twenty to fifty eggs. These are shown in Fig. 89.

Odostomia is a genus of small, spire-shelled molluscs found among stones, at all ranges of tide. About thirty-six species occur on our shores.

Buccinum undatum (the whelk) is too common to need description. It is common all around our coast, and lives both on rough and sandy bottom, from low spring tide level outwards.

Cypræa europea.—The pretty little "Cowrie," with which our earliest recollection of shells is very generally associated. This lives on rocky shores, preferring places where it has the shelter of overhanging boulders or rock crevices. It is white, with a purple blush on the dorsal side and spots of a deeper shade of the same colour. Shore-gathered specimens have as a rule lost these markings, and also much of the delicate sculpturing. In St Clement's Bay, Jersey, it is very common. It has the habit of loosing its hold upon the rock, and allowing itself to hang, spider-like, from a thread of mucus. Numbers may thus be seen hanging from the roofs of little grottoes at low-tide level, in suitable districts.

Transitional between the forms we have just dealt with and the Nudibranchi, or shell-less molluscs, are those in which the shell is more or less completely enclosed by lobes of membrane. They form a sub-division termed the *Tectibranchiata.* Of these the best known is:

Aplysia punctata (the "Sea-hare"—Fig. 90).—This is erratic in its occurrence on the shore, sometimes occurring in great profusion, then being for a long period absent. It is a peculiar and conspicuous sluglike animal, from four to six inches in length. The colour varies, according to locality, from olive-green, through various shades of brown, to purple. On this coast it is invariably of a deep, almost black, purple, with a velvety appearance, and usually finely speckled with white. It has four stout, earlike tentacles, and the side lobes project, flaplike, above the back, and partly cover the shell. The shell is thin, horny, and transparent, in size and shape like the bowl of an egg-spoon, of a pale brown colour.

When injured, or even irritated, the animal exudes a vast quantity of a purple fluid, which stains whatever it touches very deeply. (This is a different secretion to the

Fig. 90.—*Aplysia punctata.* $\frac{2}{3}$ Natural size

"Purple of Tyre," which is said to be the product of a form allied to *Purpura lapillus*, although some maintain it was obtained from a large species of Aplysia.) Aplysia has a powerful odour of cedar oil, which is no doubt protective. So powerful is this odour that repeated washings fail to remove it from the hands after touching a specimen.

Its eggs are within capsules, in long strings, constricted at intervals of about a quarter of an inch. These strings, which are of a pink tint, may frequently be seen, like tangled skeins of twine, among sea-weeds and stones, at all parts of the shore.

A larger species (*Aplysia depilans*), six to eight inches long, and of a greyish brown colour, is also met with, but some authorities do not consider that it is a distinct species, but simply a variety. It feeds chiefly on the sea-grass (*Zostera*), biting off and swallowing pieces about half-an-inch in length.

Pleurobranchus membranaceus and *Pleurobranchus plumula* are somewhat allied forms. The former, of brown colour, about three inches in length, is rarely taken on shore, but is frequent in the dredge. The latter, about half this size, of a beautiful, waxy, almost transparent, yellow, is found in the littoral, under stones in rock pools. These have a beautifully striated internal shell.

Philine aperta, *Lamelligera perspicua*, and one or two other small forms allied to these, occur under stones and among corallines at low-tide limit.

The Nudibranchiata.—These are represented on our shores by about twenty species, the most familiar of which is *Doris tuberculata* (the " Sea-lemon "—Fig. 91). This is in shape, size, and colour very much like half-a-lemon, except that the gills, in the form of a beautiful tuft of plumes, arise from near its posterior end, and a pair of earlike tentacles from the anterior. It is tolerably common on most rocky coasts, crawling over rocks and boulders in sheltered situations. It feeds on sponges, and is the only animal, as far as I am aware, that does so.

It is curious, in dissecting a Doris, to see how the stomach is fairly crammed with the needles, daggers, and stars of flint, the indigestible portion of this curious diet.

In localities where Doris is found there may always be seen, during the summer months, conspicuously fixed

Fig. 91.—*Doris tuberculata*. ½ Natural size

against rocks or boulders, curious white gelatinous rosettes, about two inches in diameter. These contain the eggs of this mollusc. The eggs are placed, four or five, within a little spherical sac, and these sacs, in immense number, are embedded in a gelatinous substance, in the shape of a ribbon.

The ribbon is about twenty inches long and one and a half wide, and is beautifully frilled, and coiled with one edge to the rock, exactly like a rosette.

If a portion of one of these ribbons is taken when the young are just hatched (which can be known by the ribbon beginning to break up), and viewed under the microscope, a beautiful sight will present itself.

The capsules are closely set in the ribbon, and within each there are three, four, or five young. Each has a beautiful, transparent little shell of nautilus shape, and the portion of the little animal which projects is ciliated. These young are very active, and by the action of their cilia swim round and round within their little prison, the whole looking like a bewildering bit of mechanism. A rough idea of this arrangement, as seen under a low power of the microscope, is shown in Fig. 92.

The presence of a shell in the young is interesting, as it points to the descent of the nudibranchi from shell-bearing ancestors.

Another Doris, less frequently met with than the above, but sometimes occurring abundantly, is *Doris pilosa*. This is only about an inch long, of a pure white, and the skin is covered with minute, velvet tufts.

Other forms present on our coast are *Doto*, *Dendronotus*, and *Eolis*. In the first two the branchial organs are branched, in arborescent fashion, along the back. In *Eolis* they are in leaflike papillæ, and part of the digestive system is situated in them.

The commonest species of the latter genus is *Eolis papillosa*. This is sluglike, of a yellowish white or a pale grey colour. It is about two inches long, and when not in motion, but with head and tentacles retracted, it could easily be mistaken for some kind of anemone. It feeds chiefly on anemones, taking a meal off the living mass and passing on. It is the only animal I know of that preys on these. It deposits its eggs in threadlike skeins, very like those of Aplysia, only of a pure white colour.

Under the microscope they show the same arrangement as those of Doris, three or four young ones in each of the embedded capsules.

Elysia viridis is a pretty little bright green nudibranch,

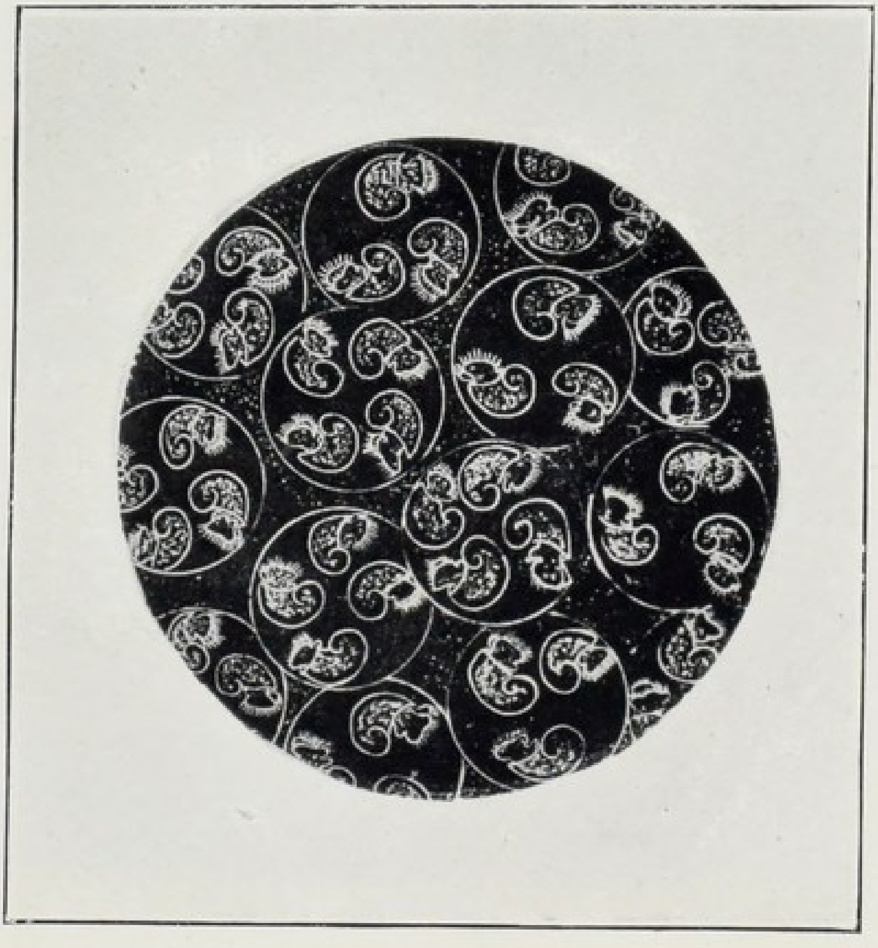


Fig. 92.—Egg Capsules, with enclosed veligers (larval stage) of *Doris*. About 25 diameters

about three-quarters of an inch in length. It is sometimes found in numbers on the dark green spongelike sea-weed, *Codium tomentosum*.

The Cephalopoda (" Head-footed ").—This term is usually employed as embodying but the cuttle-fishes (squid, octopus, etc.), but in precise application it should include the *Pteropoda* (or "Sea-butterflies"), for they also are *Cephalopodous*, but this point in classification is another of those on which doctors differ, and as the sea-butterflies belong to the ocean rather than to the shore we can pass on to the undisputed members of the class. The class is divided into two orders, thus:

ORDER I. *Tetrabranchiata* (four gills). One genus only of this order lives at the present time. This is the *Nautilus*.

ORDER II. *Dibranchiata* (two gills).

Order II. is again divided as follows:—

SUB-ORDER I. *Octopoda* (with eight arms). Examples: the common *Octopus* and the *Eledone* of our shores, and the *Argonaut* of southern seas.

SUB-ORDER II. *Decapoda* (with ten arms). Examples: the so-called squids—*i.e.* *Sepia*, *Loligo*, *Ommatostrephes*, and *Sepiola* of our seas, and many examples in foreign waters. The best known of all these is the common squid (*Sepia officinalis*, Fig. 98).

On the British coasts this is somewhat erratic in its occurrence, occasionally arriving in large numbers, then being absent for many years. On the southern side of the Channel, including the Channel Islands, it is constant during the summer months.

Much has been written about the octopus, from sensational, and generally very wild, newspaper paragraphs to the most elaborate details of its anatomy in books of science. But as regards its *appearance* and its *habits* nothing, to my knowledge, has been so far attempted.

The specimens that occur in these seas are, when full grown, of about eight feet in spread of arms. This is the usual way of expressing the dimensions of this animal, but it is apt to give an exaggerated idea of its actual size.

The body of such a specimen is of about the size and shape of a cocoa-nut, the head, which is only marked off from the body by a slight constriction, adding about another three inches to the length of this. The eight arms or tentacles are about three and a half feet long, about three inches in diameter at the base, and tapering gradually

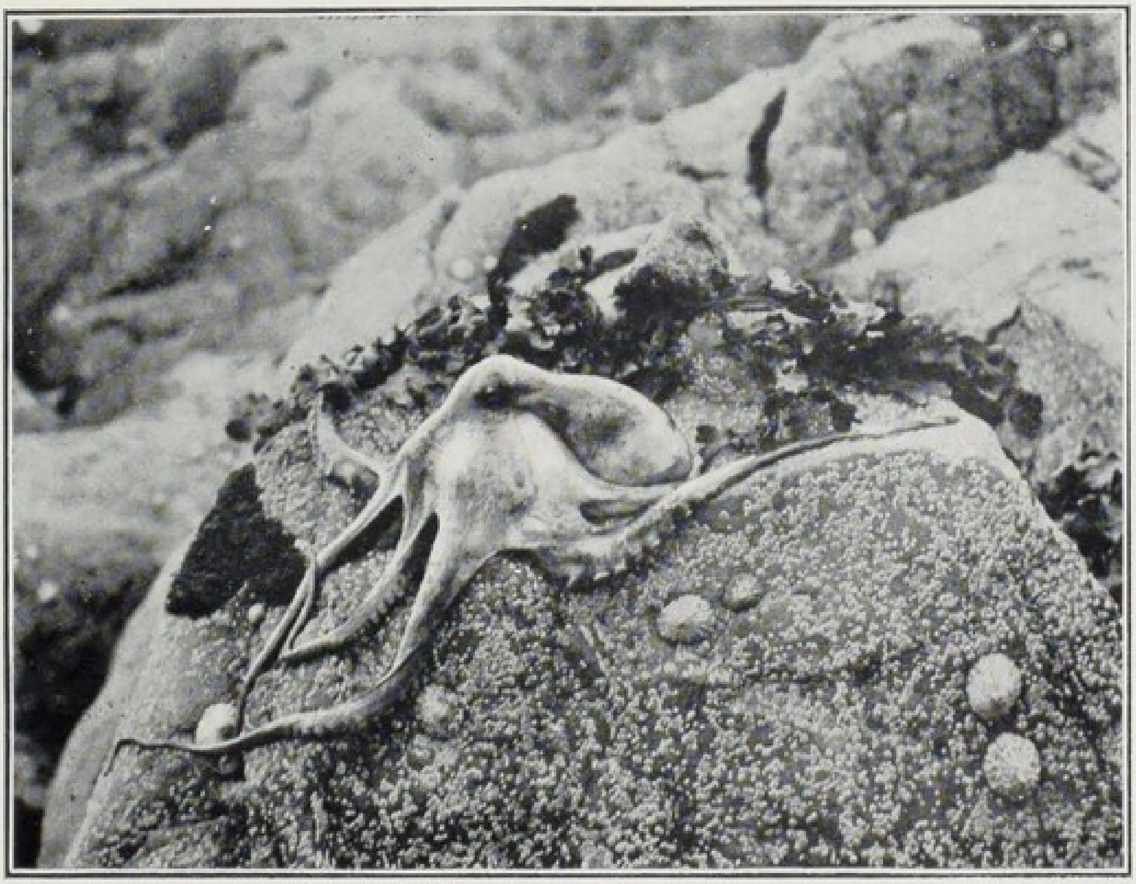


Fig. 93.—*Octopus vulgaris*. $\frac{1}{8}$ Natural size

down to the diameter of a straw. Two rows of suckers, ranging from an inch and a half in diameter at the base of the tentacles to about one-sixteenth of an inch at their tip, are set so as to just touch one another throughout the length of the tentacles. There are about three hundred suckers to each. The tentacles are joined for about one-fourth of their length by an elastic membrane, a kind of "web-footed" arrangement. In the centre of the disc from which the tentacles arise is the mouth (Fig. 94), and this is furnished with a horny, parrotlike beak, which can be protruded or retracted.

The under side of the body is in the form of a flap, like the outer half of a folding, india-rubber tobacco pouch. Within the cavity thus formed are the two gills and an ink bag—for Octopus, like its allies, has this protective arrangement, the use of which we shall presently see—and pointing forward in a median line is the *Syphon*, a funnel-shaped arrangement with the small end outwards, and formed of thin, strong membrane. At each inspiration water is taken in through the opening of the flap or mantle fold, and in *expiration* the water is forced through the tube in a strong stream, the membraneous edge of the tube closing during the act of inspiration. In a large specimen the diameter of the syphon is about half-an-inch. It is through the same tube that the ink is expelled when occasion requires.

The skin of the octopus is like damp kid leather, and is very elastic. At times it lies smooth and even, but can also be raised in little papillar eminences, sometimes in ridges, like little mountain chains. A tall papilla is invariably raised, hornlike, just over each eye.

These elevations are only shown when the animal is quiescent, and considers itself in security.

The coloration of the octopus is very remarkable: I do not think any animal can make such a series of colour variations so rapidly.

When at rest and unexcited the general tint is purple brown, but there is a constant series of slight changes—grey, brown, purple—passing, wavelike, over it. When highly content, as after a meal, and perched, as it is fond of perching at times, upon an eminence, the papillæ are erected, and these are always of an orange colour.

Oftentimes the whole body will be marked off in irregular, honeycomblike patches, or more like crocodile-skin. First some of the patches are purple, others orange, then these colours are reversed.

When danger threatens, or even when the hand is moved towards it, as if to strike, the animal winces, and turns to an ashy grey.

I have kept many of these animals in confinement in

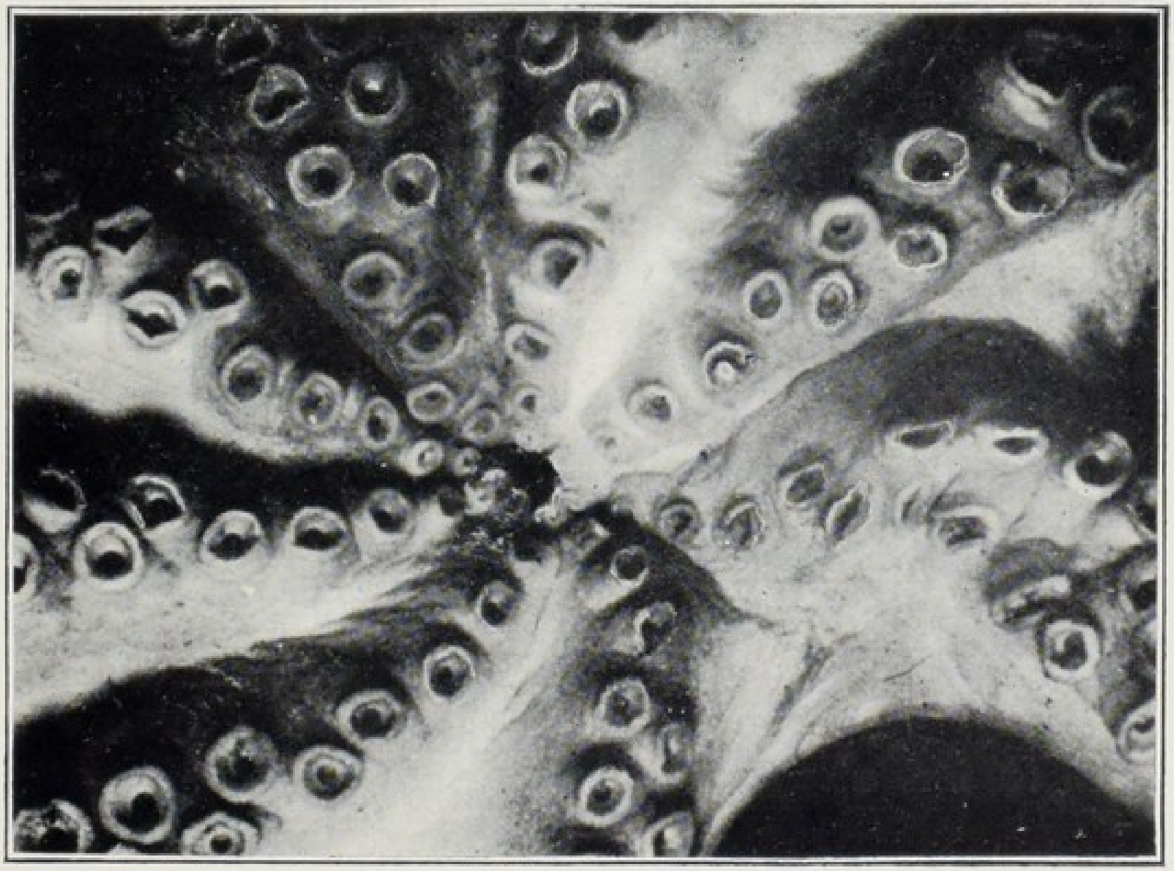


Fig. 94.—Central Disc and Mouth of Octopus. ¼ Natural size

aquarium tanks, and also in kind of rabbit hutches, with wire-netting tops, ballasted down in the rock pools which were their once freer homes, and have under these conditions carefully watched their ways.

The octopus has an amount of intelligence which is rather astonishing, when we consider it is a mollusc.

I have seen one kill a little rock-fish, and place it in such position that crabs which were attracted to it would be just in easy reach of a tentacle—for the octopus will only eat fish when hard pressed, crabs and molluscs are its favourite and regular food.

The octopus has memory, which extends over several days at least. Some captive specimens that were hungry were offered some large oysters. Great efforts were made to open these, the threadlike tip of a tentacle feeling around the edges of the shell for some small point of admission for hours, but with no result.

The same oysters were offered to them a week after, but were only favoured with a moment's glance, they were not even touched.

Its methods of capturing its prey are varied. If the crab is in the open and the octopus is out on the hunt it rises above its victim, and with tentacles so outstretched that the web that joins them part of their length forms a parachute it descends like a cloud on its victim. Oftentimes the octopus lies in wait within a crevice, or a hollow under a boulder which it has excavated by blowing out the sand or gravel; there it watches, and if a crab passes by throws out a tentacle, which, neatly rolled into a vertical coil, *unwinds* itself gently towards the crab, flicks it with the sucker-clad tip of the tentacle, and draws it to its lair.

It is remarkable that with little exception the crab does not attempt the least resistance to the octopus. If a crab, scuttling along, espies the lair of an octopus it halts in its career, and raises its claws in a defensive attitude, but that is all. The tentacle "flicks" it, and makes it fast to its suckers, and in its defiant attitude, as if petrified, it is drawn into the lethal chamber.

I have seen a moderate-sized octopus thus catch seventeen crabs in succession, just storing them in the custody of its manifold suckers, to await their turn.

The octopus does not break the shells of its victims, but simply disarticulates them, and with the slender tips of its tentacles removes every vestige of the edible parts. The horny beak does not seem to be employed, except in taking from the tentacle suckers the portions they have removed.

The only active resisters I have seen to the attentions of the octopus are the lobster and the fiddler crab. This last, as I have stated in describing it, is very pugnacious, and even the presence of the crab's arch-enemy does not make it quail. But its resistance and clanging of claws avails it nothing: a hundred or two of active suckers attached to flexible and muscular arms render it powerless in a second.

The lobster, if a large one, the octopus approaches with circumspection, endeavouring to secure its claws with tentacle tips, and, of course, manages this in a very short time.

In an animal possessing such an outfit of motile appendages it is natural that the means of locomotion would be varied, and they are so to a degree.

The octopus can proceed at a goodly rate by the simple process of walking, spiderlike, although it more frequently seems to glide along, throwing its long arms as far forward as they will reach and making fast its suckers to the ground, releasing the hold, and repeating the operation as it brings its body up to the advanced point. For a short distance swim it paddles with its tentacles, with the queerest antics that can be imagined, but for a ' business " swim, as on its migrations, it propels itself body foremost, tentacles, closed together to a tapered point, bringing up the rear. This progression it performs by filling the mantle cavity with water and expelling it with force from the syphon tube—just the process of breathing performed with some additional vigour.

Each expulsion of water drives the animal along six or eight feet, so that it travels at an amazing rate. It is represented swimming in Fig. 95.

In the Channel Islands, and on the opposite coast of France, octopus fishing is quite an institution, both professional and amateur fishermen catching them for bait for their conger lines, and also for table, for the snow-white flesh of this grotesque animal is certainly very palatable, although somewhat " firm."

There are several methods of taking the octopus, the most common one being to seek their hiding-places, beneath boulders and in rock fissures—which hiding-places are usually betrayed by a kitchen midden of crab and cockle-shells at the entrance—and then drag them out with gaff hooks.

The gesticulating, remonstrating quarry is then taken with the hand, and dashed unmercifully against a rock. The mantle is turned inside out, and the viscera and ink bag removed. Quietness now supervenes, and the octopus is basketed.

Another method is to repair with a boat to localities they are known to frequent, then to lower a stone, with a net bag containing broken crabs, by a strong rope. Sometimes half-a-dozen octopus will fasten on to this bait and get hauled up into the boat, where boat's tiller and sea-boots are brought to bear upon them.

Yet another plan, much used in the autumn, especially on the north coast of Jersey: in this particular locality, and at this time, they sometimes swarm on the sea surface, swimming in the method last described, no doubt on their way to some more genial shore. Men armed with long bamboo rods, with large hooks at the end, station themselves on outlying rocks, and simply hook them out as they pass. I have seen many tons' weight caught in one locality by this method, and being used to manure the land.

Much has been said about the danger of bathing where this animal is found. This may exist, but I can only say

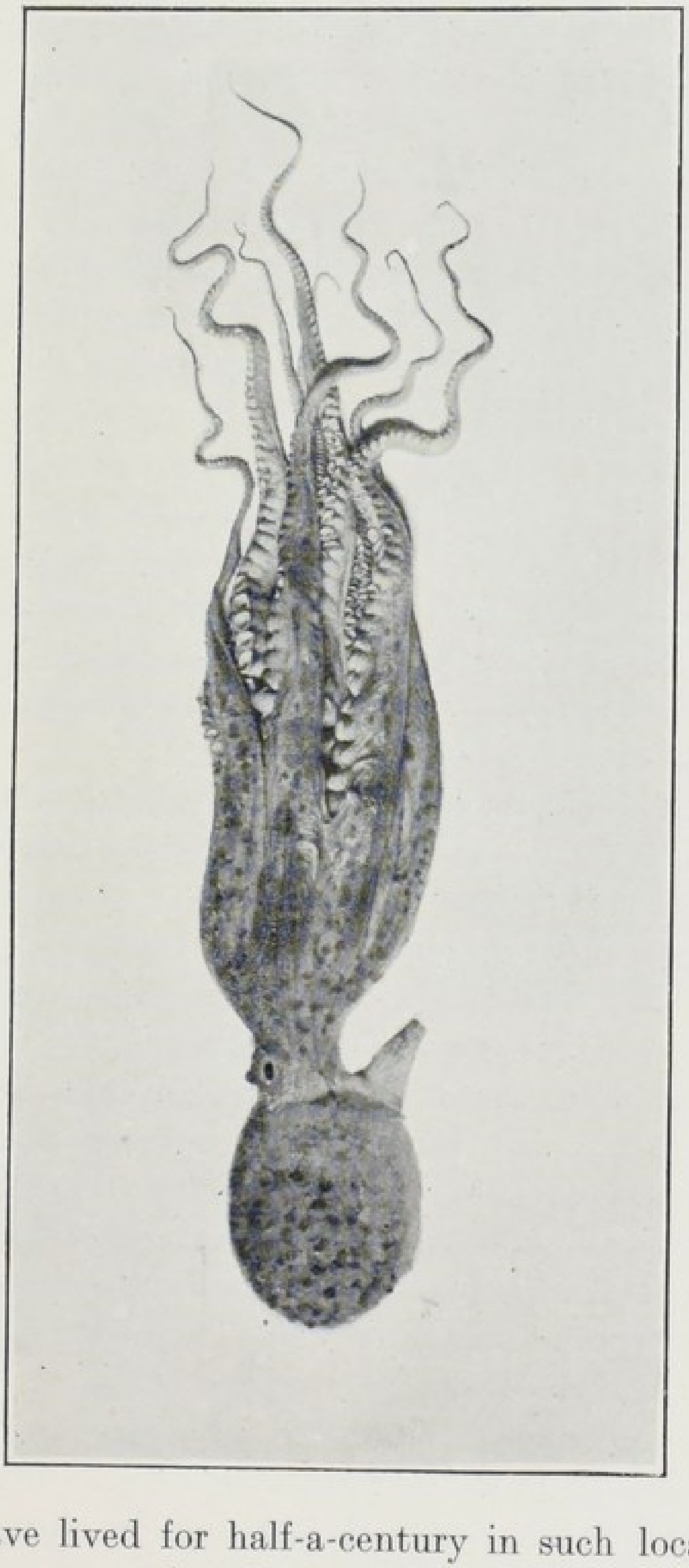


Fig. 95.—Octopus swimming. $\frac{1}{6}$ Natural size. The Photo shows the position of the tentacles during the momentary pause between each advance

that I have lived for half-a-century in such locality and have never seen or heard of any case.

My experience is, and I have caught many hundreds, that the octopus is just a passive resister. There is a creepy sensation when it winds its tentacles around one's hands and bared arms, but, beyond a transitory redness on the skin as the suckers detach, no harm accrues. Its relative, the squid, will often bring its beak to bear, giving a somewhat sharp bite, but I have never known the octopus to do this. Nor does the octopus throw out its ink on slight provocation, as do other cephalopods. I have only known it do so when injured.

Closely allied to the octopus, and, at the first glance, easily mistaken for it, is *Eledone moschata*. This is structurally very similar, but of more slender build, and instead of a double row of suckers on each tentacle it has but a single one. It is far less common on these (South Channel) shores than the octopus, but seems to have a greater range, extending more northward. It takes its specific name from its possessing an odour of musk.

Of the other cephalopods only one may strictly be said to belong to the littoral zone. This is the beautiful little *Sepiola rondettii* (Fig. 96). It is about two inches long, the body round, and the eight primary tentacles short, and forming a circle about three-quarters of an inch in diameter. It is a *decapod*, for beyond the eight primary tentacles it has two others, which are on long stalks, and have only the little spatulate tip furnished with suckers. Pockets, one on each side, allow the long stalk to be curled in at will, so that only the sucker-clad portion remains in view. This little cephalopod is very common in our sandy bays, and always forms an undesired item in the products of the shrimper's net.

Its colour is opalescent white, but it is abundantly furnished with a brown-red pigment, which causes a constant succession of spots and dashes on its skin.

It ejects its cloud of ink on the least alarm, and while the eye of the would-be capturer lights on this the Sepiola is far away.

Loligo media, one of the calamaries, may often be seen in the large, sand-bottomed pools. This species is about four inches long, slender and graceful. It is usually seen in little shoals of a score or so, and they manœuvre with military precision. Their colour, pearly white, with pink dots (variable at will), closely assimilates with the sandy bottom, but they are conspicuous by the large, metallic, green eyes.

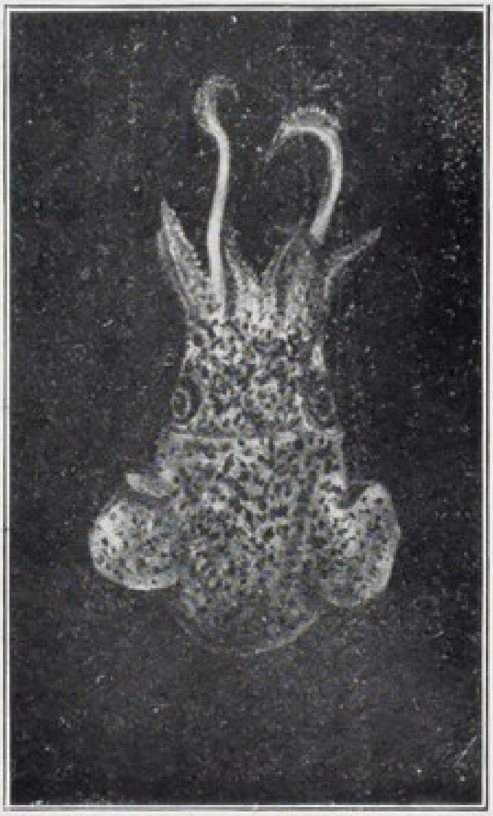


Fig. 96.—*Sepiola rondettii*
Natural size

This is given as a *species*, and perhaps it is, but I have a suspicion that it is but the young of the large common squid.

(If they were adults their egg capsules would certainly be observed, but I have never known of any.)

The common "Long Squid," "Cuttle," or "Calamary" (*Loligo vulgaris*), does not, when adult, belong to the littoral, but is taken, sometimes abundantly, in the trawl close inshore. It attains a length of about twenty inches, and is much prized as bait by the fishermen. Its eggs are frequently seen at low-tide level. They are set in little capsules, which are aggregated into long, cylindrical, gelatinous arrangements, and these are fixed by a string, in bunches of a dozen or so, to various objects—stones, shells, stems of laminaria, etc. The ropes hanging from buoys or attached to crab pots are favourite situations for these egg clusters.

