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Some Cases of New Growths in Fish.

By

G. Harold Drew,
Beit Memorial Research Fellow.

With Plate IV.

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A FIBRO-SARCOMA OF RAIA MACRORHYNCHUS.

This specimen, obtained from one of the Plymouth trawlers, consisted of a large tumour on the dorsal surface, near the left angle of the fin (see Figs. 1 and 2). Only part of the fish was available for examination, so the presence of metastases and other details could not be determined.

The tumour was roughly circular, measuring about 4 inches in diameter, and was elevated above the skin about 1¼ inches. It consisted of a broad central pedicle, hard and fibrous and white in colour, surrounded by a broad cauliflower-like mass of a greyish colour, and of much softer consistency than the central mass. This peripheral part of the tumour was covered by a very thin layer of epithelium which lined the outside of the pedicle and was continuous with the epidermis; it extended into all the folds and hollows of the outer papilliform portion of the tumour, but was absent over the flat upper extremity of the pedicle.

An incision made along a diameter of the growth, and carried down into the tissues of the fish, revealed the fact that the tumour arose from the fibrous perichondrium of one of the fin rays. The central mass consisted of closely packed strands of white fibrous tissue of pearly whiteness, running at first in a direction perpendicular to the skin, and then branching out into the surrounding ring of softer tissue.

Sections of the pedicle showed that it consisted of strands of typical white fibrous tissue; these were closely packed, but a few small round cells, having a somewhat indefinite nucleus, and little or no cytoplasm, were present between the fibres, and occasionally the elongated nuclei of the fibrous tissue cells were observable. Sections of the softer peripheral part of the tumour (Fig. 3) showed irregular loosely packed strands of fibrous tissue containing a few elongated nuclei, and large numbers of the small round cells, described above, often occurring in small aggregations between the strands and fibrils of the fibrous tissue stroma. No definite blood-vessels were present, and blood spaces were rare. Superficially this portion of the growth was entirely covered by a single layer of squamous epithelial cells continuous with the epidermis, but there was nothing in this covering corresponding to the other layers of the skin, and no denticles or mucous glands were present.

It would thus appear that the tumour had been originally a simple fibroma arising from the perichondrium of one of the fin rays, and that later this had taken on a sarcomatous type, and had proliferated freely. Considering the very poor blood supply to the peripheral part of the tumour, the fact that this portion should have become of a distinctly sarcomatous nature, its evident free proliferation, and the absence of necrosis, is remarkable.

AN ENDOTHELIOMA OF AN EEL (CONGER VULGARIS).

This tumour was found on an eel caught at Plymouth. The fish was an immature female, about four feet long, and appeared in good condition.

The growth consisted of a nearly spherical mass in the region of the basi-hyal; it was about 1 inch in diameter and protruded about 1¼ inches from the level of the skin. The tumour was of a whitish colour, but in parts was somewhat haemorrhagic; the surface was rough and irregular, with, in places, minute pits lined with thickened epidermis. The skin was not continuous over the surface of the growth, but gradually thinned away at its margin until the junction of skin and tumour became indistinguishable and inseparable. The outer portion of the growth was moderately soft, but it felt as though there was a hard central part which was continuous with the basi-hyal; the arrangement suggested a considerable outgrowth of thickening of the basi-hyal in an anterior direction, and that this outgrowth had penetrated through the skin and become closely adherent to it at the margin. An incision made along a diameter of the tumour showed a central bone-like core, apparently formed by an outgrowth of the basi-hyal, and small areas of highly vascular tissue interspersed among patches of white fibrous tissue, in some of which deposition of lime salts was taking place. Other areas appeared semicartilaginous and some seemed myxomatous.

Microscopic sections presented very varying pictures according to the particular part of the tumour from which they were taken. The central part of the mass, after decalcification, could be recognised as consisting of fibrous tissue in which a considerable deposition of lime salts had taken place; this mass surrounded and merged into the bony tissue of the basi-hyal, and was penetrated in all directions by narrow blood spaces. These spaces were filled with blood corpuscles and rounded cells with large nuclei and distinct nuceoli; the amount of surrounding cytoplasm varied considerably in different cells, but was seldom great. From the fact that these blood spaces were more plentiful in the outer part of the central mass and did not penetrate to the centre, it would seem probable that the hard fibrous tissue had first been formed and had undergone partial calcification, and that then it had been invaded by the formation of ingrowing capillary blood spaces. Other sections from the softer parts of the tumour showed areas of loose and compact fibrous tissue, and other areas undergoing myxomatous degeneration: blood corpuscles and the rounded cells described above were present in varying numbers in almost every part of the growth. The surface of the marginal part of the tumour was irregularly covered with the cutaneous epithelium which had a tendency to form ingrowths of compact masses of epithelial cells, but did not show signs of becoming epitheliomatous. The more highly cellular portions of the growth presented the appearance shown in Fig. 6. Masses of rounded epithelioid cells were present, and irregular channels containing blood corpuscles could be distinguished between the cell masses. The boundaries of these channels showed a more or less regular arrangement of the epithelioid cells, which in places had a tendency to become elongated in the direction of the long axis of the blood channel; many of these cells were also present among the corpuscles in the blood spaces. In addition to these spaces with very ill-defined boundaries, other blood channels with more definite walls, usually circular in section, and more resembling capillaries, were present. These channels were bounded by a very delicate sheath, but no endothelium within the sheath could be distinguished. Comparatively few mitoses were observed in any of the sections, so it is probable that the growth was not extending rapidly at the time of examination.

The tumour can obviously be diagnosed as an endothelioma, arising from the endothelium of the blood vessels, and it appears identical in structure, growth, and arrangement of the cells to similar endotheliomata occurring in man.

No metastases were present.

A FIBRO-SARCOMA OF A PLAICE (PLEURONECTES PLATESSA).

This tumour was found on a plaice caught at Plymouth, and was brought up to the Laboratory a few hours after death. The fish was a female, 12 inches long, and was in good condition.

The growth consisted of a white ovoid mass situated over the operculum on the ocular surface of the fish. It measured about ¾ inch by ½ inch along its longest and shortest axes respectively. It was soft to the touch and was covered with a very delicate epithelial layer containing a few pigment cells. Sections showed that the tumour was a fibro-sarcoma, similar to the fibromata and fibro-sarcomata that are relatively of such common occurrence on the opercula of plaice, but in this case the sarcomatous element prevailed to a much greater extent than usual. No metastases were present.

A TUMOUR OF A WHITING (GADUS MERLANGUS).

This tumour occurred in a male whiting, measuring 20 inches in length, caught at Plymouth. Its position and relative size are shown in Fig 4. It was soft in consistency, greyish in colour, but flecked with red from the presence of blood-vessels. The surface was bare and uncovered by the cutaneous epithelium. A median incision showed that the tumour arose from the fibrous tissue layer forming the dermis; there was no tendency to invade the subjacent muscles, and no metastases were present.

Sections (Fig. 5) showed that the growth consisted of a uniform reticulum of fine strands of some fibre-like substance, containing a number of small rounded cells with little or no cytoplasm, which were usually arranged along the fibres. These cells were seldom aggregated together into masses, and no mitoses were observed. A few more elongated nuclei resembling those of fibroblasts were seen, and irregular spaces filled with blood corpuscles were present.

At first sight the tumour somewhat resembled a fibrinous exudate of inflammatory origin, but a more careful examination and comparison of the small round cells with the normal leucocytes of the blood of the whiting showed that they had little in common, and the delicate reticulum of which the growth was chiefly composed in reality bears little resemblance to any exudate or tissue produced as an inflammatory reaction.

It seems probable that the tumour arose from a peculiar type of pathological multiplication of connective tissue cells, or fibroblasts, and so is perhaps related to the sarcomata, but until more extended observations can be made on other cases, this must remain as the merest surmise.

HAEMANGIOMATA OF A SPOTTED RAY (RAIA MACULATA) AND OF A GURNARD (TRIGLA LINEATA).

These tumours were accompanied by the presence of parasitic copepods; unfortunately in each case the body of the copepod had been broken off, leaving merely the haustoria imbedded in the growth, so that their species could not be determined.

In the case of the gurnard a small reddish soft tumour was present on the inner surface of the operculum; in the case of the ray, a similar tumour was present on the skin in the mid-ventral line of the body at the level of the fifth gill arch.

Sections showed a condition identical with the capillary Haemangiomata found in man. The tumours consisted of an irregular mass of dilated thin-walled capillaries filled with blood cells: the haustorial branches of the parasites could be easily recognised in the middle of each tumour.

In these cases it is impossible to say whether the tumours developed first, and then were attacked by the parasitic copepods, or whether they represent a peculiar type of reaction on the part of the host to the presence of the parasite. The former alternative would seem the more probable, since in by far the majority of cases of infection by parasitic copepods, little or no sign of an inflammatory reaction on the part of the host is present.

A PIGMENTED TUMOUR OF A MACKEREL (SCOMBER SCOMBER) OF INFLAMMATORY ORIGIN.

This fish, a male, 11 inches in length, caught at Plymouth, showed a large diffuse swelling on its side, situated about 3 inches from the tail. The surface of the skin was not broken, but was very darkly pigmented.

On cutting through the skin and deep into the subjacent muscular tissue, the cut surface appeared soft, haemorrhagic and degenerated, and was of a brownish colour; in places small black specks, due to the aggregation of pigment granules into masses, were visible to the naked eye. The swelling was not circumscribed, but passed imperceptibly into the surrounding normal muscular tissue: the vertebral column was not affected.

Sections of the diseased area presented an appearance superficially resembling a melanotic sarcoma, so much so that without some experience of the histology of inflammation and muscular degeneration in fish, it might very easily be diagnosed as such. The sections showed that there was a great increase in the number of the muscle nuclei, and loss of definite striation of the fibres, followed by atrophy: some increase in the amount of fibrous tissue surrounding the muscle bundles had taken place, and in many cases this thickened muscle sheath was filled only with muscle nuclei and leucocytes, all trace of the muscle itself having disappeared. Fibroblasts in all stages of division were present as well as many leucocytes.

The blood capillaries in the neighbourhood were dilated, and in regions where the inflammatory process was most severe, irregular blood spaces without definite walls were found. The whole of the diseased area was crowded with minute pigment granules, often aggregated into small masses; many of the leucocytes contained large numbers of these pigment granules, but otherwise the granules were always extra-cellular. The skin showed little sign of disease, but contained a few pigment granules in the dermis, deposited in thin layers parallel to the surface; the most intense area of pigmentation was between the dermis and the muscles, where an almost continuous sheet of pigment had been formed.

I have experimentally produced a condition closely resembling this melanotic myositis by long-continued repetition of the application of a strong solution of Iodine to a circumscribed area of the skin of Fundulus heteroclitus. In cases where the irritation due to the Iodine was sufficiently intense to cause inflammation of the subdermal muscular tissue, a condition characterised by atrophy of the muscles, great multiplication of the muscle nuclei, and development of pigment granules, accompanied by the usual phenomena of inflammation, was produced. In this case also the presence of numbers of cells arising by multiplication of the muscle nuclei, together with the pigment granules and leucocytes, gave at first sight a picture suggestive of a sarcomatous growth of a melanotic type.

The particular swelling here described as occurring in a mackerel may thus be considered as a melanotic myositis of unknown cause, and it is perhaps worthy of note that the formation of granules of a pigment apparently resembling melanin can be artificially produced in the tissues of fish by causing mild but continued inflammation.

DESCRIPTION OF PLATE IV.

Illustrating Mr. G. H. Drew's paper on "Some Cases of New Growths in Fish."

Fig. 1 × $\frac{5}{8}$. Photograph of Fibro-sarcoma of Raia macrorhynchus, cut open to show internal surface and origin from perichondrium of one of the fin rays.

FIG 1.

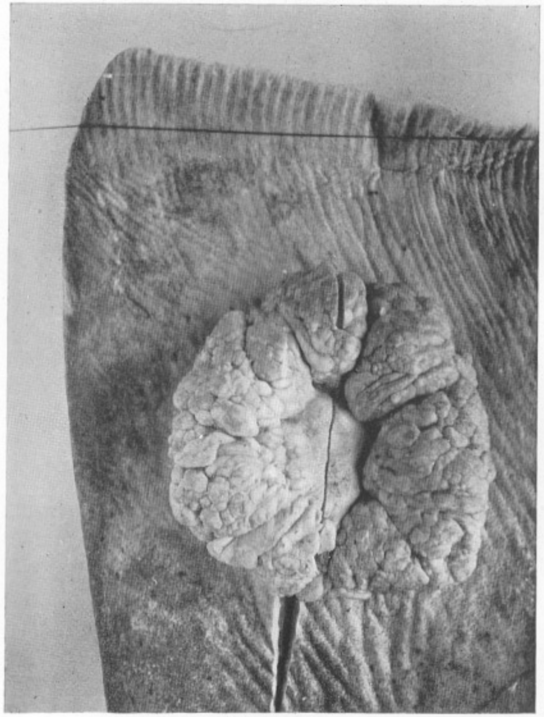


FIG 2.

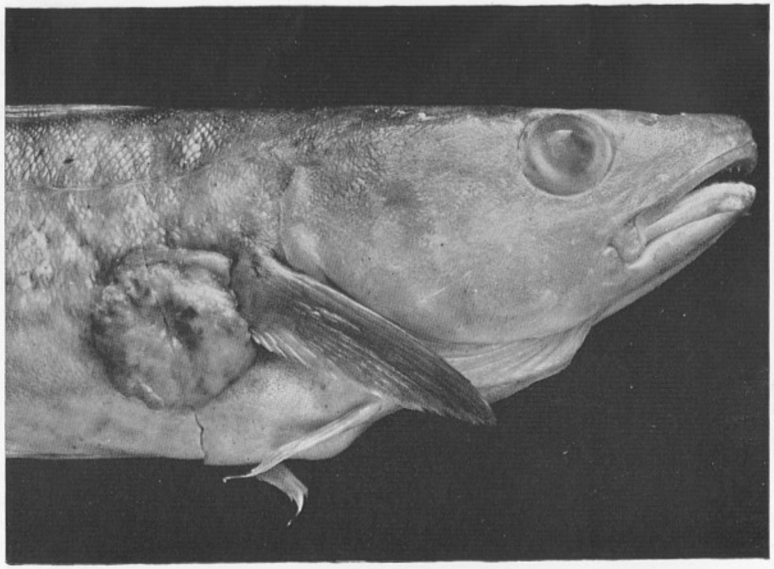


FIG 4.

FIG 3.

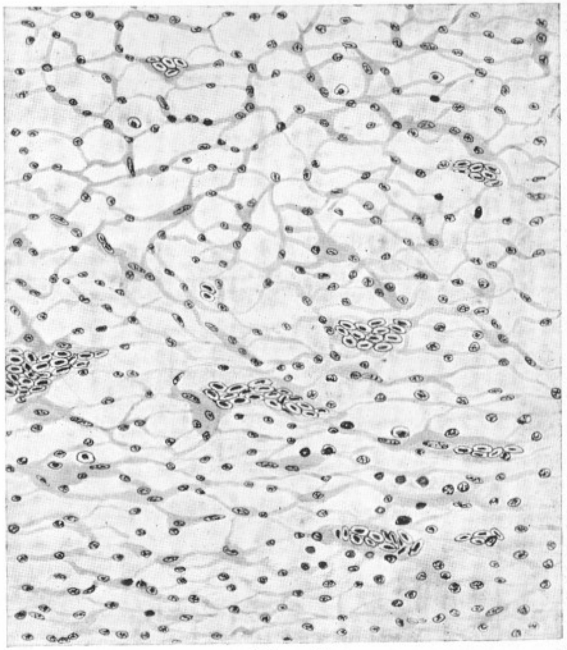


FIG 5.

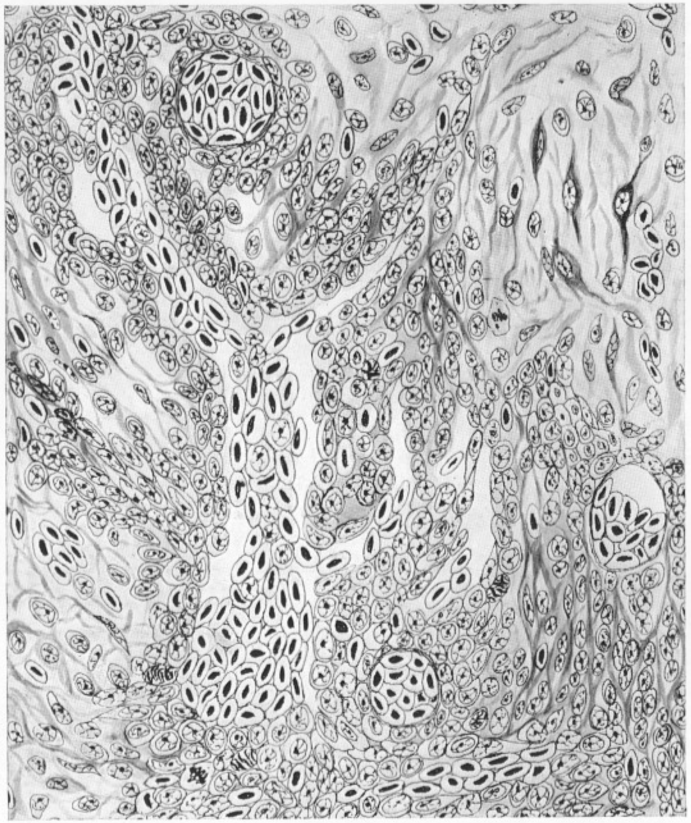


FIG 6.

Fig. 2 × $\frac{7}{16}$. As Fig. 1, but showing position of tumour on the fin.

Fig. 3 × 150. Section of tumour shown in Figs. 1 and 2. Irregular strands of fibrous tissue are present, with numbers of small round sarcomatous cells.

Fig. 4 × $\frac{1}{2}$. Photograph of Whiting, showing position of the tumour.

Fig. 5 × 150. Section of tumour shown in Fig. 4. A fine reticulum of a fibrous nature forms the groundwork of the growth, and small round cells are situated on the strands forming this reticulum. Spaces containing corpuscles are present.

Fig. 6 × 400. Section of endothelioma of Eel. Masses of endothelial cells divided by irregular spaces containing blood corpuscles are present, together with some blood spaces with more definite walls.

(N.B.—For the sake of clearness the red blood corpuscles are represented with dense black nuclei, showing none of their nuclear structure.)

Notes on the Respiratory Mechanism of Corystes Cassivelaunus.

By

Kathleen E. Zimmermann, B.Sc.,
University College of Wales, Aberystwyth.

With Plate V.

I. INTRODUCTION.

In his paper in the Journal of the Marine Biological Association for August, 1896, Garstang treated of some structural peculiarities of *Corystes cassivelaunus* in relation to their biological significance. A brief summary of his observations on the respiratory mechanism may be given as follows: In *Corystes cassivelaunus* the second antennae are greatly elongated and are fringed by a ventral and a dorsal row of hairs. The opposing rows of hairs interlock, with the resulting formation of a median "antennal tube." The double row of hairs is continued back along the three basal joints of the antennae, which joints are bent at right angles to one another; these hairs, projecting towards the median line, together with a median tuft of hairs springing from the rostrum, form the hairy roof of the proximal part of the antennal tube. The antennal tube opens posteriorly into a median "prostomial chamber," which in turn leads by a wide aperture to the branchial cavity of each side. The prostomial chamber is roofed by the rostrum, the antennal and epistomial sternites, and the prelabial plate. Its floor is imperfect, and is formed by the anterior part of the third maxillipeds behind and in front by a quadrangular sieve of hairs springing from the two basal joints of the second antennal, the anterior pterygostomial processes, and a special anterior process of the fourth joint of the external maxillipeds.

The habit of Corystes is to burrow beneath the sand, where it remains concealed, with only the tip of the antennal tube projecting above the sand surface. A current of water (the respiratory current) is sucked down through the antennal tube, and passes backwards into the prostomial chamber, where it divides into right and left streams, which pass into the right and left branchial chambers. The stream eventually emerges from the branchial chamber along the whole extent of the edge of the branchiostegite.

II. SOME STRUCTURAL PECULIARITIES WHICH APPEAR TO HAVE PASSED UNNOTICED BY GARSTANG.

On that part of the ventral body wall which forms the posterior part of the dorsal wall of the prostomial chamber is a fairly prominent calcified **V**-shaped ridge, the point of the **V** being directed backwards. This ridge is formed by the projecting anterior edge of the epistomial sternite, and is fringed with a row of fairly long hairs, which project quite halfway across the entrance to each branchial chamber.

Some of the mouth appendages of *Corystes cassivelaunus*—first maxilla and first maxillipede—show a rather curious modification. Comparing these appendages with those corresponding to them in such a type as Cancer (*vide* Pearson's "Cancer," L.M.B.C. Memoirs, No. xvi), the enlargement of the endopodite is very noticeable. Corystes has the endopodite lobe of each of these appendages (Figs. 4 and 5) specially produced and fringed with hairs of a fairly complex type (Fig. 7).

The mandible of each side is placed with its "apophysis" pointing obliquely backwards, and forming a very prominent ridge projecting towards the ventral side of the animal. Across this ridge lie the specially enlarged endopodite lobes of appendages iv and vi, and over it they are turned up in a dorsal direction, so that their hairy fringes project across the entrance to the branchial chamber proper, meeting the fringe of hairs arising from the **V**-shaped ridge of the epistomial sternite (cf. Figs. 1, 2 and 3).

Garstang himself notes that the prostomial chamber is but imperfectly floored; it is noticeable that to its central part there is no floor whatever, even a hairy one; and even around its sides the hairs which spring from different parts and converge to the centre neither interlock to any great degree, nor have sufficient individual complexity of structure to constitute anything like a barrier to restrain the in-current of water.

The simple structure of the hairs on the antennae should be noted (Fig. 6): there is complete absence of any kind of arrangement for filtering the water as it passes from the exterior into the antennal tube, and thence into the prostomial chamber. The habit of *Corystes cassivelaunus* is to lie buried in sand; the water directly above the surface must necessarily contain some particles of sand or mud, and it is from this by no means clear water that the supply for the respiratory stream is drawn. The complete absence of any arrangement for filtering the water of the incoming current has already been noted, but the sieve-like partition formed by the hairs projecting from the specialised endopodites of appendages IV and VI (Fig. 7), together with those of the epistomial ridge, appears to constitute a very efficient filter by which particles are rejected at the entrance to the branchial chamber itself. [N.B.—In specimens examined, the hairs of this strainer are muddy.]

The in-current, on reaching the posterior part of the prostomial chamber, must be slightly affected by the presence of the dorsal V-ridge, which, however, seems to be not of sufficient importance to change the course of the whole body of the current. The main mass of the current doubtless sweeps on, is split into right and left streams along the arms of the inverted V formed by the apophyses of the mandibles, and enters the branchial chambers; meanwhile the small secondary current produced by the influence of the epistomial ridge flows out ventrally through the gap in the hairy ventral wall of the prostomial chamber, sweeping away in its course such particles of mud, etc., as have been prevented by the hairy sieve from entering the branchial chambers with the main current.