These clusters bear a curious resemblance to a bunch of the old-fashioned dip candles, in miniature—"Christmas-tree" size. When the eggs are on the point of hatching they furnish interesting objects of study.

The little ones, on emerging, are about an eighth of an inch in length, and are not of the form of the parent, but

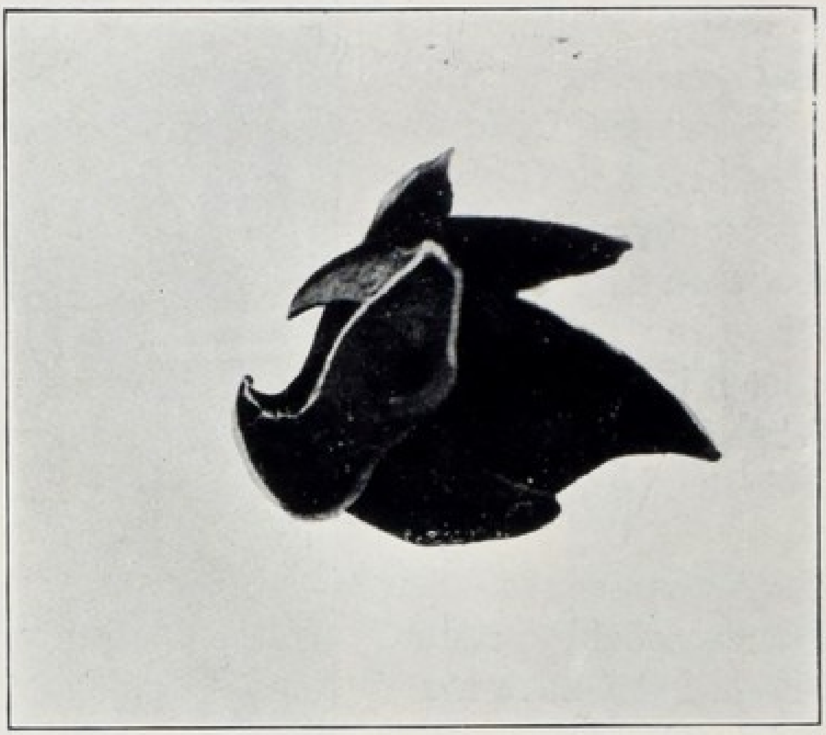
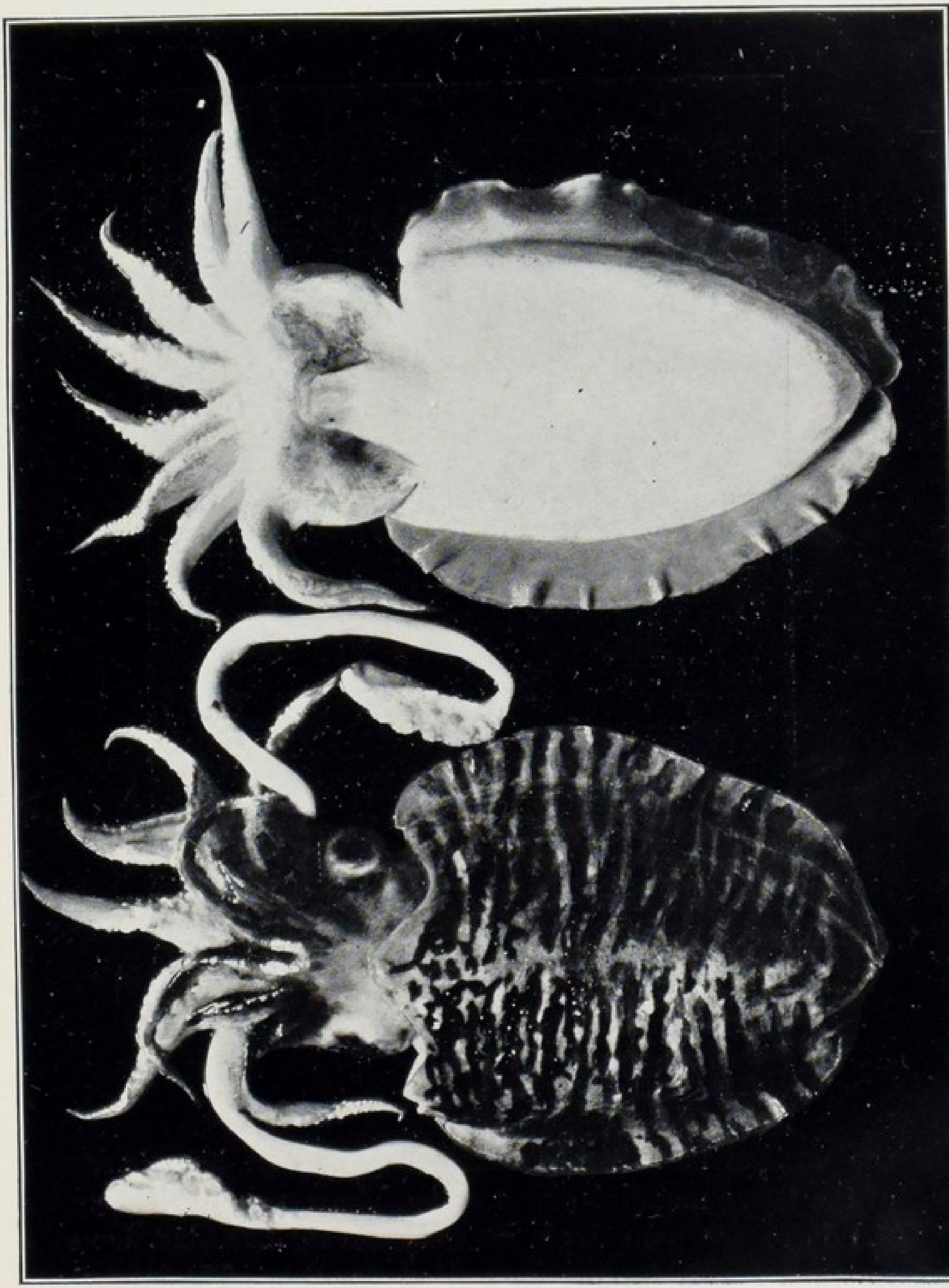


Fig. 97.—Beak of *Sepia*. Natural size

are just like little *Sepiolas*. Each is already furnished with a little bag of ink, for defensive purposes.

The short squid or cuttle (*Sepia officinalis*), the white, highly calcareous shells of which are familiar objects on the sands, and which, when powdered, form the *Os Sepiæ* of the druggists' shops, are occasionally, not often, found in pools between tide-marks.

Unlike the octopus, whose chief menu consists of crabs and molluscs, all the *decapod* cephalopods are fish feeders. The beak, which is shown in the photo (Fig. 97), has a peculiar action, readily understood by considering the figure



a moment. The top mandible descends and closes within the under one, but in such a way that the sharp edge of

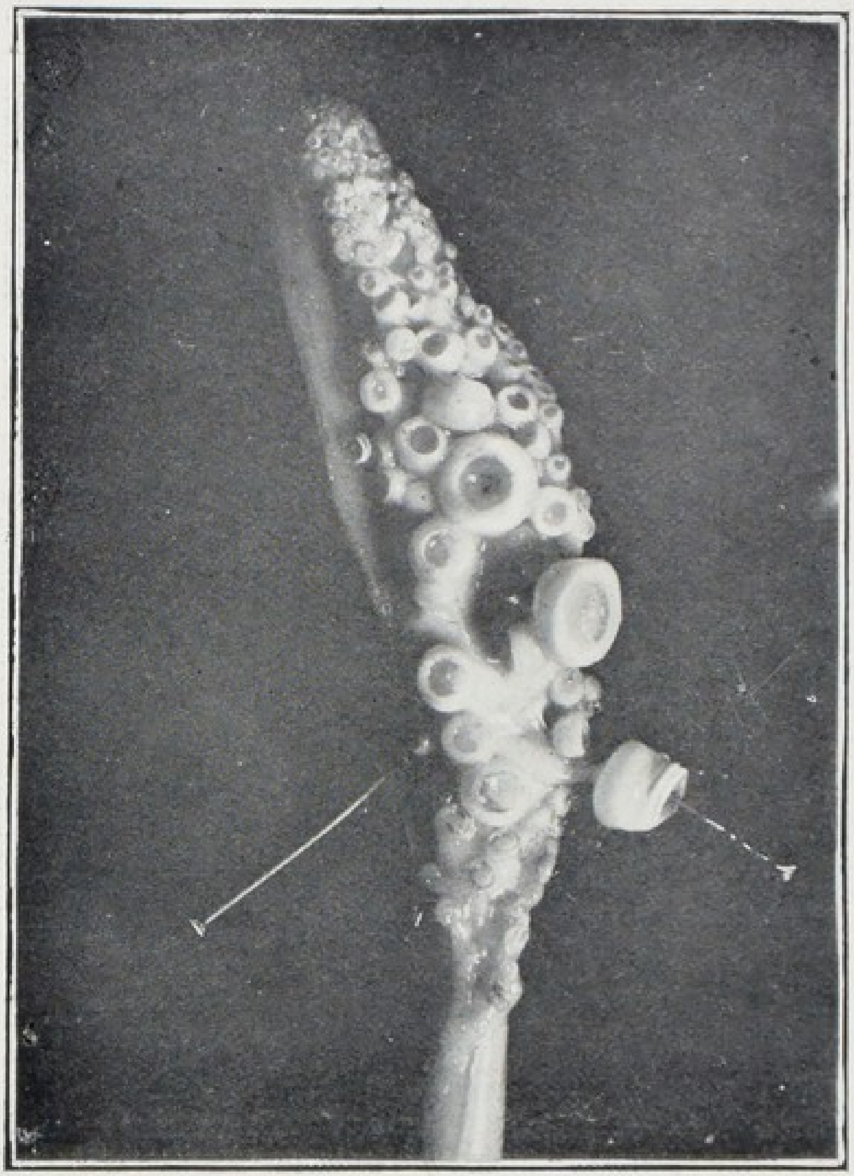


Fig. 99.—End of one of the long arms of *Sepia*, showing stalked suckers and their shelly ring (extended with pins). Natural size

the vertical plate works obliquely upon the sharp edge of the lower mandible, thus acting like a pair of shears.

I have not seen Sepia attack a living fish, but have watched a pair feeding on a dead dog-fish. The scissor-like beak cuts openings of sufficient size to the interior of the fish, then the long, tentacled arms, lax as they are when not in use, are inserted, and the suckers on the widened end bring up morsels and convey them to the beak. The long tentacles are thus used as spoons, with peculiar adaptations for taking up the portions of food.

Fig. 98 shows two specimens of *Sepia*, one viewed from the dorsal, the other the ventral, side.

In the former the tentacular arms are exerted, in the latter, although present, they are not visible, being entirely packed away in the side pockets.

Fig. 99 shows the end of one of the tentacular arms, with its peculiarly shaped suckers. Each sucker is on a little stalk, and on many of them other little suckers are developed. The edge of each is fitted with a little shelly ring, exactly like a miniature napkin ring. In the Photo, one sucker is drawn out by a pin to show the stalk and ring.

The eggs of Sepia are not packed into capsules, like those of Loligo, but are single, and very much larger; each has a thread, by which they are fastened in bunches to some object.

The eggs are purplish black, in size and colour much resembling large black currants. They are known to fishermen as *Sea-grapes*.

Sepia elegans, in size and form something between *Sepia* and *Sepiola*, is sometimes taken in the littoral, but it is rare.

CHAPTER X

THE BRACHIOPODA

I AM placing this group at the end of the mollusca, in common with many others, but it is very certain that they are not related to the mollusca.

They have also for a long time been classed with the Polyzoa and the ascidians, as *Molluscoidea*, but in accordance with the most recent researches they must be placed in a group by themselves, although they have some affinity with the *Polyzoa*.

These animals have a large body and a bivalve shell, but the valves of the shell do not lie, as in the mollusca, one on each side, but are placed dorsally and ventrally. They have two coiled arms on the margin of the mouth. These arms, or feet, as the name of the group implies, have branchial functions—that is, they are respiratory organs. With the exception of one small species they are not found in the littoral. They are better represented in the Mediterranean and in southern seas than on our shores, but one large species, the "Serpent's Head Shell" (*Terebratula caput serpentis*), is found in the North Sea.

Few and scattered at the present day, they abounded in the primeval seas, and are a common fossil in Silurian, Devonian, and other formations.

CHAPTER XI

CHORDATA

This designation, in its narrower limits, is applied to a group of animals which possesses many structural points that pertain equally to the vertebrates in their embryological stages, thus forming a connecting link between the two great divisions.

In its broader sense, and in some of the most recent classifications, it *includes* the vertebrates.

Balanoglossus.—This animal has long perplexed naturalists. It is of wormlike form, and by the earlier writers *was* classed as a worm.

In the developmental stages of some of its species there are structures which are closely parallel with the larval stages of Echinoderms, so by some authorities Balanoglossus has been ranked as an outlying division of these.

Not until 1883, when Bateson made an elaborate study of this strange animal, were its affinities with the higher orders discovered.[1] It has many resemblances to the lancelet, and to the embryos of all vertebrates.

For some time it has formed a division of its own, under the title of *Enteropneusta.*

Balanoglossus has a wide geographical range, extending from the Arctic Seas to New Zealand.

[1] Some years prior to this I had, while dissecting some specimens which I had brought from Herm Island, been astonished on finding branchial arches, and corresponded with a scientific friend, Mr C. Davey, B. Sc., on the matter, but was not sufficiently sure of my ground to make the matter public.

The one found on our shores is *Balanoglossus sarniensis*, or, more properly, *Ptychordera sarniensis*. (Its specific name is from the first specimens having been obtained from Guernsey, the classical name of which island is *Sarnia*.)

It is, as I have said, of wormlike form, about thirty inches in length and half-an-inch in diameter. The anterior portion, for about eight inches, is either orange or yellow in colour. The next portion, for about eight or ten inches, is green, the remainder creamy white. The orange-coloured portion is of fairly firm texture but all the remainder is exceedingly fragile, being little more than a semi-gelatinous membrane, gorged with the sand which the animal takes in feeding.

At its anterior end is a conical proboscis, at the base of which is the mouth. Then follows a collar, about half-an-inch wide, with the upper edge frilled and projecting, then the part which bears the openings to the gills.

It feeds in the same manner as the earth-worm—that is, as it progresses through the sand or gravel the portion of this which in the ordinary process of boring would be pushed aside is taken in by the mouth, and is left behind at the posterior end of the body, the organic matter which may have been mixed with it having served as food.

Balanoglossus has a peculiar and powerful odour, closely resembling that of iodoform.

Often, when digging in shell gravel for Synapta, etc., I have been apprised of the proximity of Balanglossus by this odour, which pervades the sand for a considerable distance, several feet, if not yards, around it.

After touching a specimen this odour clings so persistently to the hands as to be appreciable for days, repeated washings notwithstanding.

Owing to its fragility it is very difficult to obtain the animal unbroken. I have only succeeded in doing this once, and it is from this specimen (now in the Guernsey Museum) that I am able to give the length.

It is tolerably frequent in the Channel Islands, at Chausey, and the Minquier reefs. As to its localities on the English shore, I have no data, but it must be pretty well distributed, for its larval form (*Tornaria*) is frequent among the minute organisms that live at, or near, sea surface, and which are collectively termed "Plankton."

The distinction between Balanoglossus proper and *Ptychordera* is in some details in development; the latter showing the Echinoderm resembling larval stages, the former having a more direct method of development. The former is also the more northern, the latter the southern form (see excellent article on Balanoglossus in "Encyclopædia Britannica").

The Tunicata or Ascidians.—The first of these titles is applied to the class of animals before us on account of their being enveloped in a more or less leathery "tunic" or test, the second on account of their form, which bears some resemblance to an ancient leather wine-bottle (*Ascis*).

A very great deal of interest attaches to the tunicates, as they are believed, by the authorities most competent to decide, to be allied to the forms from which the vertebrates have evolved.

In outward appearance an ascidian seems to be of very lowly organisation, fixed (the greater number of species) to rock, stone, or sea-weed, with no power of movement beyond, to a slight extent, the protrusion and retraction of the slight tubes which border the openings to the body —"inhalant" and "exhalant" apertures. Reference to the diagram (Fig. 102) will help readers to understand the general plan of their anatomy. In function they closely resemble the lamellibranch molluscs, the inhalant aperture taking in, by means of the action of the cilia which line it, the sea-water, which, entering the cavity termed the *Pharynx*, bathes the extensive and regularly fissured arrangements, the "branchial sac," for respiratory purposes.

At the same time such minute floating objects as the inhaled water may contain—diatoms, spores of sea-weeds, larval forms of other animals, etc.—are secured for food.

Both sexes are represented in each individual, but each is not self-fertilisable, fertilisation depending upon the spermatozoids set free by other individuals.

The eggs are hatched within the parent, and when advanced to a certain stage the young are temporarily packed in a chamber, the *atrium*. The excretory ducts, alimentary and genital, open into this chamber, whence their products are expelled, together with the water, which has served its purpose, through the "exhalant aperture."

It is in these just liberated young that the greatest interest centres, for they differ much from the parent.

The little ones, which are of tadpole form, are active and free-swimming. They possess a *Notochord*, that incipient dorsal axis which occurs in all vertebrate embryos, and the calcification of which results in the "backbone" (Fig. 102). Not only have they this, but a spinal cord, which expands at its anterior end into a "brain," and an *eye*, with retina and crystalline lens.

But after this quasi-vertebrate stage the next and final one of development is what appears like reversion.

After the little "tadpole" has led a few weeks of active life it settles down, and becomes an animal of what we would consider much lower status.

At its anterior end the little tadpole has three sucker arrangements, by means of which it attaches itself to some support, head down, tail up.

The tail, with its notochord (or *Urochord*), its pro-vertebrate nerve system, brain, and spinal cord are absorbed: the former disappears, the latter dwindle down to a simple nerve ganglion. It envelops itself in a protective " tunic," and becomes as we see it in Fig. 102.

In one species, however, a diminutive one, named *Appendicularia*, which abounds in our seas, the tadpole form, with very little modification, only that of loss of symmetry, is permanent through life.

On our rocky shores, in pools that do not drain dry, fairly well down in tide range, the intending student will find attached to the sides of stones, below their water line, and on their under sides, clusters of the beautiful little crystal bell, *Clavellina*, and in the months of May and June he will easily find some in which the atrial chamber contains a vast number of the tadpole larvæ, which will, with a little persuasion, readily emerge, and swim nimbly in a dish of sea-water, affording an entertaining object of study.

All species, in proper season, offer the same facilities, but clavellina, being transparent, shows if the larvæ are present without dissection.

The tunicates are roughly divided into three sections—viz.

" Simple Ascidians," which are usually of large size, and live isolated ; " Social Ascidians," in which the individuals, while in one sense separate, are still joined into colonies by a stem or " stolon," and the " Compound Ascidians," those in which the individuals combine into large colonies, usually in colonies of little families, and are enveloped in one spreading, leathery tunic, common to all, and which forms encrusting coatings to stones, etc. The " Starry Botryllus " is one of these (see Figs. 100 and 101).

Some tunicates, considerably modified in outward form, float, either singly or in curiously arranged chains, in the open sea (*Salpa*, *Doliolum*, etc.).

The tunicates, both in number of species and number of individuals, abound on our shores. The compound forms being most numerous.

From half tide to the lowest littoral zone, wherever slabs of rock overhang, or where some large boulder is supported, cromlechlike, upon others, vast colonies of the

Fig. 100.—*Botryllus morio*, on fucus
Natural size

common "Sea-squirt" may be seen, densely crowded, on the under side.

These are *Cynthia aggregata*. They are of a deep red colour, with the projecting tips of the apertures of a lighter red. They range from the size of a pea to that of a small walnut. Smaller allied forms (the nomenclature of which is still hazy) form similar coatings to the stems of the oar-weeds, or form slightly elevated bosses on stones and shells.

The beautiful, crystal-looking *Clavellina lepadiformis* lives in clear pools, not necessarily far down in tide range. Clusters of them may be obtained by tilting or overturning boulders that are in whole or part submerged.

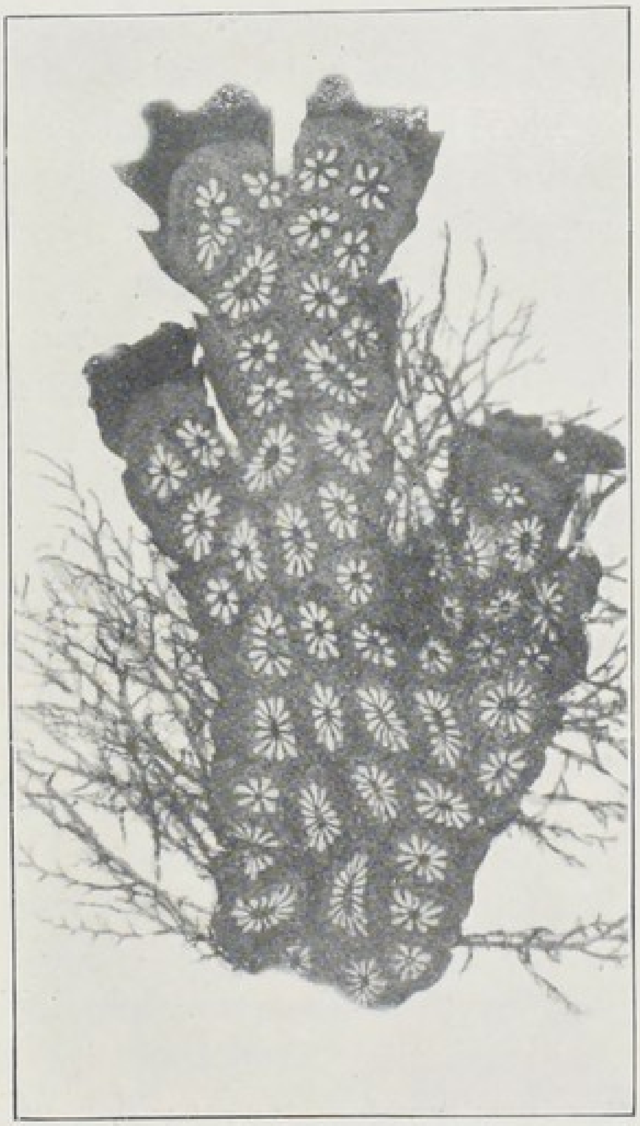


Fig. 101.—*Botryllus schlosseri*, on fucus. Natural size

The novice may easily overlook them, for they are transparent as glass, only lines of yellow, like some fine gold twist, and some dark lines, yellow and red, marking the intestine and other details of their anatomy. They are from half-an-inch to three-quarters of an inch in length, and are always attached in clusters to a creeping stem or stolon.

They multiply in two ways—viz. by the liberation of tadpoles, as described, and also by budding up from the stolon, like mushroom caps from their mycelium.

In the same localities, still less conspicuous, although perhaps more abundant, are little round ones, like glass beads, or rather like grains of cooked tapioca, in size, colour, and feel.

These are *Perophora Listerii.* They usually lie, one layer deep, on the clean gritty under side of stones in clear rock pools, when the stones do not lie in close contact with the bottom, but are propped up by others.

The young student, possessed of a microscope, will do well to collect some of these, and take a supply of sea-water for their observation at home.

Placed in the hollow of a sunk slip, with a drop of water, and a cover glass lightly laid on (a "Compressorium," supplied by the dealers in microscopes, is the proper, but not actually needed, arrangement), they will show, not only the details of structure given in the diagram, but will show function—*e.g.* that of the curiously acting *heart.* This organ gives a number of pulsations, usually forty, which propel the blood in one direction. Then there is a few seconds' pause, then an equal number of pulsations sending the current in the reverse direction. This circulation can also be traced in the stolon which connects the individuals.

Clavellina will show this as well, but it is rather too bulky for the micro slip.

Where the foregoing are found there will also be many of the compound ascidians. Very common on most shores is *Morchellium argus.* The colonies of this one are seen in the form of soft, pear-shaped lumps, about two inches long by three-quarters of an inch in diameter at the wide end, and they hang from the sides, or from underneath the boulders. They are of a brick-red colour.

One of these clusters pinched between forefinger and thumb into a saucer or watch-glass with sea-water will release the individuals. They are about three quarters of an inch long, slender in form, and of blood-red colour. Each shows, under the microscope, the same details of anatomy as those given in the diagram (Fig. 102).

In the same, or similar, places may be seen more sessile clusters, of a beautiful rose-pink, with white dots in waved

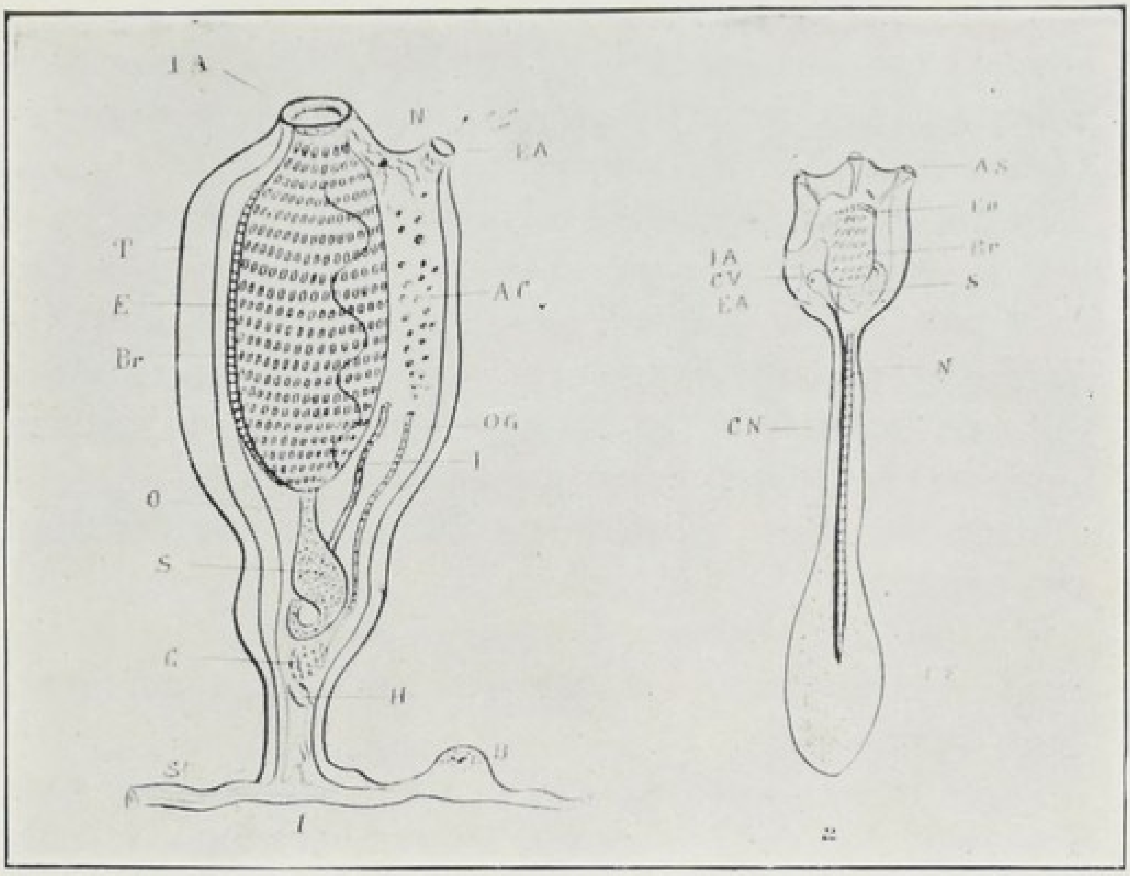


Fig. 102.—Diagrams of—1. *Clavellina*; 2. Tadpole stage of *Fragarium*

Explanation—in 1

IA. Inhalant aperture.
EA. Exhalant aperture
T. Test.
E. Endostyle.
Br. Branchiæ.
O. Œsophagus.
S. Stomach.
G. Genital gland.
AC. Atrial chamber (with enclosed Tadpoles, some freed at EA.).
I. Intestine.
OG. Opening of genital gland.
N. Nerve ganglion.
St. Stolon.
H. Heart.
B. A new individual appearing —that is, a "bud."

(About 5 diameters)

Explanation—in 2

IA. Inhalant aperture.
EA. Exhalant aperture.
CV. Cerebral vesicle.
AS. Suckers.
En. Endostyle.
Br. Branchiæ.
N. Notochord.
CN. Caudal nerve.

(About 25 diameters)

lines on the surface, each cluster of about the size of a walnut. These are *Fragarium elegans* (the generic name, applied from their resemblance to a strawberry).

In August and September this species is in reproduction—that is, in its sexual reproduction—and a lump treated as described for the last will reveal not only the adult individuals but large numbers of the tadpole larvæ, which will swim actively in the saucer. The diagram of ascidian tadpole (Fig. 102) is taken from this species.

There are many allied forms, but those just described are common, and are typical.

The familiar "Starry Botryllus" can be seen at the same zone as these, but they are more abundant lower down in tide range.

There is an endless variety of these, but whether each difference represents a species, or whether some are only varieties of the others, I am not competent to say.

In Giard's beautiful monograph, "Les Ascidies Composées," there are numerous enlarged and coloured figures for the determination of the different species, but the number there figured falls far short of actuality.

In the genus *Botryllus* the individuals are small, not more than a quarter of an inch long, and they are arranged in more or less perfect circles, with their mouth openings outward, forming a star-shaped pattern, and these "stars" are closely set in the general investing matrix, which is the common "tunic."

Each of these little individuals has the same structure as the large ascidians, only that they have their exhalant apertures towards the inner end, as regards the star, where they join into one common *Cloaca*, which is the centre of the star.

The most abundant species is *Botryllus violaceus*. This forms large patches on the sides of, and underneath, boulders, often six or eight inches across. These patches resemble in texture patent leather, they having a bright, fine surface. The colour of the species is purple, with the stars a violet-blue.

A closely similar one is *Botryllus aurolineatus*. In this the matrix is purple, and the stars are conspicuous by each individual having a golden line down its centre.

Very abundant is *B. smaragdus*. This one forms bulky colonies, sometimes thin and encrusting, but often nodular, of the size of a large duck's egg. The colour is dark green, with the stars a paler or yellowish green.

B. schlosseri is similar in form and arrangement, but the colour is a beautiful lemon-yellow, with the stars a deeper yellow or orange. In one variety (*B. schlosseri*, variety *Adonis*) the individuals have a scarlet line along the centre and a tiny scarlet circle around the mouth.

B. myosotis, as its name implies, bears a resemblance to our beautiful little flower the forget-me-not.

B. rubra has stars of bright red on a pale brown ground.

B. morio is dressed in half mourning. The stars are white, upon a black ground. This is the species shown in the photo (Fig. 100). The other (Fig. 101) is *B. schlosseri*. These are only a few of our species, a repetition of details would be wearisome, and of no service.

Allied to *Botryllus* is a very closely allied genus—viz. *Botrylloides*. The difference between the two genera is readily apparent, even to the casual observer. In this genus the individuals are not arranged in stars, but are in symmetrical double lines, the general cloacal chamber being linear instead of circular.

I know but of one species on our shores. It is *Botrylloides rubrum*. The colour is usually orange-red, sometimes crimson, and, rarely, claret. It is of softer texture than the preceding, and it forms encrustations around the stems of fucus, etc., also on stones, but it is most abundant encircling the base of the blades of the sea-grass.

In all suitable localities, such as the rock crevices, etc., I have constantly referred to, in all clean, sheltered situations, may be seen a great diversity of other compound ascidians, but in which the individuals are not apparent to the unaided eye, the colonies looking simply like uniform waxy or leathery patches.

Encrusting stems of weeds and forming nodular encrustations on stones is a white, stony-textured one, that may be easily mistaken for a lime deposit. This is *Amoroucium albicans*. There are buff-coloured ones with waxy surface, some buff with purple marbling, etc., mostly belonging to the genus just named. Very striking among those that live at the foot of rocks, at the lowest spring tide range, is a brilliant vermilion one. This is *Leptoclinum Lacazii*. It forms polished leathery patches, of sometimes a foot across and about a quarter of an inch thick.

This is, doubtless, what Victor Hugo refers to in his "Toilers of the Sea," where, in describing the cave in the *Roches Douvres*, he says: "The walls were splashed with crimson stains, as if giants had been fighting there."

Under stones in pools is another red one, *Leptoclinum fulgidum*, but this forms patches of only an inch or two across, and the red is not so vivid.

One that I have never seen described or referred to is of a bright, ultramarine blue. It is found, with the previous one, under stones. I venture to suggest for it the name *Leptoclinum cœruleum*. It is not common, but I meet with it pretty well every spring tide.

This genus can only be well studied by means of microscopic sections.

The matrix which envelops the individuals in most of these is thickly supplied with stellate spicules of symmetrical form, very beautiful under the microscope. The student will do well to collect and preserve specimens for this purpose.

The Zostera fields are another good hunting ground for the compound ascidians, many forms are abundant there which are scarce elsewhere. Besides the *Botrylloides* already mentioned he will find large, almost flocculent, masses of a light grey colour. These are colonies of *Aplidium gelatinosum*, pealike clusters of *Aplidium zostericola*, and many others, some difficult to distinguish from the egg clusters of some of the gastropod molluscs which occur amongst them.

In these compound ascidians the reproduction, from the original founder of a colony, is chiefly by *budding* (gemmipartite reproduction), but, especially in autumn, they all give rise to a " tadpole " generation. These little " tadpoles," swimming away, and finally settling, form new colonies.

(The nomenclature given above is after Giard.)

In the simple or solitary ascidians the field is not so large.

In rock crevices, and at the foot of rocks in oozy, low-tide situations, may be found, very conspicuously exposed, the large *Ciona intestinalis* (Fig. 103). It is of a pale green colour, with the protrusible part, the tubes, of the apertures still paler, nearly white.

The test of this ascidian is very thin and membraneous, the whole animal almost gelatinous to the feel. It is usually about three inches long, but in favourable situations may grow to a length of six or eight inches.

Of about the same size, but invested in a tough cartilaginous tunic, with the apertures barely discernible, is *Ascidia mentula*. This one is usually attached by the entire side to rocks and stones, chiefly the under side of the latter, at low-tide limit.

A knife is required to collect these satisfactorily, as in trying to detach them by hand the side of the test attached to the stone usually breaks away.

Molgula impura is a simple ascidian, of about the size, shape, and texture of a gooseberry. It lives unattached (unless it be to a bit of gravel), in shell gravel at extreme low water. Its test is strengthened by being invested with grains of sand, etc. Its specific name is very badly chosen, for it lives under the most hygienic of conditions in clean, shell gravel, where it must be rolled and washed by every tide.

These are but a few of the great class of tunicates. An enumeration and brief description of each of our species would occupy this volume.

The Lancelet (*Amphioxus*).—This little animal is of fish-like form, and was formerly classed with the fishes. It is about two and a half inches long by a quarter of an inch wide, somewhat flattened laterally. It is pointed at both ends (hence its name, *Amphi-oxus*). Its colour is a nearly transparent greyish buff.

This curious little animal—the "Sheet Anchor of the Evolutionist," as it was called, before it was recognised that every living thing is a sheet-anchor in the same sense—is not very common on our shores, or at least not *generally* so. I have walked over sandy parts of the coast where I have disturbed them at every step, then again I have been many consecutive years without finding one. (In the Mediterranean it is common, and fishermen employ it as bait.) It has folds of skin along both the dorsal and ventral sides of its posterior half, which form a fin very much as in the eel, but these folds are not a true fin, as they have no *rays*, as in fishes. For a mouth it has simply an oval aperture surrounded by bristlelike, tentacular filaments.

The water taken in by the mouth enters the pharynx, which is lined by a branchial arrangement, as in the ascidians. The water is not "gulped" in, as by fishes, but is drawn in by ciliary action, as in ascidians, lamellibranch molluscs, and sponges. The water after having

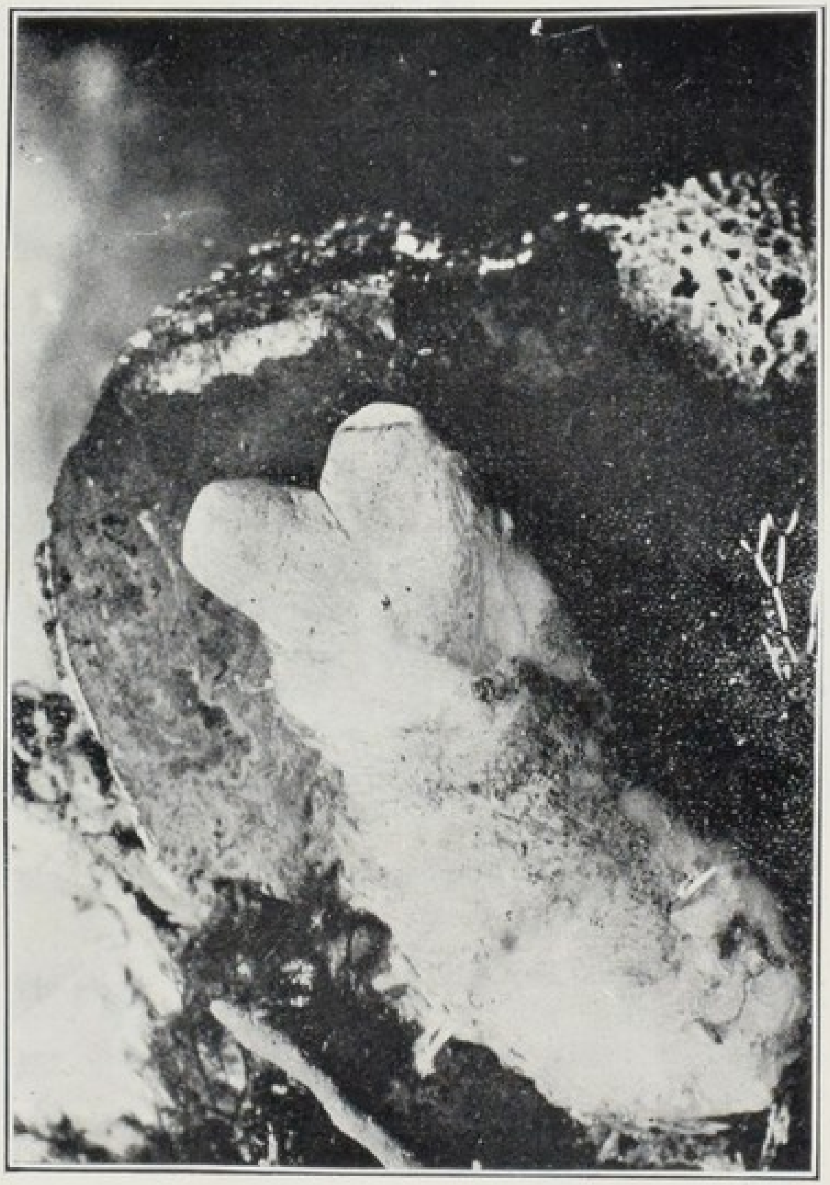


Fig. 103.—*Ciona intestinalis* on side of rock
$\frac{2}{3}$ Natural size

passed the branchia passes into an atrial chamber, as in the ascidians.

It has a *notochord*, that incipient form of "back-bone," as have the ascidians and the embryos of vertebrates, a spinal cord, but no brain. A pigment spot at the anterior end of the dorsal cord foreshadows the eye of the vertebrates.

It has no *heart*, in the proper sense, but the blood is propelled to the branchiæ for oxidation by an arrangement of the ventral muscles, while a similar arrangement on the dorsal side sends the purified blood to the different parts of the body.

The young pass through developmental stages very like those of some of the worms.

The lancelet lives for the greater part of its time buried

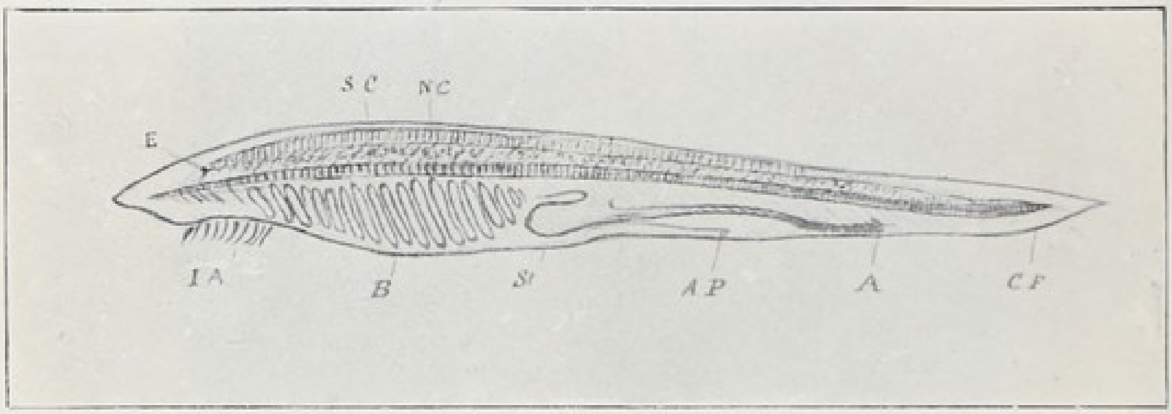


Fig. 104.—Diagram of *Amphioxus*

E.	Eye.	St.	Stomach.
SC.	Spinal cord.	AP.	Atrial pore
NC.	Notochord.	A.	Anal opening.
IA.	Inhalant aperture.	CF.	Caudal fin.
B.	Branchiæ.		

(About $1\frac{1}{2}$ Natural size)

just below the surface of the sand or fine shell gravel, in a slanting direction, with just the tentacled orifice which serves as mouth projecting above the surface.

It swims with difficulty—a few spasmodic efforts to rise, and then it drops, as if exhausted, to the bottom, and swiftly buries.

It may frequently be taken at low spring tide limits in the situations described, but is more usually obtained with the naturalist's dredge, which is fitted with small-meshed netting, for this and other small forms.

The sexes are separate, but can only be distinguished by means of microscopic sections of the organs. A diagram showing the principal parts of its anatomy is given in Fig. 104.

CHAPTER XII

VERTEBRATA

Pisces.—A definition of what constitutes a fish seems rather superfluous, but for the sake of uniformity we must render it.

The text-books define the fishes as follows :—

Cold-blooded, aquatic animals, generally clothed with scales ; swimming by means of fins ; breathing exclusively by gills ; sexes separate, and reproduction by eggs, which in a small number of species (*e.g.* sharks) hatch within the parent.

Treating of the fishes in a book which is intended to apply simply to the animals of the shore—that is, to those that occur between tide limits—presents some difficulties ; for, while a great number of fishes are *essentially* shore-haunting—that is, breed between tide limits and spend their lives in pools, or in situations that are accessible when the tide is at lowest limit—there are many others which, when adult, live in deep water, but spend their earlier lives inshore, notably the flat fishes.

It will be well, therefore, to draw a more or less imperfect boundary line, and count as shore fishes only those that are more frequently seen within tide limits than beyond.

We shall take them, also, not according to classes, but approximately in the order in which they are most frequently encountered by the shore collector or observer.

On rocky coasts, or where these are loose stones inter-

Fig. 105.—Group of Smooth Blennies (*Pholis lævis*), at home. Natural size

mingled with a growth of sea-weed, the following species will be met with :—

Pholis lævis or Blennius pholis (the "Smooth Blenny"), also popularly termed the "Shanney."—This pretty little fish is very common. It lurks under stones, in the crevices of rocks, loose joints in the masonry of piers, and all such situations, from almost the highest tide-level to the lowest. It is frequently found out of water, and can live for hours out of its native element. It is about five inches in length. Its colour is a dark green, mottled with black, white, and buff, without any regular disposition of these markings. It is pugnacious, and bites savagely when captured. It breeds about the month of May, and its eggs, which are round, and about the size of small pin heads, are fastened in an even layer to the under side of stones, usually in rock pools. It frequently uses its pectoral and pelvic fins as legs, as it were, *walking*, lizardlike, over the rocks. It is shown in the photo (Fig. 105).

Gobius paganellus (the "Rock Goby").—This is found in nearly similar situations to the last, but at a lower zone, and more usually under stones in pools than in crevices, and it does not allow itself to be left dry. These are nearly always found in pairs, possibly male and female, for there is usually a difference in markings.

It does not grow beyond about five inches in length. The colour is olive-green, with buff and reddish mottling.

The eggs are affixed, like those of the smooth blenny, to the under side of stones, but they are spindle-shaped, and are attached in close-set symmetrical order by one end.

At first the eggs are colourless, all but the yolk, which shows through the transparent envelope, but as the young develop the eggs appear of a bright, metallic green, owing to the large and conspicuous eyes of the little fishes enclosed, which are of this colour.

It is very interesting to watch the escape of the little fishes from the egg. A few scraped from the stone and placed in a saucer of sea-water can be well observed with the naked eye, although better with a lens. As the period of liberation approaches the little fish wriggles violently within its prison, then the membrane breaks at one end and the little prisoner emerges, tail first; sometimes he is stopped half way, then the wriggles cease, to afford a little rest, then they are renewed, and the little fish swims off in a matter-of fact way, as if it had been in the habit of being hatched.

The yolk, enclosed in a sac, remains attached to its ventral region, and affords a supply of nourishment until it is able to capture prey, which is a matter of several days.

I believe, but am not sure, that the male keeps watch while the eggs are undergoing incubation, as a male fish is always present under the stones where the eggs are found. A pair of these gobies are shown in the photo (Fig. 106).

Tolerably common in the same situations, but also among weeds at the foot of rocks, is the "Father Lasher" or "Sting-fish" (*Cottus bubalis*). This, in appearance, is a formidable fellow, the head is very large in proportion to the body, and is armed with four spines on the gill covers. It has a habit of swelling out these gill covers when disturbed which increases its terrifying aspect. As a matter of fact it does *not* sting, at least in the manner of the true sting-fishes—viz. the *Weever* and the *Dragonet.* Full-grown individuals are about six inches long. The colouring is very varied, but always beautiful; the prevalent tints are green and blue, arranged without definite order; sometimes there is an admixture of red with the green and blue, and some individuals are of a uniform crimson.

But the colours are changeable. I have had some crimson ones in a tank, and in a few days they were green and blue, the ordinary livery. These colours do not seem to be due to environment, as one would expect, for often green and red are taken in the same stroke of the net.

Cottus lays its eggs in early spring, March and April.

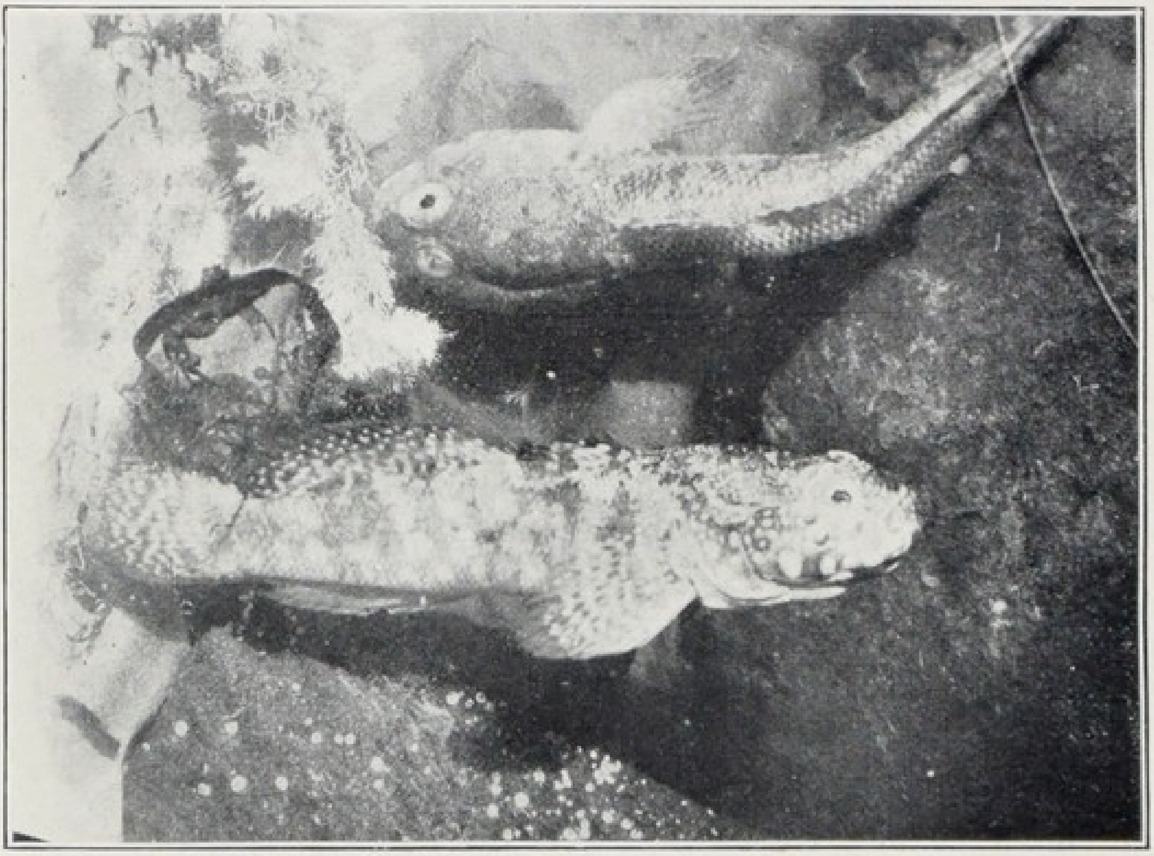


Fig. 106.—*Gobius paganellus* at home. Upper one female, lower one male. ⅔ Natural size

They are round, and agglutinated into crisp-feeling masses of about the size of a walnut, firmly cemented in some rock crevice, but often on the bare face of the rock. At first the eggs are of a whity-brown colour, but soon appear green, as in those last described.

If a cluster of these eggs, when they are green and the mass begins to disintegrate, is brought home *dry*, and then placed in a jar of sea-water, the liberation of the young

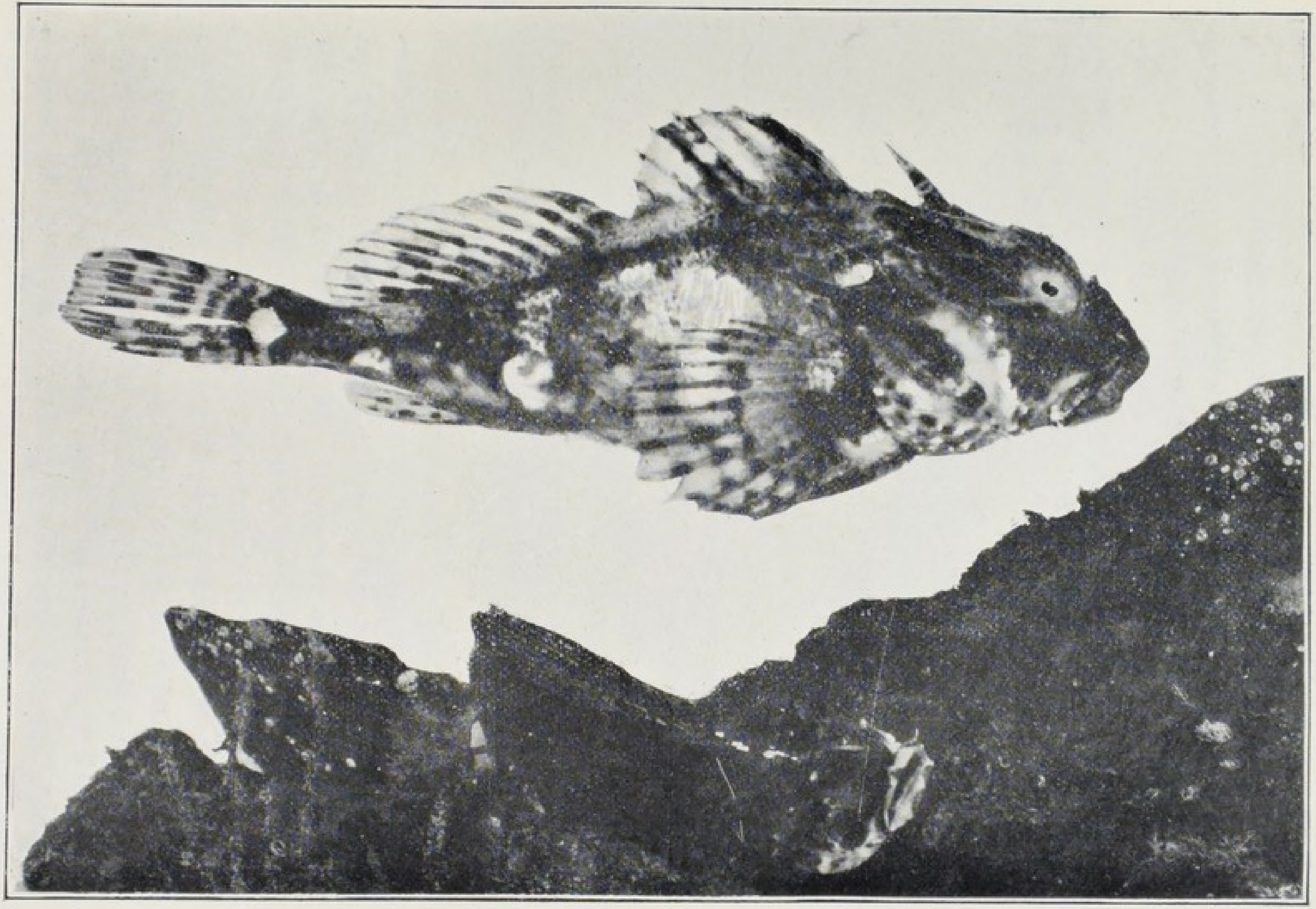


Fig. 107.—*Cottus bubalis.* Natural size

takes place at once, the effect of part drying being to hasten the process.

No fish furnishes a better object for the study of the circulation, etc., than does this little thing. It holds to life persistently, and can be easily manipulated.

Placed in a sunk cell, with a drop of water and a cover-glass, as before mentioned for Perophora, the action of the heart, and the whole plan of circulation, can be seen very plainly, the large, oval blood corpuscles are seen rolling and tumbling over in the rushing stream.

An allied species is figured and described, which bears close relations to the last, and which is named *Cottus quadricornis*, and which is said to be nearly as common. The distinction is that in the latter species the gill spines are longer, and the colours brighter, usually shades of red.

As to this being a separate species I am very sceptical. As to *colour*, it goes for nothing, as colours change markedly and rapidly in each individual. The longer spines are not a much better character. I believe these are one species. *Cottus bubalis* is shown in Fig. 107.

Cottus exhibits a peculiar feature. If a living specimen is held on the hand, or even touched with the forefinger and thumb just behind the head, a peculiar vibratory movement is felt. I have sometimes thought that it is electrical, as the sensation is much the same as when fore-finger and thumb are placed on the terminals of a coil when a weak current is passing. I have not tried the galvanometer on the fish, but this experiment would be worth trying.

Under stones, but usually at a lower zone, may be found the curious little "Butter-fish" (*Centronotus gunellus* or *Gunellus vulgaris*). It is about six inches long, of eellike form, but flattened laterally. The colour is light brown, and it has a series of nine or more large, black spots along the back. each spot bordered with yellow. It belongs to the same family as the blennies. Its popular name, "Butter-fish," is given it on account of its slipperiness, for it is more difficult to hold than even the proverbially slippery eel. It is also sometimes called the "Nine Eyes," from the number of spots on its back. It is less

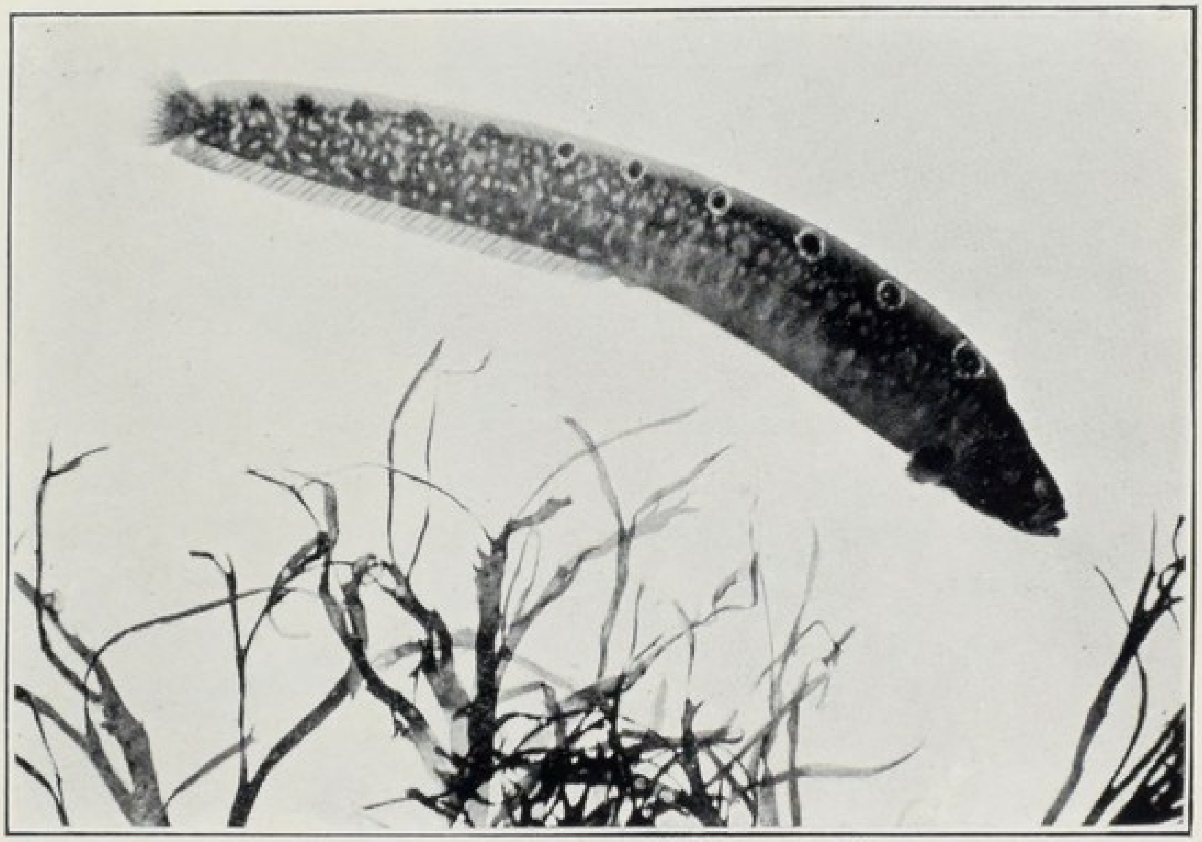


Fig. 108.—*Centronotus gunellus*. ⅔ Natural size

common than any of the preceding, but is not rare, by any means. It is shown on Fig. 108.

Motella quinquicerrata.—The five-bearded rockling (or "Little Sea-loach") is common under stones, in weedy and gravelly places. It belongs to the *Gadidæ* or cod family. It is about five inches long, of a red brown colour. It has five barbules on the snout, by which it is distinguished from its larger relative, the three-bearded rockling (*M. tricirrata*). This last is not often taken on the littoral. It is shown in the photo (Fig. 109).

At very low spring tide, in rocky situations under stones, may often be found the curious sucking fishes, the genus *Lepadogaster*.

The most abundant species is *Lepadogaster cornubiensis*. It is about three inches long, of a peculiar form, flat on the under side and strongly arched dorsally. The head is

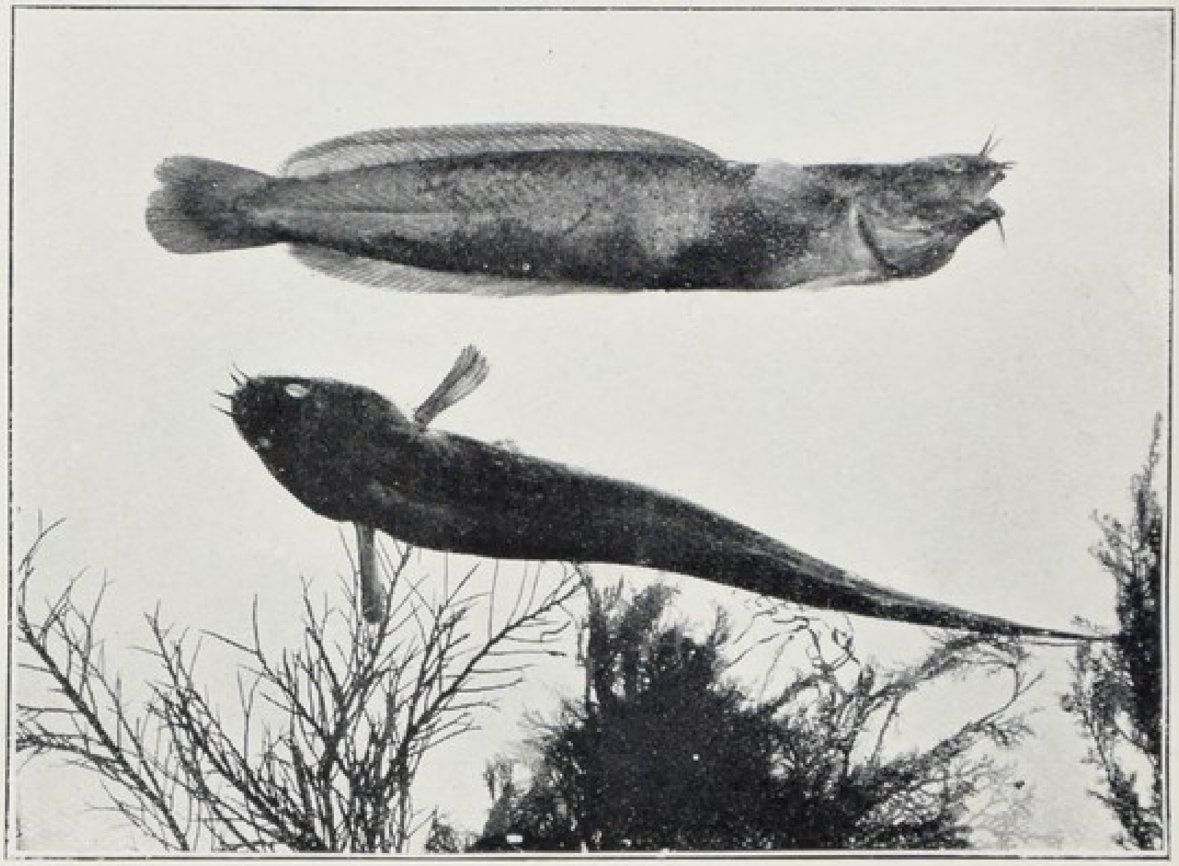


Fig. 109.—*Motella tricerrata*. ½ Natural size

broad at the base and tapers to a pointed snout. The fish also tapers off suddenly to the tail. Its colour is pink, and at the back of the head, or junction of head and body, are two conspicuous eyelike spots, which are blue, with a yellow centre.