SUMMARY.

Corystes buries itself in sand for protection, with the tip of the antennal tube, through which enters the respiratory current, projecting. The water which enters the antennal tube cannot be quite clear: there is a hairy filter, which rejects particles of mud, etc., at the entrance to each branchial chamber. The main body of the in-current is split into right and left currents, owing to the position of the apophyses of the mandibles, and these two currents enter respectively the right and left branchial chambers. The epistomial ridge on the roof of the prostomial chamber turns aside some portion of the in-current, which portion passes out ventrally through a gap in the floor of the chamber, carrying out with it foreign particles brought in by the in-current and rejected by the sieves guarding the entrances to the branchial chambers.

EXPLANATION OF PLATE V.

Fig. 1. Front end of body of *Corystes cassivelaunus*, ventral view.

a. incompleteness in hairy floor of prostomial chamber.

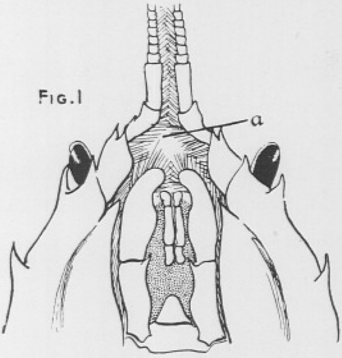
Fig. 2. View of prostomial chamber from ventral side after removal of most of the mouth appendages.

a. epistomial ridge, fringed with hairs.
b. labrum.
c. entrance to branchial chamber of left side.
d. mandible.

Fig. 3. Diagram longitudinal section a little to one side of the median line.

a. position of antennal tube.
b. prostomial chamber.
c. hairy strainer.
d. branchial chamber.
e. hairs flooring prostomial chamber.
f. position of maxillae.
g. gap in the hairy floor.

FIG. 1



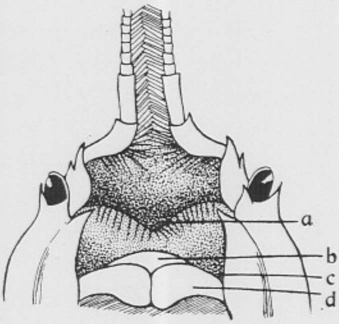


FIG. 2

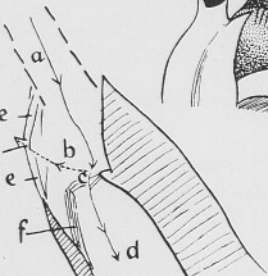


FIG. 3.

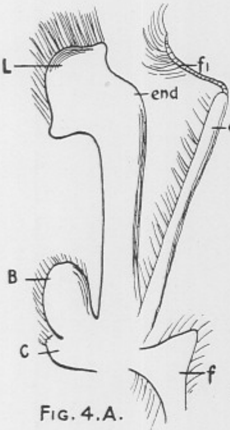


FIG. 4. A.

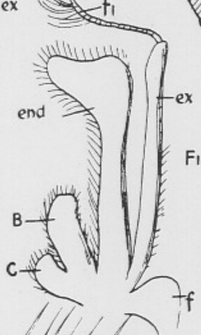


FIG. 4. B.

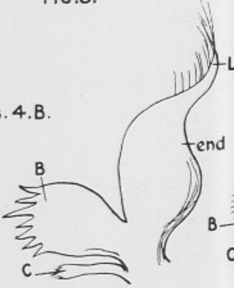


FIG. 5. A.

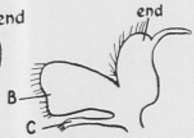


FIG. 5. B.

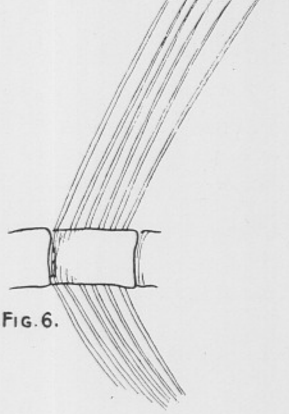


FIG. 6.

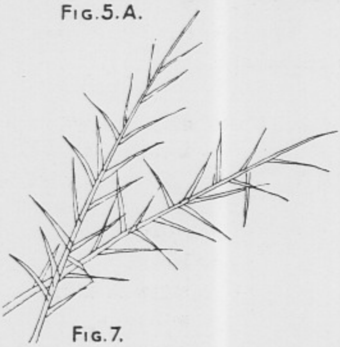


FIG. 7.

Fig. 4A. First maxillipede of Corystes.
B. basipodite.
C. coxopodite.
ex. exopodite.
fl. flagellum.

Fig. 4B. First maxillipede of Cancer.
f. flabellum.
end. endopodite.
l. special endopodite lobe, fringed with straining hairs.

Fig. 5A. First maxilla of Corystes. Lettering as for 4.

Fig. 5B. First maxilla of Cancer.

Fig. 6. Part of antenna of Corystes, to show the two rows of simple hairs.

Fig. 7. Straining hairs, such as fringe the endopodites of 4 and 6 in Corystes.

On the Fauna of the Outer Western Area of the English Channel.

By

L. R. Crawshay, M.A.

With Plate VI.

IN a previous number of this Journal* a Report was published by Mr. R. H. Worth on the geological collections made in the English Channel by the Association's steamer *Oithona* in 1906, combined with other previously unpublished geological records relating to the same area. The general features of the area concerned, with details of the dredgings on this occasion, were described by me (4) in an accompanying paper. It was hoped that the Report on the Fauna then collected, for which indeed the cruises were specially arranged, would be published long before now; but owing to unavoidable causes the complete working out of the material has been unfortunately delayed for a long interval.

The area of investigation as illustrated by the accompanying chart extends roughly from ten to fifty miles outside the Eddystone Lighthouse, in a S.W. Mag. direction, and ranges from 40 to 53 fathoms in depth, reaching about the mid-Channel line near the latter sounding. A few points already dealt with in the paper referred to may be repeated here. The nature of the ground over the whole area, with the exception of the first few miles, may be generally described as shell, sand, and gravel, largely intermixed with stones, which often reach very considerable dimensions, and show a gradual increase in average size as the distance increases outwards, the highest average being obtained near the outermost point that was reached. The inner limit of exposure of these stones was found at fifteen miles to the south-westward of the Eddystone. At positions falling inside this point the bottom deposit consists of a clean shell sand, much finer than is found at any other point in the area concerned.

As regards the gear employed, the otter trawl was used at Positions 3 and 4, within the fine sandy area last mentioned, and at Positions 7, 8, 49, 64, 66, 68 and 78, outside it; but the frequent occurrence of large stones involved too great a risk to use the otter trawl often at the outer positions, and with the exception of those taken with the Agassiz trawl at Positions 45, 46, 52, 59 and 60, all the remaining

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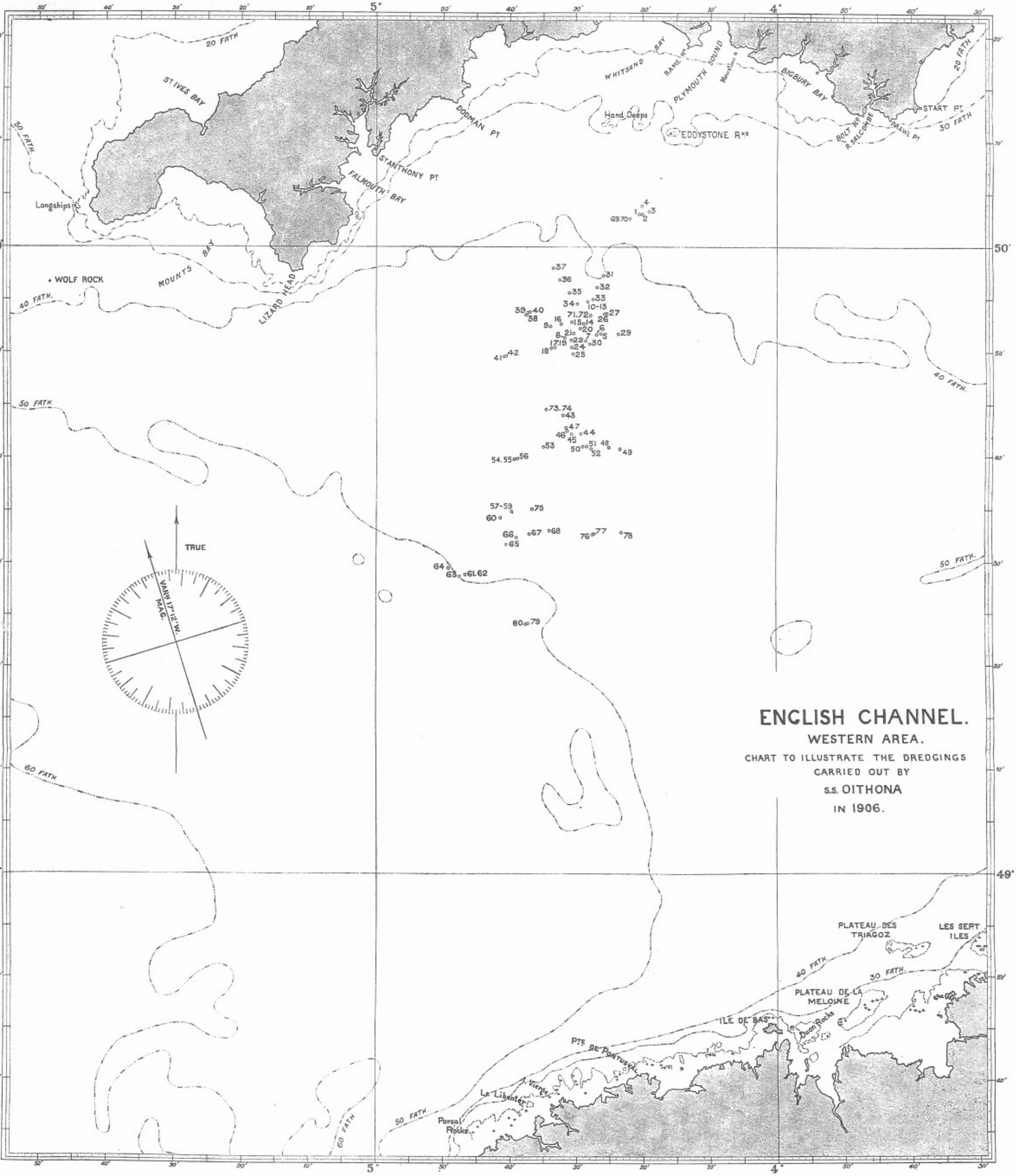
* *Journ. Mar. Biol. Assoc.*, N.S., Vol. VIII., p. 118.



ENGLISH CHANNEL.

WESTERN AREA.

CHART TO ILLUSTRATE THE DREDGINGS
CARRIED OUT BY
S.S. OITHONA
IN 1906.

hauls were made with the dredges. Of these latter, fifteen were bottom samples, most of them not exceeding one minute in working duration; fifteen were made with a 3 ft. rectangular dredge, averaging twelve minutes in duration; eighteen were made with a 3 ft. 6 in. rectangular dredge, averaging eight minutes in duration; and seventeen with an equiangular dredge, measuring 2 ft. on the side, averaging seven minutes in duration. The short length of these hauls must therefore be borne in mind in considering the intensity of occurrence of any of the species recorded. In the following list of hauls all positions are referred to their true bearing from the Eddystone Lighthouse. Samples 16 to 30 inclusive were taken more especially as rock samples, and in consequence only a rough record of species, made on board at the time, was preserved. They have not therefore the value of others in which the unidentified material was brought home for examination. They concern, moreover, a limited area, from eighteen to twenty-three miles outside the Eddystone, and in point of species recorded from them are merely additional to other hauls made within the same area.

LIST OF HAULS.

No.	True Bearing from Eddystone.	Distance. Miles.	Depth. Fathoms.	Gear Used.	Length of haul. Minutes.	Remarks.
1	S. 21° W.	8·3	40	3′ 0″ Dredge	15	
2	S. 19° W.	8·1	40	1′ 6″ Dredge with canvas bag	3	Bottom sample
3	S. 15° W.	7·8	40	Otter Trawl	30	
4	S. 21° W.	7·6		,, ,,	30	
5	S. 19° W.	20·2	42	3′ 0″ Dredge	15	
6	S. 20° W.	20·4	42	,, ,,	10	
7	S. 23° W.	21·2	42	Otter Trawl	30	
8	S. 27° W.	21·8		,, ,,	30	
9	S. 31° W.	21·7		3′ 0″ Dredge	20	
10	S. 26° W.	17·8	42½	,, ,,	5	
11	,,	,,	42½	,, ,,	10	
12	,,	,,	42½	,, ,,	10	
13	,,	,,	42½	,, ,,	17	
14	S. 24° W.	20·0		,, ,,	15	
15	S. 27° W.	20·3		,, ,,	10	
16	S. 29° W.	20·9	44	,, ,,	10	
17	S. 28° W.	23·3	45	,, ,,	11	
18	S. 29° W.	23·4	45	,, ,,	10	
19	S. 28° W.	23·3	45	,, ,,	10	
20	S. 25° W.	20·5	44	,, ,,	10	
21	,,	21·2	44	Triangular Dredge	9	
22	,,	21·9	44	,, ,,	4	

No.	True Bearing from Eddystone.	Distance. Miles.	Depth. Fathoms.	Gear Used.	Length of haul. Minutes.	Remarks.
23	S. 25° W.	21·9	44	Triangular Dredge	–	Bottom sample from previous haul
24	S. 24° W.	22·5		,, ,,	5	
25	,,	23·0	46	,, ,,	8	
26	S. 20° W.	18·4	44	,, ,,	8	
27	S. 19° W.	18·3	44	,, ,,	8	
28 29	S. 14° W.	19·8	44	,, ,,	7	
30	S. 21° W.	21·5	43½	,, ,,	10	
31	S. 25° W.	15·0	40	3′ 6″ Dredge	10	
32	,,	16·3		,, ,,	7	
33	,,	17·5		,, ,,	7	
34	S. 28° W.	18·5		,, ,,	8	
35	S. 32° W.	18·0		,, ,,	8	
36	S. 37° W.	17·5	43	,, ,,	8	
37	S. 41° W.	17·1		,, ,,	9	
38	S. 38½° W.	22·2	44	,, ,,	7	
39	S. 38° W.	21·9	44	,, ,,	4	
40	,,	21·7	44	Triangular Dredge	5	
41	S. 36½° W.	26 6	44	,, ,,	7	
42	S. 36° W.	26·4	44	,, ,,	6	
43	S. 21° W.	28·8	45	,, ,,	10	
44	S. 17° W.	29·8	46½	,, ,,	10	
45	S. 18° W.	30·1	47½	Agassiz Trawl	15	
46	S. 19° W.	29·9		,, ,,	15	
47	S. 19° W.	29·7		1′ 6″ Dredge with canvas bag	½	Bottom sample
48	S. 11° W.	30·5		,, ,,	½	Bottom sample
49	S. 9° W.	30·4		Otter Trawl	30	
50	S. 16° W.	30·9	43	1′ 6″ Dredge with canvas bag	2	Bottom sample
51	S. 15° W.	30·8	43	Triangular Dredge 3′ 6″ Dredge	5 10	The two consecutive samples were labelled "51" in error
52	S. 14° W.	31·0	43	Agassiz Trawl	25	
53	S. 22° W.	32·2	46	3′ 6″ Dredge	10	
54	S. 26° W.	34·5	49	1′ 6″ Dredge with canvas bag	1	Bottom sample
55	S. 25½° W.	34·4	49	,, ,,	1	
56	S. 25° W.	34·3	49	Triangular Dredge	4	
57	S. 22° W.	39·0	49	1′ 6″ Dredge with canvas bag	2	Bottom sample
58	,,	,,	49	3′ 6″ Dredge	10	
59	,,	,,	49	Agassiz Trawl	25	
60	S. 24° W.	40·0		,, ,,	30	

No.	True Bearing from Eddystone.	Distance. Miles.	Depth. Fathoms.	Gear Used.	Length of haul. Minutes.	Remarks.
61	S. 25° W.	46·4	50	1′ 6″ Dredge with canvas bag	1	Bottom sample
62	,,	,,	50	3′ 6″ Dredge	7	
63	S. 25½° W.	46·8	50	Triangular Dredge	7	
64	S. 27° W.	46·6	53	Otter Trawl	30	
65	S. 22° W.	42·2	52	1′ 6″ Dredge with canvas bag	1	Bottom sample
66	S. 21° W.	41·1		Otter Trawl	30	
67	S. 19° W.	40·5		Triangular Dredge	10	
68	S. 17° W.	39·6		Otter Trawl	55	
69	S. 25° W.	9·0	40	Conical Dredge	⅙	Bottom sample
70	,,	,,	40	3′ 6″ Dredge	11	
71	S. 23° W.	19.0	43	Conical Dredge	¼	Bottom sample
72	,,	,,	43	3′ 6″ Dredge	7	
73	S. 24° W.	28.8	45	Conical Dredge	⅙	Bottom sample
74	,,	,,	45	3′ 6″ Dredge	4	
75	S. 20° W.	38·1	49	Conical Dredge	⅓	Bottom sample
76	S. 9° W.	38·9	49	,, ,,	½	Bottom sample
77	S. 11° W.	38·8	49	3′ 6″ Dredge	7	
78	S. 7° W.	38·3		Otter Trawl	65	
79	S. 16° W.	48·7	51	Conical Dredge	¼	Bottom sample
80	S. 16½° W.	48·9	51	3′ 6″ Dredge	7	

VII. Records of species made under this Roman numeral refer to a doubtful position in Cruise VII. In the course of this cruise, one of the labels of part of the material that had been collected was lost by a mishap, and it was not possible afterwards to locate the position. The cruise extended over an area of twelve miles in width, covered by the hauls 54 to 68, and the material can only be considered as belonging to one of these positions, ranging in depth from 49 to 53 fathoms.

The Director has given me much assistance with the Polychaeta and in many other ways. The few Gephyrea recorded were identified by Mr. G. Southern. The more difficult of the Polyzoa were worked out by Miss Alice Heath, and against records for which she is responsible the letter (H) is placed, as opposed to my own records followed by the letter (C). I have also to record my thanks to Dr. Hartmeyer for the naming of the Tunicata, with his notes on the species, subject to his most recent revision of that group; to Mr. A. E. Hefford for the identification of some of the Fishes; and to others who have kindly assisted me on special points arising. For the working out of the material, where not otherwise stated, I am myself responsible.

GENERAL REMARKS.

The most marked feature of the fauna of this outer area of the Channel is its close conformity in the main with that of the Plymouth neighbourhood. Regarding the latter as the area enclosed by a line passing from Start Point to the Eddystone Lighthouse and thence to Looe Island, the fauna of the outer area may be compared with that of the Plymouth neighbourhood under three heads, concerning (1) species common to both areas, (2) species occurring in the Plymouth area which are absent from the outer area, (3) species occurring in the outer area which are absent from the Plymouth area.

(1) By far the greater bulk of the material comes within this category. With the exception of those that can scarcely be considered among the commoner species, and which are therefore less often met with generally, and excluding strictly littoral species, the majority of the species were found extending with more or less frequency over the whole area. Reference here then will only be made to those more familiar species the limited records of which seem to point to a limit of distribution, or to species which call for special remark in other ways. Distances where mentioned are from the Eddystone Lighthouse, and roughly to the south-westward in direction.

PORIFERA. *Clathrina coriacea* was only once recorded. The species, usually of littoral habitat, gives place at about 18 miles to forms which I have referred to *Clathrina primordialis.* One of the latter approximates closely in spiculation to *C. coriacea*, and great as is the difference of spiculation between the two extremes, I am bound to admit a certain doubt as to whether a gradual transition may not prove to exist between them associated with a difference of habitat, in one and the same species.

Leucosolenia complicata, though occurring nearly everywhere, was remarkable for its slender, straggling habit of growth, possibly due to a lack of proper food-supply.

Sycon ciliatum was only obtained at two closely approximate positions about 22 miles distant. Outside this, the only closely allied species was the southern species, *Grantia capillosa,* which was obtained as close in as the first position, 8 miles distant. The latter species certainly also occurs near or even inside the Eddystone, though the few Plymouth specimens in the Laboratory Museum are without data of locality.

Leucandra fistulosa, generally distributed in the Sound, only once occurred at the first position, 8 miles distant.

Polymastia mammillaris, common at certain points on rocky ground in the Sound, was obtained only at 31 and 39 miles, in contrast to *P. robusta*, which occurred fairly commonly over the whole area.

Ficulina ficus, though of common occurrence as far as 40 miles out, was always of remarkably small size—much more so than it often occurs on the Eddystone Grounds. This reduction of growth, as contrasted with the comparatively enormous size it often attains within the breakwater, is no doubt attributable to the diminution of waste organic matter on the distant grounds.

Suberites carnosus, comparatively common on the Eddystone, Grounds was only twice found, at 17 and 22 miles respectively. These also were extremely small specimens.

HYDROMEDUSAE. Except at the first few positions, on the fine sand about 8 miles distant, and again at the outermost point reached, where in 51 fathoms two southern species showed a healthy luxuriant growth, the examples recorded were on the whole remarkably small, and the occurrence of well-grown colonies was quite exceptional. In the same connection the dwarfed form of *Plumularia setacea* at two outer positions in about 50 fathoms is remarkable.

Merona cornucopiae was taken as far as 31 miles distant, which was 10 miles beyond the outermost record of its common associate *Dentalium entalis*.

Hydractinia echinata was only taken at 31 miles.

Tubularia was only recorded at the first position, 8 miles distant.

Halecium halecinum was not recorded outside about the 34-mile point.

A fragment only of *Thuiaria articulata* was taken at 18 miles.

Antennularia ramosa, though occurring as far out as 40 miles, was not found common anywhere. The allied species, *A. antennina* was common over the whole area.

Plumularia catharina was the commonest of its genus obtained, *P. pinnata* alone approximating to it appreciably in point of frequency. The creeping variety, which occurred over the whole area, was perhaps the most frequent and certainly the most flourishing in point of growth. It is difficult to assign a cause for this mode of growth. A colony of *Bougainvillia*, reared by Mr. E. T. Browne at the Plymouth Laboratory some years ago (cf. *Journ. Mar. Biol. Assoc.*, N.S., Vol. VIII, p. 37) assumed a persistent stoloniferous habit of growth from the first. It was fed with mixed plankton regularly and grew rapidly, but in the several months of its existence, except in very rare cases, it made no attempt to assume the ordinary branching habit, even though it ultimately succumbed to an overgrowth of small algae. This single instance affords no evidence that food-supply alone influences the manner of growth where the latter is variable. Yet the seeming scantiness of the Hydroid fauna over most of the outer area, coupled with the frequent records of small colonies, and distinctly dwarfed colonies in the case of *P. setacea* point to conditions that are unfavourable to healthy growth in the group.

ECHINODERMATA. *Palmipes placenta* was not found outside the 17-mile point, and at the latter only as small specimens.

Echinus acutus was not recorded inside a distance of 15 miles, which is about the inner limit of the stony ground. *E. esculentus*, on the other hand, occurred over the whole area, and in considerably greater numbers.