The pelvic fins are joined together and modified into a very perfect sucker, by means of which the fish attaches itself instantaneously when it settles upon any object.

What has sometimes been taken for another species, of smaller size, of a blue black colour, with instead of spots a yellow line across the head, is, I believe, the young of the one just described. Specimens preserved in spirit change to *pink*, the line disappears, and faint indications of the pair of spots appear.

On the Scottish coast this little fish is common, and is known as the "Cock Paidle."

A specimen showing the sucker is represented in Fig. 110. It is clinging to the glass of a small aquarium tank.

Fig. 110.—*Lepadogaster cornubiensis*, attached by its sucker to front glass of aquarium tank. Natural size

Montague's sucker (*Lepadogaster Montaguii*) is found in the same situations. In this species the head is rounded and the snout blunt. It is of rather smaller size than the last. Its colour is a yellowish pink, finely speckled with red. It is less common than the preceding.

Numbers of these little sucking fishes are sometimes found clinging to floating weed at some distance from land.

The pools that occur in the Zostera beds, large, flat-bottomed, gravelly pools, are a productive fishing ground for the naturalist.

In the shelter of the overhanging masses of Zostera that line their banks lurk many beautiful fishes.

A thrust or two of the ordinary shrimping net beneath the Zostera roof will invariably result in the capture of some of the "Rock-fishes" or "Wrasses" (*Labridæ*).

The variety of these is very great; some are a brilliant grass-green, others crimson, some self-coloured, others spotted, marbled, mottled, all with red, brown, green and orange, scarcely two, even in a large catch, being even approximately alike in colour or marking.

With all this variety they are resolvable into two or three species, although there has been, in this family, a tendency to multiply names.

One, however, among a catch such as I have described cannot be confounded with any other. This is the young of the Great Spotted Wrasse (*Labrus maculatus*).

The adult of this is certainly the most beautiful of our fishes, and one that can offer to vie with the gorgeous dwellers in southern seas. It is about eighteen inches long, its colour varying from chestnut-brown to crimson on the back and sides. These are closely covered with oval spots, of about the size of a lentil. The spots are pearly white, with a faint blue border. The spots extend to fins and tail in beautiful symmetry.

The under parts are pearly white, with orange or red marbling, while over all there is a faint sheen of green and purple, like on what is termed "shot silk."

The French fishermen term this fish "*Le Perlé*" (the "Pearl Bearer").

The young have the colours of the adult, but the regularity of marking is not yet apparent. One is shown in the photo (Fig. 111).

Tolerably common in these places—viz. Zostera pools—

is the little *Acantholabrus exoleta*, popularly known as the "Rock Cock." It is about seven inches long, and the male is beautifully marked in diamond-shaped spots, green and blue, upon a dark, red-brown ground.

The "Corkwing" (*Crenilabrus melops* of the books).—Now here is a point upon which I am certain, and which

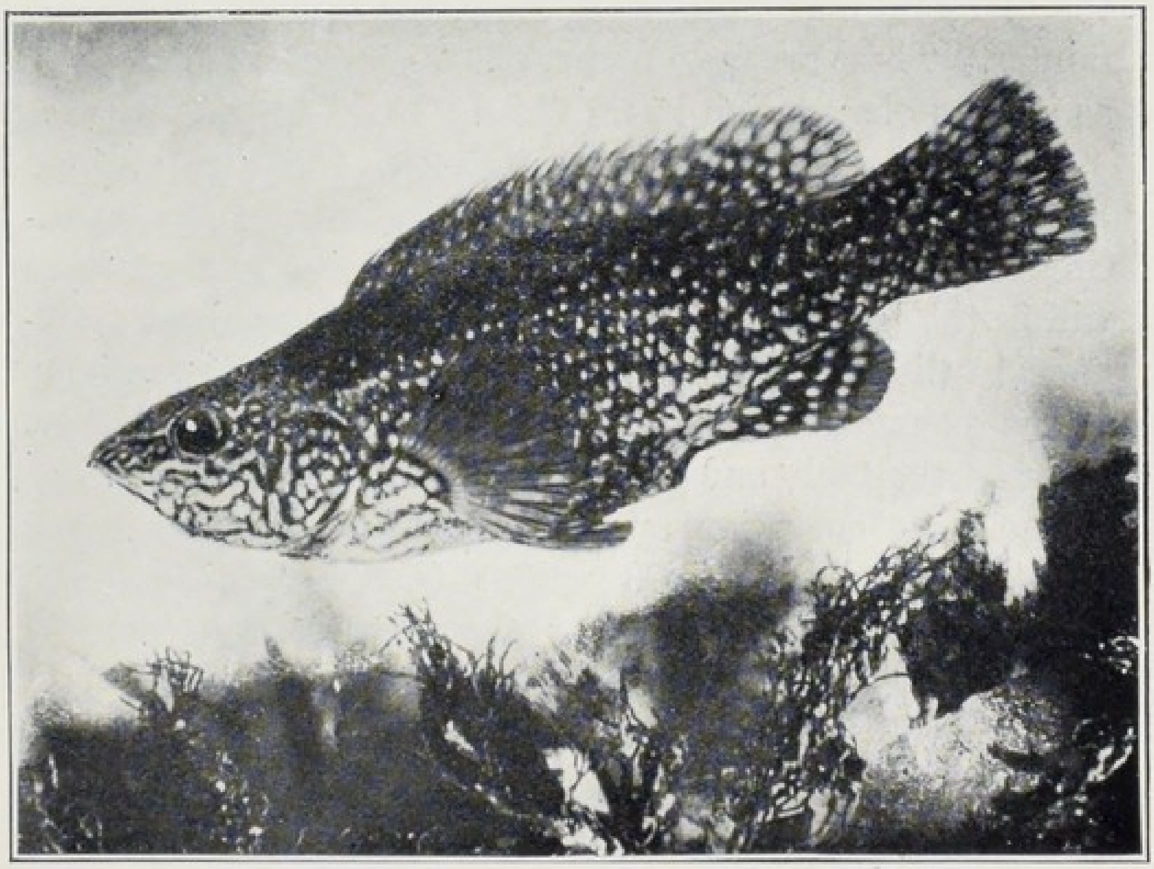


Fig. 111.—Young of Great Spotted Wrasse. *Labrus maculatus*
Natural size of actual specimen, $\frac{1}{8}$ size of adult

justifies me in questioning much as regards the identification and nomenclature of our less important fishes.

The two last-named, it will be observed, are not only given as two species, but as representatives of *two genera*, and they are but *male* and *female* of the same species.

It struck me, many years ago, that I could never find a male *Crenilabrus* nor a female *Acantholabrus*.

The female, named the "Corkwing," is of a yellowish buff, with faint, irregular dark mottling; a round black spot is constant on each side of the tail.

These colours, of male and female, apply to the breeding time, May to August. As winter advances the male loses his brilliant tints, and in some specimens a faint trace of the spot on the tail appears, while the female shows traces of the diamond markings of the male, the tail spot becoming fainter. These are from observations on captive specimens, as well as observation in the "field."

The coloured figure of *Acantholabrus* in Crouch's "British Fishes" is evidently taken from a specimen in the transition colouring, the summer splendour being lost. I have within the last hour (on September 20th) examined specimens in the fish-market which corroborate the foregoing.

The young, male and female, are alike: a compromise between the male and female colourings (see Fig. 47).

The same confusion applies to another member of the *Labridæ*, the blue-striped wrasse (*Labrus mixtus*). The female of this is described as another species, under the name of *Labrus trimaculatus*. But this is not a "shore" fish, and its description is not needed here; however, I shall refer to it in the chapter on "Coloration," etc.

As regards this last I note that Dr Günther has expressed his suspicion that the two species are one.[1]

The genus *Acantholabrus* (and "*Crenilabrus*") is easily distinguished from the young of the larger wrasses by their having the edge of the outer gill covers or "cheeks" (*pre-operculum*) finely toothed.

The wrasses breed inshore, constructing nests, which consist of soft sea-weeds, chiefly *Rhodosperms*, tightly packed in the crevices of rocks. Sometimes more than a peck of weed is used in the construction of one nest. The large, amber-coloured eggs are loosely scattered all

[1] It is given correctly in Day's "British and Irish Fishes."

through the tangle, and the male stands by during incubation, and drives off intruders.

The same haul of the net which brings forth the little wrasses may very frequently bring to light the "Fifteen-spined Stickleback" (*Gasterosteus spinachia*).

This elegant little fish is about five or six inches long. Its colour is dark olive-green, with buff markings on the sides. The under parts are silvery. It has a row of fifteen short spines along the back, which can be raised or depressed at will.

Like its little relative of our inland waters, and its neighbours the wrasses, it builds a nest, but, unlike the last, has some idea of architecture, the nest being usually round or pear-shaped, the weeds of which it is made being laced together with mucilaginous threads. The male keeps guard on the nest and its precious contents, and, like the wrasse, attacks all wanderers that come near. Gasterosteus is shown in the photo (Fig. 112).

Many other fishes live and move and have their being in the Zostera fields—*e.g.* the lovely little "one-spotted" and "two-spotted" gobies; the "Mackerel Midge," and the young of the grey gurnards. These last are curious little purple brown fishes, with large side fins, that are resplendent with purple and blue, a large spot of these tints, that looks just like the "eye" of a peacock's feather, occupying the centre of the large, fanlike fins, making the little fish look like some brilliant, large-bodied exotic butterfly. The gurnards have the first few rays of the pelvic fins free—that is, they are not joined by membrane. These rays are stout and many pointed. By means of these the gurnard *walks*, like some huge insect, on the bottom.

In some sunny pools at low tide little shoals of these, from two to four inches long, may be seen.

Still in the Zostera pools we find, sometimes abundantly, the curious "Pipe-fishes" (the *Syngnathidæ*).

Very interesting are these aberrant fish forms. They form a sub-order of the great order of *Teleosteans* or bony fishes. They have a long, tubular snout, as if the jaws were fused together (hence *Syn-gnathus*), but the jaws proper are at the extremity of this snout or " pipe." The gills are in the form of tufts, and the gill openings very small. The skin is armoured, there being a bony

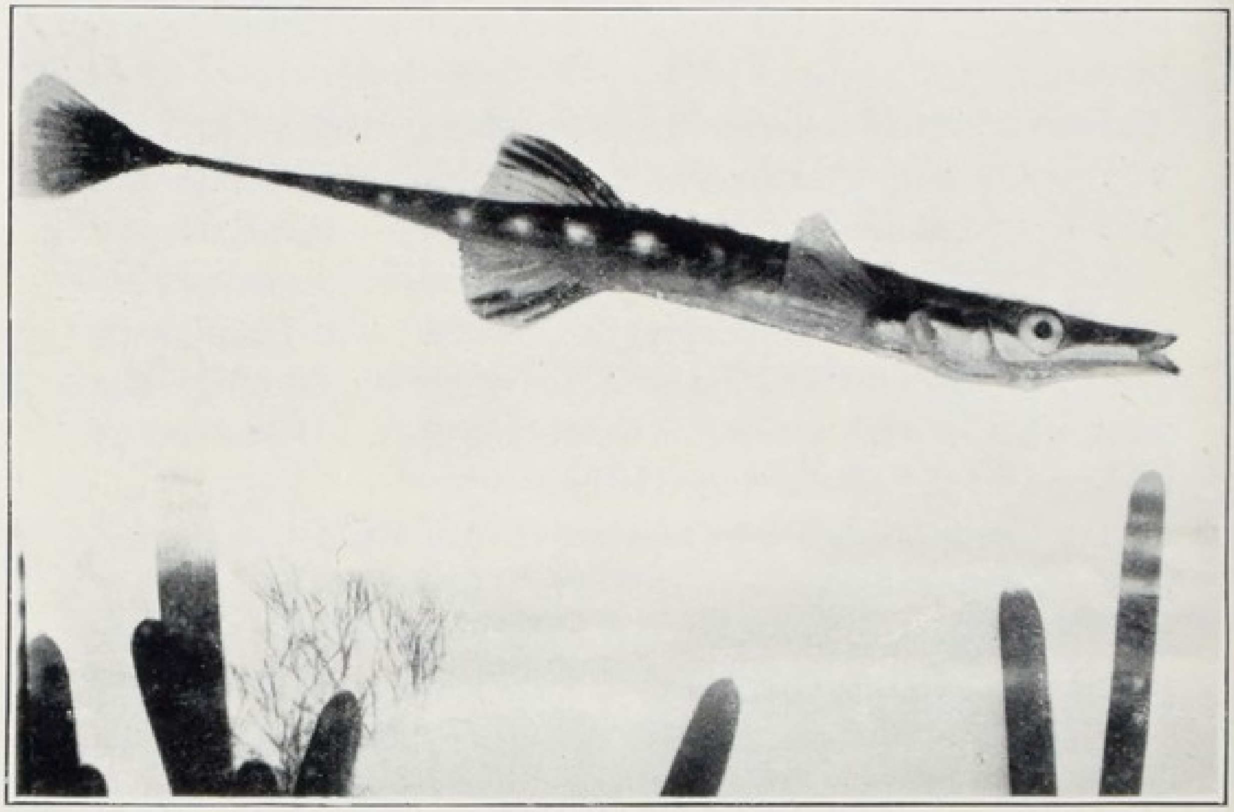


Fig. 112.—*Gasterosteus spinachia*. ¾ Natural size

skeleton enveloping the whole body, which skeleton is built of plates, finely incised, and pretty firmly joined together. (A photo of a portion of this skin armour is shown in Fig. 114.) The body is long and whiplike, and very rigid.

The species most frequently met with on these shores is the "Great Pipe-fish" (*Syngnathus acus*). It is about sixteen inches long, and in its abdominal region about as thick as the finger.

Syngnathus typhle resembles this, but is rather smaller, and can at once be distinguished by the flattened form of the snout, which is also broader than in its relative.

Syngnathus ophidion (the "Snake Pipe-fish") is also frequently taken with the latter. It is sometimes two feet long, or even more. It is of more rounded form, and has no tail fin.

A species termed the "Ocean Pipe-fish" (*S. Æquorea*) is also described. It is said to closely resemble the last, only to be of more oval section in the body. I am sceptical as to its being a separate species to the last-named.

The "Worm Pipe-fish" (*S. lumbriciformis*) is a small species, with a short head and snout. It is seldom more than six inches long. It is of rounded section, and dark brown in colour. This one is more frequently met with under stones than in the open.

The "Sea-horse" (*Hippocampus brevirostris*), dried specimens of which are familiar objects at the shops of dealers in shells, etc., is sometimes, not often, taken on our shores, usually in the shrimping net, when this is worked over sandy ground, where there is a stunted growth of Zostera and bits of fucus growing from pebbles. On one occasion I had a haul of five, which has proved the sum-total of my captures of the species.

Its being a pipe fish is readily apparent by the tubular snout, etc., but it is shorter, and stouter bodied. The tail is always twisted into a coil. The shape of the head, and its position relative to the body, has suggested its fanciful, popular name.

A peculiar arrangement in the *Syngnathidæ* is that the males are furnished with means of supporting the eggs when these are deposited by the female.

In the "Snake Pipe-fish" and the little "Worm Pipe-fish" the eggs are firmly cemented to the under side of the body, in an even layer. In the "Great Pipe-fish" and

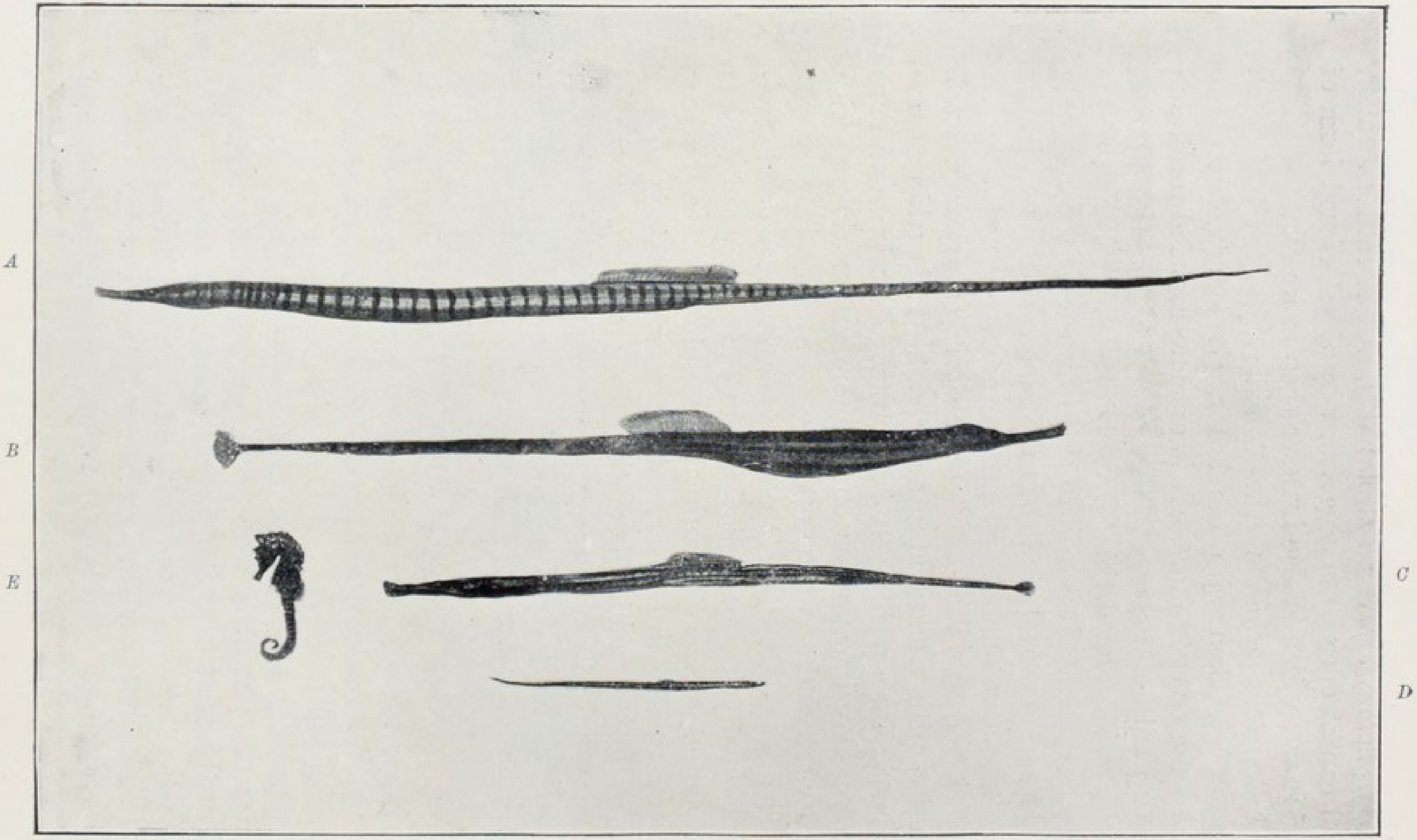


Fig. 113.—The British Pipe-fishes

A. *Syngnathus ophidion.* B. *S. acus.* C. *S. typhle.* D. *S. lumbriciformis.* E. *Hippocampusbrevirostris* the "Broad-nosed Pipe-fish" there are folds of skin from the sides which, like an unbuttoned overcoat, fold over and protect the eggs, and in the "Sea-horse" the edges of these folds are joined together, forming a tube, in which the eggs are hatched.

I have kept specimens in aquaria during this incubatory process, and it is interesting to watch how the young, until they are about an inch or so in length, follow the male parent in a little shoal.

The origin of this incubatory pouch in the male affords

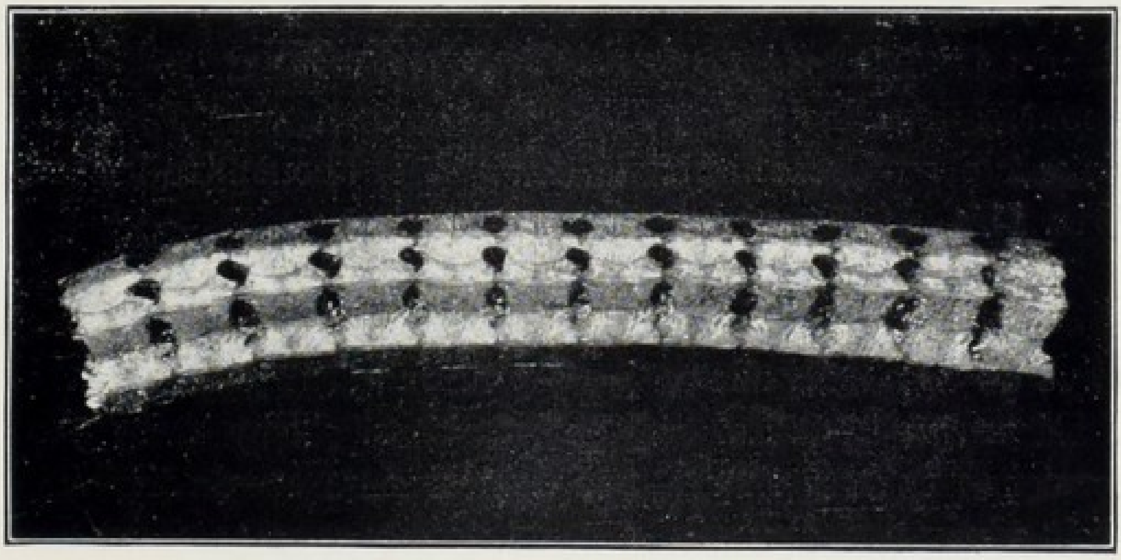


Fig. 114.—Portion of bony armour of a Pipe-fish. *Syngnathus acus* Natural size

room for some speculation. It may, perhaps, be traced by observation on other fishes; for instance, in the blennies and gobies the female attaches the eggs to the under side of stones, and the male fish lies beneath, and takes charge. It is but one step from this to affixing them to the body of the male himself; then the development of flaps, and their final fusion, in the "Sea-horse," completes this "brood pouch."

The *Syngnathidæ* are very sluggish in their movements, swimming slowly, in a semi-vertical position. They allow themselves to be taken by the hand, without an attempt to escape.

They feed on small crustaceans (Entomostraca, etc.), chiefly, but have no means of capturing very active prey.

Fig. 113 shows our five local species.

On the open shore, low down in the shell-gravel reaches, another fish fauna presents itself.

Here, buried in the loose gravel or in the fine white sand which is heaped into ridges, are the sand-eels (another misnomer, for they are not *eels*, but belong to a totally distinct family, the *Ophidiidæ*. The eels are *Murenidæ*).

We have two species on our shores—viz. the "Great Sand-eel" (*Ammodytes lancea*), which attains a length of about sixteen inches, and the "Lesser Sand-eel" (*Ammodytes tobianus*), which attains a length of about nine inches (Fig. 115).

The colour of the first is green on the back, silvery on the sides and underneath. The lesser sand-eel is yellowish-olive on the back, silvery on the sides and underneath.

These are beautiful and active fishes. They swim the open sea in vast shoals, but detachments break off, and visit sandy and gravelly bays on all our coasts. They do not remain long, and in a bay which is crowded to-day there may not be one to-morrow, but fresh incursions are constantly made. They go in shoals according to age, sometimes a beach will be swarming with some that do not exceed two or three inches in length, at other times only the very large ones will be present, but as a rule our visitors are those of medium size—about nine inches.

It is chiefly at night that they are found thus inshore, except in the autumn and early winter, when they are equally numerous by day.

On some parts of the English coast, in the Channel Islands, and on the opposite coast of France, sand-eeling is not only an industry but a pastime with all ranks. Parties are

A

B

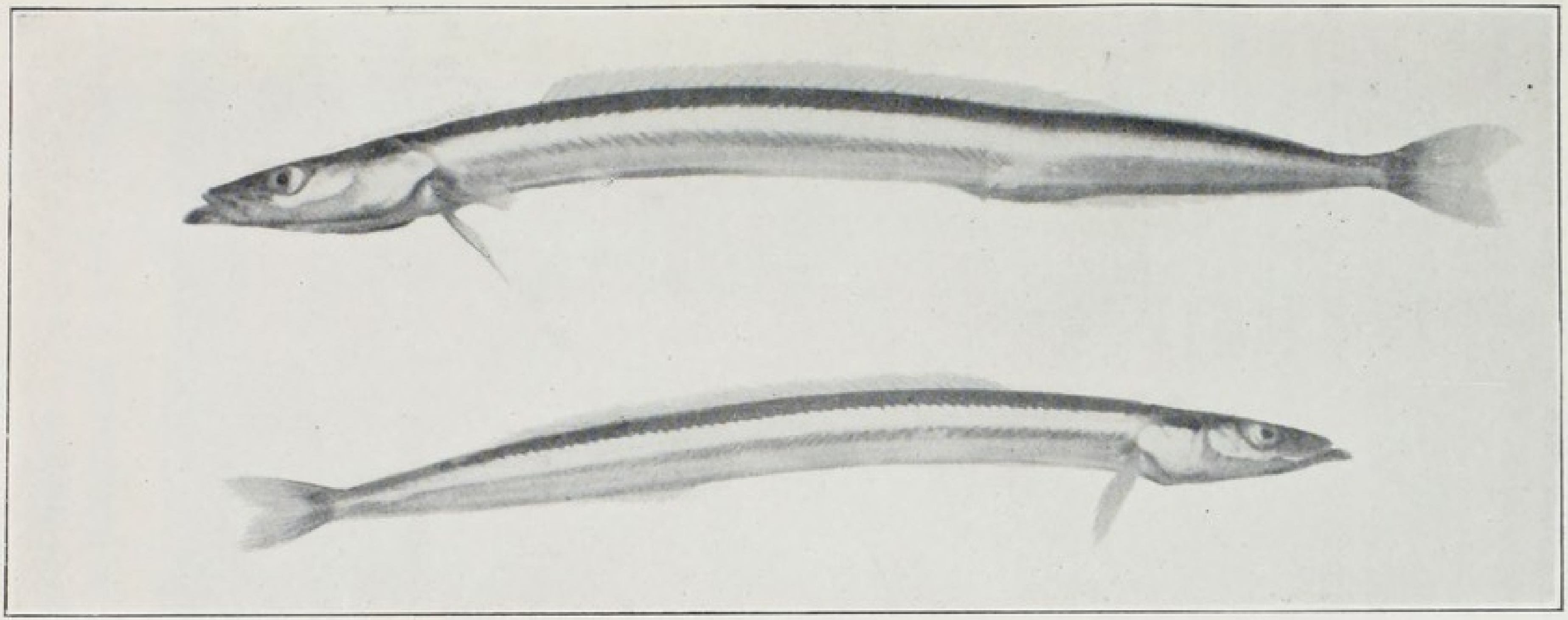


Fig. 115.—*A. Ammodytes lancea.* ½ Natural size. *B. Ammodytes tobianus.* ⅔ Natural size

made up (my experience is Channel Islands especially) of a score or more, with a qualified guide, for some of the outlying reaches are dangerous, owing to being on high ground, beyond the rocky reefs, where it is a very easy matter to be surrounded unawares.

These parties are armed with sickle-shaped hooks, with which the loose sand is scraped, causing the sand-eels to emerge, which they do with great energy, and spring about in a lively manner.

Expert hands catch them readily, but not so the novice, and it is very often that the latter returns with empty basket although his friends have heavy catches.

Moonlight nights are usually chosen for this fishing, but on the new moon tides lanterns are employed.

A description of this "Sand-eeling" does not seem to commend it very strongly, but the sport has many votaries, and its votaries comprise all who have once indulged in it.

The larger sand-eel is highly prized for table, the lesser one is largely used as bait by the fishermen.

A third species, the "Blunt-nosed Sand-eel," is mentioned, but I have not seen one, and consider its existence problematical.

On the same gravel reaches, tolerably common—much *too* common to please sand-eelers—is the "Sordid Dragonet" or "Dusky Sculpin" (*Callionymus sordida*). It is a large-headed fish, of flattened form—that is, flat from back to under side—about six inches in length. In colour and marking it closely imitates the shell sand on which it lives, a fine example of protective coloration.

At the corners of its gills it has a three-pointed spine which can inflict a nasty wound, inflammation always following.

Frequently it is seized in mistake for a sand-eel, with disagreeable consequences.

It is shown swimming in Fig. 116, and Fig. 117 shows one on the gravel, closely imitating its surroundings.

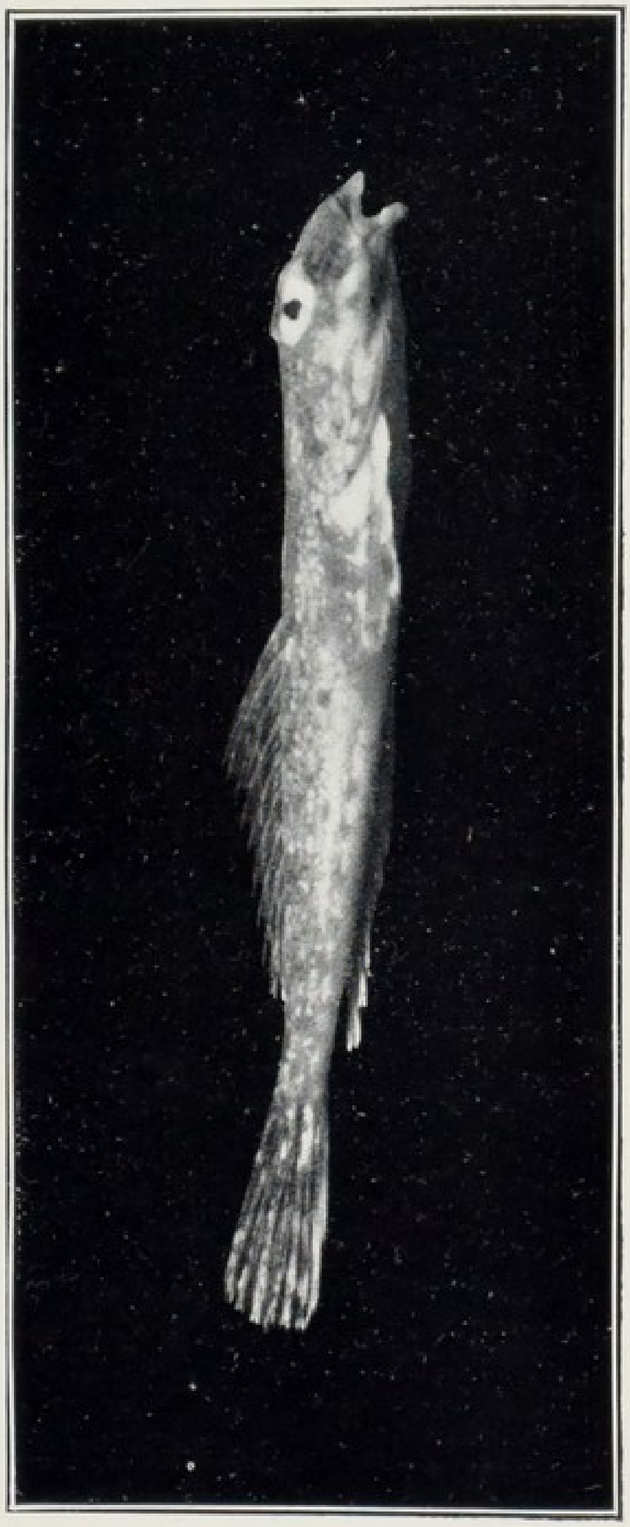


Fig. 116.—*Callionymus sordida*, swimming. $\frac{3}{4}$ Natural size

I have followed the books in naming this, but it is another instance of the multiplication of species: it is the female and the young male of the *Gemmous Dragonet* (*Callionymus lyra*).

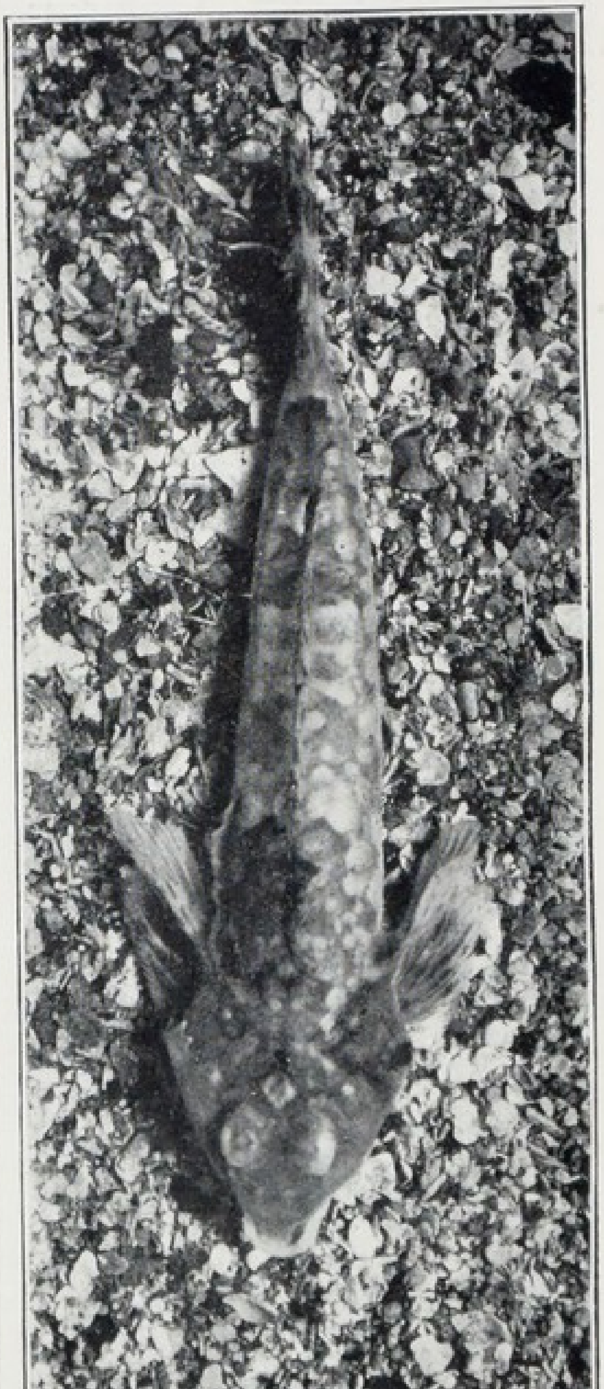


Fig. 117.—*Callionymus sordida*, lying on shell gravel bottom. $\frac{3}{4}$ Natural size

This error has, however, been rectified in the newer publications.

The adult male is a gorgeous fish, of a bright yellow, with stripes and dashes of blue. The first ray of the dorsal fin is very long, as long as the body of the fish, and supports a scimitar-shaped membrane, which is mottled yellow and blue. The adult male is very rarely seen inshore.

The "Flat Fishes" (*Pleuronectidæ*) do not strictly belong to the shore, but as they all spend their early life in our sandy bays reference must be made to them.

The flat fishes spawn in deep water, as do nearly all our food fishes, and the eggs float and hatch on the sea surface. Winds and tides waft eggs or newly-hatched young to shallow waters, where they go through their metamorphoses, and may be seen in hundreds at, and just beyond, tide margin when there is suitable ground.

When first a flat fish—say the plaice—emerges from the egg it is in a larval form, not nearly so far advanced in structure as are the little fishes we have described.

Then when a similar stage is reached only the expert icthyologist would recognise in them the young of the flat fish, for they are symmetrical in every way, the same as the young of ordinary fishes, and they swim at all depths of water. Then they take to bottom, and lie upon one side (the plaice, etc., on the right side, the turbot and some others on the left, the position constant in each species). The eye which is on the now *under* side begins to migrate, the bones of the skull twisting accordingly, until the curiously asymmetrical form we are so familiar with is reached.

Specimens in all stages of change can be found in numbers during the months of May and June, in all our sandy bays, at tide margin and in shallow pools.

A strange member of the *Pleuronectidæ* may often be met with at low spring tides on rocky shores. This is "Muller's Top Knot" (*Rhombus hirtus* or *Rhombus punctatus* or *Zeugopterus maculatus*).

(There may be reason for a revision of names, but it seems to me that some writers have imagined that they were the first to describe, and consequently to name, any specimen that came before them, and this must lead to confusion for those who have not all the literature at hand.)

Well, this little *Rhombus punctatus* (this is the name accepted by Dr Günther in his catalogue of fishes in the British Museum) is rather rarely seen, but a careful search

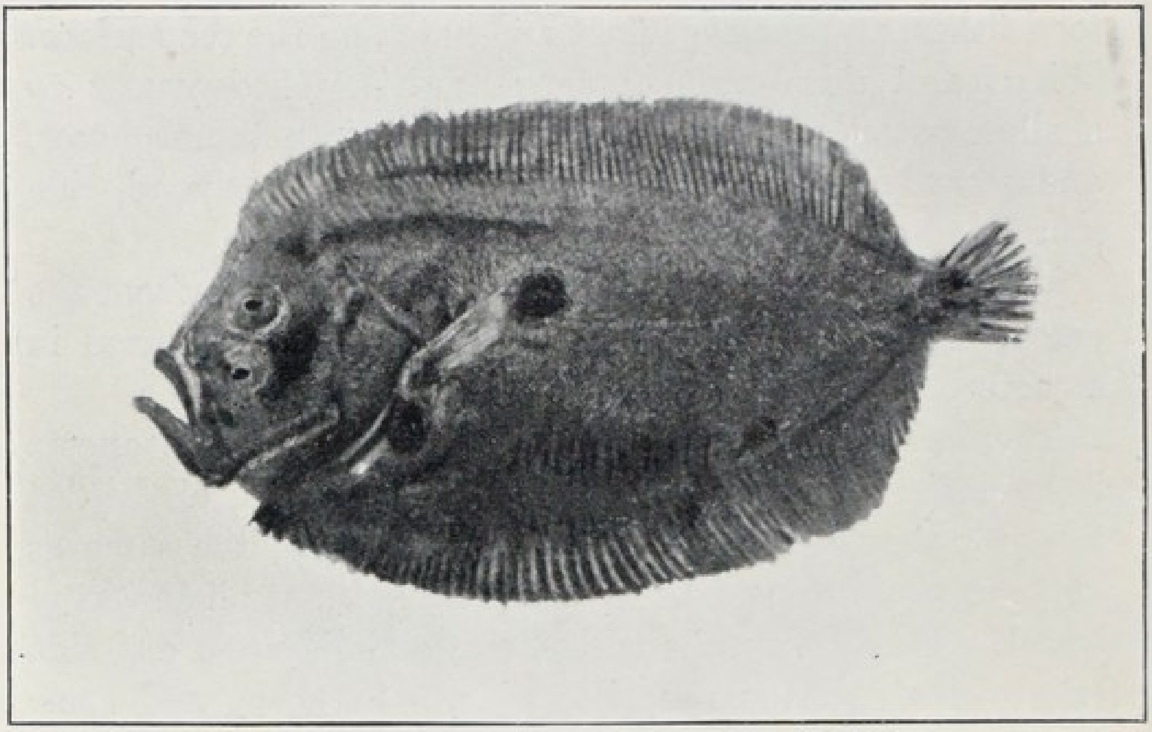


Fig. 118.—*Rhombus punctatus.* ½ Natural size

at the sides of rocks, when there is a very low spring tide, will often furnish an example or two.

It is about six inches long and four in depth. The dorsal and ventral fins form, with the under side of the body, a sucker arrangement, whereby it attaches itself to the vertical side of a rock or large boulder, and there it sticks, limpetlike, and often allows the tide to recede, leaving it high and dry. Its colour is a rich brown, with black markings.

There are two species on our shores, the "*one-spotted*" and the "*two spotted*," but I only know the former. It is shown in the photo (Fig. 118).

Frequently in early spring a beautiful little fish comes to our shores, and has the unusual habit of committing suicide there. This is the "Boar-fish" (*Capros aper*). It is of about the build of the John Dory, but has not the tall

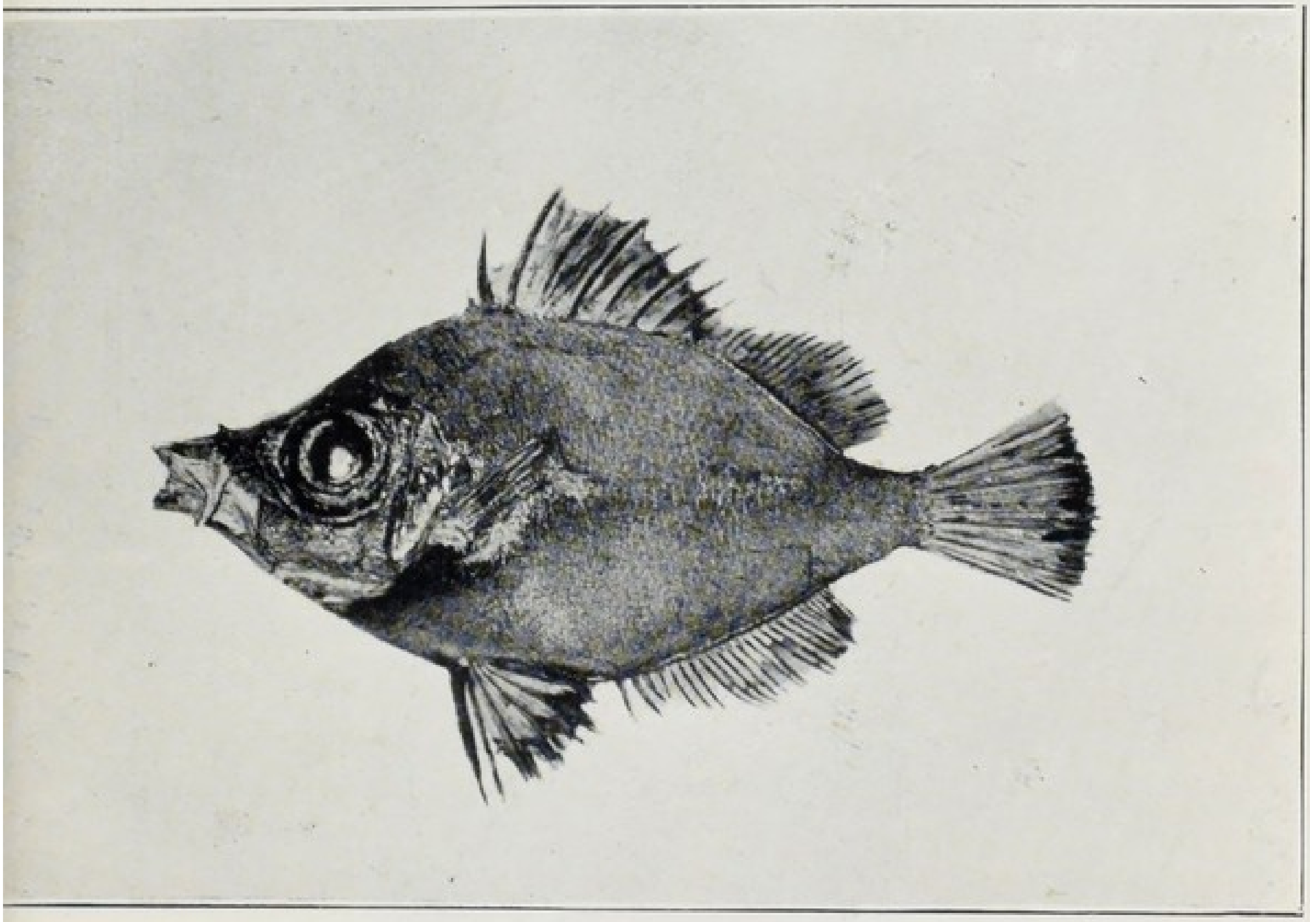


Fig. 119.—The Boar-fish. *Capros aper*. ½ Natural size

dorsal fin. It is about six inches in length, and of a beautiful red colour. The edges of the scales are finely toothed, and this gives it a velvety appearance.

I have on one or two occasions stood in a sandy bay and seen shoals of them approach. As they came to the shallow tide margin they would lie on one side and flop themselves high and dry for several feet on the sand. This, with a receding tide. To pick them up and throw them back into the water was love's labour lost—they would flop to land again. A specimen is shown in Fig. 119.

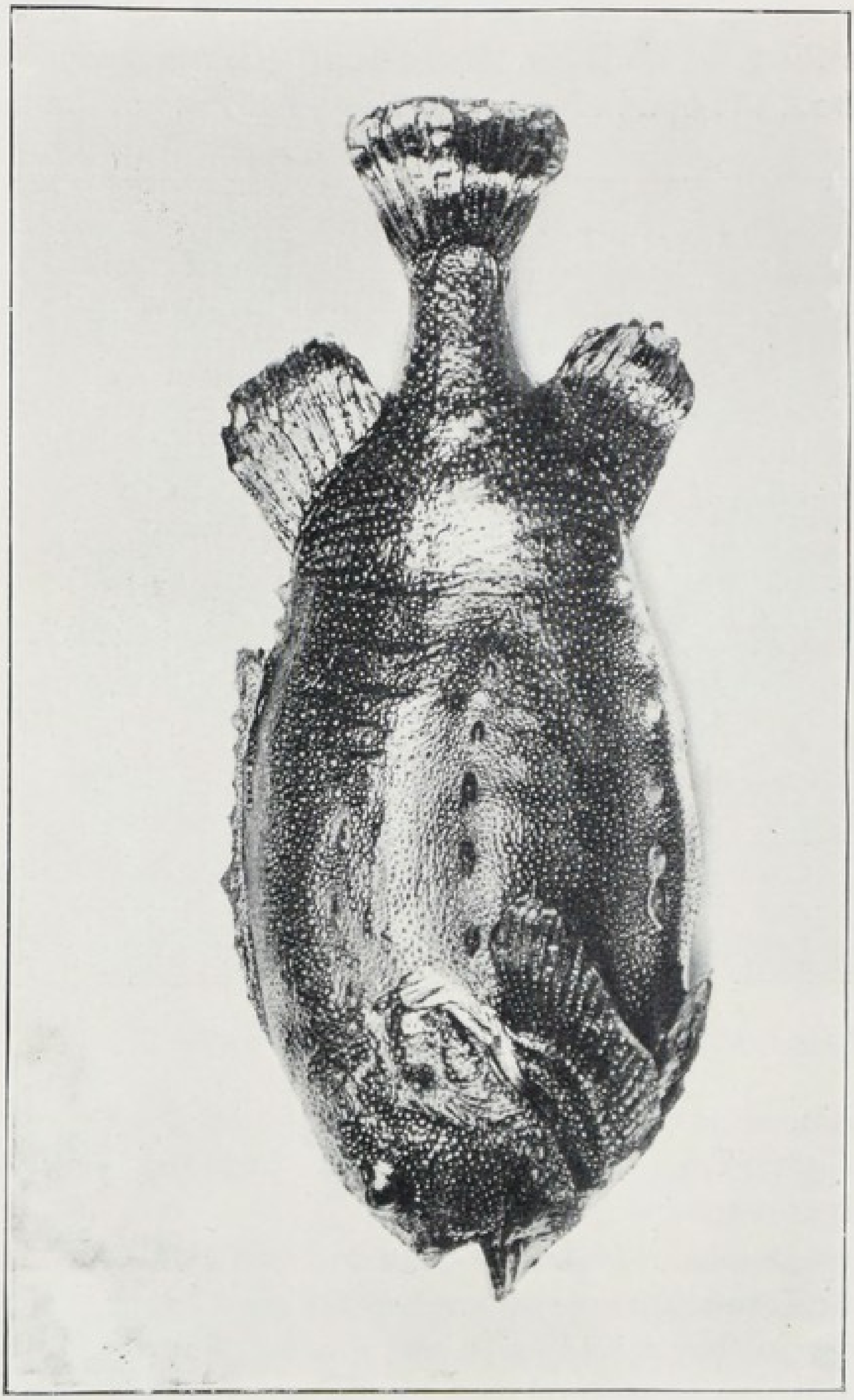


Fig. 120.—The Lumpsucker. *Cyclopterus lumpus*, male. ¼ Natural size

One fish more—a bulky one—in conclusion, the great

"Lump-fish" (*Cyclopterus lumpus*). This strange fish lives on our rocky shores, and comes well inshore to spawn. It arrives from deep water in the month of March, and at this time may frequently be found among the low-tide rocks.

The male is about twelve inches long, by four or five in breadth and depth. It has a thick leathery skin, closely studded with small, round tubercles, and with several rows of larger conical ones. The colour of the male during the breeding season is deep crimson, except on the under side, which is orange.

The female is very much larger than the male—I have had one twenty-six inches in length, and which weighed over fifteen pounds. The colour of the female is slate-grey.

The eggs are deposited in large masses, firmly glued together, like those of *Cottus*, in clefts and at the foot of rocks.

The pelvic fins in this species are joined together to form a large round sucker, as in Lepadogaster, and by means of this the fish attaches itself to the vertical sides of rocks. I have taken it twice in the littoral, and have had many specimens which were taken in the same localities by fishermen.

A male is shown in Fig. 120.

CHAPTER XIII[1]

THE FAUNA OF THE MARITIME ZONE

THAT strip of land, with sand dunes and lichen covered rocks, over which the sea spray is scattered when the winds are high has, besides a flora of its own—the thrift, the sea-holly, the sea-convolvulus, the sea-spleenwort, and a host of minor plants dear to the botanist—a number of animal forms which are found nowhere else.

Foremost among these are beetles (*Coleoptera*). They are represented by fifteen known species—viz.

Phytosus spinifer.—Under stones and rubbish.

Trechus lapidosus.—In sandy places just above high-water mark. This one is local, but is recorded from Ventnor, Southend, Shoreham, Deal, Dover, etc.

Nebria complanata.—In similar localities, but more general.

Brosus cephalotus.—South coast of England, and Channel Islands.

The late Mr Robert Foster thus writes about this species in "The World of Insects": "They are found only in the sand, and live in dens about three inches deep and half-an-inch wide, which are made in a diagonal position, where the sand is mixed with the decomposed stalks of *Elymus arenarius.* They appear to roam during the day, but upon any alarm run swiftly to their dens, projecting from the mouths of which their heads may be seen watching for

[1] For the material of this chapter I am indebted to my friend, Mr W. Luff, of Guernsey, Fellow of the Entomological Society.

their prey. On holding another beetle to the hole the one within would immediately seize it, and allow itself to be dragged out rather than relinquish its hold. They appear to be very ferocious, and from the number of elytra and others parts about the sand it may be supposed that they prey upon each other."

Many beetles draw back before the tide, and return as it recedes. These inhabit the shingle and masses of rolling sea-weed, and are often mixed up with it. These are: *Lithocaris maritima*, *Filonthus fincicola*, *Homolata princeps*, *Homolata plumbea*, *Tachyusa civida*, *Tachyusa sulcata*, and *Bryaxis waterhousii*.

Heaps of sea-weed just above high-water mark are very productive of beetles.

The curious *Lymnæum nigropiceum* is found only among shingle on the sea-shore.

The sand close to the sea, even that which occasionally covers, is the breeding ground of several beetles, such as the beautiful "Tiger Beetles" (*Cicindelæ*).

Three species of these occur on the south coast. One species (*Cicindela hybrida*) is abundant on the coast of Lancashire and North Wales. *C. germanica* is found at Yarmouth and Swansea.

Anomala frischii is a large, bronze-coloured beetle, rather rare, but to be found in sandy places near the sea.

Otiorhynchus ligustici lives among the roots of the maritime plant *Anthyllis vulneraria*, and *Centrorhynchus verrucatus* at the roots of the yellow horned poppy.

The *Hemiptera* are represented by several species, the most remarkable of which are:

Ripersia Europæa.—Common under stones in ants' nests.

Prostemma guttula, a very striking insect, with scarlet legs and wings.

Pyrrochoris aptera.—This, also, is a striking form. It does not appear to have been found on the English coast, but in the Channel Islands, especially in Jersey, it is so abundant as to form coloured patches on the sand banks. It is about half-an-inch in length, bright scarlet, with black markings in grotesque caricature of a human face.

Pionosomus varius.—Very common in Jersey, apparently not recorded from England.

Therapta hyoscyami lives in the flowers of the sea-lavender, sea-holly, etc. This species resembles *Pyrrochoris aptera*, but has ample wings.

Dactylopius luffi, a species new to science, discovered by Mr Luff on the sandy shore of Richmond in Guernsey.

Orthoptera.—A beautiful grasshopper, with bright blue wings, named *Ædipoda cœrulescens*, is abundant on the coast of Jersey, but is not recorded from England. It occurs sparingly in Guernsey.

Forficula auricula (variety *forcipata*), a large species of earwig, is found in the Channel Islands, and in the Farne Islands on the Northumberland coast.

Arachnida.—The maritime zone is rich in the mites and spiders, but they do not seem to have been thoroughly worked. *Atypus sulzeri*, one of the "trap-door" spiders, occurs in Guernsey and on the south-west coast of Jersey, and probably in many other localities. A small species which has, I believe, not been recorded occurs at St Owen's Bay, Jersey, and is an exact miniature of the great Mygale of Brazil.

In the mites there is a large variety of species. A remarkable form is *Rhincolopus plumipes* (Fig. 121).

The long posterior legs, which are tufted at the extremity, are no doubt of protective value, for when the mite is at rest these are raised vertically, and form a very close resemblance to a moss with sporangia. This form has only lately been recorded so far north, hitherto only in Algeria and Corfu. It is not uncommon in Jersey.

Of the "Bristle-tails" (*Thysanuridæ*)—to which belongs the little "Silver Eel" (*Lepisma saccharina*), a swift-running, silvery insect, very common in houses, among old books, and in little-used cupboards—there is a representative on the coast. This is *Machilis maritima.* It is larger than the familiar, house-infesting one just mentioned, and is a beautiful, bronze-coloured insect, with iridescent reflections. It may be seen in numbers running swiftly over rocks close to the sea in bright sunshine.

The Podurids (or *Collemhola*) are also represented in this

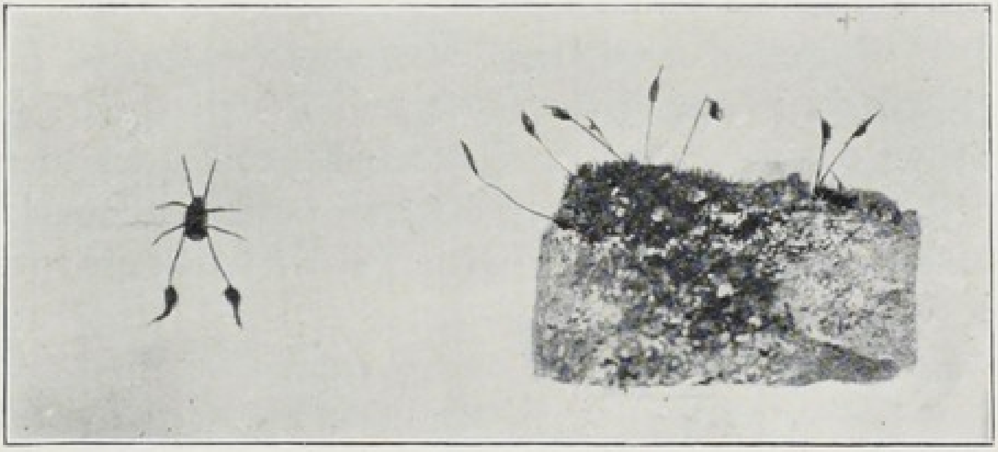


Fig. 121.—*Rhincolopus plumipes*, Lucas. Natural size, displayed. And slightly reduced, among moss. The mite on the right-hand side. (I believe the male only has the plumosa feet.—J. S.)

zone, but no authentic list of them has yet appeared. They offer a good field for investigation to the young naturalist.

The *Lepidoptera.*—The sea-shore has also its own characteristic forms among the moths. The beautiful "Spurge Hawk Moth," has its breeding ground on the coast, and its larva feeds on the spurges which grow in sandy places. It was formerly abundant in the Channel Islands, but seems to have disappeared.

Aporophylla Australis.—The larva of this is found under stones on the edge of the beach. Other coast species are :

Leucania putrescens, *Leucania l'album*, *Agrotis lunigera*, *Agrostis saucia*, etc.

The " Thrift Clearwing " (*Sesia philanthiformis*) is a coast species, its larva feeding in the interior of the clumps of thrift, selecting chiefly those that are isolated and starved.

One of the rarest of the British butterflies also lives on the coast, at Dover, and is fairly common in Jersey, at St Owen's Bay.

The Hymenoptera.—Sandy tracts near the sea are quite a paradise for the fossorial members of this order.

In the summer of 1902 Mr E. Saunders, F.L.S., took fifteen species of wasps and bees on the coast of Jersey which had not as yet been recorded.

Three species of bees form their nests in the sand banks. They are leaf-cutters; they line their cells with oval bits which they cut from various plants, and the tops are covered with two or three circular pieces.

The female does the leaf cutting, and may often be seen flying homeward with her burden, looking like a flying leaf.

These species are *Megachile maritima*, *Megachile centuncularis*, and *Megachile argentata*.

Diptera.—Several species of the " two-winged " flies also live exclusively on the coast. Among these is a striking form, *Anthrax velutina*, which has more than half of the wing jet-black, and *Thereva annulata*.

The minute forms of *Clunio* have been mentioned in the chapter on the " Marine Insecta."

CHAPTER XIV

COLOUR AND COLORATION, MIMICRY AND MIMETIC ARTIFICE, AMONG SHORE ANIMALS

To add to what has been written on these subjects may seem rather presumptuous, but those who have made marine zoology, in the field, their special study must be aware that, with all that has been done in this particular section, it has not received its full share of attention. Moreover, some that *has* been written on it is entirely wrong.

I have touched on the subject in several instances in the preceding chapters, so there will be a little repetition in this one.

Starting with the sponges, the lowest forms of animal life that show colouring to any definite extent, we have, in the same localities, under the same conditions, growing side by side, and often intermingling and intertwining, some that are bright *green*, others that are *orange* or *crimson*, to say nothing of less marked colours—purple, buff, white.

Now it has been accepted as an axiom that every marked and constant colour must be of service to the possessor, and this has been brought under four headings—viz.

When an animal is defenceless, and is good to eat, in a district where eaters are present it imitates the colour of its surroundings, and thus manages to escape observation to some degree.

The second is when an animal is *not* good to eat, has a nasty taste, or is armed, and consequently dangerous to interfere with, and yet might by mistake be attacked. It prevents the liability to such mistake by assuming some conspicuous colouring, to remind the enemy that has once ventured to attack it that it is not good to do so. This is termed *warning colour*.

The third is that colour, or arrangement of colours, referred to *sexual selection*, in which their use is to entice or charm the opposite sex.

The fourth when the conspicuous colour serves to lure prey (or in the case of *flowers* to lure insects to render service).

As a general rule all these are well-established facts, and illustrations in support could be supplied by the thousand. Some of them are strikingly obvious to the least observant. Who, for instance, has not seen a kitten or a puppy catching flies, and noticed that if a *wasp* comes within range it is generally left to go unmolested, or even causes the retreat of the fly molester.

The conspicuous yellow banding is impressed upon the senses of the kitten or the puppy, not necessarily by experience of its own, but by that of some of its ancestors, which noted the connection between the "yellow bands" and the pain their owner could inflict, and then handed down, in the form of that hereditary memory we term "instinct," their experience to their offspring.

This is a homely illustration of the use of "warning colour." The use of mimetic colouring is still plainer.

If a creature were good to eat, had no means of defence, had enemies present, and was *conspicuous*, then, obviously, it would soon *not be*, unless, indeed, its reproductive powers were such as to bear the toll.

It seems that the above series of uses of colour were broad enough in their provisos to cover all cases, but let us try to apply them to the red sponges.

Mimetic colouring is out of it: they are strongly conspicuous.

Sexual selection of course does not apply.

Attraction to prey does not come in, for they feed on infusorians, etc., brought within range by the currents caused by the action of their cilia.

There then remains *warning colour*—sponges well stuffed with flinty needles are apparently not good food for anything, yet one animal eats them. The Nudibranch mollusc *Doris* browses on them quite regardless of colour. Then, again, how about the equally nasty ones that have no warning colour, nor mimetic colour either.

Evidently *this* does not apply. Beddard, in the introduction to his "Animal Coloration," mentions this red of sponges. He attributes it to a pigment named *Zoonerythrin*, which, he says, has the property of absorbing oxygen and converting it into ozone, "hence it is clearly of great importance as a respiratory pigment, being in a way analagous to the chlorophyll of plants."

This does not seem to explain it, at least not the colours of sponges generally, only a few species have (on our shores) this red colour: *Hymeniacidon Ingallii*, *Halichondria sanguinea*, and the thin encrusting *Ophlitaspongia*.

The vast majority are yellow, brown, grey, and white, so do not possess this red *Zoonerythrin*, and obviously have as much need of respiration as their neighbours. Yet there must be a reason for these bright tints, and no solution has yet been given.

Passing to the *Echinoderms*, we have brilliant colours—in many rich purple and bright green in the same species (*Echinus lividus*)—and these strikingly opposite colours in individuals living side by side under the same boulder.

Sexual selection does not apply to animals the fertilisation of whose ova takes place in open sea.

Warning colour is not needed: the bristling, sharp, and rigid spines would be sufficient warning to any investigating nose.

The other suggestions fail equally, for they do not lure prey, and they are not, and need not be, *mimetic*.

Passing to the *worms*, we have gorgeous colours in many that never come to the light. The large scarlet Nemertean *Valencia splendida* is a good example. This colour is due to pigment.

The *Nereids*, with their brilliant tints, due to lamellar arrangement in the cuticle, on a dark ground, have had their tints put down to "warning colour." But such is not the case. Nereis is *very* good to eat, in fishes' estimation, and is the most valued bait for inshore line fishermen.

The gorgeous, peacock-rivalling dress of *Aphrodita acullata* has been also considered a "warning," but this aphrodita is not strongly armed, and dog-fishes often have their stomachs crammed with them, while the terribly-armed *Hermione hystrix*, with its hosts of multi-barbed spikes, that *should* have a warning notice, is dull brown.

In the *Ascidians* the same difficulty presents itself. In some the colours are most varied, even amongst those, such as *Botryllus*, which cluster side by side, often on the same frond of fucus.