POLYCHAETA. The outer limit of occurrence of *Aphrodita aculeata* was at 20 miles; that of the nearly allied *Hermione hystrix* extended to 46 miles. The latter species seems generally to favour grounds of a coarse character.

Halosydna gelatinosa occurred only at 39 miles.

Onuphis conchilega was not found beyond the 26-mile point.

CRUSTACEA. *Portunus depurator*, often an abundant species in the Sound, and found abundantly by Dr. Allen (1) 3 miles east of the Eddystone, was only once obtained at 17 miles.

Atelecyclus septemdentatus has been recorded from as much as 100 fath. and even 400 fath. (cf. Allen, 1), but in the area here considered it was not found beyond 30 miles. This species is scarcely likely to have been much missed in the work owing to the constant use of the dredges with a special view to deep working. Allen considers that a certain amount of muddy deposit contributes to the most favourable conditions for the species, and it is possible that the almost entire absence of any such deposit on the outer grounds may explain its infrequency and even disappearance at the more distant positions visited.

MOLLUSCA. *Craspedochilus onyx* was not recorded beyond 20 miles.

Capulus hungaricus, taken on five grounds by Dr. Allen between Start Point and the Eddystone, at 30 fathoms, was not found alive in the area here under consideration, though dead shells occurred as far out as 27 miles.

Of *Pecten maximus* there is a noticeable scarcity at all points as contrasted with *P. opercularis*, which was at times abundant. About five living specimens were obtained at three positions, all situated about 20 miles out. At other positions from one to three only occurred, and the total number obtained probably did not exceed forty. On the grounds near the Eddystone it was found by Dr. Allen with much greater frequency, two or three specimens being generally taken in each haul with the dredge.

Dentalium entalis was not found outside the 18-mile point.

Nucula nucleus, which occurs commonly down to 30 fathoms on the Eddystone Grounds, was only obtained at the first position, 8 miles distant, where the large deposit of fine clean sand occurs.

Pectunculus glycimeris, occurring as far as 39 miles out, was remarkable for the small size of specimens obtained.

Cardium echinatum was of rare occurrence, being only once obtained alive at 9 miles distant, while only one dead valve was recorded at a point slightly closer in.

Cardium norvegicum, common on gravel on the Eddystone Grounds, was only recorded at four points, and as far as 31 miles.

(2) Of the members of the Plymouth fauna that are absent from the list, there is little of special interest to mention, these being for the most part essentially littoral species, or those favouring a rocky habitat, or such as are of too infrequent occurrence generally to serve for purposes of comparison. Among the absent species:—

Adamsia polypus (*Sagartia parasitica*) was conspicuously absent despite the frequent occurrence of its host *Eupagurus bernhardus*. On the Eddystone to Start Point Grounds, it is an interesting fact that on gravels Dr. Allen always found this hermit-crab without the anemone, though on the fine sands it was commonly associated with it. It is true the anemone did not occur in the few hauls made on the fine sand of the outer area at about 8 miles, yet its non-occurrence in other hauls suggests that the generally coarse ground of the latter, as in the case of the Eddystone to Start Point gravels, may account for its absence.

Holothuria nigra is generally found at Plymouth in close proximity to rock ledges. Such too was the case in the Eddystone to Start Point fauna where the species occurred only on gravel adjoining the Eddystone rocks. It is not improbable that such rock ledges are still exposed in places on the more distant grounds here dealt with, but there was no clear evidence of this fact afforded by the rock material dredged up at any point.

Antedon bifida, which extends southward to the Mediterranean, and as deep as 100 fathoms (cf. Bell, 65), has not been recorded in the Plymouth fauna outside the Mewstone Ledge.

Echinocardium cordatum occurs on fine sand on the Eddystone Grounds to 35 fathoms, and was obtained occasionally by Dr. Allen on similar ground between the Eddystone and Start Point. It is recorded by Ludwig (72) from southern waters at Marseilles, Naples, and the west coast of Italy, and as deep as 85 fathoms.

Maia squinado is moderately common, especially among rocks in the

Plymouth area, extending as far as the Eddystone Grounds. A few specimens only were obtained by Dr. Allen, on fine sand, between the Eddystone and Start Point.

Corystes cassivelaunus appears to be exclusively associated with deposits of a fine nature, and such as were only met with on the first position at about 8 miles.

With these few species may also be considered certain of those mentioned under the preceding heading, the infrequency of which almost amounts to their absence from the outer fauna. Such are *Suberites carnosus, Hydractinia echinata, Tubularia sp., Thuiaria articulata, Halosydna gelatinosa, Capulus hungaricus,* and especially *Portunus depurator* and *Cardium echinatum.*

(3) Of the species hitherto unrecorded from the Plymouth area, *Clathrina primordialis,* as regarded by Haeckel (14), is of almost universal distribution. The remainder are divided as follows, the present records for the English Channel being included in the distribution :—

(A) From Scandinavia through the region of the Shetland Is. and Hebrides to Irish Waters and English Channel.

Sertularella tenella. (Including also Arctic regions, S.W. Atlantic, and Pacific.)

Pectinaria pusilla. (Scandinavia and West of Scotland only.)

Thyone raphanus. (Excluding Scandinavia.)

Tritonofusus propinquus. (Including North Sea.)

Anapagurus hyndmani. (Excluding Scandinavia, and including Channel Is.)

Gobius scorpioides. (Excluding Shetlands and Hebrides.)

(B) The same area, and including the Mediterranean.

Peltogaster sulcatus. (Excluding Shetlands, Hebrides, and Ireland, and including Brazil and Pacific.)

Gonothyrea gracilis. (Including North Sea and S. America.)

(C) The same as (A), including the Bay of Biscay and Azores.

Ditrupa arietina. (Including Mediterranean, Canary Is., and Pacific.)

Inachus leptochirus. (Excluding Scandinavia and Irish Waters, and including Channel Is., Adriatic, and Cape Verde Is.)

Diphasia alata. (Excluding Irish Waters.)

Polyplumaria flabellata. (Excluding Shetlands, Hebrides, and Irish Waters.)

Portunus tuberculatus. (Excluding Scandinavia and Irish Waters, and including Mediterranean.)

(D) From Irish Sea southwards.

Xantho tuberculatus. (Including Bay of Biscay, Coast of Portugal, N.W. African Coast and Cape Verde Is.)

Bathynectes longipes. (Including Channel Is., Mediterranean, Adriatic, and Black Sea). Frequent at Plymouth in recent years.

(E) From English Channel to Azores.

Clathrina contorta. (Including Mediterranean.)

Rhizaxinella elongata. (Including Mediterranean.)

Polymastia agglutinans.

(F) English Channel and Adriatic.

Grantia capillosa.

PORIFERA.

Calcarea.

CLATHRINIDAE, Minchin.

Clathrina coriacea (Fleming).

One small specimen on a dead *Pecten* shell, at Position 33.

Depth, 42 fath.

Clathrina primordialis (Haeckel).

At Position 34, one, on shell of *Fusus*, occupied by *Eupagurus*.	Greatest measurement	9 mm.
„ 38, one, on tube of *Pallasia*	„ „	10 „
„ 45, one, on *Inachus*		
„ 59, two, on dead valve of *Pecten*	„ „	10 „
„ 62, one, on *Volsella*	„ „	4 „

Depth 42–50 fath.

These five small specimens which I have assigned to Haeckel's *Ascetta primordialis* show a good deal of individual variation. The habit of growth is in every case that of a simple network of anastomosing tubes, with a few short oscular processes, forming a thin investment on the object of attachment. The skeleton is composed almost entirely of equiangular triradiates with the component rays often of slightly unequal length. The size of the spicules is fairly uniform in individuals, but between different individuals the average dimensions of the spicular rays range from about 65μ[*] in length by $6{\cdot}5\mu$ in width at base of ray, to about 110μ in length by 10μ in width. The rays are gradually tapered to a rather sharp or sometimes a somewhat blunt point, the tapering being more strongly marked in the distal half of the ray. In one specimen (No. 240), the rays are more linear and almost *coriacea*-like. In two specimens the skeleton is entirely composed of triradiates.

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[*] The sign μ is used to designate ·001 mm.

In the three others a few quadriradiates of the same ray-form and size are present, in which the fourth ray is rather smaller but not much shorter than the basal rays. These quadriradiates are so scarce that they might easily escape observation.

Under his "Connexive Varietäten" of *Ascetta primordialis,* and later in the text, Haeckel (14) mentions the existence of this variety with a tendency to form a gastral ray as *Ascaltis primordialis,* though he gives no data concerning its occurrence. In the present case it may be noteworthy that the three specimens possessing quadriradiates were obtained from depths between 42 and 44 fathoms, while those without them were from between 47 and 50 fathoms.

Excepting specimens recorded by Hanitsch (15) from the Liverpool District which he subsequently referred (16) to *C. lacunosa,* the species does not seem to have been recorded north of the Mediterranean.

Clathrina lacunosa (Johnston).

At Position 34, one, on shell of *Fusus,* growing beside *C. primordialis,* Length 6 mm.
„ 47, one, on *Scrupocellaria* „ 5 „
„ 62, one, on *Sertularella* „ 7 „
Depth, 42–50 fath.

Clathrina contorta (Bowerbank), Minchin (28).

A small patch of spicules undoubtedly belonging to this species was found attached to a surface section of a *Reniera* from Position 58, on or in close proximity to which the specimen would seem to have been growing.

A single quadriradiate spicule, apparently also of this species, occurs similarly on a section of *Raspailia stuposa* from Position 67.

Depth, 49–52 fath.

Though it may appear somewhat hazardous to record the occurrence of this species on the evidence of a few spicules, and in the second case, of a single spicule, I have no doubt, after examining a specimen of *contorta* which Prof. Minchin kindly gave me, concerning the identity of the first record, and little doubt as to the second. In the former case, both of two marked features of *contorta* are very distinct, namely, the very high proportion of quadriradiates, and,—more important,—the long and slender gastral ray of these. In the latter case, the single quadriradiate spicule is of the same form. Monaxons are absent from the fragment from Position 58, a condition which Minchin regards (28, p. 14) as a juvenile feature. It is of interest to note that the two positions lie close to one another, that is, as nearly as the reckoning fixes them, not more than about two miles apart.

The species has been recorded from the Liverpool district by Hanitsch (16, p. 233). An earlier British record by Carter is questioned by Minchin (28, p. 18), who also leaves localities given by Bowerbank (Channel Islands, Scarborough ?) open to doubt, owing to a confusion of species in his material. The natural habitat of *C. contorta* is in the more southern waters: Sark, Luc-sur-mer (Topsent, 35); Roscoff (Topsent, 37; Minchin, 28); Belle Isle (Topsent, 36); Banyuls-sur-mer, extremely abundant (Minchin, 28); Azores, abundant (Topsent, 38); Adriatic (Lendenfeld, 22, pars. (?)—cf. Minchin 28, p. 14). It is apparently one of those species that extend with difficulty within the border line of the British Fauna.

LEUCOSOLENIIDAE, Minchin.

Leucosolenia complicata (Montagu).

Recorded from 24 positions—1, 3, 4, 11–15, 31–37, 40, 43, 45, 49, 51, 52, 58, 59, 64.

Depth, 40–53 fath.

Mostly on Hydroids, *Cellaria* and *Cellepora*, also on shells of *Pecten* and tubes of *Pallasia* and on *Inachus*. At some positions several specimens were obtained, at twelve positions a single one only.

The habit of growth, which varies little among all the specimens obtained, is very different from that of the ordinary shore form. This is a straggling growth, often a confused tangle of slender rambling tubes, in no case exceeding 1 mm. in diameter, usually considerably less, and with no tendency to specialization. Many of the specimens are extremely small. Of the larger ones two especially deserve mention: the first from Position 32, a thickly grown specimen with rambling tubes of less than 1 mm. in diameter, on *Cellepora*, measuring about 35 mm. in extent; the second from Position 37, a very fine specimen of 50 mm. in breadth and 60 mm. in height, forming a tangled shrub-like growth on a shell of *Pecten opercularis.*

SYCETTIDAE, Dendy (13).

Sycon ciliatum (Fabricius).

At Positions 38 (five), 40 (one).

Depth, 44 fath.

I make use of the name *ciliatum* provisionally for the specimens here recorded, on grounds of priority, because after examination of many specimens I am quite unable to separate this form from Haeckel's *Sycandra coronata* as defined by him. In the main they conform more to the latter type than to *ciliatum* in point of the relative length of the gastral ray to that of the facial rays in the gastral quadriradiates; while in regard to the second point used by Haeckel (14), namely the relative width of the monaxons to that of the triradiates and quadriradiates, the character appears to me to be too variable to serve for purposes of distinction. As regards the first character, however, both types are exemplified in the Plymouth forms with every gradation between the two extremes, and further, the short gastral ray of the *ciliatum* type is apparently more characteristic of the in-shore specimens, while the longer corresponding ray of the *coronatum* type commonly occurs in the deeper water. A still more important point arises in the occurrence of at least one instance I have seen, in which both the short and the long gastral ray are present in the same specimen. A careful examination of a larger number of examples is needed to establish the point satisfactorily, but in the meantime I am unable to regard the two forms as specifically distinct.

In three of the six specimens here considered the relative length of the gastral and facial rays is roughly as 7 to 8, 3 to 4, and 1 to 3, severally; while the average relative width of the monaxons and radiates is about 1½–2½ to 1.

GRANTIDAE, Dendy.

Grantia capillosa (O. Schmidt).

At Positions 1 (one), 3 (one), 4 (three), 36 (one), 37 (two), 49 (one very young), 53 (one very young), 70 (two), 80 (one).

Depth, 40–51 fath.

The genus *Grantia*, to which this species is referred, is here regarded as it is defined by Dendy (13), but with the modification that it does not of necessity exclude the occurrence of the monaxons in bundles at the distal ends of the radial tubes. This reservation would seem alike to involve Dendy's family *Grantidae*, although as defined by him (13) it is not literally restricted on the point. In other respects the species *capillosa* seems to have its proper position in this family and genus, owing to the presence of a distinct dermal cortex covering the distal ends of the radial chambers. The arrangement of the monaxons is rather irregular. For the most part they are grouped in bundles about the ends of the radial chambers, this arrangement being often retained even where the latter are subject to branching, as frequently occurs at the extreme apex. Less frequently they are disposed without much regularity. But they are always large and stout, and usually penetrate for a considerable distance towards the gastral surface. Their disposition is in fact near the border line between the two forms of arrangement which Dendy defines for the Sycettidae and implies for the

Grantidae respectively. Since, however, the arrangement of the monaxons depends, as Dendy observes, on the variation of the canal system, it seems to me inadvisable to limit the latter family too stringently in regard to this character, which may in greater or lesser degree still retain the Syconoid form, as in *capillosa*, after the branching of the chambers has begun and a definite cortex has been assumed.

Mr. C. F. Jenkin first called my attention to this sponge among some unnamed material, and identified it as this species on Haeckel's description. Recently Mr. Kirkpatrick has kindly afforded me the opportunity of examining at the British Museum a co-type of Oscar Schmidt's labelled "*Sycon capillosum*" in his own handwriting, which enables me without doubt to confirm Mr. Jenkin's identification. It will not improbably be found that some confusion has arisen concerning the identity of the species, like many other Calcarea. Particular features which characterize it are: (1) its tendency to interruption of outline, as though through injury, in the region of the osculum, as figured by Scmidt (32, Pl. I, Fig. 6); (2) the shape of the dermal triradiates, approximating somewhat to the remarkable form of those in *Leucandra fistulosa*, though much stouter, with longer basal ray, and smaller unpaired angle than in that species; (3) the slender sub-gastral triradiates with very long tapering basal ray, shorter lateral rays nearly at right angles to it, and often with a fourth ray developed in about the same plane as the latter.

The species was originally recorded by Schmidt from Lebenico in the Adriatic (32, p. 17). Haeckel (14) also records it from Lesina on his own authority and that of Heller. Lendenfeld (22) adds Muggia, Pirano, and Rovigno to these localities. It has also been said to occur at Naples, but as the only slide I have seen so labelled from that locality is undoubtedly of a different species, the latter record seems to need confirmation, and apart from this there is apparently no previous record of its occurrence outside the Adriatic.

Leucandra fistulosa (Johnston).

One specimen at Position 1.

Depth, 40 fath.

Monaxonida.

HADROMERINA, Topsent (40).

TETHYIDAE.*

Tethya lyncurium (Linnaeus.

One specimen at Position 62.

Depth, 50 fath.

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* Dr. Hartmeyer on p. 379 uses this name for an Ascidian family on the ground that the Ascidian genus *Tethyum* is of earlier date than the Sponge genus *Tethya*.

CLIONIDAE.

Cliona sp.

Specimens of *Cliona*, in all cases I believe boring in dead shells of *Pecten, Pectunculus, Lutraria*, etc., were obtained, sometimes very commonly, at Positions 4, 8, 9, 10, 11, 13, 18, 34, 44, 46, 59.

Depth, 40–49 fath.

The specimens were unfortunately not retained for further examination, and the species must therefore be left unnamed.

POLYMASTIDAE.

Polymastia robusta, Bowerbank.

Six specimens were obtained as single examples at the Positions 8, 14, 51, 55, 77, 80.

Depth, 43–51 fath.

Particulars are as follows, the measurements being made after preservation in spirit:—

At Position 8. Form, depressed hemispheroidal, with fistular processes very numerous. Measurement, 55 × 50 × about 30 mm. in height. On a flat stone. Depth, 43 fath.

" 14. (Specimen not retained.)

" 51. Form tending to bulb-shaped, with surface very even, and most of the fistular processes fusing together as one combined outgrowth from the upper surface. Measurement, 35 × 28 × 35 mm. in height. Depth, 43 fath.

" 55. Fistular processes numerous. Measurement, 50 × 40 × 35 mm. in height. Broken from base.

" 77. Fistular processes numerous. Measurement, 95 × 75 × 50 mm. in height. Depth, 49 fath.

" 80. Fragment, torn from an apparently large specimen. Depth, 51 fath.

Polymastia mammillaris (O. F. Müller).

At Position 51. One specimen; forming an investing growth on dead *Pecten* valve, with about a dozen processes. Extent, 23 × 12 mm. Depth, 43 fath.

At Position 58. One specimen; forming an investing growth on dead *Pecten* valve, with base strongly hispid, 50 × 30 mm. in extent, and with seven large smooth fistular processes 20–22 mm. in height. The differentiation between basal and fistular areas exceptionally well shown. Depth, 49 fath.

Polymastia agglutinans, Ridley and Dendy.

Single specimens at Positions 13, 32 or 33 (?), 46, 55, 59.

Depth, 42–49 fath.

The form of the specimens is in all cases that of a depressed, more or less regular spheroidal or ovoid mass from 10 to 25 mm. in horizontal measurement, with from one to eight fistular processes of 6 to 12 mm. in height, radiating from different points of the surface, the body of the sponge forming an investing growth cementing together small pebbles and fragments of shell into a compact mass. This peculiar habit is common to all the specimens, and there seems no doubt of their identity with Ridley and Dendy's *agglutinans* (31), of which the external form and habit is so very similar. Professor Dendy, who kindly examined some slides I sent him and allowed me to see some preparations of his original material, considers that there is no difference of sufficient importance to constitute specific distinction. The main characters of the skeleton are almost identically the same, though in the dimensions of the spicules there is a considerable difference. Ridley and Dendy's measurements for the large tylostyli are 1200 μ by 15·7 μ; for the microsclera, 175 μ by 4 μ. In the specimens here considered the megasclera average from 450 to 500 μ, and sometimes exceed 700 μ, but in no case have I seen one reaching 800 μ. The width of the largest is 14·8 μ. The microsclera average about 140 μ by 3·7 μ. The difference may be a local one. The megasclera are rather more like those of *robusta* than those of *mammillaris.* The microsclera are like those of *mammillaris*, but with much more pronounced heads.

The *Challenger* specimens (two) were taken off the Azores in 450 fath. on volcanic mud.

SUBERITIDAE.

Ficulina ficus (Linnaeus).

Most of the specimens of this sponge obtained were of the massive carcinoecious form, and generally occupied by a Pagurid, but none were of large size. Occasionally, as where stated in the following particulars, they occurred in the earlier stage of these investments on shells of molluscs.

At Position 1, one. Greatest measurement 20 mm.
„ 7, one. „ „ 28 „
„ 34, one. Small.
„ 35, two. Greatest measurement 23, 35 mm.
„ 37, one. „ „ 16 mm.
„ 43, one. „ „ 22 „
„ 52, eight. „ „ 16, 17, 22, 24 mm., and four, thinly investing shells of *Natica, Trochus,* etc.
„ 59, four. „ „ 15, 19, 20, 26 mm.
„ 60, one. „ „ 12 mm., investing shell of small Gastropod.

Depth, 40–49 fath.

In all of three specimens closely examined, namely those from Positions 7, 43, and 60, the centrotylote microsclera are abundant but extremely variable in size and form.

Much confusion has arisen about the identity of this species, which has frequently been referred to as *Suberites domuncula*, a species which apparently does not occur in the British fauna. For a discussion of the species with full synonymy, see Topsent's valuable account (41, p. 203). The extremely large growth often attained by the species on the inner grounds inside the breakwater seems never to occur in the deeper water, the difference being apparently due to food-supply.

Suberites carnosus (Johnston).

At Position 9. One small detached specimen. Greatest measurement 5 mm.
„ 32 or 33 (?). One small specimen of ovoid form growing on the basal portion of *Polymastia agglutinans.* Greatest measurement 10 mm.

Depth, 42 fath.

Rhizaxinella elongata (R. and D.), Topsent.

A single specimen, evidently belonging to this species, was obtained at Position 38, in 44 fathoms. Some uncertainty was felt as to its identity owing to the presence of an important internal character to which no allusion has been made in records of the species. This is the possession of a series of longitudinal belts of spicules in the form of a broken hollow cylinder surrounding and distinct from the axial core. It is difficult to understand that no mention should be made of a character that is definitely shown in the longitudinal and the transverse sections, but in all other respects it conforms so closely with the descriptions of *elongata* that I can only regard it as the same species, and conclude that the point referred to has been overlooked.

The specimen forms a slightly bent column of 60 mm. in height, widening gradually in diameter from 5 mm. at base to 8 mm. near the middle, beyond which it is sub-cylindrical, with the apex rounded. The colour in spirit is pale yellowish white. There are numerous small oscula scattered at irregular intervals over a great part of the surface, without any particular reference to the apex. The specimen was broken from its attachment, but two small rootlets are preserved in connection with a rounded base. The texture is very tough and compact.

The skeleton consists of a very compact central axial core of stylote spicules with a quantity of spongin, surrounded by a clear area, beyond which is a ring of spicular belts running parallel to the axial core, the component belts following a spiral course. In the transverse section these belts are marked off from one another by slender strands of few spicules that radiate sub-spirally outwards and upwards from the axial core, across the clear area, and through the belts to the surface. Similarly, spicular strands separate off independently from the outer side of the belts themselves and branch in a spreading fashion on their way to the surface, beyond which many of the spicules extend. At the surface they combine with innumerable radiating fasciculi of smaller and shorter styli, to form the dermal hispidation, which has the form of a closely approximating series of defensive brushes.