Of what use to the owner can be the dazzling vermilion of the Coating Compound Ascidian, *Leptoclinum Lacazii*?

Patches of this, nearly a foot square, adhering to the vertical sides of rocks at low spring tides can be seen from a hundred yards away—not *warning*, or the yellow ones by its side would need, and of course possess, *warning as well*. No present theory accounts for this either.

Ascidians are not eaten by anything I know of, let their colours be bright or dull.[1]

Beddard lays much stress on the *food* of the animals (in different groups), the transfer of the pigments of the eaten to the eater, but the ascidians, like the sponges,

[1] Dogfishes, and the Black Bream, eat the gelatinous forms on Zoetera, swallowing plant and all.

feed on all that comes to the cilia, and none (or few) of these microscopic things are pigmented.

In regard to all these forms, and possibly many others, we are without a glimpse of light, and the subject offers a fine field to the young and serious naturalist.

Arrived at the *Crustacea*, we *do* begin to find a *raison d'être* for special colours. Allusion has been made in Chapter VII. to the bright colours and rapid changes from one to another in the *Hippolytes*—*H. varians*, above all, changing from a bright red to a vivid green in a very short time.[1] All the Hippolytes have this faculty, in various degrees, except *one*, a large and beautiful species, which, I think, is the *Hippolyte Thompsonii* of Bell, but am not sure. This one is of large size, about an inch and a half ong, and fairly stout.

The general tint of this is nil—that is, it is just about transparent—but on two of the joints of the abdomen are large opaque saddles of a rich pink, as if patches of satin of this colour had been pasted on. It lives amongst pink corallines, or rather *nullipores*, at the low-tide limit (and no doubt extends to deep water), at least the specimen before me was taken in such a locality, and it was transferred to a glass tank with bits of nullipore, where it was practically invisible.

It has some minute purple and lemon-coloured dots arranged alternately in lines on the limbs and around the carapace, but these only show on close examination.

This, of course, looks like a good case of mimicry, but then it occurs—why the pink saddles ? Would not *complete* transparency be as good ? Well, no. The largest patch occupies that segment on the abdomen which forms a conspicuous hump, and a fish passing by would be

[1] I have sometimes had Hippolyte change from red to green in a plain white dish, with apparently no stimulating cause, and this at night.

convinced that it was nullipore, while a transparent hump might suggest something delectable. It is good mimicry.[1]

An error which has become classical is in regard to mysis. A large species of this has been named *Mysis chamæleon*, on account of its being supposed to vary its colour to suit surroundings, and this is often used as the typical case of colour change. I cannot understand this, except that it results from *copying* an original error.

As a matter of fact no mysis (*at least no mysis on this shore*) does change colour, nor has colour to change. They are all pretty well transparent, just a line of grey, or faint *greenish* grey spots of pigment along the back—one spot on the carapace and one on each segment. These spots have narrow, waved lines radiating from them. I have to-day been watching a swarm of *M. chamæleon* in a Zostera pool. They showed, when viewed from above, on a sandy bottom of a *grey* colour, but were not conspicuous. They swam slowly, and looked like the little bits of decayed Zostera, which were common around. A few placed in a bottle of water and viewed from the side showed the transparency and the lines mentioned.

It is with great hesitation that I make this objection to the very general opinion—especially when I consider the names that have appeared in connection with it—and again say, *on this coast, at least*, the mysids do not show change of colour, and mysis abounds here. I have already mentioned how it forms a law-regulated fishery.

I cannot help thinking that the error is due to having confounded mysis with the slender *Hippolyte* (or *Virbius*) *viridis*.

In the mollusca there is great variety of colour and

[1] Since the above has been in print, the Rev. A. M. Norman has identified this specimen for me. It is *Denicia sagittifera*. First recorded and named by him in 1851.

marking, but with the exception of those in the *Cephalopoda* none clearly indicative of usefulness.

The red, radiating lines of the "Sunset Shell" (*Psammobia vespertina*); the brown, waved lives of *Pectunculus*; the red, or red and green, stripes of *Trochus magus*; the red and blue of *Trochus zizyphinus*, and a host of other shell-bearers, is plainly neither *sexual*, *mimical*, *warning*, nor *luring*.

It has been said that the *Nudibranchi* and *Opisthobranchi* have colouring as protective coloration. Here again there are great objections to be raised. These molluscs are not good to eat. This I have remarked by very long experience in the field, and it has been made a subject of scientific test by Professor Herdman. In his experiments only once or twice, out of a large number of trials, did a fish eat one. And yet, with one exception (*Aplysia*), the colours are not *warning*, but what could be termed *mimical*—the reverse of what we should expect.

(I refer, of course, only to those of our shores; the gorgeous colours of the Nudibranchi of deep sea and of foreign lands *may* be warning.)

Aplysia punctata is strikingly conspicuous—dark, almost black, purple with white dots—and creeping on a sandy bottom is very easy to see. This may be "warning," for Aplysia is not good to eat, but it has a "warning" quite independent of this: its powerful odour of cedar would turn off any of its enemies, which would most likely be ground feeders—congers, rays, and dog-fishes—and these hunt chiefly by scent.

Aplysia depilans is less conspicuous, grey or brown. (I am inclined to think these two species are one, for I find plenty of specimens not clearly referable to one species more than the other.)

Mr Beddard, as I have already said, lays stress on the transfer, unaltered, of the coloured pigments of the food to the feeder, thus accounting for the colour of the latter.

This does not explain the case satisfactorily, for while the little *Elysia viridis*, crawling upon and feeding upon the spongy green weed, *Codium tomentosum*, is certainly of the same colour, the *Aplysia* feeds on *green Zostera*, and is deep purple within and without, and plentifully furnished with a purple dye; *Eolis* feeds on red anemones chiefly, and is usually white, sometimes grey.

In the *Cephalopods*, however, we find an unmistakable purpose, or rather service, in colour and coloration.

Frequently I have watched an octopus crawling over varied ground, and noticed that, as it passes over stones and fucus, it puts on a corresponding colour—an exact imitation; then as it traverses an intervening strip of white sand or reddish gravel the colour changes instantly to the required shade, the brown to be reverted to when the next patch of rock or fucus is reached.

Octopus has great control of colour. It has purple and orange, but these are only put on when it is in safety; especially when, as it often does, it perches itself up on the topmost bit of rock at hand. Especially after a good meal does it put on this fancy dress, and glows with the tints of satisfaction.

Occasionally, for no apparent reason, it assumes two colorations at once—one side pale grey, the other deep brown, the division *central* with mathematical precision.

The little *Sepiola* changes rapidly, just like the octopus. Anyone watching it in a shallow pool must at once be struck with this—over sand white; over gravel a little corresponding speckling; and then over rock or fucus all the available pigment is forced to the surface, and it is as brown as a ripe chestnut.

Sepia and *Loligo* also change to suit surroundings, but in a less marked way. Of course this is protective, for they are eagerly sought for by large fishes, especially the conger. A large conger disposes of a very fair-sized octopus at a mouthful—*bolus*.

The term *mimicry* in its restricted and actual sense is when some animal, good to eat and defenceless, imitates in size, form, and colour some other that it is not safe to attack, as in the case of the great saw-fly (*Sirex gigas*), which is juicy and harmless, but saves itself by mimicking a hornet, and hundreds more; or imitates some inanimate object which would not be noticed, like the "stick" and "leaf" insects, which are exact imitations of twigs and leaves; also the *Kallima* butterfly, etc.

In its broader application the term is used when some animal, like the cephalopods, just mentioned, simply imitates surroundings.

Of the latter system of mimicry there is abundance among our shore animals, but of the former the instances are rare, for it may be straining a point to say that the little, nobbly, pink coloured "Nut Crabs" (*Ebalia*) mimic the nullipores and small pebbles of their home. (I have just said "on *our shores*," for in foreign examples genuine mimicry is very apparent.)

I have a large crab (*Parthenope horrida*) from some tropical place (I have no data), and with it a bit of the bottom that was dredged with it. Although the crab is six inches in diameter it is not easy to tell where it begins or ends on the cake of hardened, calcareous bottom. This crab is of the shape of our own little *Eurynome aspera*, and its angles, rugosities, and colour are identical with the ground.

This very day I was face to face with a large male *Pisa tetraodon*. It was sitting up, in a nearly upright position, near a raised bank, on which Zostera was growing. It had decked itself with a couple of bits of Zostera, firmly fixed to the hooked bristles between its bifurcate rostrum, and these stood upright, just as if growing from a clump of mud.

It was by the merest chance that I saw it, although it was out of water, and fully exposed. It fell a victim to the camera, and is shown in Fig. 77.

Now this mimetic *artifice* is very common in the *Maidæ*. I have mentioned instances in the chapter on the "Crustacea," and given some figures.

Perhaps, to some extent, some of the smaller crustacea may be proper mimics; for instance, the skeleton shrimps (*Caprella*) live among the branches of zoophytes and polyzoa, and their linear, and sometimes tuberculated (*C. acanthifera*), forms correspond with the branches; their colour is also the same, but the form may only be due to adaptation to habit, being just the correct one for climbing between close-set branches.

The long legs of *Stenorhynchus* (Fig. 79) seem built for speed, but these crabs are the most sluggish of all the crab tribe, so their use may be, when bits of weed are attached to them, to imitate the delicate branched sea-weeds.

And yet, structurally the same, *Inachus* (Fig. 82) does not deck itself; it has no hooked hairs, and usually lives fairly in the open, clinging to the vertical side of a rock, whence it generally topples down when the tide recedes, and lies there upon its back. Its legs only seem to render it the more conspicuous.

True, its shell is of such texture, terracotta-like, that the embryos of sponges and the larvæ of ascidians readily attach themselves to it, thus helping to disguise it, but still it is conspicuous. And yet it must be good to eat; defenceless, inactive, conspicuous, and its reproduction not very great for a crustacean, the eggs being large and *comparatively* few. This is another puzzle.

When we arrive at the fishes, we find, as in the cephalopods, striking evidence of the value of colour and marking. In the fishes that habitually swim at some distance from bottom the dark tint of the back and the white or silvery under side serve to render them inconspicuous, from whatever direction they may be viewed.

Those who have seen the wooden models of ducks, showing the use of such colouring, in the Natural History Museum at South Kensington, will require no further illustration.

These models are life size, they are covered with grey flannel, and fixed at some distance from a background covered with the same.

In one specimen the flannel is left of the same tint as the back; in the other the flannel has been painted—darker on the back, lighter beneath.

The first one is easily seen, although of the same colour as its surroundings, owing to light and shade. The second has this counterbalanced by tinting, and the result is, that it is quite possible to stand a few feet from it and not see it at all. A brass rail marks the best point for observation. It was only after reading the descriptive card that I was able to perceive the tinted duck at all, and even then was not sure that my eyes were not deceived.

This dark upper and light under side obtains in all habitually swimming fishes.

In those that more usually haunt the bottom the colours and markings are those of the bottom.

The photo of the *Dragonet* (Fig. 117) illustrates this well. It will be noted that the very size and shape of the markings correspond with the fragments that constitute the shell gravel on which it lives, and the colour in life is precise—mottlings of grey, black, buff, or yellow.

Among the crustacea I have already mentioned that, while the common shrimp (*Crangon*) is, as everyone knows, exactly the speckled grey of sand, there are some on one part of this coast that, living where the rocks are diorite and the sand is a coarse mixture of the fragments of the black hornblende and whitish felspar which are its constituents, are *spotted*, black and yellowish white, in exact resemblance to this sand (Fig. 53).

Many fishes *control* their pigments to suit surroundings. The best " mimics " in this way are the brill and the turbot; in less degree the plaice, sole, etc.

An illustration easy to hand is the little minnow of our streams.

If two suitable vessels, say dessert plates, one red and one green, are used, and the fishes, whatever may be their tint, are placed in one of these, they will in a few minutes take on, not the exact colour, yet one so similar that they are scarcely visible; then if transferred to the other they will be strikingly obvious, but only for a minute or two—they will quickly put on the new colour.

For a year I kept a *Turbot*, which was about a foot long, in a shallow pond (in the Jersey aquarium). The pond was about twenty feet long by eight feet wide. The bottom was arranged in three sections: one ordinary grey sand, the next shell gravel, with large bits of oyster shell-etc., and the rest shingle, with black, buff, and white pebbles.

As the turbot rested upon either of these it was as difficult to perceive it as the South Kensington duck.

I have seen visitors look for it for a quarter of an hour, while it was fully exposed in front of them.

If it was driven to another kind of bottom—say on the shingle—it appeared strongly evident as a whitish patch; but only for a few minutes: gradually black, buff, and white spots and dashes would appear, until again it was lost to view.

The change from light and even colouring to a strongly marked one took about five minutes, while the reverse process was much more rapid.

Mr Beddard (" Animal Coloration "), referring to the *Sole*, says: " The changes of colour depend not on the nature of the ground, but on the amount of light, for [referring to an experiment] the blackest ground produced no change of colour unless the amount of light was diminished."

This has not been my experience; for in the pond above referred to the amount of light was constant—a fair subdued light, coming through the water of the large tanks which formed the walls of the room.

Mr Beddard also lays stress upon the "extremely con-

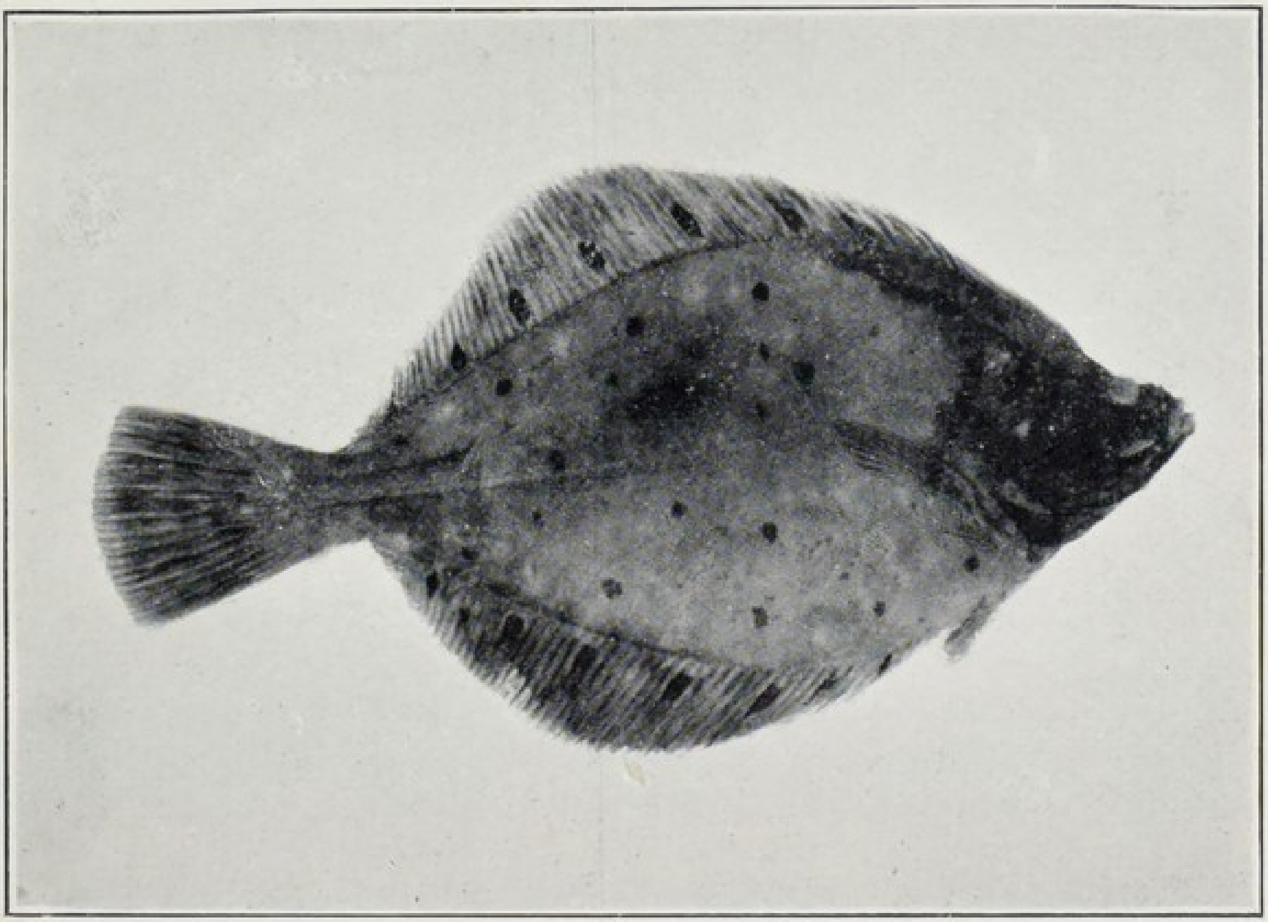


Fig. 122.—The Plaice. *Platessa vulgaris.* ¼ Natural size

spicuous" white line on the fins of the sole, that did not disappear under any of the conditions, but Mr Beddard does not point out that, in nature, the sole, and all other flat fish, on alighting on the bottom always flaps up some of the sand gravel or mud, so as to *cover* the fins and obscure the fish's entire outline (see Figs. 122 and 123).

I had a daily opportunity of studying the flat fishes, for about five years, in the large, shallow reservoirs of an oyster-rearing establishment. (One of these reservoirs is shown on page 193.)

Flat fish, chiefly plaice and soles, abounded in these

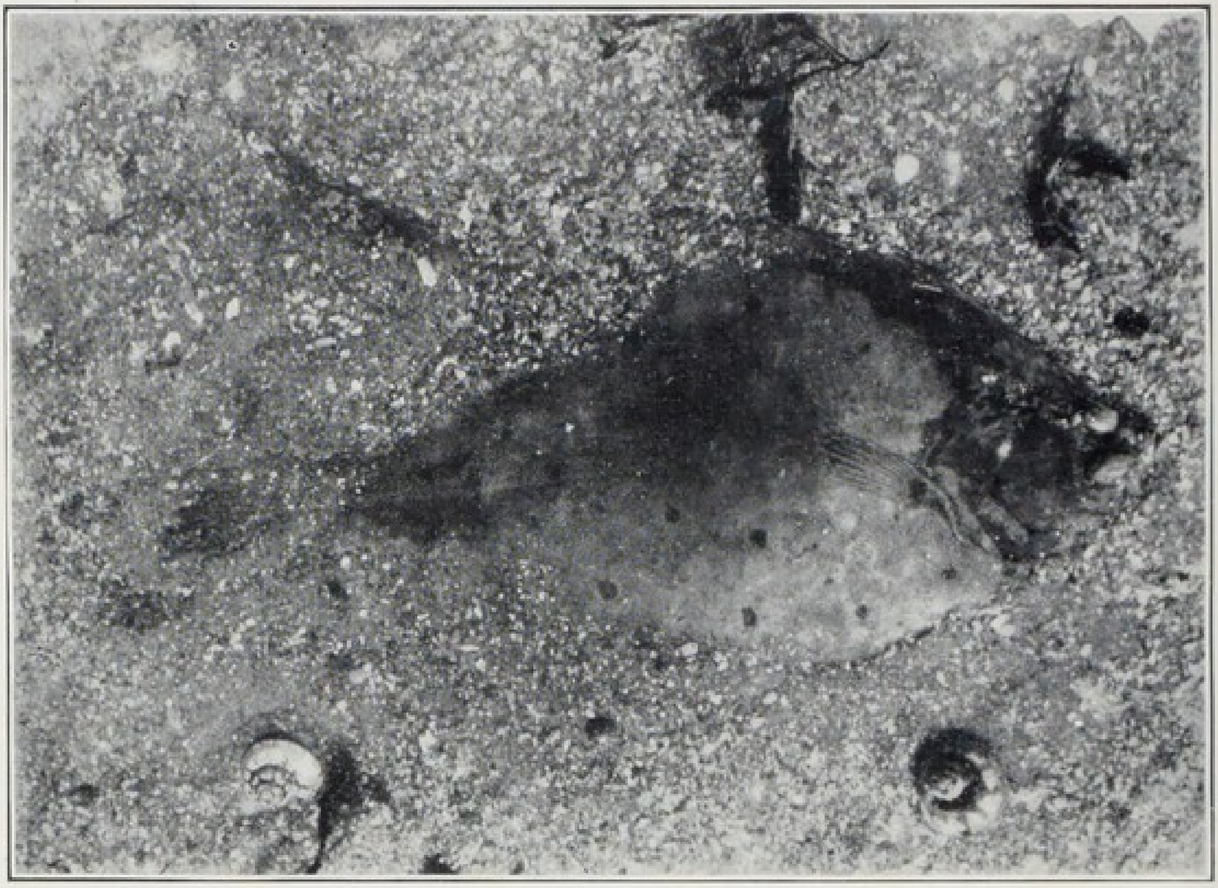


Fig. 123.—The Plaice on shell gravel, masking its outline, and modifying its coloration

places, and what I have said of the captive turbot holds good with those viewed in nature.

Fishes that lurk under stones, or live among weeds or in rock crevices—*e.g.* Goby, Blenny, etc.—are usually of a dark colour, or of a pinkish tint when in the coralline zone (*Lepadogaster*).

When they emerge for food they put on colour and markings to imitate surroundings, although in less degree than do the flat fishes.

There is, however, a rather striking exception to this in some of the rock fishes, for while the young of some are green among Zostera, brown or red among Fucus, etc., the beautiful " Blue-striped Wrasse " or " Cuckoo Wrasse " (*Labrus mixtus*) is very conspicuous at all times, but especially during the breeding season, when the colours of the *male* are as follows :—

A groundwork of deep orange, nearly red on the back, and a delicate lemon-yellow underneath. Along the sides from head to tail there are, generally, fine lines of bright blue, varying from deep ultramarine to a delicate " sky-blue." The head is sometimes marbled with blue, purple, and pink, sometimes uniformly deep blue ; the dorsal, pelvic, and ventral fins edged with blue.

The *female*, which has been described as a separate species, under the name of the " Three-spotted Wrasse " (*Labrus trimaculatus*), is of the same ground colour as the male, but instead of the blue markings it has three large spots of *black* on the back, near the tail.

This fish, which is just under a foot in length, is gorgeous in the extreme ; no coloured figure that I have seen of it conveys a fair idea of its beauty.

In the winter the male loses nearly all the blue, and shows a faint trace of three black spots on the back, while the female loses the greater part of the black in the spots, and shows a faint trace of the male's blue lines.

(Although it has always been described as two species Dr Günther expresses a *suspicion* that it is male and female of the one kind. I have watched captive specimens through the seasons, and they certainly *are* one.)

Now this conspicuous fish is unarmed, and is good to eat ; fishermen use it, with other wrasses, as bait for conger, etc.

That the colours are due to sexual selection seems very likely, but they seem in very direct opposition to fishes' general rule of *protective* coloration.

Darwin strongly holds to the theory that bright or conspicuous colours in the male are the result of the females' choice of such gaudy males.

This point Wallace (" Darwinism," p. 288) rejects, although admitting the value of these colours as a means of recognition, and attributes such conspicuous marking to the result of " superfluous energy " at certain times, and points out that such markings always follow certain centres of bone, muscle, or nerve. Now, in the bright fish just mentioned the lines and markings are not always the same : the *stripes* are always there, but they may be straight or may run zigzag, and vary from a quarter of an inch to half-an-inch or more in width. Often the entire head and fore part of the body are uniform blue, as if the fish had been dipped into a pot of paint up to a certain line. (Mr Wallace refers chiefly to *birds*, but, of course, the argument applies all round.)

Then, again, other members of the Labridæ do *not* show sexual differences to thus afford marks of recognition. In the Great Spotted Wrasse the adult males and females are equally beautifully marked, summer and winter.

These points must be put in the list of riddles yet to be solved.

This dissertation upon a strictly scientific problem, and one on which the masters are at variance, does not seem exactly in place in a popular outline of shore zoology, but I introduce it to show what interesting points there are to be looked into, and to show that our own shores furnish abundant material for research.

CHAPTER XV

COLLECTING AND PRESERVING

As regards collecting I have given a general idea of localities and situations in the chapters under the different headings, but after a little experience the young collector will enlarge his field.

For instance, in collecting crustacea he will soon learn that many are parasitic, or partly so ; that some *Isopod Crustaceans*, *Bopyrus*, etc., live under the edges of the carapace of prawns, on the gills of the lobster, the hermit crab, etc., each host accommodating some particular species ; that the larval forms of some *picnogons* live in the reproductive capsules of some zoophytes ; that many worms live in a kind of commensalism with sponges, forming, as it were, a part of their mass. Many of the rarer bivalve molluscs are in a way parasitic. Some live among the spines of the heart urchins, on *Synapta*, etc. Some are embedded in the leathery tests of the large ascidians. Some *Polyzoans* are parasitic on worms—on *Gephyreans*, etc. But I think I have given a fair indication of what would make a fair beginning for a typical collection.

The equipment necessary for shore collecting is not an elaborate one. The collector will require :

A flat-bottomed basket, with a string or wire passed across, on the width, to keep his jars from toppling.

A couple of wide-mouthed jam jars, or, what is better, a couple of new tins, with covers to fit inside tightly, like the tins house paints are sold in, each holding about a quart. With these there is no danger of breakage or of loss of contents if the basket should have a fall—a rather common occurrence.

A trowel for digging up molluscs, worms, burrowing anemones, etc.

A good-sized knife for cutting off sponges, etc.

A few corked tubes, about four inches long and three quarters of an inch in diameter. These tubes are best carried between two strips of cloth stitched together at intervals to form a series of pockets, into which the tubes can be put, like cartridges in a bandolier. This can be rolled up, tubes and all, and carried in the pocket. A few of the tubes should contain diluted spirits of wine.

A pair of fine-pointed forceps for taking up minute objects, such as small zoophytes, tiny shells, etc.

A *net*. An ordinary semicircular prawn net is good, but not the slight wire ringed ones that collapse on the first push through a bank of sea-weeds. If not convenient to carry a net like this, one can be easily made that will pack up. At the naturalists' shops a Y-piece, such as is used for the larger entomological nets, can be obtained, or a handy-man will solder together three bits of brass tubing to this shape. The main tube should be of the size to fit on a stout walking-stick, the branches of such size as to admit two bamboo rods—say half-an-inch in diameter. Then three rods of bamboo, each about two feet long, and a three-cornered net of cheese cloth with broad hems around the opening to admit of slipping in the bamboo rods.

The remainder is obvious. When the two diverging rods are passed into the hems, and have one end inserted in the tube, the third one is passed into the bottom hem and fastened to the divergent ones at the corners. This net can be "unshipped" and rolled up in paper, or pushed into an oilskin umbrella case. A stout walking-stick forms a handle.

There is an advantage in a cheese-cloth net, for many small things, *Mysids*, *Hippolytes*, *Isopods*, and *Amphipods*, slip through the meshes of an ordinary one.

This equipment will suffice for any ordinary shore work.

Shell-bearing molluscs can be put loosely in the basket; so can the larger crustacea, and all hard things; more delicate ones can be put in water in the jars.

Annelids should be brought home in water, so should the delicate star-fishes—these often break up when long dry.

Very small and fragile things, little brittle stars, small crustaceans, etc. etc., had better be dropped into the tubes of spirit at once, or into the spare tubes with sea-water.

In collecting on a large scale a garden fork and extra basket, and, if possible, an *assistant*, are required.

Objects holding mud or silt should be well rinsed in the sea or rock pool before being placed in a receptacle.

A corked bottle with some clear sea-water should be brought home, for any zoophytes, etc. that it is required to treat for the microscope, as explained in a following chapter.

Lastly, the usual word of caution: keep an eye on the rising tide. If on an open shore the advance of the tide marks the time and pace of retreat, but if, as on this coast, the collecting ground lies on distant reefs or gravel banks, sometimes a couple of miles from shore, and these banks and reefs are separated from the land by channels, often with swift currents, it is possible to be so engrossed as to allow oneself to be cut off from shore, and this is awkward, at the best.

A sure indication of the turn of the tide before encroachment can be noticed is a thin film of floating scum—bits of shell,etc., at the margin. And when this is apparent in such situations as just described it is time to pack up and go.

The Tow Net.—So far we have considered the collection of animals that live between the tidal zones and haunt the bottom, but there is a vast and varied population that is pelagic.

During the summer months especially the sea surface is pretty well a living mass of gyrating, darting forms of microscopic size, usually transparent, but sometimes so coloured as to give a characteristic tint to large areas.

An enumeration of what these are is not usually undertaken, but they are generally covered by an all-embracing term—" *Plankton.*"

This pelagic fauna varies with the seasons. In early spring the larval stages of the cirripedes abound, and the zoea stages of many of the higher crustacea begin to appear. The larval forms of worms and eggs and larvæ of fishes abound.

Later on most of these vanish and new ones take their place—Copepods and Ostracods, Amphipods and Isopods, the Mysids and the Cumas, the Megalopa stages of the crabs, and the little jelly-fish generation of the Hydroid zoophytes—a floating population in more than one sense, ever changing, but always there.

The way in which the naturalist obtains his gatherings is by means of the " Tow Net," a method of collection that is done with a minimum of trouble.

The Tow Net may be a simple, home-made affair or a somewhat mechanical arrangement.

In laboratories, where research is made as to what forms haunt different depths, etc., tow nets are employed to work at varied levels, and these open and close when the desired depth is arrived at and departed from, so as to secure *only* the animals of that particular situation.

Some nets are made of fine silk gauze, to secure the infinitely small infusorians, etc. Others have a bottle at the tail end, to bottle up the captives as they come in. But I am writing an *outline*, a little book intended as an *incentive* to the study of these things, and just as a guide for the early part of the way, and a more simple style of work will do for this.

An outfit for gathering "Plankton," in quantity vastly more than sufficient for an introductory study, can be made as follows :—

A ring of stout galvanized wire, about a foot in diameter, to which is sewn the edge of a conical net made of medium-textured "book muslin," just like a butterfly net, about two feet long. The hoop is attached by means of three lengths of strong twine (whip cord) to a stouter line three or four yards long. Such is the *net*.

In use it is simply cast overboard from the stern of the boat, the free end fastened to the ring which is always there.

The hoop sets vertically in the water, about half its diameter submerged.

The boat must proceed slowly, or the rush of water into the net will crowd and injure the delicate forms in the tail end of the net.

The net is lifted about every half-hour, turned inside out into a pail of sea-water, and well shaken and rinsed in this.

Now comes a piece of apparatus which is a little more complicated, but still very simple, and which can be made at home. There are more elaborate arrangements, but I will describe my own, which has served for many years, and I wish for no better one.

A glass pickle jar to hold about half-a-gallon, to begin with.

To this fasten a strong cord, in the form of a handle, like that of a pail.

A good, deep, tight-fitting cork is obtained to fit the mouth. Through the cork two holes are neatly bored, about three quarters of an inch in diameter. In one of these holes a bit of brass tubing is tightly fitted, so as to project an inch on either side.

To the *under* end, that which comes within the jar when the cork is in place, is fastened the end of a loose coil of wire. This coil, of about half-a-dozen turns, is four inches long and two (about) in diameter. Over it is sewn a little bag of muslin, and the free edge of the bag is tightly tied around the tubing, close to the cork. A japanned iron funnel, of nine inches diameter at the rim, and tightly fitting the free hole in the cork, completes the arrangement.

The pail, with its myriad prisoners, is gently emptied into the funnel. The jar is thus filled, and remains full, the waste water spouting out, fountainlike, from the brass tube. The muslin bag prevents the escape of the animals, and, having a large surface, they are not jammed by an out-rush of the water.