The spicules of the longitudinal belts and their branches, and those of the axial core, are slender styli, often slightly curved, with simple rounded base, sometimes faintly tylote, and with sharp tapering points. They range from 900 to 1600 μ (averaging 1300 μ) in length, and from 7 to 11 μ (averaging 9 μ) in width. The spicules of the dermal fasciculi, which are also present in small numbers, scattered between the longitudinal belts and the surface, are styli of 200 to 440 μ (averaging 280 μ) in length, and 2 to 6·5 μ (averaging 4·5 μ) in width. Many of them are simple, but a large number—perhaps the majority—are strongly tylote, and usually with a second ring-like expansion beyond the basal one, as in the spicules, e.g., of *Suberites carnosus.* The bases of these dermal tylostyli are extremely like those of the latter species, and in the vertical view of the outer surface there is a striking similarity between the two sponges.

The noteworthy points of difference from Ridley and Dendy's original description of *Suberites elongatus* (31) are, besides that referred to, the more slender form of the large styli, and the absence of a true pedicel. In regard to the last point, several specimens of the same species were collected during a subsequent cruise at a more distant and deeper position in the Channel. These all show the typical slender pedicellate growth, characteristic of *elongata*, while the spiculation of two specimens examined shows no appreciable difference from the foregoing description, except that the numerical proportion of tylote to simple styli in the dermal fasciculi is lower.

The species has been recorded from the Bay of Biscay: one, in 248 m. (Topsent, 38); one, in 180 m. (Topsent, in 10); Coast of Roussillon, two, in 94 m. (Topsent, in 10); Azores, eight, in 450 fath. (Ridley and Dendy, 31).

HALICHONDRINA, Vosmaer.

HAPLOSCLERIDAE, Topsent.

CHALININAE, Ridley and Dendy.

Siphonochalina montagui (Bowerbank)?

At Position 46, one specimen, broken from attachment—possibly *Lepralia;* forming an erect compact growth of irregularly inosculating, more or less tubular branches, the whole somewhat depressed laterally and with some external resemblance to certain broadly expanded forms of *Alcyonidium gelatinosum;* with several oscula raised on low prominences of 2–4 mm. in diameter. Height, 65 mm. Width, 62 mm.

„ 68, one broken specimen, on *Lepralia foliosa;* with massive basal portion, 50 × 40 mm. in extent, tunnelled by tubular ramifications and surmounted by at least one large tubular process, 60 mm. in height by 25 mm. in diameter, with an osculum at summit, 9 mm. in diameter.

Depth, 47–52 fath.

The texture of the first specimen is compact and rigid, and similar in general appearance to Bowerbank's figures for the species; that of the second, except for a certain rigidity about the base, is quite the opposite. In external characters the two specimens are quite distinct, but the internal structure of both, including the form and dimensions of the spicules, shows so little difference that there seems no justification for separating them. The skeleton is composed of two distinct elements:—

(*a*) A primary interlacing network, ramifying through all parts of the sponge, of very clearly defined (? keratose) fibres, each composed of bundles of fibrillae, and commonly enclosing a variable number of oxeote spicules running longitudinally within them. Sometimes the enclosed spicules are very numerous, but often they are entirely absent from the fibres. In a tangential section of one specimen some of the larger fibres attain, even close to the surface, a thickness of as much as 100 μ. In a tubular portion of the same specimen a thick fibre traverses the centre of the tube, throwing off subdividing branches to the periphery. Oxea occur likewise, though with extreme scarcity in this axial fibre and even in its slender branches to the wall of the tube.

(*b*) A secondary *Reniera*-like, and to some extent regularly disposed network of unispicular meshes, with a decided tendency to assume in the main lines an outwardly radiating direction from interior to surface. This appears to be quite independent of the primary network. The ends of the spicules are cemented together with deposits of spongin, usually to a distance of about 20 μ down the shaft from the point. The spicules composing this network are oxea of fairly uniform dimensions averaging about 90–100 μ in length by 5 μ in width. With them are associated, irregularly disposed, smaller oxea of about the same length, and half or less than half the width, and very fine hairlike oxea of about 50–60 μ by 1 μ.

The spicules of the primary skeleton are similar in form and dimensions to those of the secondary skeleton, and include the slender hairlike forms of the latter. The dimensions of the large oxea shown by Bowerbank's figure for the species are rather larger—about 124 μ by 6·5 μ.

The tubular tendency of the sponge seems to place the species in the genus *Siphonochalina* as defined by Schmidt (33, p. 7), and by Ridley and Dendy (31, p. 29); but the remarkably composite structure of the fibres of the primary skeleton, very different from the clear fibres of, e.g., *Chalina oculata*, leaves some doubt as to its identity with the species to which it is here assigned, or indeed of its true position among the Chalininae. The fibrillae of which the fibres are composed have themselves individually the form of a string of beads, each bead contributing internally a separate rod-shaped element to form a centrally-placed strand running along the string. Loisel * describes an almost identically similar condition in certain species of *Reniera*, so called. But in the present examples I find no evidence of the bead-like cells which secrete the elemental rods ultimately breaking down, as Loisel describes, so as to have a simple con-

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* *Contribution à l'histophysiologie des éponges.* Journ. de l'anat. et de la physiol., XXXIV. 1898.

tinuous strand. They appear, on the contrary, to be permanent, while the contained rods remain separated at their ends from one another by a narrow interval between adjacent beads. These fibrillae, and their contained rods in particular, give a deeper reaction to stains like eosin and methylene blue than the deposits of spongin about the ordinary skeleton, and this fact, coupled with that of the independence of the two skeletons, suggests that the substance of the primary skeleton may be of a slightly different constitution from that of true spongin.

RENIERINAE, Ridley and Dendy.

Halichondria sp.

A fragment of a *Halichondria*, too small for determination, occurred on *Inachus dorsettensis* at Position 3.

Depth, 40 fath.

The skeleton is very irregular, with a confused and broken network of loosely constructed spicular bundles forming the main lines. It is chiefly composed of large oxea 250–350 μ in length and 7–10 μ in width, together with smaller oxea 200–250 μ in length and 2–3 μ in width, not very numerous; and thinly scattered very slender oxea, 100–200 μ in length and 1 μ in width. The spiculation approximates nearly to that of Bowerbank's *H. caduca*.

Reniera, Nardo.

Without yet having had an opportunity of examining any of Bowerbank's original specimens of this difficult genus, the species here considered are named so far as possible from his descriptions and figures alone.

Reniera indistincta (Bowerbank).

At Position 3, two specimens, each forming a shallow investing growth on *Inachus*.

„ „ 12, one specimen, forming an irregular growth on a *Pecten* valve, with tubular processes; 10 mm. in extent.

„ „ 14, two specimens, one forming a shallow investing growth on *Inachus*, the other an irregular mass, 30 × 20 mm. in extent, intermingled with Hydroids and forming tumulous elevations.

„ „ 25, one specimen, with basal attachment 15 mm. in diameter, and one lateral prominence, surmounted by a tubular process 15 mm. in height; on a *Chaetopterus* tube.

Depth, 40–46 fath.

The large oxea range from about 140 to 170 μ in length by 5–6 μ in width, as against dimensions shown by Bowerbank of about 158 μ by 4 μ. With these occur numerous more slender oxea, 120–140 μ by 2 μ, and also slender hair-like oxea scattered irregularly, averaging about 100 μ by 1 μ or less.

Reniera sp. (A.).

At Position 56, one specimen, forming a small growth on *Inachus leptochirus.*

Depth, 49 fath.

Skeleton mostly unispicular and very similar to that of the preceding, but the main skeleton spicules are longer and more slender in proportion, ranging from 150 to 200 μ by 4 to 5 μ. Smaller oxea and fine hair-like oxea occur as in the last species.

Reniera sp. (B.).

At Position 6, one specimen, forming an irregular massive growth on stems of *Antennularia*, etc.

Depth, 42 fath.

Skeleton almost entirely unispicular, but with the reticulation very irregular. Large oxea of much the same length, 150–170 μ, as in specimens referred to *indistincta*, but much wider, 7–8 μ, and remarkably uniform in size. Slender hair-like oxea scarce.

Reniera pygmaea (Bowerbank).

At Position 40, one specimen growing from dead base of *Antennularia.*

Depth, 44 fath.

The specimen forms a short bifurcated growth of about 25 mm. in height, and 6 mm. in diameter of branches, arising from a narrow stem. In appearance and general texture it bears a certain resemblance to a small *Chalina oculata*, as Bowerbank remarks of specimens before him. A comparatively large quantity of spongin occurs at the ends of the spicules, which at times seem almost entirely invested by a thin layer of it. The oxea of the main skeleton, averaging 110 by 5 μ, are more slender than Bowerbank shows for *pygmaea* as 118 by 7 μ. A number of more slender oxea occur in addition.

Reniera densa (Bowerbank).

At Position 1, one specimen, forming an irregular mass of dense texture about Hydroids. Height 25 mm.

Depth, 40 fath.

The radiating lines of the main skeleton are distinct and largely multispiculous. The remainder of the reticulum is somewhat irregular. Spicules exceptionally uniform, with an almost entire absence of slender forms. Dimensions from 120 by 6 μ to 140 by 9 μ. The measurements shown by Bowerbank are 130–145 μ by 10 μ.

Reniera sp. (C.).

At Position 62, one specimen.

Depth, 50 fath.

The specimen is a fragment torn from its base, consisting of a thimble-shaped process, 25 mm. in height by 17 mm. in width, with an osculum of 5 mm. in diameter at the summit. Texture soft and flexible. Skeleton rather irregular, with spongin very little developed. Average measurement of large oxea about 190–200 μ by 8–10 μ. A few styli of about the same width but a little shorter are intermixed abnormally, also very occasionally short smooth strongyla of the same width. Slender oxea rather numerous and scattered, ranging in size from about 100 by 2 μ to 150 by 3 μ.

POECILOSCLERIDAE, Topsent.

ESPERELLINAE, Ridley and Dendy.

Esperiopsis paupera (Bowerbank).

At Position 3, one specimen, forming an irregular growth on *Sertularella gayi*. Length 25 mm.

„ 33, one small specimen on dead *Pecten* shell, 11 mm. by 5 mm., with one osculum, with ova at base.

„ 36, one specimen, forming a small column, 9 mm. in height, with narrow spreading base. On *Porella compressa*.

„ 38, one specimen, an irregular creeping growth, about 10 mm. by 4 mm. in extent, with a free raised lobe. On *Pallasia* tube.

„ 49, small patches on *Inachus leptochirus*.

Depth, 40–47 fath.

Ridley and Dendy (31) have included the *Isodictya paupera* of Bowerbank, with a query, among the synonyms of his *I. edwardsi*, and it may be that the two forms are merely varieties of the same species. I have retained, however, the former name for the five specimens here considered, because in no case do the main skeleton spicules approximate to those shown by Bowerbank for *I. edwardsi*, while their difference from those of *paupera* is inappreciable. Excepting that from

Position 33, in which there is a small raised osculum and the texture is rather more compact, the specimens have all the same meagre straggling habit of growth, with loose attachment to their base. The skeleton has a more or less regular arrangement of compact multispicular lines following a sinuous course from base to surface, with spicules connecting these largely at right angles in such a way as often to enclose with the main lines a series of rough rectangles, in the vertical section. The spicular dimensions are very variable. The larger main skeleton styli average about 180–200 μ in length, by 6–7 μ in width. In the specimen from Position 36, the average width is lower —about 5 μ. There is no clear line of separation between these and the secondary styli, averaging about the same length and half the width. Very slender, irregularly disposed, hair-like styli of 120 to 150 μ by 1 μ, or less than 1 μ, and isochelae averaging 18 to 20 μ in length, are both usually very numerous. In the specimen from Position 49 both are comparatively scarce. Except in this last-named example abnormalities are frequent, in the form of medial bulb-like swellings in the spicules. Sometimes these occur more especially in the intermediate-sized styli; often rather more so in those of the main skeleton. The tendency is very pronounced in the specimen from Position 38, in which a considerable proportion of the larger styli show this abnormality, and occasionally two such swellings appear in the shaft. In this specimen a large oxeote spicule occurs in one section, with the same swelling in the centre.

Esperiopsis sp.

At Position 5, one specimen, forming large nodulous growths, almost entirely covering a large specimen of *Inachus dorsettensis;* with two large oscula, 5 mm. in diameter, raised on prominences, and numerous small ones, 1 to 2 mm. in diameter, scattered over the surface.

Depth, 42 fath.

While very distinct in its external form and more compact texture from the preceding species, the internal structure and spiculation of this specimen differ little from it. The main lines of the skeleton have nearly the same arrangement. The chief difference lies in the dimensions of the spicules, and this is not very considerable. The larger styli average about 150 μ by 7 μ; intermediate styli, 150 μ by 2–3 μ; hair-like styli, occasionally centrotylote, 100–150 μ in length, not very numerous; isochelae of the same form and size as in the last species, very scarce. But for Bowerbank's remark concerning the great irregularity of the main skeleton of *imitata*, which can hardly be applied to this specimen, it would seem to approximate closely to that species.

Esperella sp.

At Position 72, one specimen, forming a thin even investment on one valve of living *Pecten opercularis.*

Depth, 43 fath.

I find no described species to which this specimen seems referable. The main lines of the skeleton are composed of smooth styli, decidedly but not strongly clavate; fairly uniform in size, and averaging about 240 μ by 4 μ. These arise as numerous loose fasciculi, composed of about a dozen spicules, which subdivide and occasionally anastomose in rough curves, and split up internally or at the surface in fan-like extensions. Irregularly disposed styli in the interspaces are not very numerous. The microsclera are of five forms: (1) large palmate anisochelae averaging about 30 μ in length, arranged mostly in rosettes; (2) large bidentate anisochelae of same size, often associated in rosettes with the preceding, and possibly an immature form of them; (3) small bidentate anisochelae, variable in size, but averaging about 12 μ in length, mostly scattered, not very numerous; (4) sigmata, about 30 μ (one only was observed in a preparation lying in an unsuitable plane for measurement); (5) very slender toxa about 130 μ in length. The toxa are chiefly associated with embryos at the base of the sponge, and one pole of one of these embryos is covered with rosettes of the third form of anisochelae as close to one another as they can lie. It is quite possible that this specimen is an irregular form of Bowerbank's *Raphiodesma floreum.* In habit of growth and in most of its characters it strongly resembles his description of that species. The noteworthy differences are that in the latter Bowerbank makes no reference to the small anisochelae as tension spicula, but refers to numerous small sigmata in their place which do not seem to occur at all in this specimen. That he should make no mention of toxa is perhaps not surprising, since they scarcely seem to exist in the specimen apart from the embryos, whatever their function in this respect may be. Very fine styli of about 140 μ in length are likewise associated with these embryos, and almost exclusively so.

Desmacidon fruticosus (Montagu).

At Position 7, one, on valve of *Pectunculus glycimeris.* Small sigmata very numerous.

„ „ one large specimen. Small sigmata scarce.

„ 58, two detached specimens; the largest 70 mm. in height. Sigmata and chelae very scarce.

At Position 59, one very young specimen, 7 mm. in diameter by 4 mm. in height. On dead valve of *Pecten opercularis.* Sigmata numerous. Several of the slender oxea were observed to be strongly centrotylote.

" vii., one, of irregular form, measuring 100 by 25 mm. Sigmata numerous.

" 77, one large specimen.

Other examples, not retained, occurred at Positions 8, 14, 34, 43, 44, 68, 76 (a few), 78 (a few).

Depth, 42–52 fath.

DENDORICINAE, Topsent.

Dendoryx incrustans (Esper).

At Positions 3 (five), 4 (two), 13 (one), 14 (one), 43 (one), 52 (one), 60 (one), 64 (one).

Depth, 40–53 fath.

The specimens varied in habit from that of a thin investment on *Inachus*, *Cellaria*, etc., to that of an irregular more or less massive growth on Hydroids and other objects, the largest measuring 65 mm. in height by 70 mm. in width.

Dendoryx (Iophon) nigricans (Bowerbank).

At Positions 46 (one), 59 (one).

Depth, 47–49 fath.

Ridley and Dendy (31) united Bowerbank's four species *Halichondria pattersoni*, *H. scandens*, *H. hyndmani*, and *H. nigricans*, as varieties of the one species *pattersoni*, under the genus *Iophon*, which is distinguished by the presence of bipocilli as microsclera. Topsent (31) objects to this, and particularly to the inclusion of *pattersoni*, on the grounds that Bowerbank makes no mention of bipocilli occurring in that species. I follow Topsent in treating *Iophon* as a sub-genus of *Dendoryx*, and refer the two specimens here considered to *nigricans* as more nearly in conformity with Bowerbank's description of that form, though in some particulars they vary from it.

The specimen from Position 46 is a large one, of very irregular, partly massive, partly branching and anastomosing growth, evidently attached to *Lepralia foliosa* and partly intermingled with a few hydroids. The dimensions are about 140 mm. by 100 mm., the latter probably having represented the height of the specimen, which was broken. That from Position 59 formed an irregular spreading growth on a fragment of a *Mactra* valve, measuring 25 by 20 mm. in extent. Both examples are of a soft spongy texture, with irregular corrugated surface, and dark purplish brown in colour.

The styli of the main skeleton are faintly, sometimes strongly spined, chiefly at the base, and the majority are curved. The average length is in the first specimen about 200 μ; in the second about 190 μ. In neither case does it exceed 230 μ, which is a good deal less than Bowerbank's figure shows. Many of the spicules are slightly wider in the middle. The width is very variable, ranging from 4 to 7 μ, and averaging about 6·5 μ.

The tylota average in the first specimen about 205 μ by 4·5 μ, in the second about 215 μ by 5 μ. The ends are feebly expanded or often simple and faintly spined. The intermediate portion is smooth, with the central part usually the widest.

Extremely slender hair-like styli often curved, of about 150 μ in length, irregularly dispersed, are numerous.

Anisochelae very scarce; length 22 μ.

Only very few bipocilli were observed after careful searching. These measure about 7 μ in length, and are of the form figured by Bowerbank for the species.

Dendoryx robertsoni (Bowerbank).

At Position 78, one specimen. Form massive, irregular, 70 × 50 × 40 mm. in height. Broken from attachment—probably a stone.

Depth, 49 fath.

Both in external form and skeleton, the specimen closely agrees with Bowerbank's description of the species.

Megasclera. Spined styli averaging about 185 μ in length, and mostly from 4 to 7 μ in width. Tylota with ends sometimes bluntly pointed, of about the same average length, and 4·5 μ in width at centre of shaft.

Microsclera. Sigmata, 33 μ; large isochelae, 33 μ; small isochelae, 18 μ. None of the microsclera are very numerous.

Dendoryx dujardini (Johnston).

At Position 49, one specimen, thinly investing a living valve of *Pecten opercularis.*
„ 67, one specimen, forming small patches on *Inachus leptochirus;* with a quantity of brown pigment present.

Depth, 47–52 fath.

The skeleton has a rough arrangement of sinuous multispicular lines with a large number of isolated spicules, irregularly dispersed between them, and supporting a somewhat dense and very confused dermal network. The strongyla, of which the ends are often faintly tylote, mostly range in the first specimen from 190 μ to 220 μ in length, by about 3 μ in width. In the second specimen they are longer and much more slender on the average, about 220 by 2 μ. Spined tylostyli are extremely scarce, one only, in fact, having been observed in one specimen, and none in the other. This spicule has the characteristic prominent head, and measures about 92 μ. Embryos are present in both specimens; several in one case, irregularly located. In a few instances the tylota have a prominent bulbous swelling at the centre, or some way from one end. The proportions of the spicules seem very instable in this species. In a specimen obtained from within two miles of the Eddystone Lighthouse they average about 185 μ (many falling to 120 μ) by 1·5 μ, or less, while in a preparation of another specimen only a few are to be found at all.

BUBARINAE, Topsent.

Bubaris vermiculata (Bowerbank).

At Position 15 (four), 38, 43, 44 (two), 47 (five), 59, 60.

Depth, 44–49 fath.

The examples have all the form of a thin cementing investment about dead valves and fragments of *Pecten*, *Cardium*, *Lima*, etc., and larger or smaller pebbles. The maximum extent ranges from 9 to 45 mm.

ECTYONINAE, Ridley and Dendy.

Stylostichon plumosum (Montagu).

At Position 10, one specimen, forming an irregular growth coating tubes of *Pallasia murata*, etc. Measurement, 85 × 45 × 25 mm.

„ 49, one specimen, forming a nodulous investing growth, cementing together shell fragments and gravel, with *Cellaria*, etc. Measurement, 50 × 33 × 20 mm.

Depth, 42–47 fath.

Acanthostyli: *Large*, 180–280 μ (average about 226 μ) in length, and 5·5–7·4 μ (average about 7·2 μ) in width. *Small*, 85–160 μ (average about 120 μ) in length, and 5·5–7·4 μ (average about 6·8 μ) in width. There is no distinct line of separation between these and the preceding.

Oxea. Straight, suddenly pointed: 185–207 μ (average 195 μ) in length, and 3·5–5·5 μ (average 5 μ) in width.

Isochelae. Mostly bidentate, but many tridentate: 14·5–18·5 μ.

Bowerbank mentions this coating variety, thinly investing stones, from the Diamond Grounds, off Hastings.

AXINELLIDAE, Ridley and Dendy.

Raspailia hispida (Montagu).

Specimens referred to this species occurred at Positions 3, 4 (two), 7, 8, 33, 38, 40, 43, 52, 53, and 80 (two).

Depth, 40–51 fath.

Seven other specimens were obtained at positions of which the record was lost, but which probably all lay between ten and twenty miles to the south-westward of the Eddystone.

Among the numerous and often considerable differences in external form and spiculation of these several examples, there appears to be no single character that may be regarded as affording safe grounds for separating them. In the form and proportions of the spicules especially, the extent of variation is so great, not only between one individual and another but often in the same individual, that careful examination has led me to include them all together as variations of the *Dictyocylindrus hispidus* of Bowerbank. A single specimen has the external form on which Bowerbank founded a separate species under the name of *Dictyocylindrus rectangulus*, but there is nothing in the spiculation to justify its separation from several examples having the simple, upright branching habit of growth throughout. Three specimens are of the free form (one being the *rectangulus* type referred to), branching at one or both ends, as figured by Bowerbank for *D. hispidus*, and apparently referred to by Montagu. Others have a similarly slender growth with few branches from their base of attachment. In another specimen three branches arise almost simultaneously from a common stem about 8 cm. from the base of attachment. In some others the growth is much stouter, and roughly dichotomous. In most cases growth extends in about the same vertical plane. The greatest length is attained in a free form of 36 cm. Four specimens are deeply pigmented (with a dark ruddy brown colour, in spirit); the others were, from recollection, pale or brighter yellow in life.

The axial skeleton is somewhat loose and irregular, with a large number of the spicules crossing one another at varying angles, and often lying nearly or quite at right angles to the main axis. From it, with their bases often deeply placed, spicules arise separately or in indefinite groups and nearly at right angles outwards, and extend far beyond the surface. Most of the latter are styli, but some strongyla occur among them. They are generally very similar in size to those of the axial skeleton, but often rather stouter. Sometimes their points are directed inwards. At or near the surface many of them are surrounded by a radiating fasciculus of small slender styli of about

400–450 μ in length by 3 μ in width. A varying number of similar slender styli and oxea, of the same dimensions and larger, run longitudinally or irregularly through the column, and especially close below the surface. These are occasionally strongly curved and almost sigmatoid, and often occur in pairs. The axial megasclera are extremely variable in form and dimensions. They consist mainly of styli, usually with strongyla and oxea intermixed in greater or lesser proportion.

Styli often much curved, rarely (specimen from Position 40) very sharply pointed, usually bluntly pointed or even rounded, leading to the strongylous form. Base generally simple, often more or less tylote, or, in individual spicules in certain specimens, very strongly so. Dimensions, 700–1900 μ in length and 11–22 μ in width; averages in different specimens, 1100–1700 μ in length and 14–17 μ in width, respectively.

Strongyla were not observed in specimens from 38, 40, 43, and 53; scarce in those from 4, 7, and 8; common or numerous in those from 3, 4, 33, 52, 77, and 80. They vary from short stout forms of 180–450 μ in length and as much as 33 μ in width to more slender forms of 800–1200 μ in length and 15–18 μ in width. The short stumpy forms were observed only in specimens from 3, 4, 52, 77, and in one of those of doubtful position, and appear to be often associated with the more slender habit of growth. The fact that Bowerbank does not mention the occurrence of strongyla in his description of *R. hispida* cannot, I think, be considered of sufficient importance to exclude from that species specimens which have them, often in large numbers. It is inconceivable that Montagu's original specimens, including the familiar type he figures (29, Pl. V), obtained by trawlers off the Devon coast, were distinct from some specimens here considered of identically similar habit, in which numerous strongyla occur.

Oxea were not observed or scarce in specimens from 3, 4, 8, 40, 53, and 80; numerous or very numerous, often strongly curved, in those from 7, 8, 33, 43, and 77. In number they sometimes nearly equal or exceed that of the styli. Their dimensions range from 700 to 1200 μ in length and 8 to 19 μ (average about 15 μ) in width.

Acanthostyli were not observed or scarce in specimens from 3, 4, 7, 8, 33, 40, and 80; numerous or very numerous in those from 4, 38, 43, 52, and 53. Length, generally 85 to 100 μ, occasionally reaching 140 μ. Width at base (not including basal swelling when present), 5 to 7 μ.

Raspailia ramosa (Montagu).

Single specimens at Positions 46, 49, 67, 77.

Depth, 47–52 fath.

The four examples which I assign to this species, though closely allied to some specimens of the preceding species in general characters, are distinct from them in certain details, and notably in the shape of the acanthostyli, which with comparatively rare exceptions are much longer, more slender, and more finely pointed. In external form, two of the specimens rather closely resemble that of Ridley and Dendy's figure of *Dendropsis bidentifera* (30); one, from Position 46, is of slender, straggling, long-branched growth; the fourth occupies an intermediate position between these two forms. One is lightly, the others deeply pigmented, with a rufous-brown colour in spirit.

The main features of the spiculation are very similar to those described for the preceding species, but the spicules of the axial column are rather more irregularly disposed. The large *styli* are comparatively stout. These range from 800 to 1600 μ in length, with an average of about 1100 μ (higher or lower in different examples), and from 11 to 18 μ, with an average of about 16 μ, in width. *Strongyla* are present in specimens from 46 and 67; length, 450 to 1000 μ (average about 650 μ); width, 16 to 22 μ (average about 19 μ). Round-ended styli occur in the specimen from 49, but true strongyla were not observed in this or the specimen from 77. *Oxea* occur in the specimen from 46 only; length 800 to 1100 μ; width 15 μ.

Very slender styli and oxea occur, scattered more or less numerously through the column, and commonly in pairs or small groups, as in the preceding species. There is some difficulty in distinguishing many of these paired forms from what appear to be elements in process of constructing the larger styli.

Acanthostyli longer, more slender, and more sharply pointed than in the preceding species. Length, 95 to 166 μ (average about 129 μ). Width, 4·5 to 6·5 μ (average 5 μ).

Acanthoxea occur in very small numbers, intermixed with the acanthostyli, in specimens from 46 and 49, but I have been unable to find them in the other two. The example from 49 is one of the two already referred to as rather closely resembling Ridley and Dendy's figure of *Dendropsis bidentifera*. It is an interesting fact that this species is especially characterized by the presence of small acanthoxea, and the genus *Dendropsis* was founded to receive it. In the present case, however, I can only regard these spicules as abnormalities of the acanthostyli, which vastly outnumber them. They are nearly always centrotylote, and in one instance observed the tylote expansion is elongate with a distinct constriction in the centre of it. Length, 118 to 225 μ (average 187 μ). Width, not including expansion, 4·5 to 5·5 μ (average 5 μ).

Raspailia stuposa (Montagu).

Single specimens at Positions 31, 32, 51, 53, 60, 67, 80.

Depth, 40–51 fath.

The smallest example is 22 mm., the largest 50 mm., in height. The growth is fairly uniform and symmetrical, the branches spreading roughly in the same plane, and being much compressed laterally in a plane at right angles to that of the growth. Pigmentation (in life dark brown) is absent in specimens from Positions 51, 53, and 60; moderately strong in those from 31 and 80; very deep, giving an almost black appearance superficially, in those from 32 and 67.

The stellate microsclera are very abundant in all the specimens.

COELENTERATA.

HYDROMEDUSAE.

CLAVIDAE.

Merona cornucopiae, Norman.

On *Dentalium entalis* at Positions 1 (common); 11 (two; one with gonophores); 36 (one); and on *Pectunculus glycimeris* at Positions 46 (one), and 51 (one).

Depth, 40–43 fath.

HYDRACTINIIDAE.

Hydractinia echinata, Fleming.

One colony on a young shell of *Fusus islandicus* at Position 52.

Depth, 43 fath.

PODOCORYNIDAE.

Podocoryne (?) sp.

At Position 49, in 47 fathoms, a small Hydroid colony was found growing on a *Macropodia*, which, though lacking in certain adult characters of this genus, is provisionally recorded under it because there seems to be no other genus with which it can be associated.

The colony consists of a large number of simple short polypes arising directly from a hydrorhiza, which is composed of a close network of anastomosing tubes. I have not been able to detect any trace of a chitinous perisarc investing the hydrorhiza, or any cup-like processes from the hydrorhiza surrounding the bases of the hydranths. The hydranths, which number about 200, are closely crowded together, and arise from a somewhat constricted base in direct continuation with the simple tubular stolon. They were not examined in life, but in their semi-contracted condition in spirit the largest do not exceed 1·5 mm. in height, while the majority are considerably smaller than this. The form of the more extended ones is nearly cylindrical with a width equal to about one-fourth or one-fifth of the height, with the apical portion somewhat claviform and surmounted by a rounded conical hypostome. A short way below the hypostome there is a single row, or, perhaps more correctly, a double row of simple tentacles, which often show a distinct arrangement of large and small ones alternately, the smaller ones apparently arising slightly below the origin of the others. The tentacles number from eight to twelve. There is no gonosome present in the colony.

EUDENDRIIDAE.

Eudendrium capillare, Alder.

Small colonies at Positions 3, 6, 10, 11, 38, 40, 49, 59, 80. On *Cellaria* and Hydroid stems and *Chaetopterus* tubes.

Depth, 40–51 fath.

Eudendrium sp.

A very small species, much like the preceding, but of rather stouter habit, and perhaps distinct from it, was obtained at Positions 14, 32, 40, and 53. On *Cellaria* and Hydroid stems.

Depth, 42–46 fath.

Eudendrium ramosum (Linn).

Several small colonies at Position 34, and four colonies, from ½ to 1 inch in height, on a fragment of a bivalve shell at Position 56.

Depth, 42–49 fath.

BOUGAINVILLIIDAE.

Bougainvillia ramosa (van Beneden)?

Small branching colonies of a *Bougainvillia*, probably referable to this species, but with none bearing gonophores, were obtained at Position 5, on *Inachus dorsettensis*, and at Positions 14, 35, and 59, on Hydroids and *Cellaria.*

Depth, 43–49 fath.

TUBULARIIDAE.

Tubularia sp.

A single small *Tubularia*, which was not identified, was taken at Position 1.

Depth, 40 fath.

CAMPANULARIIDAE.

Clytia johnstoni (Alder).

Only observed at Position 5, on *Inachus dorsettensis*.

Depth, 42 fath.

Campanularia flexuosa (Hincks).

At Positions 14, 31, 32, 35, 38, 43, 49, 51, 59, 60, 62, 80. Chiefly on *Cellaria*, also on other Hydroids, and one on a shell fragment. Mostly small colonies, not exceeding 8 mm. in height. The largest occurred at Position 62, on a small shell fragment with several branching growths arising from the basal stolon. Specimens from 32, 51, and 62 bore gonangia. A few of the others incline to the more slender form of *angulata*, but there seems little doubt that they all belong to the same species.

Depth, 40–51 fath.

Campanularia hincksi, Alder.

At Positions 3, 4, 7, 12, 13, 31, 32, 33, 34, 35, 38, 42, 43, 45, 47, 49, 53, 56, 60, 62, 80.

Depth, 40–51 fath.

On Hydroids, *Cellaria*, dead shells, and one on *Scalpellum*. A single colony only occurred with gonangia at Position 62.

Campanularia verticillata (Linnaeus).

One colony at Position 3, on *Cellaria*.

Depth, 40 fath.

Campanularia raridentata, Alder.

Scattered polyps, apparently identical with this species, were observed at Positions 4, 12, 13, and 49.

Depth, 40–47 fath.

Gonothyrea gracilis (Sars).

At Positions, 14, 33, 35, 51, 58, 59, 62.

Depth, 42–50 fath.

On *Cellaria*, occurring in most cases as single scattered polyps, but occasionally of erect branching form. Gonangia were borne on specimens from Positions 14, 35, and 58.

This species which has not hitherto been recorded in the Plymouth fauna has a wide distribution :—Norway, Baltic, Helgoland, Connemara, Liverpool Bay, Pas de Calais, Messina, South America (cp. Hartlaub, 53 ; Broch, 50 ; Thornely, 63).

CAMPANULINIDAE.

Opercularella lacerata (Johnston).

At Positions 4, 10, 11, 13, 14, 32, 40, 62, 64, vii.

Depth, 40–49 fath. or over.

On Hydroids and *Cellaria*. The species is probably of commoner occurrence over the area than these records show. Growth in most cases simple, with single polyps arising from a stolon. Branching specimens occurred at Positions 13, 14, and 32. One specimen with gonangium at Position 32.

LAFÖEIDAE.

Lafŏea dumosa (Fleming).

In varying-sized colonies, creeping or branched, at nearly every position, including the last, 80.

Depth, 40–52 fath.

Lafŏea fruticosa, M. Sars.

At Positions 1, 11, 12, 31, 32, 36, 45, 49, 58, 60, 62; occurring mostly in very small colonies.

Depth, 40–50 fath.

Calycella fastigiata (Alder).

Only observed at Positions 36 and 40, on *Porella* and *Cellaria.*

Depth, 43–44 fath.

Cuspidella costata, Hincks.

At Positions 3, 49, 59, vii; growing on *Cellaria.*

Depth, 40–49 fath. or over.

HALECIIDAE.

Halecium beani (Johnston).

At Positions 4, 35, 38, 43. Very small colonies, excepting a large specimen at Position 35, on which gonangia were borne.

Depth, 40–45 fath.

Halecium halecinum (Linnaeus).

At Positions 1, 3, 10, 12, 33, 51, 53, 56.

Nowhere obtained in large quantities, and usually occurring as quite small colonies.

Depth, 40–49 fath.

Halecium muricatum (Ellis and Solander)?

At Positions 14 and 32.

Two small colonies in each case, growing on *Cellaria* and the dead stem of a *Sertularian* respectively. Height, from 8 to 27 mm. These specimens appear to belong to this species, but in the absence of any gonothecae their identity is left in doubt.

Depth, 42–44 fath.

Halecium labrosum, Alder.

At Position 12; one small colony of 20 mm. in height, growing on a tube of *Pallasia murata.*

Depth, 42 fath.

Halecium tenellum, Hincks.

At Positions 49, 59, 62, 80.

On *Antennularia*, *Cellaria*, etc. Plentiful at the two last-named positions.

Depth, 47–51 fath.

SERTULARIIDAE.

Sertularella gayi (Lamouroux).

At nearly all positions, including the last, 80.

Depth, 40–51 fath.

The species occurred rather plentifully on the fine sandy ground covered by the first cruise, i.e. within 10 miles of the Eddystone. On the rougher ground outside this, fair-sized colonies were found at Positions 60 and 80, some specimens at the latter point bearing gonangia. But in the great majority of the hauls the material obtained was small in quantity, and in many cases only very young colonies were observed.

Sertularella polyzonias (Linnaeus).

This species was only recorded from Positions 33, 49, and 62, in small colonies. It is not improbable that it was overlooked in some cases among the material of the preceding species.

Depth, 42–50 fath.

Sertularella tenella (Alder).

At Positions 11, 14, 31, 35, 42, 49, 53, 56, 67, 80.

Depth, 40–51 fath.

On *Sertularia abietina, Sertularella gayi, Diphasia attenuata, Hydrallmania*, etc., and on *Cellaria*; many colonies occurring at Positions 14, 35, and 56.

The species has not hitherto been recorded in the Plymouth fauna.

Distribution: Northumberland; South Devon; Filey, Yorks; Peterhead; Wick; Hebrides; Shetland (cp. Hincks, 55); Isle of Man (G. Wood, 64); Cuba; California; Rio de Janeiro (cp. Nutting, 60); Davis Strait; Smith Sound; Jones Sound; Jan Mayen; Spitzbergen; also in Sub-Antarctic Seas (cp. Broch, 50).

Diphasia attenuata (Hincks).

At Positions 14, 35, 49, 53, 56, 59, 60, 62, vii, 80.

Depth, 43–51 fath. or over.

Chiefly on *Cellaria;* occasionally on other Hydroids; at one position on a *Pallasia* tube. Several colonies at most of the positions enumerated. Especially well-grown colonies occurred at Position 62 with a few male gonangia, and at Position 80, with numerous female gonangia, respectively.

Diphasia pinaster (Ellis and Solander).

At Positions 1, 3, 6, 8, 10, 12, 13, 14, 51, 60, 80.

Depth, 40–51 fath.

A large colony occurred at Position 8. In other cases the specimens were of rather small size or quite young colonies.

Diphasia pinnata (Pallas).

One or two specimens at Positions 14, 35 (dead), 43 (fragment), 60, 62, vii, 80.

Depth, 43–51 fath. or over.

Female gonangia were borne on colonies from 14, 60, and 62.

Diphasia alata, Hincks.

Only obtained at Position 80, where a well-grown colony occurred.

Depth, 51 fath.

It is doubtful whether this species occurs in the Plymouth fauna. There is one specimen in the Laboratory without data, and a second—a good-sized colony, separated from its attachment—which was dredged up on the Mewstone Ledge in June, 1908. It is not certain that the latter specimen may not have found its way there through the medium of trawlers from outside, but in view of the fact that the natural habitat of the species is on the rough ground in the deeper water of the Channel, and far outside the ordinary trawling grounds, it seems more probable that the specimen grew where it was obtained. In the course of a cruise made by the *Oithona* in 1910, the species was found growing luxuriantly in the deeper water between the 50-fathom and 60-fathom lines—that is to say, immediately outside the limits of the cruises dealt with in the present report. Hincks (54) gives as localities of its occurrence: Shetland, and in 40 fathoms; Hebrides, Falmouth, Cornish coast. The distribution of the species outside British waters appears to be very limited: Stavanger, Norway, 50–100 fathoms (G. O. Sars, 62). *Hirondelle:* Bay of Biscay, 131–300 m.; Azores, 130–318 m. (Pictet et Bedot, 61). *Travailleur:* Bay of Biscay, 411 m. *Talisman:* Azores, 115 m. (Billard, 48).

Sertularia abietina, Linnaeus.

At Positions 9, 11, 14, 35, 43, 45, 49, 53, 59, 60, 62, 67, vii, 80.

Depth, 42–52 fath. or over.

On dead *Pecten* shells, etc. Few of the examples were in healthy condition, and several were dead and overgrown.

Sertularia argentea, Ellis and Solander.

At Positions 3, 7, 11, 12, 44, 49, 53, 56, 60, 80.

Depth, 40–51 fath.

On shells of *Pecten opercularis, P. maximus, Lutraria, Modiola,* etc. Mostly small or young colonies.

Hydrallmania falcata (Linnaeus).

This species was found generally distributed over the whole area, and was recorded at nearly all positions, including 62, 64, and 80. It was commonly attached to shells of *Pecten*, etc., and once *Porella.* It occurred very commonly on stones dredged up nearly everywhere, and in such cases often as good-sized colonies.

Depth, 40–51 fath.

Thuiaria articulata (Pallas).

A fragment only was obtained at Position 13.

Depth, 42 fath.

PLUMULARIIDAE.

Antennularia antennina (Linnaeus).

At Positions 1, 3, 4, 6, 7–12, 14, 15, 32, 38, 40, 43, 48, 49, 56, 58, 62, 64, vii, 77, 80.

Depth, 40–51 fath. or over.

Colonies occurred growing on shells and stones at Positions 7 and 62, several being so attached at the latter point. Specimens bore gonophores at 62 and at the doubtful position in Cruise VII. A fine colony was obtained at Position 64, but the growth was not otherwise remarkably luxuriant in specimens anywhere, and the quantity obtained was in most cases small.

Antennularia ramosa (Lamouroux).

At Positions 1, 3, 7, 13, 14, 32 (dead), 43, 60.

Depth, 40–50 fath.

A colony at Position 1 carried several *Scalpellum.* The species was not numerous at any point.

Aglaophenia myriophyllum (Linnaeus).

At Positions 11 (four), 14 (one), 32 (one), 33 (two), 37 (one), 40 (one), 43 (two small), 46 (one), 56 (one), 60 (two), 62 (four), 67 (one).

Depth, 40–50 fath.

Gonangia were borne on one colony at Position 60.

Aglaophenia tubulifera (Hincks).

At Position 60; several colonies on *Diphasia pinnata,* one with gonangia.

Depth, 49 fath.

Plumularia catharina, Johnston.

At Positions 1, 3, 4, 31, 33, 37, 38, 43, 52, 56, 59, 60, 62, vii, 80.

Depth, 40–51 fath. or over.

Generally of small or very small size; on tubes of *Chaetopterus* and *Pallasia,* and on *Scalpellum, Macropodia, Hyas, Pecten, Cellaria,* etc.; often numerous, several colonies occurring at the same position; plentiful at Position 80. The creeping form described by Hincks (54) occurred exclusively at Positions 4, 37, 38, 52, 56, 59, 60; bearing gonangia at 37, 38, 52; and predominated over the branching form at 62 and 80. The branching form bore gonangia at Position 3.

Plumularia echinulata, Lamarck.

Small colonies at Positions 10, 31, 34.

Depth, 40–42 fath.

On a tube of *Pallasia,* on *Pecten opercularis,* and on *Porella,* respectively. I have been unable to distinguish these specimens from Hincks' description of *echinulata,* despite the fact that he only records it from shallow water, and that it has only hitherto been recorded at Plymouth inside the breakwater, and in the Yealm Estuary.

Plumularia frutescens (Ellis and Solander).

A fragment at Position 52, on *Macropodia.*

Depth, 43 fath.

Plumularia similis, Hincks.

A small colony at Position 56; several on *Sertularia abietina* at 60; and on *Macropodia* at 64.

Depth, 49–50 fath.

Plumularia pinnata.

At Positions 1, 3, 4, 7, 35, 43, 44, 45, 49, 51, 64, vii.

Depth, 40–53 fath.

On *Diphasia*, *Macropodia*, *Pisa*, *Cellaria*, etc. Gonangia were borne on colonies from Positions 3 and 4.

Plumularia setacea (Ellis).

At Positions 3, 36, 62, vii.

Depth, 40–50 fath. or over.

Colonies from all four positions bore gonophores.

At Position 62, and the doubtful position in Cruise VII, several colonies were obtained, growing on the creeping form of *Plumularia catharina*, and all of very slender growth and small size. In the largest group, at vii, not exceeding 15 mm. in height, two of the colonies bore numerous gonangia, and the greater number of the pinnae were monothecate. At 62 another group of four colonies occurred, of very minute size, not exceeding 3 mm. in height, and with all the pinnae monothecate. One of these bore a single gonangium. Nutting (59) refers to a minute form obtained by the *Albatross* from floating drift weed, which may be comparable with this. He treats it as an aberrant form of *setacea*, but suspects that the gonosome if present would prove it to be a distinct species. In regard to the specimens here considered, there can be no doubt that they all belong to *setacea*, while the entirely monothecate form at 62 is connected with the ordinary type by the intermediate, partly monothecate, form at vii.

Polyplumaria flabellata, Sars.

One small colony of 20 mm. in height was obtained at Position 56, and one large well-grown colony at Position 80.

Depth, 49–51 fath.

The species has not previously been recorded from British waters.

Distribution: Stavanger, Norway, 50–100 fath. (Sars, 62); Bay of Biscay, 134–300 m., and Azores, 130–318 m. (*Hirondelle*, Pictet et Bedot, 61); Bay of Biscay, 411 m., and Azores, 128 m. (*Travailleur et Talisman*, Billard, 48). Pictet and Bedot (48) regard the *Diplopteron insigne* of Allman (45), obtained off the south-west coast of Spain in 364 fath., and the *Polyplumaria pumila* of the same author (46), obtained by the *Challenger* at the Azores in 450 fath., as synonymous with *P. flabellata*.

Several fine colonies of this species were obtained during a cruise of the *Oithona* in 1910, from the deeper water between the 50–fathom and 60–fathom lines, in company with the colonies of *Diphasia alata* already alluded to under that species.

ALCYONARIA.

ALCYONIDAE.

Alcyonium digitatum, Linnaeus.

Recorded from three-fourths of the positions, including bottom samples; generally plentiful, and at 3, 53, and 68 abundant. The outermost point at which it was recorded was Position 66, distant 41 m., depth 52 fath., where it was plentiful. Of the seven hauls made outside this, three were bottom samples.

A single specimen of the yellow variety was obtained in 40 fath. at Position 4 (cp. Hickson, 53, p. 349).

ZOANTHARIA.

CORALLIMORPHIDAE.

Corynactis viridis, Allman.

Several specimens of this species were obtained on stones and on shells of *Pinna* at Position 80, but it occurred at no other position.

Depth, 51 fath.

SAGARTIDAE.

Sagartia miniata (Gosse).

Chitonactis coronata (Gosse).

Paraphellia expansa (Haddon).