The pail is filled with water ready for the next haul.

It is well to hang the bottle over the side of the boat, to avoid unnecessary slop.

As the hauls are repeated the jar begins to present a very animated appearance, for it is a poor tow netting that does not result in the capture of many thousand things. Copepods jerk, medusids pulsate, zoes and cumas and arrow-worms and mysids sail round, and often some large nereid, in its *heteronereis* stage, swims and wriggles around fiercely, to the detriment of some of the delicate things (and should be hooked out with a bent wire).

Before bringing the jar ashore it is a good thing to pour two or three pailfuls of clear water into the funnel, to wash out any mud and silt which the net has gathered, and which renders the water turbid. There is no *rush* of water towards the outlet, and the captives are not washed towards it.

There are many pelagic animals that only come to surface after dark, so evening is the most prolific netting time.

Very delightful to the zoologist are those warm calm summer nights, with just breeze enough to propel the boat gently, a sea like a mill-pond, and no sound save the ripple of water on the bows.

If it is moonlight the scene is grand, if it is a dark night the phosphorescence of the sea is more than a compensation.

On the dark nights the net comes from the water like a bagful of liquid fire of a green tint.

As the net is emptied into the pail sometimes a great blob of phosphorescence will flash out, and as quickly vanish, until it is again disturbed. This is possibly some large phosphorescent *ascidian*, or perhaps the rare and beautiful, scarlet scaled worm, *Euphrosyne*.

On one of the thwarts of the boat stands a lantern, and now and again the jar is brought in front of it, and the catch examined. The things I have named, and a myriad more, are there: glassy *Cydippes*, with their rows of waving cilia; wriggling annelids, with glistening bristles on their sides; young of prawns and shrimps; young fishes, etc. etc., *ad infinitum*.

It is well to have a piece of netting, with meshes half-an-inch across, over the top of the funnel, for fear of any large object blocking its tube and causing overflow and loss.

Arrived at home, the collection must be attended to at once, although it means the "midnight oil," for not many of the captives will live for more than an hour or two within this narrow home.

A piece of straight glass tubing, of length sufficient to reach the bottom of the jar, is needed. By placing the fore-finger on one end of the tube, so as to prevent the air it contains from escaping when it is submerged, and then directing the free end to any object in the water, the latter is easily caught. The finger is removed rapidly; then the water and the selected animal rush into the tube; the finger tip is replaced, and the contents dropped into the saucer or watch-glass in which the examination is to be made—or into preservative, as desired. It is a good plan to select and preserve right off the more valuable and the more delicate things.

The *Cydippes* and larger *Medusids* can be lifted out with a cup-shaped salt spoon attached to a handle, and these put into the ordinary formalin solution. (Sea-water is better than ordinary tap water for this.) The formalin should be *ten per cent.* of the whole.

When selection has been made replace the cork and strainer, and pour off three-fourths of the water, so as to concentrate the animals; then pour in a few drops of the osmic acid solution (p. 318). All the animals will fall to the bottom instantaneously. They should be left so for half-an-hour, then washed in fresh water, and transferred to a suitable bottle with dilute (twenty-five per cent.) spirit until next day, when they can be gradually changed into stronger grades, and finally into *seventy-five* per cent. The bottle is then well stoppered, and labelled with date and locality for future work.

Preserving specimens.—The essentials for this should all be at hand before work is commenced or, in fact, any collecting is done. They are not numerous:

A few shallow dishes—stone-ware photographic dishes, " ¼ plate " and " ½ plate," are excellent.

Some wide-mouthed glass jars, preferably the ordinary cylindrical museum jars, with either a ground-glass stopper or a ground flat rim for covering with a glass disc; but ordinary jam jars will do *pro tem.*

Some glass tubes, of from four to nine inches in length, and good corks to fit.

Some sheets of mica.

A " luting " substance, for sealing down preparations to avoid the evaporation of the spirit or other preservative fluid. Gold size is usually employed, but a better mixture can be made by melting in a tin some paraffin wax, and adding to it, as it melts, about one-fourth its weight of pure indiarubber (old bicycle tyre is good). This can be warmed and applied as required.

A good supply of methylated spirit. (There are two kinds of this : one which mixes with water to a clear solution, and one which does not, but gives a milky turbidity. It must be the *first* kind.) I mention *methylated* because it is cheap, but *rectified* spirit mixes with water without risk of turbidity.

A bottle of *Formalin* (the ordinary commercial solution of forty per cent. formaldehyde).

A solution of corrosive sublimate (perchloride of mercury) in water. This salt dissolves slowly and sparingly in water, but an *excess* should be in the bottom of the bottle, which can remain there, and water be added as the supply of solution is used up.

A bottle of ether.

Some card boxes of various sizes.

Pins, forceps, scissors, knife, needle and thread, gummed labels.

Now the work.

Foraminifera.—These, being minute, will be dealt with in the chapter on microscopic methods.

Sponges.—Those of which it is desired to make microscopic preparations will also be dealt with in the next chapter, but the specimens intended for the purpose must be taken special care of as soon as they are gathered. The best for study of histology are the small *Calcispongia* (see p. 19), say *Sycon.* One specimen will be ample for many slides, so select a nice clean one, and place it, *pro tem*, in a shallow dish in clear sea-water (it will keep alive for a day or so), for future treatment, as on page 319.

If coarser sections of the larger sponges, just to show the spicules, etc., are desired, cut out suitable portions—

cubes of about half-an-inch square—taking care to have one side showing the surface of the sponge, and put these right off into a bottle of methylated spirit. Label with name, etc.

Sponges intended to show entire, as museum specimens, can be preserved either dry or in fluid, but the latter is much the better way of showing them, for although they lose colour, to great extent, they retain their structure, which is the most important point. Either methylated spirit or a solution of formalin, one in ten of water, will do. Clean them well, and place each species in a separate jar. The fluid will have to be changed several times before they are finally sealed up, so it is a good plan just to cork the bottle without sealing, or to tie a piece of bladder, previously damped, over the mouth.

If the sponge is limp, and tends to collapse to the bottom, or if the preparation consists of small sponges attached to weeds or other objects, a piece of mica cut to fit upright in the jar is needed, the specimen being fastened to it with a stitch or two of fine thread so placed as not to show to the front.

Formalin is as good as spirit for all but the little *Calci sponges*, and it requires few changes before remaining clear.

The Cœlenterates.—These are the most difficult things there are to preserve in such a way as to retain their natural form and appearance. For instance, the beautiful *Anemones*, that so delight the eye in the rock pools, have never been satisfactorily preserved, either in form or colour. Attempts to kill them with tentacles expanded—anæsthetics, freezing, suddenly plunging into hot solutions of hardening acids, etc.—have all resulted in at least partial failure: they always draw in their tentacles.

There is, however, *one* exception. The "Opelet" (*Anthea cereus* or *Anemonia sulcata*), which does not readily close up (hence its popular name), *may* be preserved so as to show its form; and the drab variety will, in *formalin* solution, retain colour, and by good fortune more than by skill the common "Beadlet" (*Actinia mesembryanthemum*) may sometimes be managed.

The *Hydroid zoophytes*, although usually represented in collections by their polypidoms only, can be well preserved in full expansion, and make beautiful preparations. To kill these in expansion, either as specimens in jars or for microscopic slides, as described later on, the usual plan is to add, drop by drop, to the jar of sea-water in which they are living some anæsthetic or fixative. The following will as a rule answer :—solutions of *cocaine*, *chloral hydrate*, *chloroform* or *corrosive sublimate* ; but the plan I usually employ is to gently pour a layer of ether (which floats) on to the surface of the sea-water, cover tightly with a piece of bladder, and leave them undisturbed for a day or so, or until it is seen on close examination that the tentacles do not move, and *then* add a strong solution of corrosive sublimate to harden them, after which they can be transferred to the preservative. If for museum jars, to show mode of growth and polyps, formalin ten per cent. is best.

I have before me a jar with a cluster of *Plumularia similis* in which every polyp is expanded and erect, just as in life. This was prepared as just described. The preservative is ten per cent. formalin in sea-water, but tap water will do. If spirit is used, as it must be if they are being prepared to make micro slides of them, it must be added by degrees, the simplest plan being to have the jar only part filled with water (not *sea-water*), and then every few hours add a little spirits of wine, until it is about seventy-five per cent. of the whole. Then they can be put into the strongest grade for dehydration.

The *Hydro-medusids*, or alternate generation of the hydroid zoophytes, and also the larger forms—*Aurelia*, *Chrysaora*, etc. etc.—that were so difficult to preserve formerly, having to be treated with osmic, chromic, etc., before being put into spirit, can now, thanks to formalin, be preserved right away in this medium, and make very good preparations. The large ones must be suspended by a thread, well centred, this thread attached to a cross one fixed just under the stopper of the jar.

The Echinoderms.—These, with the exception of the Holothurians and the Feather Star (*Antedon*), are usually put up dry. Many species—*e.g.* the common "Brittle Star," and one or two more—often break off their arms in course of collecting or subsequent manipulation. It is a good plan to drop these right into spirit as they are caught. Some plunge them into *fresh water*, which also often kills them quickly, without damage, but spirit is the best. After killing they must be rinsed in fresh water, to remove the salt, and then in a weak solution of corrosive, after which they can be set out with pins into position on a board, and left to dry, when they can be transferred to the cabinet drawer—or, temporarily, card boxes. A thread passed over them and through the bottom of the box will keep them steady and prevent breakage.

The larger star-fishes, *Uraster*, etc. etc., can be treated in the same simple way, although some insist on the necessity of cleaning them out by the mouth, with a hooked wire, and stuffing with cotton wool. In *Solaster*, which sometimes loses its convexity in drying, I have found this necessary, but a good soaking in corrosive and a *thorough drying* are important. A soaking for a few days in a suitable vessel with methylated spirit and corrosive is very good ; the drying is then more rapid, and the preservation permanent.

The strength of the corrosive should be such that it will not dry as a white powder on the surface. The strength can be tested by dipping a black feather in it and allowing this to dry. It will, of course, show a little white in any case, but the Echinoderms are not *black*.

The *Sea-urchins* (*Echinodea*) must be emptied out, and they should be preserved as soon as taken, or the spines will lose their rigid radiation, and lie lax and unnatural.

It is a good plan to plunge them into strong spirit as soon as brought home. In this they can be left for any length of time, before proceeding further. For cleaning out, the "Aristotle's lantern" is removed, by passing a penknife through the surrounding membrane. Then the inside is taken out with a hooked wire and forceps, the inside well washed under the tap—a bottle brush is of service. Then rinse in the corrosive sublimate, and put out to dry. The "lantern" can be rinsed in corrosive, and set alongside on the final mount.

To obtain the "Test" denuded of its spines, as in Fig. 32, it is the easiest plan to *boil* them; the spines will come off readily, a fluff of membrane and the ends of the ambulacral feet will prove adherent, but a stiff nail brush and the water tap will remove these.

The Holothurians.—The "Sea-cucumber" is somewhat difficult to kill with the tentacles extended. The best plan is to treat these as directed for *zoophytes*, and then to place in spirit, in a jar of suitable size, either free or fastened to a mica plate.

Synapta has the habit of constricting itself into the form of a little string of sausages and then breaking up into chunks, which makes it difficult to preserve specimens for fair display. This may be obviated in a great measure by bringing them home in sea-water, and then dropping them, horizontally, into a dish of strong spirit. The tentacles are never *fully*, but still they are partially, extended.

The Vermes.—These must be treated with great care to make good exhibits. It will not do to plunge them into spirit while they are in full vigour, or they will harden in all manner of contortion. The proper plan is to allow them to remain in the jar of water in which they have been brought in until they are inactive; then to lay them straight, side by side, in a flat dish of sufficient length, and add spirit in gradually increasing strength, cleansing the fringe of bristles of such as have them (the *Polychetes*), with a camel-hair brush, leaving them in the dish in strong spirit until hard, when they may be put into tubes of suitable length, the spirit changed a few times, and finally sealed up. The short forms, like *Nykia* (*D* in Fig. 36), being fastened to a mica slip for better display.

The *tubiculous* worms, such as the *Sabellas* (Fig. 35), must be brought home in their tubes, then the tube carefully split up one side and the worm lifted out and treated as above. The beautiful tufts of plumes will expand without difficulty. Attempts to *pull* them out of their tubes always result in breaking them.

The spirit must be strengthened very gradually, or the fine fringe of the plumes will crinkle up.

The Crustacea.—These present little or no difficulty in preparing.

The whole of the *Amphipoda* and *Isopoda*, as well as the small species of *Macrura* and the *Stomapoda*, such as *Mysis*, *Hippolyte*, etc., are very much better preserved in spirit, in tubes of suitable size, than set out dry. But the larger *Macrura*, from the size of the prawn upwards, are usually put up dry on mounts. Those of the latter size and upwards must be cleaned out. This is easily done by allowing them to macerate for a while in fresh water; this softens the flesh and removes the salt.

In the macrurans the abdominal part is detached from the anterior one, and by means of fine forceps and a piece of wire, flattened at the end and turned up in the form of a little hoe, the flesh is easily removed. Rinse in weak solution of corrosive sublimate and then they can be set out to dry, the legs, antennæ, etc., being extended and displayed by means of pins crossed over them; this on a soft bit of board, the detached parts being carefully joined with a little seccotine or other suitable cement.

Those with membraneous or easily collapsible shells, such as *Gebia*, *Callianassa*, etc. (see Fig. 50), must be loosely stuffed with a little cotton wool.

The *Brachyura*, or true crabs, must have the carapace lifted off, and the flesh of all parts accessible removed from that opening.

In small forms there is no need to remove the flesh from the legs, the corrosive sublimate will penetrate and readily preserve this. In the large ones, such as the great edible crab, and also the larger *Macrura*, such as *Palinurus*, the flesh of the legs can be drawn out from the inside by means of the bent wire, as described.

To clean the *claws* of the large species force out the movable finger (*Dactylopodite*), and hook out the flesh that way. The finger can be "sprung" back into place without any breakage.

In large species the maceration in fresh water must be considerable—three or four days—but not up to the point of putrefaction and blackening, or some parts—viz. the mouth appendages (*Maxillipedes*, etc.)—will become detached.

When the flesh is softened by maceration it comes away readily, and the water tap (with force) will do much of the work.

Instead of corrosive sublimate for these, it does as well to apply powdered alum inside, rather plentifully. As the moisture dissolves it it penetrates to all parts, and is effective. It spreads a little on the outside, and when dry shows *white*, but this is easily sponged off.

There is a division of opinion as to whether *varnish* is admissible or not on dried specimens of crustacea. On the one hand a glairy surface is unnatural and objectionable, on the other, the dull dry surface is equally so, and the fine markings and mottlings that are present cannot be seen.

My plan has been a compromise, and my specimens look well. I take a little mastic or copal varnish, and thin it to a great extent with benzoline, bringing it to the fluidity of water. A few drops of this applied spreads by *capillarity* over the whole surface. This brings out the colour and markings, gives an appearance of *freshness*, and leaves no gloss.

Mollusca.—Preservation in this group really comes under two headings. The very popular branch *Conchology* requires no great skill. It is only necessary to bear in mind that the shells should, as a rule, be those that are taken *living*. Tide-thrown specimens are usually rubbed and worn by the attrition of sand, so that the very delicate striations and markings are obliterated.

The ordinary *bivalves*, and all the *univalves*, can be readily cleaned out by boiling and removing the flesh (from the latter), by means of a needle, pin, or forceps. But some of the bivalves—viz. those that have a fine epidermis on the shell, such as the satin-coated *Mactra helvacea*—must not be boiled, but macerated in cold water until soft.

The shells should then be wiped dry, very carefully closed (bivalves), and fastened in place until dry, by means of a thread or a slip of paper. Some of the valves should also be left open, to show the teeth, ligament, and marks of muscle attachment.

In the *univalves* the operculum should be taken care of, and in some specimens be gummed in its natural position, a little cotton wool having been previously pressed into the shell.

The *Nudibranch* and *Opesthobranch* molluscs present more difficulty. To show to advantage they should have their tentacles exserted, and when there are retractile branchiæ, as in *Doris*, this should be extended.

It is no easy matter to kill them in perfection as regards these details. There is no royal road to this end. Sometimes suddenly plunging right off into strong spirit or a hot solution of corrosive may achieve success, but what is safer is to employ anæsthetics, as directed for zoophytes. Formalin solution, ten per cent., will answer for most, but *Eolis*, that parts readily with its leaflike processes, although branches of its alimentary canal run into them, is best preserved in seventy-five per cent. spirit.

The *Cephalopoda* (*Octopus*, *Sepia*, etc.) are beautifully preserved in the formalin solution, but *Octopus*, if killed by plunging into the preservative, takes up a peculiarly symmetrical form, the tentacles curled into flat spirals, which is not natural. It is best not to put this one, at least, into the preservative until it is dead. It can then be arranged into proper form before the fluid is poured on. An hour after it has been in the formalin it will be rigid, and will retain the position in which it was arranged; a couple of changes, at intervals of a week, and they can be finally sealed up for the museum.

The Tunicates.—These give varied results as regards their appearance as museum specimens. The transparent, pelagic forms, *Salpa*, *Doliolum*, etc., preserve very well by simply immersing in formalin solution, or in spirits of wine if it is brought to strength (sixty per cent. or seventy per cent.) by degrees, but the beautifully coloured compound forms, all the varieties of *Botryllus*, etc., lose their colour entirely. A successful method of preserving them has yet to be discovered.

One species, however, *may* be to some extent preserved with natural appearance; this is the almost black and white one (*Botryllus morio*). It will keep *tolerably* in formalin solution. This is the species shown in Fig. 100.

The large simple ascidians (*Ascidia virginea*, etc.) keep well in formalin; only it is necessary to prepare them by an anæsthetic, so as to keep the processes in which are their inhalant and exhalant apertures extended (see Fig. 102).

The Fishes.—Small species, such as the gobies, blennies, etc. etc., preserve beautifully in the formalin solution. They are best displayed in the jar by fastening to a sheet of mica, having the jar of ample size, otherwise they rest on their tails (unless they are suspended to the stopper). They keep their colour remarkably well in this solution, far better than in spirit. The larger species had better be handed over to the taxidermist.

There are various methods of fish taxidermy, but even the most simple would take half this volume to explain, and then might not be clear. A few lessons from a professional would be better than a week's reading.

In recommending mica plates for fastening specimens in proper position for display I have done so on account of its being very easy, simply sticking a needle and thread through both specimen and mica (not showing to front), and tying neatly at the back; but sheets of glass cut to fit vertically inside the jar, and with holes drilled through in the proper places, are better. A small glass bead at the back of the plate gives a neat and secure fastening for the thread.

Drilling the glass is by no means difficult. It will drill easily with a simple little stock and drill, such as are used by fretwork cutters, touching up the drill now and then on an emery stone. If the surface of the glass is scratched, or just dented with the end of a broken file, the drill will "bite" at once. As soon as the point shows through the hole should be finished from the reverse side, to avoid starting off a "flake."

Diamond drills are sold for the purpose, at about one shilling, but the diamond chip usually drops out the first time of using. I have drilled many hundreds of holes with a steel drill as above, hardened in zinc chloride.

A question often arises as to the desirability or otherwise of artificially colouring such specimens as lose their natural tints in drying (or in fluid). My own opinion is that it *is* admissible, *only*, it must be done judiciously and *carefully*, keeping true to nature, and not striving for effect.

For instance, say a large *Uraster glacialis* (Fig. 23). The colour of this in life is usually a slaty grey, with pink tips to the arms. After preserving and drying it is (usually) a pale *yellow*. Now I hold that it is better to touch up the specimen a bit than give a false idea of its appearance in life. I need not specify the kinds of colours that should be used, but the aniline dyes, well diluted to tint, do very well.

Avoid *painting*; this is generally an outrage, but a faint wash of dye, the surface of the specimen having been previously moistened, will result in correct effect.

This work, like all other in the preservation of natural history, requires skill, and skill is the offspring of *practice*.

CHAPTER XVI

MICROSCOPIC PREPARATIONS IN MARINE ZOOLOGY

REQUISITES.—A *microscope*; preferably a short-tubed, Continental pattern one, that can easily be used *vertically*, with objectives of different powers—viz. (in English method of expressing powers) 1-inch, $\frac{1}{2}$-inch, and $\frac{1}{6}$-inch—these will suffice to begin with.

The lowest of these is suitable for viewing small objects in their entirety. The highest ($\frac{1}{6}$-inch) will be sufficient to reveal the majority of infusorians, the cells, collars, and flagellæ of sponges, sting cells, etc.—quite enough for the present purpose.

A *microtome*. The form and quality of this must be regulated by matters pertaining to the exchequer. They range from a few shillings to many pounds.

In some the object to be cut into sections is cemented to a little table, which can be moved to any angle, and the razor blade works across it mechanically; in others the blade is fixed, and the object fastened to a support is advanced to a regulated measure and brought down to the blade; in others there is a *well*, in which the object is embedded in wax or other medium, and the bottom of this well raises the column of wax and its contained object to the cutting level, a smooth brass plate, across which the razor is moved by hand.

For general, all-round work one of these is best, and they are not expensive. I will suppose we are using one of these.

It must be made so as to screw firmly to the edge of the table or bench. A "Hand Microtome" does very well for class work and rough demonstration, but will not be the correct thing for serious work.

It must have a steady adjustment, so as to raise the object to be cut very regularly, and *should* have a scale, to register what thickness is *really* being cut—viz. $\frac{1}{1000}$, $\frac{1}{500}$, etc., of an inch (or parts of a millimetre). Patterns and prices are to be found on any list of scientific instruments.

Reagents and *Material*.—The following are all that will be really requisite for a beginning, and will allow of really good results :—

Some absolute alcohol, say half-a-pint ; oil of cloves, 1 oz. ; oil of bergamot, 1 oz. ; turpentine, say 8 oz. ; paraffin-wax, 4 oz. ; balsam and benzole, 1 oz. ; glycerine jelly, 1 oz. ; picro carmine, 1 oz. ; borax carmine stain, 1 oz. ; hæmatoxylin stain, 1 oz. ; Scherring's celloidin in chips, 1 oz. ; ether, say 4 oz. ; a 1-gramme tube of osmic acid ; 4 oz. of a concentrated aqueous solution of corrosive sublimate ; plain glass slips, 3×1 ; thin white glass "sunk-cell" slips, with cells oval and round, different sizes, say 1 gross assorted ; $\frac{1}{2}$-oz. of $\frac{3}{4}$-inch glass covers (circles), $\frac{3}{4}$-in. diameter, or assorted up to $\frac{7}{8}$-inch ; a few dozen "metal rings," for dry mounts, about $\frac{3}{4}$-in. diameter and $\frac{1}{8}$-inch thick, or *assorted* ; a "dipping tube," with fine point and rubber top ; a glass spirit lamp ; a few lengths of plain glass tubing, about $\frac{1}{4}$-inch diameter and 6 inches long ; and one or two bits of *glass rod* ; mounting needles, two or three (ordinary sewing needles, with half their length pressed into thin wooden handles, point *outwards*, of course) ; a pair of fine forceps ; 2 razors and an oil-stone ; a few watch glasses and covered pomatum pots ; two fine sable brushes ("No. 1, water colour") ; a "turn table" ; several glass bottles, with ground-glass stoppers, some "wide-mouthed" ; a 1-oz. bottle of shellac varnish

(" brown cement "); a 1-oz. bottle of asphaltum; a 1-oz. bottle of matt black; a few old cambric handkerchiefs; slide labels; 1 box "*clips*."

This is a fair, although by no means "complete," outfit, but it will allow of really good work, as I have said. The microscope maker or dealer will supply the whole, and with the exception of the *microscope* and *microtome* the cost will not be more than about forty shillings.

Now dissolve some celloidin chips in a mixture of equal parts ether and absolute alcohol, to about the consistency of ordinary syrup; keep this in a well-stoppered bottle, in a cool place.

Take a narrow-necked, glass-stoppered bottle, of six-ounce capacity. (This should be one of dark blue or black glass, otherwise stick some black paper around it.) In this bottle put 100 c.c., or say four and a half fluid ounces, of distilled water. Then remove the label from the tube of osmic acid, and clean off all the gum smear; put the tube and its contents into this, and crack it with a glass rod, leaving the glass fragments in (do not let wood or any organic matter come in contact with this solution); keep from breathing the osmic fumes, as they are very irritating to the nose and throat. Label the bottle "Osmic Acid, one per cent.," and keep it in a dark place, as light decomposes this solution.

Now for the practical part.

It is customary to commence instruction in microscopic mounting by the most simple processes—viz. dry mounts, etc. We shall reverse this method, and begin with what is usually considered the most difficult, then the remainder will follow *easily*.

Objects that are required to demonstrate minute structure—that is, their "histology"—whether to be sectioned or mounted entire, require to be treated with some reagent that will harden the cell contents without in any way changing their form. This is termed " fixing." There are many " fixing " reagents—viz. chromic acid, bichromate of potash, corrosive sublimate, osmic acid, etc.—and each has its votaries.

A good all round fixing solution, cheaper, and some say better, than osmic can be made thus, Water 4 ounces, corrosive sublimate 40 grains, picric acid 60 grains, formalin 8 ounces. Dissolve the corrosive in hot water. When cold, add the picric, then the formalin. (This is known as " Bouin's Fluid.")

For working on the first subject I shall select—viz. *sponges*—the osmic is, I think, the best. It does not allow of much *subsequent* " staining " of the preparation, but it leaves it of a brown tint, which demonstrates as well as any stain.

The little sponge, sycon, which has either just been gathered or kept as directed in the last chapter, is freed from any adherent particles of sand, etc., and is dropped quickly into a small, stoppered bottle containing distilled water and some of the *osmic acid* solution, about equal parts—just enough to submerge the sponge need be employed, as it cannot be used again.

In a little while the sponge will turn brown, and then *black*. Let it remain there a few hours, and then wash it in distilled water, and place it in dilute spirits of wine (say half water). In a few hours place it in stronger spirit, and after a longer period, say next day, place it in absolute alcohol.

In a water bath—that is, any small jam pot, that can be stood in a small saucepan, glue-pot fashion—dissolve, say, an ounce of paraffin-wax (not letting the saucepan contain water to boil over into the wax). Now remove the sponge from the absolute alcohol, just drain it, but not to dryness, and place it in a little pot in *oil of cloves*, pressing it gently down beneath the surface. When it has been there a while, say an hour, take it out, and transfer it to the melted wax. The wax must be taken off the fire before this, and should be on the way to cooling, the top beginning to bear traces of solidification. Keep it at this same *gentle* heat, just *near* the stove, for some time, say an hour or two. (It may now be left to go cold, if desired, and warmed up another time.)

While this is going on prepare some glass slips as follows:—Clean them well, and by means of a glass rod gently smear one side (not the *ends*) with *white of egg*; by pressing the rod steadily across the slip a very thin and even layer of albumen is thus put on. It is well to prepare a number of slips at one time, placing them, supported by their ends, prepared side *downwards*, for fear of dust, until they are dry. It is well to mark with ink, on one corner, which is the prepared side, for it is not *visible*. (The spare slides can be stored for use later.)

Now screw the microtome steadily to the table, turn down the regulating screw an inch or so, and fill the well with melted wax. As the wax cools from the sides there will be a little hollow in the centre. Into this put the little sponge, vertically, holding it in place while the wax cools by means of the forceps; let all cool to solidity.

Now raise the regulating screw until a quarter of an inch or so of the column of wax is exposed, and with a penknife cut away a good bit of the wax from around the sponge, only allowing a little ring to remain around it (this is to avoid having to slice a lot of wax to no purpose); then turn back the screw, and press the column back to where it was.

See that your razor is very sharp. Elevate the object and cut off the top; throw away this bit, and gradually raise the object, slicing off a little at a time until the whole of the contour of the sponge is seen, like a neat little pattern in the cone of white wax.

Now great care is required. Raise the screw a very little, holding the razor in the right hand, and pressing the end of the blade tight down to the brass plate. Cut smartly, *from you*. A thin section will either remain on the blade or curl off in front of it. These sections which should look like little bits of the thinnest tissue paper, mere *cob-web* thickness, should be put on a sheet of white paper. Now have a bowl full of fairly warm, not " hot," water, and with the fine forceps throw a section into the water. If the section was *curled* it will straighten out and the wax will just soften and float, section and all, like a little film, on the water.

Take a slide, albumen upwards, and insert it under the section. Coax the latter to the exact centre of the slide by means of a mounting needle; raise it gently from the water, and drain carefully. Wipe off all the water you can with a cambric handkerchief, free from fluff, and let the slide dry. When dry, or nearly so, hold the slide at some distance over the spirit lamp, section upwards, until the wax just melts. Now drop on with the dipping tube a few drops of turpentine, shake them off, and repeat (or you can soak in benzoline); the wax will be washed away and the sponge section will stick fast to the glass.

With a glass rod put on a drop of *oil of cloves*, remove the surplus, either with the corner of a cambric handkerchief or a bit of blotting-paper, but beware of fluff.

Now with a glass rod put a small drop of *balsam and benzole* on top of the section; take a thin cover circle with the forceps (see that it is clean), warm the cover in the spirit lamp flame, and place it gently over the section, not *flat* at once, but letting one edge touch first and then let it tilt over gently—like the cover of a book. This avoids the formation of air bubbles under the cover, which spoil the slide. Now put on a spring *clip* and put the slide to dry.

This seems a lot of trouble, but in practice it is *not so.* It all comes in readily and easily. Then I am writing as if for preparing *one* slide. I need scarcely explain that a considerable number can be done at once, and the end fully justifies the labour. The slide just described should show the full structure of the sponge—the canals, the amœboid, and the collared and flagellated cells, in fact, all its *histology.* The *Spicules*, of course, are not well distinguishable in such a fine section. Coarser ones are made for spicules, etc. I have given the following details as regards a *sponge* section, but it applies, exactly the same, to all soft tissues.

If instead of osmic acid another fixative has been used, say *corrosive sublimate,* or Bouin's Fluid, the section will be white, and will require staining to bring out its details.

In this case, when you have arrived at the stage in which the wax has been washed away by turpentine, treat the section to absolute alcohol by means of a dipping tube, repeating this two or three times (shaking off the alcohol each time). This will remove the turpentine. Now put on a drop of stain, let it rest until the section is well permeated (two or three minutes), wash off the loose stain with a little distilled water, then drop on some strong spirit; follow this by absolute alcohol, drain off, and put on a drop of oil of cloves. You will easily see when the section is clear: it will become glassy-looking, uniformly all over. If any opaque spots show, and refuse to clear, it has not had enough absolute alcohol, so repeat this, and *then* oil of cloves; drain off, or rather remove the surplus oil, as already directed, put on the Canada balsam, cover, and clip.

As the slides are finished, so far, place them side by side, with their clips on, in a warm place, to harden. They harden most quickly near a stove, but must not get *hot*, or the balsam will boil up, the object frizzle, and all your labour be lost.

In a few days, when the exuded balsam is hard and brittle, scrape it off right up to the edge of the cover—an old knife made hot in the spirit lamp flame takes the balsam off quickly. When scraped fairly clean dip a rag in methylated spirit and finish cleaning off. Methylated spirit is not a solvent of balsam, but it breaks it up, and allows ready cleaning. If a true *solvent* is used, such as turpentine, benzole, etc., it will join the balsam under the cover, and spoil the slide.