The records of these three species are incomplete. I am indebted to Mr. C. L. Walton for having pointed out to me the identity of some of the specimens which he examined in life, admitting of the general statement that *Sagartia miniata* occurred at about fifteen positions, extending over the whole area investigated, while the occurrence of *Chitonactis coronata* and *Paraphellia expansa* was limited to comparatively few positions, though hardly less limited in extent.

Adamsia palliata (Bohadsch).

At Positions 6, 8, 11, 13, 35, 43, 46, 49, 59.

Depth, 42–49 fath.

In most cases as single specimens, and always with the species *Eupagurus prideauxi* when a Pagurid was present (see p. 355).

It is remarkable that though *Eupagurus bernhardus* was frequently recorded, its common associate *Adamsia polypus* never occurred (see p. 299).

ZOANTHIDAE.

Epizoanthus incrustatus, Düben and Koren.

Two specimens were obtained at Position 43, of the carcinoecious form, with six and seven polyps respectively.

Depth, 45 fath.

Epizoanthus couchi, Johnston ?

At Position 15, in 44 fath., two colonies apparently of this species occurred, each growing on a stone. In each case the polyps, which number seven and about fifteen respectively, are partly connected by a ribbon-shaped band, and partly isolated. All are strongly contracted, with the height not exceeding the diameter, which ranges from 5 mm. in the largest to 2 mm. in some of the young polyps. They are thickly incrusted with sand.

Epizoanthus sp.

At Positions 7 (one) and 42 (one), in 42–44 fath., a free form of *Epizoanthus* was obtained which rather closely resembles Holdsworth's description of *Zoanthus rubricornis* (57), and may belong to that species, but the colour of the tentacles was not observed in life. The first specimen consists of two polyps arising at an acute angle from a common base, the largest being 15 mm. in height by 4 mm. in diameter at apex. In the second specimen two polyps arise from a common base at an obtuse angle, their height and greatest diameter being 20 mm. by 5 mm., and 9 mm. by 4 mm. respectively.

TURBINOLIDAE.

Caryophyllia smithi, Stokes.

Recorded at Positions 7, 8, 9–13, 15, 18, 19, 33, 35, 37, 43–45, 47, 53, 56, 58, 59, 62, 64, 80.

Depth, 42–53 fath.

More than one and often several specimens occurred at each position, on shells and stones; many specimens at Position 80. The barnacle *Pyrgoma anglicum* was associated with individuals at 7 (one), 11 (one), 45 (two), and 59 (one).

ECHINODERMATA.

ASTEROIDEA.

ASTROPECTINIDAE.

Astropecten irregularis (Pennant).

A few specimens at Position 4, and single specimens at Positions 37, 49, 59, and 68.

Depth, 40–52 fath.

Luidia sarsi, Düben and Koren.

Single specimens at Positions 34 and 68.

Depth, 42–52 fath.

Luidia ciliaris (Philippi).

At Positions 7 (a few), 10, 18, 26, 28, 34, 35, 40, 43, 46 (juv.), 52, 62 and 64 (one each), 68 (five), 72 (one), 78 (two).

Depth, 42–53 fath.

In his Report on the fauna between the Eddystone Grounds and Start Point, Dr. Allen (1) records three specimens of the preceding species but no occurrence of *L. ciliaris,* and refers to the statement of Ludwig that *L. ciliaris* is generally taken on hard ground, while *sarsi* prefers a muddy or sandy ground. The comparative frequency of *ciliaris* and scarcity of *sarsi* in the area at present under consideration may perhaps be chiefly attributed to the frequently rough character of the ground in this region being more favourable to the former species than to the latter. Ludwig's expression (73, p. 81) . . . "sandigen Boden, namentlich solchen, der mit kleinen Steinen, Conchylien, Corallineen und allerlei Detritus untermischt ist" nearly describes the general character of this area, or at least the smoother parts of it.

Distribution: Sicily, Gulf of Naples, Nice, Gulf of Marseilles, Gulf of La Ciotat, Banyuls, Minorca, Cape Verde Is., Arcachon, Concarneau, Roscoff, Plymouth, Polperro, Falmouth, Stackpole Head, Isle of Man and Irish Sea, S.W. Coast of Ireland, in 55 fath., Kenmare R., Arran,* Berwick Bay, Shetland Is., Scarborough, Faeroe Is., Jutland (?),† Skager Rak (cp. Ludwig, 73; Bell, 65; Forbes, 66).

Vertical Distribution, 4–159 m. (cp. Ludwig, 73).

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* In quoting this record, which is apparently the same as that of Forbes, Bell does not refer to the fact that Forbes does not in this case make it clear to which "variety," as he terms it, the record applies, i.e. whether to *ciliaris* or *sarsi,* but it may be that Bell had definite data to refer to.

† Ludwig questions the certainty of this record (73, p. 81).

GYMNASTERIIDAE.

Porania pulvillus (O. F. Müller).

At Positions 7 (one ?), 8 (two), 20 (one), 34 (three), 36, 37, 59 (one); 64 (one).

Depth, 42–53 fath.

ASTERINIDAE.

Palmipes placenta (Pennant).

At Positions 1 (one), 3 (one), 34 (one small), 37 (one small), 70 (a few).

Depth, 40–43 fath.

SOLASTERIDAE.

Solaster papposus (Fabricius).

At Positions 7 (a few), 8 (a few), 15 (one small), 20 (one), 31 (a few), 34 (one small), 43 (one young), 49, 62, 66 (one), 67 (one), 68 (two).

Depth, 42–52 fath.

ECHINASTERIDAE.

Henricia sanguinolenta (O. F. Müller).

At Positions 8 (four), 25, 44 (one), 45 (one), 59 (two), 77 (one).

Depth, 43–49 fath.

ASTERIIDAE.

Asterias glacialis, Linnaeus.

At Positions 3 (several), 7, 8 (a few), 11 (one), 12 (one), 28 (a few), 34 (one), 35 (two very large), 37 (one), 49 (one), 56, 64 (one), 68, 70 (one).

Most of the records, excepting that at 35, are entered as "large" specimens.

Depth, 40–53 fath.

Asterias rubens, Linnaeus.

At Positions 3 (several), 7, 8 (about a dozen), 22 (one), 31, 32 (two), 34 (two), 35 (three), 36 (one), 37 (four), 49 (one), 51 (one), 53 (one young, diam. 35 mm). 59 (one small), 64 (one), 66 (one), 68 (two), 70 (three), 72 (three), 78 (two).

Mostly entered as "large" specimens.

Depth, 40–53 fath.

OPHIUROIDEA.

OPHIOLEPIDAE.

Ophiura ciliaris (Linnaeus).

At Positions 1, 3, 7, 10, 11, 14, 31, 34, 37, 56, 58, 68, 72.

Single or few specimens at each position. Perhaps 35 specimens in all.

Depth, 40–52 fath.

Ophiura albida, Forbes.

At Positions 1, 2, 11, 12, 15, 31, 32, 37, 43, 44, 47, 53, 55, 56, 63.

A few specimens, or more often single specimens, at each position, excepting several—about ten—at 43.

Depth, 40–50 fath.

Ophiura affinis, Lütken.*

At Positions 5 (four), 46 (one).

Depth, 42–47 fath.

A single specimen of this species obtained by Dr. Allen on the Bolt Head shell gravel ground in 1895 (1, p. 470) is the only previous record of its occurrence in the English Channel.

Distribution: Seaham (Hodge, 68), Firth of Clyde, Shetland (very abundant near Balta), Northumberland coast (Norman, 78, 79; Hodge, 69), Peterhead, Bass Rock, Dogger Bank, Skager Rak (Möbius and Bütschli, 77), Christiania Fjord, The Sound (Lütken, 74), S.W. of Ireland (Haddon, 7), Lesina, Ragusa (Heller, 67), S.E. of Long Island (?) (Leyman, 76).

Vertical Distribution, 6–294 fath.

AMPHIURIDAE.

Ophiactis balli (Thompson).

Recorded from 33 positions in the following proportions:—

From one to five specimens at Positions 1, 5, 7, 40, 47, 53.

A few or several specimens at Positions 6, 8, 10, 11, 12, 16, 18, 32, 33, 34, 43, 44, 45, 56, 59, 62, 80.

Many, or common at Positions 3, 14, 38, 49, 55.

Very common or abundant at Positions 9, 13, 15, 70.

Depth, 40–51 fath.

While these terms serve as a rough approximation to the proportionate distribution of the species, it must be added that they probably in many cases tend to show an under-estimate of actual numbers, and with the exception of the fine sandy ground covered by the hauls 1–4, it might be nearly correct to describe the species as usually very common and often abundant throughout the whole area.

OPHIOCOMIDAE.

Ophiocoma nigra (O. F. Müller).

Recorded from 41 positions, including the first and the last.

Depth, 40–52 fath.

The species was nowhere obtained in large numbers. Many speci-

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* Mr. W. De Morgan kindly determined this species.

mens, perhaps twenty or twenty-five, occurred at 31 and 53; about a dozen at 21, 22, 30, 34–36, 44–46, 52, 56; few specimens or single specimens at all other positions, including 1 and 80.

OPHIOTHRICIDAE.

Ophiothrix fragilis (O. F. Müller).

Recorded from 23 positions, including the first and 63 and 64, but not 80.

Depth, 40–53 fath.

Nowhere obtained in large numbers. The greatest number, not exceeding about a dozen, occurred at Positions 5, 59, and 70. At the other points only a few or single specimens occurred. Small or young specimens were recorded at ten positions, viz. 1, 4, 5, 9, 10, 33, 40, 46, 53, 63.

The frequent occurrence of these small specimens is remarkable, while no such entry occurs in the records of the preceding species. In point of numbers and frequency of occurrence it seems evident, from whatever cause, that *Ophiocoma nigra* is by far the predominating species on these outer grounds. Reducing the comparative terms of entry used for the several records to rough numerical estimates where figures are not shown, I calculate that the total numbers recorded of the two species, *O. fragilis* and *O. nigra* respectively stand in the proportion of about 1 : 2·75.

ECHINOIDEA.

ECHINIDAE.

Echinus acutus, Lamarck.

At Positions 7, 31, 35, 36, 43, 49, 52, 72.

Depth, 40–47 fath.

These positions all lie between fifteen and thirty-one miles from the Eddystone, at a depth of 40–43 fath. Very few specimens of the species occurred, not more than three being recorded from any position.

Echinus esculentus, Linnaeus.

In marked contrast with the preceding, the extent of occurrence of this species will best be shown by giving the records, as far as they were made, in actual figures. Where numbers are omitted after a position the number of specimens was not recorded, but may be regarded as one or few.

At Position 1 (one), 3 (few), 7, 8, 12 (one), 20 (few), 22 (one), 32 (one), 34 (seven), 36 (one), 43 (two), 45 (four), 46 (nine), 49 (twenty, and two young), 51 (one)' 52 (five), 53 (three), 56 (one) 58 (one young), 59 (one young), 66 (thirteen), 67 (two), 68 (eight), 70 (few), 72 (few), 78 (eleven), 80.

Depth, 40–52 fath.

The total number recorded is about 120, as opposed to about 15 of the preceding species. In his Report on the fauna between the Eddystone Grounds and Start Point, Dr. Allen (1) discusses in detail the conditions influencing the distribution of these two species. In regard to the great numerical difference between them in the area now dealt with, it is probable that Dr. Allen's remarks on the bare survival of *acutus* in the Plymouth area as being on the outskirts of the deep-water area, where it abounds, are directly applicable to the present case, since the deepest positions now under consideration extend very little beyond the 50-fathom sounding. It is this line that apparently marks the inner limits of the conditions especially favourable to the species, and its non-occurrence in the few hauls that were made near that depth may be due to local conditions.

In a recently published number of this Journal, Shearer, De Morgan, and Fuchs* express a difficulty in distinguishing many specimens of *acutus* and *esculentus* from one another, and even a doubt as to their true specific distinction. As regards specimens here recorded, no such confusion between the two forms as separated was noticeable, though in most cases where *acutus* was found the two species occurred together.

Echinus miliaris, Linnaeus.

A single specimen was obtained at each of the positions 1 and 80.

Depth, 40–51 fath.

CLYPEASTRIDAE.

Echinocyamus pusillus (O. F. Müller).

At Positions 1 (several), 45 (a few), 56 (one).

Depth, 40–49 fath.

Spatangus purpureus, O. F. Müller.

Large specimens at Positions 5, 9, 10, 11, 74 (one each), and 67 (two).

Medium-sized specimens at Position 46 (a few).

Small or young specimens at Positions 5 (a few), 17 (one), 20 (one), 31 (a few), 36 (one), 46 (several), 51 (a few), 56 (one), 58 (several).

Depth, 40–49 fath.

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* "Preliminary Notice on the Experimental Hybridization of Echinoids," *Journ. Mar. Biol. Assoc.*, N.S., Vol. IX, 1911.

The large proportion of small specimens is remarkable.

The mollusc *Montacuta substriata* was attached to some of the specimens at Position 46, but it was not recorded in other cases.

SPATANGIDAE.

Echinocardium pennatifidum, Norman.

Five specimens on rough ground at Position 58.

Depth, 49 fath.

Length, 29, 34, 38, 39, 41 mm. respectively.

HOLOTHUROIDEA.

CUCUMARIIDAE.

Cucumaria brunnea, Thompson.

At Positions 3 (one), 4 (one), 43 (two).

Depth, 40–45 fath.

Cucumaria hyndmani, Thompson.

One specimen at Position 35.

Depth, 43 fath.

Thyone fusus (O. F. Müller).

One specimen at each of the Positions 11 and 33.

Depth, 42 fath.

Thyone raphanus, Düben and Koren.

One specimen at Position 14.

Depth, 44 fath.

Two examples of this species, which has not previously been recorded in the Plymouth fauna, were recently identified by Mr. J. H. Orton from three miles south of Rame Head, where they were obtained in July, 1911. Bell (65) gives as its distribution: British and Norwegian seas and Mediterranean; with the British localities: Faeroe Channel, 570 fath.; Shetland; The Minch; Dingle Bay, 40 fath., off the S.W. coast of Ireland. Also Irish Sea (Herdman, 9).

ANNELLIDA.

POLYCHAETA.

SYLLIDAE.

Typosyllis alternosetosa, de St. Joseph.

At Positions 14 (one), 33 (one), 38 (two), 43 (one), 45 (one), 52 (one), 56 (one), 58 (one), 59 (one).

Depth, 42–49 fath.

Typosyllis variegata, Grube.

At Positions 38 (two), 43 (one), 53 (one), 58 (one).

Depth, 44–49 fath.

The specimens appear only to differ from the account of Langerhans in the smaller number of articulations in the dorsal cirri of the body. Langerhans gives these as 34 and 24 in alternate segments. In these specimens they number about 24 and 16 respectively. Grube (83) first described the chaetae as with simply hooked end-pieces. Subsequent authors have described them as bifid. In all the specimens here considered they are very faintly bifid in some of the anterior segments, but distinctly so in the median and posterior segments. The transversely-placed 8-shaped dark marking, as described by Langerhans, in the dorsal surface of the segments, is distinct in the anterior segments of some specimens but absent in others (as preserved in spirit).

HESIONIDAE.

Castalia punctata (O. F. Müller).

One specimen at Position 33. Length in spirit, 10 mm.

Depth, 42 fath.

APHRODITIDAE.

Aphrodita aculeata, Linnaeus.

At Positions 6 (one), 11 (one), 31 (a few).

Depth, 40–42 fath.

Hermione hystrix (Savigny).

At Positions 8, 11, 16, 17 (one each), 18 (two), 19 (one), 20, 22, 25 (two), 31, 35 (one), 37 (one), 38, 43 (one), 44 (two), 58 (one), 59 (three), 62.

Depth, 43–50 fath.

The greater frequency of this species in comparison with the preceding is probably due to the generally rough character of the ground being more favourable to it (cp. Allen, 1).

Lepidonotus squamatus (Linnaeus).

At Positions 13 (one), 34 (one), 70 (two).

Depth, 40–42 fath.

Lagisca floccosa (Savigny).

At Positions 10, 12, 13, 14, 32, 33, 34, 35 (one each); 45 (three young), 49, 51 (two each), 58 (three), 59 (four), 60, 62 (two each), 70 (four), 72 (one), vii (two), 80 (seven).

Depth, 42–51 fath. or over.

Harmothöe setosissima (Savigny).

At Positions 46 (two), 52 (one), 53 (one), 56 (one).
Depth, 43–49 fath.

Harmothöe fraser-thomsoni, McIntosh.

One specimen at each of the Positions 56 and 80.
Depth, 49–51 fath.

Harmothöe lunulata (Della Chiaje).

One specimen at the doubtful position in Cruise VII.
Depth, 49 fath. or over.

Evarne impar (Johnston)?

One specimen at each of the Positions 10 and 32.
Depth, 40–42 fath.

The specimens only differ from the description and figures of McIntosh (91) for the species in the character of the ventral chaetae, in which the secondary process is very largely lacking. In one specimen this is absent from about the inferior third of the series. In the other it is only visible as a very fine process in about ten of the extreme superior chaetae. With the absence of this process is associated a corresponding diminution and even entire absence of the spinulation on the chaetae concerned. In the second specimen referred to, especially, many of the inferior chaetae are entirely bare in this respect. These remarks refer to about the tenth foot in each case. Both are young specimens, the largest not exceeding 10 mm. in length, and the nearer approximation of this latter to the type suggests that the difference may be due to immaturity.

Halosydna gelatinosa (M. Sars).

One specimen at Position 59.
Depth, 49 fath.

The specimen was broken into three pieces, but measured about 7 cm.

AMPHINOMIDAE.

Euphrosyne foliosa, Audouin and Edwards.

One specimen at Position 60.
Depth, 49 fath.

PHYLLODOCIDAE.

Phyllodoce rubiginosa, de St. Joseph.

One specimen at each of the Positions 45, 46, 58, and two at 59.
Depth, 46–49 fath.

NEREIDAE.

Nereis fucata, Savigny.

One specimen at each of the Positions 6 and 46, associated in each case with *Anapagurus laevis*.

Depth, 42–47 fath.

Nereis pelagica, Linnaeus.

One specimen at each of the Positions 7, 38, 46, 49, 58.

Length as measured in spirit, 35, 40, 40, 25, 20 mm., severally.

The specimen at 46 occurred in a *Pallasia* tube; the others were free.

Depth, 42–49 fath.

EUNICIDAE.

Eunice fasciata (Risso) = *E. harassii*, Audouin and Edwards.

One specimen at each of the Positions 4, 7, and 31.

Depth, 40–42 fath.

Eunice vittata (Della Chiaje).

One specimen at Position 32.

Length in spirit, 53 mm.

Depth, 42 fath.

Not apparently recorded from Plymouth since the time of Bate.

Distribution: Guernsey; *Porcupine* Expedition, Sta. xxvii, xxviii, xxviii*a*; Galway; Polperro; Plymouth; shores of France; Madeira; Mediterranean; Japan; Adventure Bank, *Porcupine*, 92 fath.; Cape Verde Is. (cp. McIntosh, 93).

Onuphis conchilega, M. Sars.

At Positions 6 (two), 13 (one), 16 (one), 32 (nine), 37 (one), 42.

Depth, 42-44 fath.

Hyalinoecia tubicola (Müller).

Recorded at 23 positions: 1, 5, 10–15, 17, 19, 22, 31, 35–37, 41, 42, 49, 51, 52, 56, 58, 67.

From one to about fifteen specimens at each point, the number averaging about four.

Depth, 40–52 fath.

Lumbriconereis fragilis, O. F. Müller ?

A single specimen at each of the Positions 46 and 58.

Depth, 47–49 fath.

A considerable portion at each extremity is lost in both examples.

The feet and bristles agree with those described and figured by McIntosh for this species.

Distribution: At various stations off the British shores, in 15–1380 fath. (*Porcupine*); W. and S.W. coast of Ireland, in 30–50 fath.; Connemara; Nova Zembla; Siberia and Behring Strait; Canada; (cp. McIntosh, 93).

SPHAERODORIDAE.

Ephesia gracilis, Rathke.

Single specimens at Positions 11, 15, 32, 33, 38, 49; and apparently occurring at other points not definitely recorded.

Depth for recorded specimens, 42–47 fath.

CHAETOPTERIDAE.

Chaetopterus variopedatus, Renier.

Living specimens were obtained at Positions 3, 4, 7, 9, 10, 12, 13, 43, 58, 59, 68, 70, 80; single specimens or a few only, in each case; in tubes of *Pallasia*, in a shell of *Buccinum*, winding through the whorls of *Fusus islandicus*, etc. Empty tubes only were recorded at Positions 1, 2, and 55.

Depth, 40–51 fath.

TEREBELLIDAE.

Polymnia nebulosa (Montagu).

At Positions 11, 31, 40, 45 (one each), 58 (two), 59 (three), 64 (one), vii (five).

Depth, 40–50 fath. or over.

Large specimens occurred at 59, and vii, attaining to 12 or 13 cm. in length.

Polymnia nesidensis (Della Chiaje).

One specimen at Position 60.

Depth, 49 fath.

Lanice conchilega (Pallas).

Empty tubes only of this species were obtained at Positions 10, 11, 32, 35, 60.

Nicolea venustula (Montagu)?, de St. Joseph.

At Positions 11 (one), 12 (two), 43 (two), 59 (three), 60 (two), 62 (one), 72 (one).

Depth, 42–50 fath.

The specimens range from 2 to 5 cm. in length. All have two pairs of gills, and so far as can be ascertained 17 setigerous segments. The only doubt as to the latter point concerns a few specimens that were partly broken, and in which the number of segments is not quite clear. The species is undoubtedly the *Nicolea venustula* of Marenzeller (96) and de St. Joseph (101). But whatever may be said of the justification for Marenzeller's reference of this type to the *Terebella venustula* of Montagu, with 3 pairs of gills, the evidence he quotes in favour of his conclusion that the *Nicolea zostericola* of Oersted, sec. Grube et Malmgren, is synonymous with *venustula* seems far from convincing, and his view is not shared by de St. Joseph. Neither Marenzeller nor de St. Joseph finds any departure in the examples of *venustula* personally recorded by them respectively, from the typical condition of 2 pairs of gills and 17 setigerous segments. Such also is the condition, probably without exception, of the specimens recorded here. It is significant that in Plymouth both types occur distinctly. Dr. Allen has found *zostericola* common within tide-marks in Plymouth Sound. Among 14 examples of his material recently examined, I have found the number of setigerous segments invariably 15, excepting in one specimen which was slightly damaged and in which, probably in consequence, only 14 were distinct. All of these are of small size, not exceeding (in spirit) 2 cm. in length. On the other hand, seven specimens of *venustula* obtained by him from a position 32 miles S. of Start Point, in about 40 fathoms, have, without exception, 17 setigerous segments. Some of these range as low as 2 cm. in length, so that the difference in the number of such segments between the two types would seem to be independent of size or age.

These facts, and the occurrence of the two types near Plymouth under different respective conditions, and apparently without variation in the characters mentioned, favour the view that they are specifically distinct. In Plymouth at least, *zostericola* appears to be essentially a littoral form of comparatively slender habit and small size, while *venustula* frequents the deeper water and assumes a stouter form and larger size. The number of setigerous segments moreover, 15 in *zostericola* and 17 in *venustula*, may apparently be regarded as a sufficiently stable character on which to separate the two species from one another.

Thelepus cincinnatus, Fabricius.

At Positions 1, 3 (a few), 14 (one), 32 (one), 33 (two), 34, 35, 43 (one each), 45 (three), 49 (one), 51 (two), 56, 60 (three each), 64 (one), 70 (two).

Depth, 40–50 fath.

In referring the examples recorded to the species *cincinnatus* more importance has been attached to the character of the gills, which are present without exception on two segments only, than to the uncini, which are very variable in form. The specimens range from young examples of about 12 mm. in length to large ones of 10 cm. Between such extremes the only noticeable difference in the uncini is one of size. The irregularity of form occurs in both, though the range of variation seems greater in the larger specimens. The uncini conform on the broad lines with the description and figure of de St. Joseph (103), but often differ much in detail.

Regarding the uncinus from the face and tracing it from below upwards, there is first (a) the large central tooth, or "great fang," so termed by McIntosh. Above this (b) are usually two, but very often three, strong teeth, of which the central one, when present, has a slightly higher origin than the laterals. Next follows (c) a range with two small lateral teeth and one larger central one. This central tooth is the homologue of the large central tooth in the (b) range, and when present in the latter it is therefore absent from the range above in the reckoning adopted, and the (c) range then has the two small laterals only. Finally (d) occurs a range of very small teeth, about three to five in number, which fill in the apical space. These occasionally extend around the apical margin of the uncinus, so that their two extreme laterals lie one on either side of the (c) range, and the latter then appears to possess altogether five teeth, or four as the case may be. In a preparation of a young specimen of 18 mm. in length, the condition with three teeth in the (c) range is the most frequent, while apically the arrangement is much confused, and the remaining teeth are crowded together with little appearance of order. It must be added that the use of the term "range" is quite artificial, all of the teeth lying closely apposed, so that any irregularity occurring is liable to confuse the scheme of arrangement considerably.

In the profile view a difference occurs from the figure by Malmgren (94), which shows the uncinus rather narrower in antero-posterior measurement, and with the apex simply rounded and without the slight projection where the extreme apical teeth are borne. Malmgren's figures are as a rule so true to life that this difference presents some difficulty. The second point, however, is involved in Marenzeller's figure of the species (96), where the apical projection is distinctly shown. From the description of the species by Marenzeller and de St. Joseph the only important discrepancy is the frequent enlargement of the central tooth in the (c) range and its extension as a third tooth into the range immediately below. This character, which is not mentioned by either of these authors, occurs, I believe, in every preparation of the species I have seen, including some specimens collected by the *Huxley* in the North Sea.

AMPHICTENIDAE.

Pectinaria (Petta) pusilla, Malmgren.

One specimen at each of the Positions 33 and 34. Length (in spirit), 13 and 15 mm. respectively. The second example was associated with an Ascidian inside a valve of *Pecten opercularis.*

Depth, 42 fath.

The specimens only differ from Malmgren's description (94) in the point of the membranous fold under the paleolae. This is triangular, as in *P. assimilis,* McIntosh (90). The shape of this, however, is not clearly defined by Malmgren, who figures it slightly emarginate in the dorsal view, and overhanging in the ventro-lateral view of the whole animal. It is conceivable that in the single specimen he had before him the natural outline of the process was indistinct. In all other respects the examples are in close conformity with Malmgren's account of the species. Since the occurrence of Malmgren's specimen, which was obtained by Loven off the coast of Bohus in the Skager Rak, the species seems only to have been recorded from the Firth of Clyde (cp. Gemmill, 82).

SABELLIDAE.

Sabella pavonina (Savigny).

Usually small specimens at Positions 1, 7, 8, 31, 34, 35, 37, 40, 53, 59, 80.

Depth, 40–51 fath.

Dasychone bombyx (Dalyell).

At Positions 1 (several), 3 (one), 55 (a few), 59 (one), 60 (one), 70 (three), 72 (one), vii (one).

Depth, 40–49 fath. or over.

SERPULIDAE.

Serpula vermicularis, Linnaeus.

At Positions 7 (a few), 8 (several), 9 (very common), 13 (two), 14 (a few), 32, 43 (one), 49 (several large), 59 (one), 60 (two), 72 (one).

Depth, 42–49 fath.

Commonly attached to stones and shells of *Pecten.* The records are probably incomplete.

Pomatoceros triqueter (Linnaeus).

At Positions 6, 7, 80, and probably in several other hauls.
Depth, 42–51 fath.

Hydroides norvegica (Gunn).

Recorded at Positions 4, 6, 11, 13, 32, 58. About 50 examples on a valve of *Pecten opercularis*, at Position 13.
Depth, 40–49 fath.

Ditrupa arietina (O. F. Müller).

One specimen at Position 36.
Depth, 43 fath.

The species does not appear to have been previously recorded from the English Channel.

Distribution: Gulf of Naples, Teneriffe, Madeira, Azores, Bay of Biscay, S.W. of Belle Isle, N.W. coast of Ireland, W. coast of Scotland, Shetland, Norway, Philippine Is.—cp. Lo Bianco (88), Langerhans (87), McIntosh (89, 90), Roule (98), de St. Joseph (103), Johnston (85), Sars (105), Grube (84).

Filograna implexa (Berkeley) ?

At Positions 7, 8, 37.
Depth, 42–43 fath.

De St. Joseph (101) distinguishes *Filograna implexa*, as with opercula, from *Salmacina dysteri* as without them. Cunningham and Ramage * treat the two as synonymous, a view which is shared by Prof. McIntosh. The specimens which were recorded in the preliminary list as *Filograna implexa* were unfortunately not retained for examination of this character, and the species is therefore left in doubt.

Protula tubularia (Montagu).

Single specimens at each of the Positions 9, 33, 59, vii.
Depth, 42–49 fath. or over.

Spirorbis spirillum (Linnaeus) ?

A small *Spirorbis*, apparently of this species, occurred commonly on Hydroids, especially on *Sertularia abietina*, at many points, and was definitely recorded at Positions 11, 14, 35, 42, 43, 53, 60, 62, 67, 80.
Depth, 42–51 fath.

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* "The Polychaeta Sedentaria of the Firth of Forth," *Trans. Roy. Soc. Edinburgh*, Vol. XXXII, p. 635.

HERMELLIDAE.

Sabellaria spinulosa, Leuckart.

Recorded in small numbers at Positions 4–7, 13, 31–33, 35, 44, 45, 47, 49, 51, 53, 56, 59, 60, 72, vii, 80.

Most commonly on shells of *Pecten*, also on tubes of *Pallasia* and on stones.

Depth, 40–51 fath. or over.

Pallasia murata, Allen.

Tubes or portions of tubes of this species were obtained at Positions 5, 6, 7, 10, 11, 12, 14, 17, 19, 31, 32, 37, 46, 53, 56, 63, 72.

Depth, 40–50 fath.

Living specimens or fragments of such were obtained at Positions 17, 63, and 72. A large colony was passed through at Position 17, where portions of about six specimens of the living animal were brought up in the dredge. This was by far the largest settlement touched in the course of the work (cp. Crawshay, 4, p. 103), though the absence of living specimens in the great majority of the hauls is largely to be explained by the difficulty of working the dredge deep enough to secure them.

HIRUDINEA.

Pontobdella muricata, Linnaeus.

One specimen at each of the Positions 44 and 52.

Depth, 43–46 fath.

At Position 44, in addition to the specimen, four lots of ova were obtained in dead valves of *Pecten opercularis*.

SIPUNCULOIDEA.

Phascolosoma vulgare (de Blainville).

One specimen at each of the Positions 15 and 38. Length 30 and 20 mm. respectively.

Depth, 44 fath.

Mr. G. Southern kindly identified this species.

ARTHROPODA.

CRUSTACEA.

CIRRIPEDIA.

BALANIDAE.

Balanus crenatus, Bruguière.

Recorded only at Position 4, but probably present in other hauls.

Pyrgoma anglicum, Leach.

On *Caryophyllia smithi*, at Positions 7, 11, 44, 45, 59.

Depth, 42–49 fath.

VERRUCIDAE.

Verruca stroemia (O. F. Müller).

Recorded at Positions 4, 35, and 72, on shells of *Pecten opercularis* and *Fusus islandicus*. Probably present in other hauls.

Depth, 40–43 fath.

LEPADIDAE.

Scalpellum vulgare, Leach.

Generally in small numbers, at Positions 1, 3, 5, 9, 11–14, 17, 19, 31, 32, 33, 35, 37, 38, 40, 42, 43, 46, 49, 59, 60, 62, 64, 67, 70, 77, 80. On *Antennularia antennina*, *A. ramosa*, *Aglaophenia myriophyllum*, *Halecium halecinum*, and other Hydroids; and at Position 64, about 50 specimens on tube of *Lanice conchilega*.

Depth, 40–51 fath.

PELTOGASTRIDAE.

Sacculina carcini, Thompson.

One specimen at each of the Positions 14 (on *Pisa biaculeata*), and 60 (on *Macropodia longirostris*).

Depth, 44–49 fath.

Peltogaster sulcatus, Lilljeborg.

Eight individuals of this rare species were obtained at Position 59, parasitic on a specimen of *Eupagurus cuanensis*.

Depth, 49 fath.

Geoffrey Smith (135, p. 108) recognizes, among the various names given to the genus, only two certain species, *P. paguri* and *P. sulcatus*. Under the synonyms of the latter he records, as the hosts and distribution of the species: *Pagurus cuanensis*, *chiracanthus* and *laevis*, from Danish and Norwegian Seas; *E. prideauxi* and *meticulosus*, from Naples; an unnamed host from French coasts; *Pagurus sp.* ? from Brazil; and *Ligella gracilis* and *affinis* from Valparaiso.

The species is recorded by Norman (130, p. 226) "on examples of *Pagurus cuanensis* dredged in Teignmouth Bay." It was earlier recorded by him (127, p. 185), as "gregariously parasitic on *Pagurus laevis*, off Sunderland. New to Britain."

AMPHIPODA.

AMPELISCIDAE.

Ampelisca spinipes, Boeck.

One specimen at Position 1.

Depth, 40 fath.

LEUCOTHÖIDAE.

Leucothöe spinicarpa (Abildgaard).

At Positions 3 (four), 4 (two), 8 (two), 40 (one), 43 (one), 51 (one young).

Depth, 40–45 fath.

PARAMPHITHÖIDAE.

Epimeria cornigera (Fabricius).

At Positions 45 (four), 46 (one), 52 (one).

Depth, 43–47 fath.

Distribution: W. coast of Norway, Shetland and many localities off the British Isles, Bay of Biscay, Naples (cp. Chevreux, 112). Many examples obtained by the *Huxley* in the Bay of Biscay in 1906 have recently been recorded by Mrs. Sexton (134). Though recorded from Falmouth and South Devon by Leach and Montagu, the species has not been observed in the Plymouth fauna of late years.

IPHIMEDIIDAE.

Iphimedia obesa, Rathke.

One specimen at Position 1.

Depth, 40 fath.

PHOTIDAE.

Gammaropsis erythrophthalma (Lilljeborg).

Three specimens at Position 45.

Depth, 47 fath.

JASSIDAE.

Jassa pusilla, G. O. Sars.

At Positions 4 (two ovigerous females), and 5 (eleven examples). On a sponge coating *Inachus dorsettensis.*

Depth, 40–42 fath.

Mrs. Sexton kindly examined these specimens, and separated those from the latter position as follows:—

Full-grown,	3	males ;	1	ovigerous female.
Young	2	„ ;	5	„ females.

For details concerning these specimens, see her account of the species (134, p. 216).

Distribution: South and west coasts of Norway, Hammerfest, Cumbrae (?), Firth of Forth, Port Erin, Eddystone, south-west of Belle Isle, Bay of Biscay (cp. Sexton, 134).

COROPHIIDAE.

Erichthonius abditus (Templeton).

Three specimens at Position 45.
Depth, 47 fath.

CAPRELLIDAE.

Phytisca marina, Slabber.

One male at Position 3.
Depth, 40 fath.

Protella phasma (Montagu).

At Position 3, two females, one with young in pouch.
" 6, three males ; five females, some with young.
" 56, twelve immature specimens. Length, 3–5½ mm.
Depth, 40–49 fath.

ISOPODA.

ANTHURIDAE.

Anthura gracilis (Montagu).

One specimen at Position 7.
Depth, 42 fath.

A particular point of interest attached to this specimen is the fact that it was found deeply intruded, head downwards, in a tube of the Polychaet worm *Sabellaria spinulosa*, the only part visible being the ends of the uropoda lying nearly flush with the opening of the tube. With these peculiarly shaped organs lying in this position, their appearance was so deceptive to the eye that they might easily be mistaken at a rough glance for the anterior region of the original occupant of the tube. Whatever significance may be attached to this resemblance, the main fact goes to suggest that the animal was preying on the *Sabellaria*. This inference is supported by the view that the oral parts of the Anthuridae point to a parasitic habit, though the mode of parasitism has not hitherto been stated (cp. G. O. Sars, 132, p. 44). The peculiar shape of the animal and the unusual form of the uropoda would seem well adapted to association with any such host.

AEGIDAE.

Rocinela damnoniensis, Leach.

At Positions 1, 5, 10 (one each), 11 (two), vii (one).
Depth, 40–49 fath. or over.

CIROLANIDAE.

Conilera cylindracea (Montagu).

One specimen at Position 10.

Depth, 42 fath.

ARCTURIDAE.

Astacilla longicornis (Sowerby).

Two specimens at Position 1.

Depth, 40 fath.

DECAPODA.

MACRURA.

PANDALIDAE.

Pandalus brevirostris, Rathke.

At Positions 1 (four), 33 (one), 45 (six), 52 (three young).

Depth, 40–47 fath.

HIPPOLYTIDAE.

Hippolyte varians, Leach.

Four specimens at Position 45.

Depth, 47 fath.

ALPHEIDAE.

Alpheus macrocheles (Hailstone).

One at each of the Positions 58, 59, 62, 68.

Length of specimens, 21, 17, 23, 40 mm., the last being an ovigerous female.

Depth, 49–50 fath.

CRANGONIDAE.

Crangon allmanni, Kinahan.

One specimen at Position 60. Length, 38 mm.

Depth, 49 fath.

ANOMURA.

GALATHEIDAE.

Galathea dispersa, Spence Bate.

Recorded from positions as follows:—1 (two), 5 (one), 13 (one), 40 (two), 43 (three), 49 (two), 51 (one), 52 (three), 56 (two), 58 (one), 59 (two), 62 (three), vii (one).

Depth, 40–50 fath. or over.

The records of this species are probably incomplete.

Galathea nexa, Embleton.

At Positions 58 (six), and 59 (one).

Depth, 49 fath.

The tendency in recent years has been to combine this species with the preceding, but I have followed Bonnier (110) in retaining it as distinct. The peculiar *facies* of *G. nexa* is remarkable to the naked eye owing to the much stronger spination and hispidation of the first peraeopods especially, and also in the generally shorter form of these appendages than in *G. dispersa*. These distinctions cannot be sexual in character, for though in a different degree they occur in both sexes, and the chelae are more strongly spined in the females of *nexa* than in the males of *dispersa*, the difference being especially marked in the large spine on the carpopodite.

The chief character of distinction used by Bonnier, namely, the relative length of the ischiopodite and meropodite of the third maxillipede, seems to me of little value as compared with the character of the large spine in the ventral region of the meropodite of that appendage. This is centrally situated and isolated in *nexa* as figured by Bonnier (Pl. XII, Fig. 7), but more distally situated and as a rule accompanied by a second smaller though prominent spine nearly adjacent and distal to it in *dispersa*. Bonnier's figure of this joint in *dispersa* is very misleading, owing conceivably to its having been drawn in such a position as to throw out the perspective, creating the impression that the large spine has a distal position. Milne Edwards and Bouvier (124, p. 72) correct this, describing the position as "vers le milieu du bord inféro-interne," which accurately represents the position of the spine in the specimens now under consideration. It is chiefly owing to the same difficulty of Bonnier's figure that Hansen (114, p. 31) unites the species with *nexa*, and records his material under this as the prior name.

Another character of distinction which may prove of considerable value, is the nature of certain setae closely adjacent to the large spine in question. Bonnier makes no allusion to these setae, but figures them distinctly as faint pencil marks in his drawing of the third maxillipede of *G. nexa* (Pl. XII, Fig. 7). They are from two to four in number, and arise close to the origin of the large spine. In all the specimens of *nexa* I have examined, these setae are quite simple, while in those of *dispersa* they are clearly pinnate. The only exception occurs in a specimen of *dispersa* in which the largest of them is simple or nearly so, the others being pinnate. This character needs confirmation in a large number of examples, but the evidence points to its being a reliable mark of distinction. The point is remarkable in view of the fact that the condition is the reverse of that in the chelae. In the latter case it is the strongly pinnate setae—the "longs poils serrés" of Bonnier—covering the carpopodite and propodite, and forming the pronounced hispidation in *nexa*, that are contrasted with the comparatively scarce setae, only partially pinnate or quite simple, in *dispersa*.

Distribution: Lofoten Islands, and southern coasts of Norway; British Islands, from Shetland to Cornwall; Galoper, Luc-sur-mer, and Channel Islands (cp. Bonnier, 110). Kemp (117), in recording the species collected by the *Huxley* in the Bay of Biscay in 1906, follows Hansen and others in treating *dispersa* and *nexa* as synonymous, and on grounds of priority uses the latter name. He finds a closer resemblance, however, in the maxillipedes to the *dispersa* of Bonnier, and as a specimen of his material I have since examined is certainly of that species as here regarded, it is probable that the same applies to all of them.

Galathea intermedia, Lilljeborg.

One specimen at each of the Positions 1 and 43.

Depth, 40–45 fath.

Galathea squamifera, Leach.

Single specimens at Positions 10 and 33.

Depth, 42–43 fath.

PAGURIDAE.

Eupagurus bernhardus (Linnaeus).

Single or few specimens at Positions 1, 6, 7, 14, 20, 31, 32, 34, 36, 37, 42, 43, 52, 56, 59, 70.

In shells of *Buccinum undatum*, etc., and in the sponge *Ficulina ficus*. The records are unfortunately incomplete in detail, but few large specimens were obtained and there was no occurrence of the associated anemone *Adamsia polypus* (see p. 299).

Depth, 40–49 fath.

Eupagurus cuanensis (Thompson).

One or two specimens only at Positions 11, 12, 14, 16, 37, 52, 59, 60, 72.

In shells of *Fusus islandicus*, and once in *Murex erinaceus*, as far as recorded. A specimen occurred at Position 59, infected with the rare parasite *Peltogaster sulcatus* (see record of the latter species, p. 349).

Depth, 42–49 fath.

Eupagurus prideauxi (Leach).

Single or few specimens at Positions 1, 5, 6, 7, 9, 11, 13, 17, 20, 37, 43, 46, 49, 52, 53, 56, 59; and several at Position 60.

Depth, 40–49 fath.

The associated anemone, *Adamsia palliata*, was only definitely recorded in a few instances. It is most probable that this was an omission, due to the constancy of its occurrence with the species.

Eupagurus sculptimanus (Lucas).

From one to three specimens at Positions 10, 11, 12, 16, 19, 34, 36, 37, 40, 52, 80.

In shells of *Turritella*, *Dentalium*, etc.

Depth, 42–51 fath.

Anapagurus laevis (Thompson).

Single or few specimens at Positions 5, 6, 11, 46, 60, and probably present in other hauls.

Depth, 42–49 fath.

A single specimen was recorded with the commensal Polychaet, *Nereis fucata*, at Position 6.

Anapagurus hyndmanni (Thompson)?

Two specimens apparently belonging to this species were obtained at Position 59.

Depth, 49 fath.

The species has been recorded from Shetland, the Frith of Forth, the Firth of Clyde, Portaferry and Belfast Bay, Liverpool Bay, coasts of Devon and Cornwall, and Channel Islands, cp. Bell (109), Norman (11, 127, 128), Scott (133), Walker (136).

BRACHYURA.

PORCELLANIDAE.

Porcellana longicornis (Linnaeus).

Recorded at Positions 1, 3, 4, 9, 10, 11, 32, 53, 56, 58, 59, 63.

Depth, 40–50 fath.

LEUCOSIIDAE.

Ebalia cranchi, Leach.

At Positions 19 and 31. Apparently one specimen in each case.

Depth, 40–45 fath.

Ebalia tumefacta (Montagu).

One specimen at each of the Positions 19 and 63.

Depth, 45–50 fath.

The position of this species is far from satisfactory. The difficulty of its identification appears to me to consist in the separation of it, not from *E. tuberosa*, as found by Walker (136, p. 98), but from *E. cranchi*. *E. tuberosa* is readily distinguished from it, as from the latter, by the more elongate "hand" in the first peraeopods, and also especially by the much longer claws, both sexes showing these characters alike. These points are mentioned by Montagu (126, p. 86) in his original description of *Cancer tumefactus*, and figured by Leach and by Bell, while the last author even expresses his inability to account for the two species being confused with one another. Bell (109), as he interprets the species, describes the meropodite or "arm" of *E. tumefacta* (= *E. bryeri*) as not more than twice as long as broad, and that of *E. cranchi* as three times as long as broad, using this, moreover, as one of the distinctive characters between them in his description of the latter species (109, p. 149). On this interpretation, while *E. tumefacta* is distinct in this appendage from *E. tuberosa* by the shorter meropodite and propodite, it is separated from *E. cranchi* by the shorter meropodite only. The number of specimens of *E. tumefacta* I have seen, satisfactorily to be regarded as such, and bearing out this character, is very few, and unless the species is extremely local in its habitat, it is difficult to consider it as more than a variety of *E. cranchi*. Dr. Allen's record of it as abundant to the westward of the Eddystone (1) would support the former alternative, but in this case some difficulty arises in the fact that the specimens concerned showed a close similarity to *E. tuberosa*. In the absence of any clear evidence to the contrary, it seems best to retain the species as distinct, though probably it has often been confused with others in records of the genus.

Ebalia tuberosa (Pennant).

At Positions 1, 3 (one), 11 (one), 13 (two), 15 (one), 16 (three), 19 (one), 22 (a few), 28 (one), 31 (a few), 32 (one), 36 (one), 37 (one), 42 (one), 43 (a few), 44 (two), 46 (two), 53 (two), 62 (six), 63 (six).

Depth, 40–50 fath.

INACHIDAE.

Macropodia aegyptia, A. Milne-Edwards.

Single specimens at Positions 43 and 52.

Depth, 43–45 fath.

Macropodia longirostris (Fabricius).

At Positions 4, 7, 10, 20, 43, 45, 49, 52, 59, 60, 64, 66, 67, 77, 78.

Depth, 40–53 fath.

Single or a few specimens occurred in every case, except at 52, where several were obtained. At Position 60 a female was infected with *Sacculina.*

Macropodia rostrata (Linnaeus).

From one to five specimens at Positions 1, 5, 6, 7, 37, 44, 45, 52.