A slide left in this way, and neatly labelled, is really finished, as far as utility is concerned, but if it is desired to work a " ring " around the cover place it on the turn table, the edge of the cover exactly coinciding with one of the circles engraved on the brass of the turn table. Revolve the table a little, to see if the cover is really central and not excentric. Adjust it with precision. Then dip a No. 1. *sable* brush (camel-hair brushes are no good) into the shellac cement, and, resting the hand holding the brush firmly on the block of the turn table, revolve the disc steadily with the other. Hold the brush *vertical*, and just allow the point to touch; the result will be a neat little circle of cement, which should just lap a trifle over the edge of the cover and extend a little bit on to the slip.

Place the slides away to harden for a day or two; then replace on the turn table and give a ring of black asphaltum. This is neat and durable. Scarlet, blue, white, and gold rings are sometimes spun around the cover, but, to me at least, this fancy work seems not to enhance the value of the slide, but to detract from it.

(Do not use the asphaltum without the ring of shellac underlying it, or it will run in under the cover, its solvent being the same as for balsam.)

Embedding in Celloidin.—This presents many advantages when a considerable number of sections of one thing are required, but it does not allow of such thin section cutting as does the wax process. Still, with a small object, the sections may be cut to the five-hundredth of an inch.

Dissolve chips of celloidin in equal parts of absolute alcohol and ether to the consistency of ordinary syrup. A stock of this can be made, and kept in a well-stoppered bottle.

(Ordinary *collodion*, as sold at the druggist's, will do instead of this ; but it must not be the " Elastic Collodion," which contains an oil.)

The object to be embedded is best stained " *en bloc*." This saves a lot of work, only it must be remembered that some things are not readily permeable to the stain ; but the majority of things can be so stained. For staining, cut the object to the size that the area of the sections are to be, and give it a prolonged soaking in weak stain. It must have the appearance of being much too dark, as the colour is deceptive when seen in the lump.

The object, being properly stained and washed, must be placed for a while in medium strength spirit, then in stronger, then in absolute alcohol until " dehydrated." It must now have a few hours in equal parts of alcohol and ether, after which it is put in the celloidin mixture, in a wide-mouthed, stoppered bottle. Here it may remain, no matter how long, but must have, at least, time for the celloidin to penetrate it all through. This depends upon the nature of the object and its size, but as a rule two or three days will do. It must then be transferred to a *stiffer* celloidin solution, or the stopper of the bottle may be left out until the solution is very viscid and " stringy " when the object is lifted. Now take out the object, and drain it of the excess of celloidin, just allowing a film to adhere to its surface. Now place it in methylated spirit, or still better, in chloroform, and the celloidin will harden, and become transparent. In a day or two it will be firm, and object and all will feel like a bit of cartilage. (It can remain in methylated spirit indefinitely.)

To fix it in the microtome surround it with some melted paraffin-wax. As the wax cools in the well it will very likely leave a little space around the sides, and perhaps around the object, due to uneven shrinkage of the two things. The wax must be only at melting point, or the object will griddle up. If there is a little space, as I have said, warm a wire, and stick it in here and there until everything is firm. Small objects are best cemented to a bit of wood for a support, cementing with stiff celloidin, and then hardening in chloroform.

Now proceed to cut, as previously directed, only the razor must be used so as to *draw* cut. Cut slowly, yet unhesitatingly.

If the section is thick at one side and thin at the other, or if the razor passes over once or twice without taking off a section and then takes a *thick* one, the embedding is faulty: there is something "springy," or else you have altered the angle at which the razor was held. Rectify this.

There will be many failures at first, but success will come. As the sections are cut they can be put into methylated spirit, and either left for another day or mounted at once.

To mount them they must first be cleared. Put them in strongest methylated spirit a little while (*not* in *absolute alcohol*, as this dissolves celloidin); then transfer them to a little pot, with *oil of bergamot*. (*Oil of cloves* dissolves celloidin.)[1] They will clear very slowly, but they can be left in the clearing a long time without injury. When they

[1] A splendid clearing fluid, which does not dissolve celloidin, and which clears any object direct from ordinary methylated spirit, can be prepared thus:—Dissolve one ounce of carbolic crystals (absolute phenol) in a mixture of equal parts of the oils of cedar and bergamot, employing gentle heat to hasten the solution. The same quantity, in a little pot, can be used several times over.

are bright and transparent they can be lifted out with the forceps, laid nice and flat on the centre of the slip, the superfluous oil drained off, and Canada balsam applied. Cover and finish as before directed. The celloidin, although it shows like a little leaf of gelatine around the section, and between the parts of the object, where it holds them together, will be invisible when the slide is finished.

Beautiful sections of the sponges, to show spicules, etc.; also sections of such things as the compound ascidians; the columns of anemones, to show the radiating mesenteries, etc.—in fact, anything where the minute, histological details, for high powers, are not needed—can be mounted.

It will occur to the reader "What about the dense masses of flint spicules in the sponges?" These do not trouble a bit: the razor passes freely through all, and only gets blunted a little, but the oil-stone must be kept at hand to touch up the edge pretty frequently.

Mounting Zoophytes and Polyzoa with Tentacles extended.—Methods for killing these in a state of extension have been given in the chapter on preserving museum specimens. This is the plan to be followed, *only* that, after they are anæsthetised, they should be *fixed.*

A few drops of osmic acid, or a strong solution of corrosive sublimate should be added to the water in which they are; or they can be placed for a while in some Bouin's fluid (see page 319). Then wash them in fresh water; place them in rather dilute stain; wash again in water, and pass through grades of spirit up to absolute alcohol.

Then select the desired branches, and place them to clear in a little pot, with oil of cloves. (Never allow these, or, in fact, any other thing, to *dry* between the changes of media.)

They should be mounted in a "sunk-cell slip," without being pressed or distorted. Fill the sunk cell well with balsam and benzole, in fact, *overfill* it, or you will get an air bubble. When the cover is in place put *two* clips on, one at each edge. If the clip bears on the centre of the cover it will press it in, then when it is removed the cover will reassert its level, and draw a bubble of air in under. Entire objects of any kind—larval stages of crustaceans, young fishes, little annelids, etc.—are mounted in the same way, in sunk-cell slips. See that you have good, colourless balsam for this, or it will show yellow in the deep part of the cell, and look bad.

Mounting Objects dry.—In dry mounting the first thing that suggests itself is what we mentioned, and saw how to collect, in the first chapter—viz. the *Foraminifera*. These may be mounted *mixed*, as collected, or singled out and duly labelled as types, which is *the* scientific plan. To pick them out easily proceed thus.

Have a piece of card, about four inches by two. Over this stretch tightly a piece of black, corded silk (*Gros de Naples*), and gum the edges underneath. On this bit of silk-covered card put a pinch of the cleaned shells; shake it a little, and tilt it over sideways into a sheet of paper.

Shells will remain in straight rows between the cords of the silk, and the card and its burden can be placed on the stage of the microscope, and "read off" without the chance of missing one shell or the bother of twice going over the same ones.

Have a piece of black paper, lightly smeared with *gum arabic* (very thin) and let dry, at hand. Now, while the left hand moves the card about, in the right one hold a *bristle* fastened to a little handle; touch your *forehead* with the bristle, then the desired foram. It will hold lightly to the bristle, and can be lifted. Now breathe on the gummed paper, and place the foram on it; it will stick. Thus they can be sorted out—for instance, the *Lagenidæ* together, and so forth. In fact, this is a good way of mounting slides right off.

I have some by me that were prepared thus. A large card (about a foot by eight inches) was covered with black paper. On this cross bands of *white* paper were pasted, so as to divide it into squares (36). In the corner of each square was neatly written, in white, a *number*. Then this was *photographed* down to the required size (one inch long), and a paper print made. This was mounted on a card, lightly gummed, and three shells of each species put on each square, to show the opposite sides and edge of each (or bottom, as the case might be). Another card, with the centre cut out to the size of the mount, was then gummed on, while a very thin, three-inch by one-inch slip formed the cover.

If the reader is inclined to go to this trouble he will do well to use a photo-mechanical plate and a vigorous developer, so as to get good black and white. Note must also be taken to write the figures "reversedly," for the microscope reverses the image.

For *ordinary* dry mounting a slip must be put on the turn table, a ring of brown cement spun upon it, and a metal ring of suitable size stuck on. The inside of the cell thus formed must be painted with the "matt black," and, when dry, just lightly gummed, so that the shells will adhere when it is breathed upon. All being satisfactorily in place, a narrow line of brown cement is made on top of the metal ring, and allowed to set. A cover, just a shade smaller than the metal ring, is then made hot, and put on; it will stick fast, and the cement will not run on the under side of the cover, as it would do if put on while the cement was liquid.

A ring of brown cement is now spun around, covering that part of the cover which lies on the metal, for the sake of neatness, and well filling the angle made by the metal ring and the slip. Finish with black.

To mount Foram Shells in Balsam.—This is usually done with mixed gatherings. The photo-micrograph (Fig. 2), is made from such a slide.

To obtain good results lightly gum the glass slip and let it dry, put on a pinch of shells, breathe upon them, then tip off the loose ones and remove any bits of foreign matter or bits of broken shells. Place slip and all in a wide-mouthed bottle, in benzoline, and leave them for some days, giving a little shake occasionally, until all the air in the shells is expelled ; then lift out the slide, put on a drop of balsam and benzole, cover, and *clip*. Finish in the ordinary way.

A more rapid but less certain way is to put the balsam and benzole on the shells without a preliminary soaking ; put on cover and clip, and then hold the slide (cover upwards) over the flame of the spirit lamp until the balsam boils. There will be a great commotion of bubbles beneath the cover as the air rushes out from the shells and the balsam fills them, but as a rule all bubbles disappear, and the slide is ready to clean and finish.

Preparing Spicules of Sponges.—To obtain the spicules free from organic matter for mounting, either dry or in balsam, the soft parts are destroyed by boiling the sponge in caustic potash or, if a *Siliceous* sponge, in nitric acid.

If it is *Calcareous* spiculed place it in a test tube with water and a bit of caustic potash (about the size of a French bean) ; boil over the spirit lamp until no lumps of sponge remain ; let the deposit settle ; pour off the liquid, and fill with clean water. Repeat this wash two or three times, and the spicules will remain at the bottom, quite clean. They can then be placed in a tube until wanted, either in water or in dilute spirit.

The *Silicispongia* are best managed by means of nitric acid. This requires a little care. Place the piece of sponge in the test tube, and just rather more than cover it with strong nitric acid. Warm it over the spirit lamp until ebullition begins; then stand the test tube in a cup or small jar, with a saucer underneath; there will be violent action, and the nitric acid will boil over the top of the tube (that it why it must be stood in cup and saucer).

The bit of sponge may run to the top of the tube with the froth; push it down with a glass rod. As soon as the sponge is dissolved fill up with clean water (save what has overflowed, and put all into the tube), and allow the spicules to settle. Wash thus two or three times. If any little bits of sponge, now of a yellow colour remain, boil once more in nitric acid, and wash.

There will be a surprising mass of the beautiful spicules, as a snow-white deposit, at the bottom of the tube. Some should be mounted dry, on black background, others in balsam. These present no difficulty.

To prepare the Odontophores of Mollusca.—The *Gastropod* molluscs, the *Cephalopoda*, *Scaphopoda*, and the *Pteropoda* all possess a toothed ribbon, which is variously described as the "*Odontophore*," "*Radula*," "*Lingual Ribbon*," and "*Palate*." This is a narrow, chitinous strip of membrane, closely set with fine-pointed, flinty teeth in regular pattern.

These *Odontophores* are not only interesting objects of study, but they are among the most beautiful objects upon which the microscope has ever been brought to bear. Their use has been alluded to in writing of the molluscs which bore holes through the shells of the oyster, limpet, etc. The non-boring molluscs employ them as rasps for mowing down fine vegetation, and for breaking up food generally.

These are easily prepared for the microscope, no skill in dissection being necessary. All that need be done is to cut off the anterior part of the mollusc, and place this in its entirety in a bottle, with a fairly strong solution of caustic potash. (An ordinary stick of this, as sold at the druggist's, to about half-a-pint of water.) In a short time the mass will swell up, gelatinise, and finally dissolve, leaving the *Odontophore* free. The liquid must be poured off, and replaced by several changes of water. The *Odontophore* can then be laid on a glass slip and straightened out. It will be noticed that it is somewhat folded inwards from the sides, and invested with a very thin transparent membrane. This membrane must be removed with needle and fine forceps. The object can then be mounted, either in balsam or dry. Every species has its characteristic form of teeth, and a skilled zoologist can at once tell to what particular mollusc any one belongs. In some species—*e.g. Haliotis*—it is a large and conspicuous object, an inch and a half long by a quarter of an inch wide; in the common winkle it is a mere thread, and in the great octopus it is not larger than in the whelk.

There is no need to wait for a visit to the shore to begin work on these. The "whelk" of the street vendor, and the snails and slugs of the garden, furnish beautiful examples.

Preparing Sections of Shells.—There is an interesting study in the structure of shell. The different layers—viz. the outer, median, and inner *pearly* layers—have all their special arrangement in the crystals of carbonate of lime.

To prepare them, with a small saw cut off as thin a slice of the shell as possible; then, on a sheet of ground glass, with emery powder and water, grind one surface quite flat—begin with medium grain powder, and finish up with the finest "flour emery." Wash the bit of shell well with water. On a bit of thick glass put a drop of Canada balsam (or your balsam and benzole), and hold it over the flame of the spirit lamp until it boils; then press the smooth surface of the bit of shell well into it, in close contact with the glass. It will be set fast in a couple of minutes. Now, by holding the glass between finger and thumb, grind away the shell on the emery as before, until only the merest film remains. In finishing off with the flour emery wash frequently, and examine, so as not to rub away the slice altogether, but it must be brought to transparency, not thicker than tissue paper.

Now place the bit of glass and its adherent section in a saucer with turpentine. The balsam will dissolve, and the section will be free. Wash it well in turpentine, and see that no emery grains are on it. Then transfer to the centre of a glass slip ; put on a drop of balsam and benzole ; cover, clip, and finish as in previous work.

A section of the great *Pinna* shell is a good type for illustration of shell structure.

This method of grinding down and mounting applies to all hard substances—bones, teeth, and *stones*. (A flat iron plate is used for the last instead of ground glass.)

Mounting entire Objects in Balsam, etc.—We have now gone over what is usually considered the difficult portion of microscopic manipulation. The mounting of objects in their entirety is a simple matter. The proceeds of the *tow net* (page 299) furnishes abundant material—the young of fishes, crustaceans, the little pelagic annelids, etc.

These objects for balsam mounts usually require staining. This is done by giving them a rather prolonged immersion in a *dilute* stain. If a strong one is used the outside parts will be too deeply stained while the internal structure, which it is desired to show, is not stained at all. In all cases it is well to remove some of the superficial stain. This is done by placing the objects in dilute spirit, to which a *trace*—the very slightest perceptible—of nitric acid has been added. (For *Calcareous* objects this must, however, not be employed.) Watch the progress of decoloration, and check it at the desired point, by rapidly transferring the objects to pure spirit. Transfer to absolute alcohol, and let them dehydrate *thoroughly* ; clear well in oil of cloves, and mount, without pressure, in a sunk cell of such depth that the cover glass does not bear on the object. If the object is pressed by the cover, not only will you have no end of trouble, but the parts will be distorted.

Whole objects may be mounted with very good results in glycerine jelly. These do not show fairly as transparent mounts, but give splendid and lifelike results for illumination by the spot lens or paraboloid, which accessory to the microscope shows the object brilliantly illuminated on a background of black.

Mounting in this way is simple. Place the objects for a little while (either from water, or from the spirit in which they were preserved) in somewhat dilute *glycerine.* Place the bottle of glycerine jelly in a pot of hot water until the contents are quite fluid; warm the sunk-cell slip, and with a glass rod fill the cavity. Place the object symmetrically in place, warm a cover glass, press it down in the usual way, and put clips to the cover edges. In a few hours the jelly will be set. Wash off the exuded portion with *cold* water and a little brush—a soft *tooth-brush* is excellent. Place on the turn table, and give a *good strong ring* of the brown cement, or of japanner's gold size, or of any substance that runs well and is not soluble in water. Finish in black.

This is not a *complete* exposition of microscopic technique, but it embodies every point that is required for the marine zoologist.

There may be various exigencies now and again to be met, but none that ordinary intelligence will not be able to cope with.

One little point, however, that still requires mention, or a difficulty may present itself.

When an entire object, say a young shrimp, is taken from the absolute alcohol and placed in the oil of cloves to clear it will *float*, and the alcohol, evaporating at a greater rate than the clove oil penetrates, may admit air into its interstices, and spoil it entirely. To obviate this, either place a little weight, say a cover glass, on the object to keep it submerged or, what is better, carefully pour a layer of absolute alcohol on the surface of the oil. The object will slowly sink into the denser medium, after which the alcohol can be decanted, or, if there has been mixture, the object can be placed in new oil of cloves.

If, in "clearing," an object of any kind retains an opaque spot, which does not disappear, even in half-an-hour's soaking in the oil, dehydration has not been complete. Put the object back into the absolute alcohol, and go over the process afresh.

All slides should be neatly labelled, with as plain a gummed label as procurable. Some labels have heavy ornamental borders. These are not suitable for a scientific collection.

Slides should be stored in trays in which they lie *flat* ; racked boxes, in which the slides are on edge, are not good : very often, in a *cell* mount, the object will gravitate to the side.

CHAPTER XVII

ARRANGING A MUSEUM COLLECTION

The methods of displaying, attaching to mica or glass, etc. I have already given (chapter on "Preserving"). There only remains to say that after the spirit or formalin solution requires no further changing, but remains *bright*, the glass disc on the top of the jar must be securely "luted" down, proof against evaporation, with either gold size or gold size and red lead, or, what I find better, the mixture of india-rubber in melted wax, as described previously, then the margins cleaned off and finished with black enamel.

Dried specimens — *Crustaceans*, *Echinoderms*, *Shells* — should be fastened to suitable mounts. Very excellent ones, which are made of thin wood, cut with precision, and covered with neutral-tinted paper, are to be had at the natural history stores.

All these dry specimens should be kept in drawers, away from the light, or they will bleach to some extent, and while this does not interfere with the specimens, from the purely scientific point, it detracts greatly from their appearance.

A system of classification must be decided upon, the most recent preferably, and the specimens arranged accordingly, blank spaces being left where, if a specimen is not on hand, yet there is possibility of obtaining, it may be put.

The jars with *fluid* should not be filled quite to the top, but a little cushion of air left for compression, etc., as temperature may vary, otherwise an "air leak" will occur.

Moths and mites are not so likely to attack a collection of this kind as one of birds or insects; but still, they *may* put in an appearance, the corrosive sublimate employed in preparing the specimens notwithstanding, so it is well to have in the corner of each drawer or box a little card box, with a perforated lid, containing some camphor or napthaline—the latter is the best, as it does not so rapidly evaporate—and a review of the specimens must be held from time to time.

CHAPTER XVIII

THE MARINE AQUARIUM

To the lover of marine zoology a little aquarium at home has always been a desideratum, but has usually been considered to present insurmountable difficulties.

Unlike the fresh-water one, which thrives best when most neglected, it appears to require constant attention and change of water.

It goes wrong from the first, and becomes a malodorous failure at the last.

The gorgeous anemones retract their tentacles, loose their hold upon the rock, and roll about. The surface becomes covered with a scum of colonies of putrefactive bacteria, and the gay little fishes float, *in extremis*, wrong side up.

I think this is about the experience of the majority of aspirants to the possession of a small aquarium. And yet some succeed in maintaining one with little trouble. What, then, is the secret of success?

I write this for those who are living far from the sea, where sea-water has to be purchased, and is not at all times obtainable.

Firstly, the choice of a vessel. This should be of such form as to present a surface of water to the air considerably greater than the depth. A fish that will live for months in a pint of water in a pie-dish will not live six hours in a pint of water in a jug.

The bell-shaped glasses obtainable at all the glass and china shops are the best to employ for a small aquarium. The more "squat" and wide the shape the better.

In the bottom of this there should be a few inches deep of well-washed shingle, and the vessel should be only about three-fourths filled with water.

The aquarium should be placed in a cool situation, in a good light, yet away from the direct rays of the sun.

Of sea-water there should be obtained a *reserve* supply to meet emergencies. This can be corked up in a large stone jar, in a cool place.

For a self-supporting one—that is, where there is no means of obtaining circulation of water—there must be a considerable preponderance of plant over animal life, and the weeds should be of the green kinds—*Chlorosperms*. (The "Sea Lettuce" (*Ulva*); the narrow *Cladophora rupestris*, and the lovely *Bryopis plumosa* are excellent.) If they can be brought from the shore attached to small stones so much the better, but the stones to which they adhere must be well cleansed at the sea-side before being brought home, for there will usually be adhering to them a large number of organic things, that will soon decompose and spoil the intended results.

Now, what *animals* can we keep to the best advantage? The anemones, universal favourites, first commend themselves, but they do not *all* thrive under aquarium conditions. The great "Dahlia Wartlet" (*Tealia crassicornis*), which is shown in Fig. 14, lives splendidly, and feeds and thrives to perfection; so do the following:—the "Gem Anemone" (*Bunodes gemmacca*); the "Beadlet" (*Actinia mesembryanthemum*); and all the *Sagartias*, including the parasitic *Sagartia* or *Adamsia parasitica*, which will thrive as well on a rock as on its usual tenanted shell. The great "Plumose Anemone" (*Dianthus plumosa*) is exceedingly beautiful, and lives well, but it requires great attention. It will not take large morsels of food, and as any rejected portions are not readily seen they may decompose and contaminate the water.

We are sometimes instructed to keep a few crabs or prawns with the anemones, to act as scavengers. The idea is good, but, sooner or later, these come in touch with a tentacle, and come to grief. I would rather recommend keeping the anemones by themselves, and have several small aquariums rather than a large one.

The anemones can be fed upon almost anything in the fish or " shell-fish " line—whelks, winkles, bits of fish from the shops—always taking care to remove, by means of a pair of wooden forceps, any rejected pieces.

A slight bamboo rod, split for half its length and bound with twine at the termination of the cleft, makes a good instrument for removing things from the bottom.

If things are going wrong the first intimation will be that the anemones retract their tentacles, protrude their œsophagus, and loose their hold on the rock, swelling up meanwhile, like little balloons. This does not mean that they are dead, but this is a provision of nature. These animals, having little locomotive power, thus render themselves transportable by sea-currents when, from any cause, the hygienic conditions of their old home renders it unsuitable. If this happens do not throw away anything. Wash the anemones and the rocks and weeds in some of the reserve stock of sea-water, and the glass and shingle under the tap ; replace all, and fill with the reserve water.

The contaminated water, as well as that which has been used for washing the anemones, etc., is as good as new if it is treated thus. With a large enamelled funnel from the hardware shop, and a grey filter paper from the drug-stores, filter the water into an open vessel, exposing it well to the air, whisking it up now and again to oxygenate it. It can then in turn become the " reserve."

Loss by evaporation, causing the salinity of the water to become too great, is to be made up with clean tap water. To ascertain whether the salinity is correct there are little glass balls, sold at the dealers in aquaria, which can be left always in the aquarium. They are so weighted that when all is correct one floats and the other sinks. If the salinity is too great both float, and if you are adding too much tap water both will sink. This is very ingenious, but a simpler plan is to have a salometer. Note upon the scale to what level it submerged in the original stock of sea-water and be guided by this. The too great *reduction* of density can only occur through carelessness in adding from the tap.

By this simple plan I once kept a lobster for nearly three years in a flat, bell-shaped, cake-covering glass obtained from a confectioner's. As weeds grew to too great an extent I weeded them out, and in this simple tank I watched the shell-casting, and noted rate of growth of my little lobster, as well as could be done in a scientifically appointed laboratory.

In regard to the anemones; strangely enough, a species that occurs in every rock pool, even up to high-water level, that at times gets half boiled in the sun and at others deluged with rain water, and in nature thrives amazingly, will not do at all well in the aquarium. This is the "Opelet" (*Anthea cereus*), of Gosse.

Other animals that live well are, firstly, the prawns—the whole of these, including the beautifully coloured little *Hippolytes* (see page 134). These are active, graceful, and highly interesting little creatures, but it will not do to try and keep them with anemones.

Of fishes, the fifteen-spined stickle back (page 262) lives well; so do the pipe-fishes, the blennies, and the gobies. The wrasses also live well, and are exceedingly beautiful. Little grey mullets also live well.

Fishes of the herring tribe—sprats, whitebait, etc.—will *not* live, nor will the sand-eels.

Of molluscs, the *Trochi* and the *Littorinas* live well, not so the *Limpet*—another puzzle, for this one would imagine the hardiest of all, but as a rule a week or two is its lease of life in an aquarium.

It is a good plan to have a glass syringe, and with this draw up some of the water from the aquarium, and squirt it back with force from an inch or so above the surface, until the water sparkles. This, if done daily, will greatly enhance the chances of success.

If arrangements at home will admit of such plan, an aquarium through which the water circulates is the best of all. A reserve tank is placed at an elevation above the aquarium, and the water is allowed to flow through a glass tube drawn to a very fine point into the aquarium, preferably striking the surface from an inch or so distance, so as to aerate it, as I said just now could be done with a syringe.

There must be an overflow arrangement to the aquarium, the water falling into a vessel on the floor, from which it is to be transferred, as occasion requires, to the upper tank.

With either this circulating plan, or with attention to the few hints I have given in regard to a non-circulating one, there need be no difficulty whatever in keeping at home, and under daily observation, some of the most beautiful denizens of our rock pools.

The beautiful plumed worms figured on page 85 can be kept with the minimum of attention, and so can most of the beautiful zoophytes, and many of the polyzoa.

If there is plenty of vegetable growth in the aquarium there will be multiplication of microscopic animals sufficient for their food.

After the many elaborate plans that have been from time to time published on the marine aquarium I am afraid that my simple system will be criticised, but all I can say is that I have had over four decades of experience in the matter, and this system has answered with me, and with many friends to whom I have recommended it.

If there is a green growth on the glass—as there will be, especially on the side towards the light—do not remove this: it is a good thing, as will easily be seen when the light is full on it. Little bells of freed oxygen will be seen forming all over this confervoid growth, which now and again break away and rise to the surface; these are supplying the life-giving element, the dearth of which is the cause of all breakdown.

In regard to feeding, it is surprising how little food is required by most of these animals. The great *Dahlia* anemone is the most voracious of all, and a whelk per week will be ample supply for it, and a week *without* food, although it may cause it to look smaller, will do it no harm.

For fishes, prawns, etc., little bits of any fresh fish, shredded fine, will be all that is needed, except for the wrasses—if these are kept. *These* fish do not care for an approach to cannibalism. In nature their food consists chiefly of crabs and worms. I have seen very hungry wrasses in the aquarium decline sand-eels—the choicest menu that could be offered to the majority of sea fishes. Bits of whelk or bits of crab or lobster would be best for these.

Hatching and Rearing.—For the young student who may be desirous of going a little deeper into the subject of marine zoology, and would like to note for himself the processes of development, the simple aquarium tank will not answer, but some plan which causes currents of water or movement of the eggs will be required.

If a female lobster carrying maturing eggs is watched in an aquarium, it will be seen that the "swimmarets" to which the eggs are attached maintain an incessant movement, and that every now and again the impending mother pays attention to these egg clusters, the claw of the last leg, now on one side then on the other, being called into requisition to comb out and separate any too crowded mass, so as to allow full contact with the ever-renewing water surface.

In fishery stations, where fish ova are hatched on a large scale for restocking depleted districts, this movement is imitated by machinery—false bottoms to the shallow hatching tanks being made to rise and fall with slow and regular action.

In scientific laboratories, where it is required to hatch and rear a few forms at a time, this is accomplished by means of "plunger jars"—vessels in which a pistonlike arrangement is moved by clockwork, so as to slowly rise and fall through the water in the vessels—thus maintaining constant currents.

A simple plan which answers well is as follows:—Suppose it is desired to hatch some eggs of lobster—these can often be found on the parent in the fish markets. As the eggs are maturing they show black patches—the large black eyes of the little lobsters that are to be. It is best to secure them at this stage.

Within a vessel of sea-water place an upright, glass jar, well submerged above its rim. At a little distance from the bottom of this jar, say half-an-inch, have a false bottom of perforated zinc, and from a reserve tank at a height of a few feet above the vessel have a rubber tube terminating in a pointed glass nozzle. Let this glass nozzle be passed through the perforated zinc false bottom to the bottom of the jar.

The eggs are now placed, an inch thick, or less, on the perforated zinc, and the current from above allowed to run through. The eggs will be gently moved, forced up, and allowed to settle, with a gentle and regular movement.

These are the conditions necessary (given fair temperature, say about sixty degrees Fahr.). As the young lobsters hatch and gain sufficient strength (usually ten or twelve hours after hatching) they will swim over the top of the jar into the larger vessel, whence they can be fished out and examined from time to time. The same plan can be employed to advantage with eggs of any other marine animal.

There will be a heavy mortality, but this must not discourage the student. The same takes place, perhaps to quite as great an extent, in nature, and he will find abundant material for observation and study.

Another plan, and one by means of which I have reared, or I had better say "raised," many unusual larval forms, is by means of a series of dishes arranged on a gradient, so that the flow from the reserve tank passed from one dish to the other through glass tubes let through their ends, the overflow of one dish supplying the next, and the *final* overflow, into a large pan, being once a day transferred to the upper tank.

The inner ends of the glass tubes that carried overflow were covered with muslin, to prevent the young animals from being carried out.

The larval stages of nearly all marine animals—crabs, prawns, fishes, molluscs, etc.—and the alternate or medusid generation of the zoophytes, can be studied in this way, and interesting and instructive recreation be thus obtained.

And now my task is done. I had promised "an outline," and I have given one—a very bare one, I am aware. Still, I have pointed out the chief lines of a pursuit which has yielded me pleasure for many years, and this pleasure is enhanced by the thought that perhaps by means of this little book I may be able to pass it on.

LIST OF A FEW BOOKS USEFUL TO THE BEGINNER

GENERAL.—A good text-book of zoology, say *Claus-Sedgwick's.*

FORAMINIFERA.—"Recent British Foraminifera." By Dr Williamson. Ray Society. (It is from this splendid work that the types shown in Fig. 1 have been selected.)

PORIFERA.—Bowerbank's "British Sponges."

HYDROZOA.—Hincks' "British Hydroid Zoophytes."

ECHINODERMS.—Forbes' "British Star-fishes."

VERMES.—Johnson's "Catalogue of Worms in the British Museum." Quatrepage's "Annelés."

POLYZOA.—Hincks' "British Polyzoa."

CRUSTACEA.—Bell's "British Stalk-eyed Crustacea"; Spence Bate and Westwood's "British Sessile-eyed Crustacea."

SARS' "Crustacea of Norway" (5 vols.).

MOLLUSCA.—Sowerby, or any of the numerous works on conchology, etc.

ASCIDIANS.—Giard's "Ascidies Composées."

FISHES.—These are numerous. Dr Günther's "British Fishes" is recent and good.

JOURNALS, ETC.

The Journal of the British Marine Biological Association.

Proceedings of the various microscopical societies, etc.

Rev. A. M. Norman's articles in annals and magazines of Natural History.

The various articles in "The Encyclopædia Britannica."

Publications of the Ray Society.

The list of the various scientific books publishers should also be consulted.

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