Depth, 40–47 fath.

Only small specimens were recorded at Positions 1, 6, 37, and 44, that at 44 being an ovigerous female.

Inachus dorsettensis (Pennant).

At Positions 1 (several), 3, 4, 5 (two), 7 (one), 9 (one), 13 (three), 14 (one), 18 (two), 20 (one), 31 (a few), 34, 35, 37, 41 (one), 43, 45 (two), 49 (two), 52 (ten), 53, 56 (a few), 59 (a few), 60, 78 (a few).

Depth, 40–49 fath.

At Position 1, four specimens were dressed, severally, with *Lafóea fruticosa, Plumularia catharina, Halecium* sp., and *Halichondria* sp. No other record was preserved of examples illustrating this habit.

Inachus leptochirus, Leach.

At Positions 45 (two), 49 (one), 52 (two), 56 (one), 67 (one).

Depth, 47–49 fath.

Distribution: Shetland (Norman, 11); Moray Firth (Gordon, 113); Firth of Clyde (Elliot, Laurie, and Murdoch, 6); western coasts of Devon or Cornwall and Bigbury Bay (Leach, 120); Falmouth (Norman, 130); Channel Islands (Norman, 128); north side of Bay of Biscay (Kemp, 117); N.W. coast of Spain, N.E. of Cape Verde Islands, Azores (Milne-Edwards et Bouvier, 125); Azores (Miers, 122), (Milne-Edwards et Bouvier, 123); Spalato in Adriatic (Heller, 115).

MAIIDAE.

Pisa biaculeata (Montagu).

At Positions 14 (one female with *Sacculina*), and vii (one ovigerous female).

Depth, 42–49 fath. or over.

Hyas coarctatus, Leach.

Single specimens at Positions 1, 14, 32 (ovigerous female), 43, 67.

Depth, 40–52 fath.

PARTHENOPIDAE.

Eurynome aspera (Pennant).

At Positions 1 (three), 6 (one), 10 (one), 11 (one), 31, 32 (one), 34, 35 (two), 36 (three), 37 (two), 38, 43 (a few), 44, 46 (one ovigerous female), 47 (one), 53 (one), 56 (one), 58 (one), 59 (four).

Depth, 40–49 fath.

CANCRIDAE.

Cancer pagurus, Linnaeus.

One large specimen at Position 25, and two specimens at Position 64. Depth, 46–50 fath.

At the former point the haul was one of eight minutes' duration, made with the triangular dredge, the bottom consisting of shell and gravel mixed with small stones. At the latter point the otter trawl was used for half an hour, and as no stones were touched by this, and few by the dredge haul immediately preceding it, it may be assumed that the ground was soft and comparatively free from them.

Xantho tuberculatus, Couch.

At Positions 9 (one ovigerous female), 28 (one ovigerous female), 33 (one), 36 (one ovigerous female), 44 (one), 58 (one male), 59 (two females), 63 (one), vii (one female), 80 (one).

Depth, 44–50 fath. or over.

Of the three ovigerous females recorded, two (at Positions 9 and 36) were secluded in empty shells of *Buccinum undatum*, and the zoaea larvae hatched out off the last one on the following day.

The species was discovered by R. Q. Couch, who found it repeatedly in the crevices of *Lepralia foliosa* in the deep water in Mount's Bay, Cornwall, but states that it approaches the shore, being found under stones in summer, and breeds in June. Though it has been recorded from Liverpool Bay, and more recently from Cumbrae in Scotland, it is especially characteristic of the extreme south-western British fauna, and even its inclusion among the species of Plymouth Sound, properly speaking, is open to doubt. Garstang (6, p. 339) records its addition to the Plymouth type collection, but with no data as to its locality. An earlier record by Heape (8, p. 170), "Frequent, 4–45 fathoms," included in a list compiled by Bate, involves the same question of locality, since the material concerned is only referred to by the last author in his original report (2, p. 276), as collected "mostly between Bigbury Bay towards the east and the Dodman towards the west," and "within a distance of about twenty miles of the shore in water that has not exceeded fifty fathoms in depth," thus defining the area for the whole list recorded. The point is of some importance because *Xantho tuberculatus* is one of those species which appear to be rather definitely limited in distribution by certain physical conditions associated with the extreme western area of the Channel, outside the influence of which they exist only in diminishing numbers and soon disappear from the fauna.

Distribution: South-west coast of Ireland (Bourne, 3, p. 314); Cumbrae (Patience, 35); Liverpool Bay (Walker, 137, p. 97); between Bigbury Bay and the Dodman, frequent on stony ground in 4–45 fath. (Bate, 2, p. 276); Mount's Bay, Cornwall (Bell, 109); north side of Bay of Biscay (Walker, 139, p. 158); Bay of Biscay, coast of Portugal, Azores, 166–793 m. and between 748 and 1262 m. (Milne-Edwards et Bouvier, 123, p. 33, and 124, p. 32); Bay of Biscay (Koehler, 10); Bay of Biscay, north-west African coast to Cape Verde Islands (Milne-Edwards et Bouvier, 125, p. 93).

The records from Pirano and Lesina in the Adriatic by Heller, (115, p. 69), were found by Bouvier (111) to refer to *Xantho floridus*. The species is not recorded by Norman from the Channel Islands (128).

PORTUNIDAE.

Portunus depurator (Linnaeus).

One specimen at Position 37.

Depth, 43 fath.

Portunus marmoreus, Leach.

One rather small specimen at Position 46. Width of carapace 19 mm.

Depth, 46 fath.

Portunus pusillus, Leach.

At Positions 1 (two; one an ovigerous female), 3 (one ovigerous female), 13 (one), 31 (one), 35 (two), 48 (one), 62 (three; width of carapace, 18, 14, and 11 mm.), 67 (one; width of carapace 17mm.).

Depth, 40–52 fath.

Portunus tuberculatus, Roux.

Single specimens at Positions 35, 43, and 59.

Depth, 43–49 fath.

Distribution: Shetland, abundant in 80–120 fath. (Norman, 11, p. 268); Mediterranean (Costa); Gulf of Naples, rare (Heller, 115, p. 84); Bay of Biscay, 180 m. and between 300 and 400 m. (Caullery. See Koehler, 10); north coast of Spain and Azores, 560 m. (Milne-Edwards et Bouvier, 125, p. 63); Azores, 454 m.; Cape Finisterre and Bay of Biscay, 136–250 m. (Milne-Edwards et Bouvier, 123, p. 25); north side of Bay of Biscay, 75–109 fath. (Kemp, 117, p. 417).

Bathynectes longipes (Risso).

At Positions 46 (one male) and 80 (one immature female).

Depth, 47–51 fath.

Distribution: Cornwall, Swansea, cp. Bell (109, p. 361); Penzance, Mount's Bay, Falmouth, Polperro (cp. Norman, 130, p. 3); Plymouth, near Eddystone (Garstang); and of frequent occurrence in recent years on different Plymouth grounds; Channel Is. (Sinel. See Norman, 128); Genoa, Naples, Sicily; and in the Adriatic, at Quarnero, Lesina, and Lissa, in 30–40 fath.; Black Sea (cp. Heller, 115, p. 89).

Subsequent to the occurrence of the species referred to by Garstang in 1897, it does not seem to have been observed at Plymouth till 1905, when a specimen was found far inside the breakwater, in Millbay Pit. In 1907 it was recorded on the Rame-Eddystone ground and the Mewstone Ledge, and in every year subsequently occasional examples have occurred mostly on the Mewstone Ledge, but also again in Millbay Pit. On the Mewstone Ledge, Mr. Orton tells me he has repeatedly seen it in the crevices of *Lepralia foliosa.*

It is conspicuously absent from Bay of Biscay records.

CORYSTIDAE.

Atelecyclus septemdentatus (Montagu).

At Positions 4 (one), 10 (one), 13 (one), 14 (three), 20 (one), 22 (one), 31 (a few), 32 (one), 34 (a few), 35 (four), 36 (one), 37 (three), 43 (two), 49 (one), 51 (one).

Depth, 40–47 fath.

ARACHNIDA.

PYCNOGONIDA.

Mr. Hodgson kindly identified the species obtained in this group.

Nymphon brevirostre, Hodge.

One specimen at Position 62.

Depth, 50 fath.

Achelia echinata, Hodge.

At Positions 49 (three), 56 (three), 59 (one), 60 (one), 62 (two).

Depth, 47–50 fath.

Endeis spinosus (Montagu).

One specimen at Position 58.

Depth, 49 fath.

BRYOZOA.

As with the rest of the fauna, such of the Bryozoa as could be easily named at sight were recorded on board in the course of the work, and the rest were brought home for examination. The greater part of the latter, and such as presented no difficulty, were then worked out and added to the list. Subsequently Miss Alice Heath kindly undertook to identify the more doubtful or difficult material that remained. In consequence of this, many of the species are absent from her list. Records by Miss Heath are distinguished by the letter H. The others, for which I am responsible, are followed by the letter C. Miss Heath writes the following note on the specimens submitted to her:—

"The greater part of the material sent to me for identification was in a dry state; the remainder was preserved in alcohol. There proved to be 30 genera and 54 species. Twenty-one species are recorded from one station only. The classification and names given are those used in the Plymouth Fauna List (*Journ. Mar. Biol. Assoc.*, N.S., Vol. VII, p. 155). *Lepralia foliosa* was represented by only one small piece worked up into a worm tube. In *Membranipora flustroides* the zooecia fitted rather more closely together, were less oval than in Hincks's illustration, and the spines were represented by three only. On one small zooecium these spines were flattened and glossy; the others were lost, their points of attachment only showing. One species of *Alcyonidium* I have not been able to identify. Zoarium, erect, delicate, transparent, flattened, about 2½ cm. in height by 1 cm. in breadth; attached to a piece of *Pecten* shell; not as firm and opaque as either *A. gelatinosum* or *A. mytili*. Surface smooth. The superficial boundaries of the zooecia could be distinguished, but very littlt of other details. Brown bodies apparently occupied the interior."

AETEIDAE.

Aetea anguina (Linnaeus).

At Positions 9, 49 (H); 80 (C).
Depth, 42–51 fath.

Aetea recta, Hincks.

At Positions 49 (H); 32 (C).
Depth, 42–47 fath.

EUCRATEIDAE.

Eucratea chelata (Linnaeus).

At Positions 12 (H); 62 (C).
Depth, 42–50 fath.

CELLULARIIDAE.

Scrupocellaria scruposa (Linnaeus).

At Positions 35, 47, 49, 56, 64, 80 (H); 4, 36, 59 (C).
Depth, 40–51 fath.

BICELLARIIDAE.

Bicellaria ciliata (Linnaeus).

At Positions 49, 80 (H); 1, 3, 4, 10, 11, 12, 32, 45, 56 (C).
Depth, 40–51 fath.

Bugula avicularia (Linnaeus).

At Positions 4, 32, 45, 62 (C).
Depth, 40–50 fath.

Bugula flabellata, J. E. Gray.

At Positions 4, 43, 49, vii (C).
Depth, 40–49 fath. or over.

Bugula calathus, Norman.

At Position 36 (H).
Depth, 43 fath.

Bugula turbinata, Alder.

At Positions 43, 80 (H).
Depth, 45–51 fath.

Beania mirabilis, Johnston.

At Positions 49 (H); 11, 12, 32, 33, 35, 45, 47, 49, 59, 62, 80 (C).
Depth, 42–51 fath.
On other Bryozoa and on Hydroids: plentiful at 47 and 49.

MEMBRANIPORIDAE.

Membranipora catenularia (Jameson).

At Positions 43, 49, 59, 60 (H).
Depth, 45–49 fath.

Membranipora dumerili (Andouin).

At Position 36 (H).
Depth, 43 fath.

Membranipora flemingi, Busk.

At Positions 11, 36, 45, 59, 62 (H).
Depth, 42–50 fath.

Membranipora flustroides, Hincks.

At Positions 46, 58 (H).
Depth, 47–49 fath.

Membranipora lineata (Linnaeus.)

At Position 51 (H).

Depth, 43 fath.

MICROPORIDAE.

Micropora coriacea (Esper).

At Positions 8, 43, 56, 60, 80 (H).

Depth, 43–51 fath.

CELLARIIDAE.

Cellaria fistulosa (Linnaeus).

At Positions 1, 3, 4, 8, 10, 11, 13, 14, 32, 33, 34, 35, 40, 49, 51, 56, 58, 59, 60, 62, 64, vii, 80 (C).

Depth, 40–51 fath.

This, the most common species of *Cellaria* obtained, seldom occurred in any considerable quantity except at the first three positions above named where, on the fine sandy ground, it was fairly plentiful.

Cellaria salicornioides, Lamouroux.

At Positions 3, 4, 8, 10, 11, 13, 14, 33, 47, 49, 56, 59, 60, 62, vii, 80 (C).

Depth, 40–51 fath. or over.

This species occurred far less frequently than the preceding, but the same general statement applies to it.

Cellaria sinuosa (Hassall).

At Positions 40, 45, 47, 56, 58, 60, 62, 80 (H); 13, vii (C).

Depth, 42–51 fath. or over.

The comparative scarcity of this species, which is common on the Eddystone Grounds, is remarkable. It is possible, however, that it was overlooked at some of the innermost positions.

CRIBRILINIDAE.

Cribrilina figularis (Johnston).

At Position 59 (H).

Depth, 49 fath.

Cribrilina radiata (Moll).

At Positions 8, 11, 12, 38, 44, 45, 49, 56, 59, 60, 80 (H).

Depth, 42–51 fath.

Membraniporella nitida (Johnston).

At Position 59 (H).

Depth, 49 fath.

ESCHARIDAE.

Lepralia foliacea (Ellis and Solander).
At Positions 51 (H); 46, 56, 58, 59, 63, 64, 68, vii, 78, 80 (C).
Depth, 43–51 fath. or over.
Plentiful at Positions 59 and 68.

Chorizopora brongniarti (Audouin).
At Positions 36, 45, 56, 59, 60 (H).
Depth, 43–49 fath.

Porella concinna (Busk).
At Positions 8, 13, 44, 53, 56, 60 (H).
Depth, 42–49 fath.

Porella compressa (Sowerby).
At Positions 36, vii (H); 9, 33, 34, 38, 46, 47, 53, 62 (C).
Depth, 42–50 fath. or over.

Smittia reticulata (Macgillivray).
At Position 36 (H).
Depth, 43 fath.

Smittia trispinosa (Johnston).
At Positions 8, 12, 40, 45, 56, 59 (H).
Depth, 42–49 fath.

Mucronella peachi (Johnston).
At Positions 43, 49 (H).
Depth, 45–47 fath.

Mucronella variolosa (Johnston).
At Positions 8, 51, 58, 72 (H).
Depth, 43–49 fath.

Mucronella ventricosa (Hassall).
At Positions 9, 12, 13, 36, 46, 59 (H).
Depth, 42–49 fath.

Palmicellaria skenei (Ellis and Solander).
At Positions 43, 62 (H).
Depth, 45–50 fath.

Hippothoa distans, Macgillivray.
At Positions 11, 12, 51, 56 (H).
Depth, 42–49 fath.

Hippothoa divaricata, Lamouroux.

At Positions 11, 43, 49, 53 (H).

Depth, 42–46 fath.

Schizoporella johnstoni, Quelch.

At Position 51 (H).

Depth, 43 fath.

Schizoporella linearis (Hassall).

At Positions 9, 38, 43, 44, 46, 47, 49, 56, 72 (H).

Depth, 42–49 fath.

Schizoporella unicornis (Johnston).

At Positions 8, 12, 45 (H).

Depth, 42–47 fath.

Schizoporella discoidea (Busk).

At Position 59 (H).

Depth, 49 fath.

CELLEPORIDAE.

Cellepora avicularis, Hincks.

At Positions 8, 10, 11, 13, 34, 35, 38, 40, 43, 49, 51, 53, 56, 59, 60, 62, 64, 70, 80 (H); 1, 3, 4, 6 (C).

Depth, 40–51.

Cellepora dichotoma, Hincks.

At Positions 10, 36, 49 (H).

Depth, 42–47 fath.

Cellepora pumicosa, Linnaeus.

At Positions 10, 38, 44, 49 (H); 46 (C).

Depth, 42–47 fath.

Cellepora ramulosa, Linnaeus.

At Positions 8, 11, 13, 33, 35, 38, 40, 43, 45, 47, 49, 52, 60, 62, 72 (H); 1, 32, 37, 46, 80 (C).

Depth, 40–51 fath.

Crisia ramosa, Harmer ?

At Positions 40, 49, 52, 56 (H).

Depth, 44–49 fath.

DIASTOPORIDAE.

Diastopora patina (Lamarck).

At Positions 9, 38, 46, 56, 72 (H); 80 (C).
Depth, 44–51 fath. or over.

TUBULIPORIDAE.

Tubulipora liliacea (Pallas).

At Positions 36, 56, 62, 64 (H); 1, 3, 4, 8, 9, 10, 11, 32, 35, 40, 49, 53, vii, 80 (C).
Depth, 40–51 fath. or over.

Entalophora clavata (Busk).

At Position 62 (H).
Depth, 50 fath.

Stomatopora granulata (Milne-Edwards).

At Position 50 (H).
Depth, 49 fath.

Stomatopora johnstoni (Heller).

At Position 13 (H).
Depth, 42 fath.

Stomatopora major (Johnston).

At Position 11 (H).
Depth, 42 fath.

Stomatopora dilatans (Johnston).

At Position 80 (H).
Depth, 51 fath.

Stomatopora deflexa (Couch).

At Positions 11, 13, 60, vii (H).
Depth, 42–49 fath. or over.

LICHENOPORIDAE.

Lichenopora hispida (Fleming).

At Positions 9, 11, 59, 60, 72 (H).
Depth, 42–49 fath.

ALCYONIDIIDAE.

Alcyonidium gelatinosum (Linnaeus).

At Positions 1, 3, 4, 7, 31, 35, 37, 43, 47, 51, 52, 56, 59 (C).
Depth, 40–49 fath.
As single or few colonies in all cases.

Alcyonidium mytili, Dalyell.

At Position 67 (H).
Depth, 52 fath.

Alcyonidium sp.

At Position 40.
Depth, 44 fath.

For description of this doubtful species, see Miss Heath's note at the commencement of this group.

VALKERIIDAE.

Valkeria uva (Linnaeus).

At Position 49 (H).
Depth, 47 fath.

Specimens apparently also belonging to this species were obtained on *Hydroids* and *Cellaria* at Positions 3, 4, 14, 47, 59, and 62, and probably occurred at several other points (C).

PEDICELLINIDAE.

Pedicellina cernua (Pallas).

At Positions 3, 10–14, 32–34, 37, 38, 49, 53, 56, 59, 62, 80 (C).
Depth, 40–51 fath.

Pedicellina gracilis, Sars.

At Positions 11–14, 32, 35, 37, 40, 45, 47, 49, 59, 62, 80 (C).
Depth, 42–51 fath.

MOLLUSCA.

Where not otherwise specified, records refer to living specimens.

AMPHINEURA.

NEOMENIIDAE.

Rhopalomenia aglaopheniae (Kowalevsky and Marion).

At Positions 37 (one), 38 (one), 43 (two), 56 (one); on *Aglaophenia myriophyllum*.
Depth, 43–49 fath.

Myzomenia banyulensis (Pruvot).

At Positions 32 (two), 38 (one), 45, 59 (one), 60 (one); on *Lafōea dumosa.*

Depth, 42–49 fath.

ISCHNOCHITONIDAE.

Craspedochilus onyx (Spengler).

At Positions 1 (several), 3 (one), 4 (several), 11 (one), 13 (two), 15 (one), 32 (two), 35 (one), 36 (one).

Depth, 40–43 fath.

GASTROPODA.

PROSOBRANCHIATA.

FISSURELLIDAE.

Emarginula fissura (Linnaeus).

Single specimens at Positions 33 and 58.

Depth, 42–49 fath.

TROCHIDAE.

Gibbula tumida (Montagu).

One specimen at Position 33.

Depth, 42 fath.

Calliostoma exasperatum (Pennant)?

A *Trochus* apparently belonging to this species was obtained at Positions 45 (two) and 52 (one).

Depth, 43–47 fath.

Calliostoma montagui (W. Wood).

One dead shell at Position 52.

Depth, 43 fath.

Calliostoma granulatum (Born).

At Positions 32 (one), 52 (two), 60 (one).

Depth, 42–49 fath.

Calliostoma striatum (Linnaeus).

One dead shell at Position 43.

Depth, 45 fath.

Calliostoma zizyphinus (Linnaeus).

At Positions 1 (two), 17 (one), 52 (one), 59 (one), 60 (one).

Depth, 40–49 fath.

CAPULIDAE.

Capulus hungaricus (Linnaeus).

Single dead shells at Positions 1, 7, 41.
Depth, 40–44 fath.

CYPRAEIDAE.

Trivia europaea (Montagu).

Single specimens at Positions 45 and 51.
Depth, 43–47 fath.

The specimen at Position 51, measuring 9·5 mm., had a very smooth, shiny surface, with the ribs but faintly marked, and the spire quite distinct, showing three whorls, thus retaining the young characters to a remarkable degree.

Ovula patula (Pennant).

At Positions 1, 3 (one), 10 (one), 53 (one), 59 (three).
Depth, 40–49 fath.

Erato laevis (Donovan).

One dead shell at Position 1.
Depth, 40 fath.

NATICIDAE.

Natica alderi, Forbes.

At Positions 46 (two dead), 49 (one dead), 52 (two), 60 (one).
Depth, 43–49 fath.

LAMELLARIIDAE.

Lamellaria perspicua (Linnaeus).

At Positions 32 (one) and 59.
Depth, 42–49 fath.

SCALIDAE.

Scala clathrus (Linnaeus).

One specimen at Position 1.
Depth, 40 fath.

Scala turtoni (Turton).

One specimen at Position 36.
Depth, 43 fath.

EULIMIDAE.

Eulima polita (Linnaeus).

Single specimens at Positions 11 and 47.
Depth, 42–47 fath.

TURRITELLIDAE.

Turritella communis, Lamarck.

At Positions 1 (two) and 10 (one).

Depth, 40–42 fath.

APORRHAIDAE.

Aporrhais pes-pelicani (Linnaeus).

One dead shell at Position 1.

Depth, 40 fath.

BUCCINIDAE.

Buccinum undatum (Linnaeus).

At Position 3 (spawn only), 5 (one), 7 (one), 8 (two and spawn), 9 (one), 10 (one), 17 (one), 59 (one).

Depth, 40–49 fath.

The spawn obtained at Position 3 hatched out on the following day.

Tritonofusus gracilis (Costa).

Specimens were obtained at Positions 10 (two), 11 (three), 12 (several), 14 (five), 25 (one), 32 (one), 34 (one), 35 (several), 43 (one), 46 (one), 52 (a few), 58 (one), 59 (one), 60 (one), 67 (one), 72 (five), 80 (one).

Depth, 42–51 fath.

The great majority of these specimens were empty shells, or those occupied by *Eupagurus cuanensis* or *E. prideauxi*, in most cases the former. Living specimens were only recorded at Positions 25 (one) 58 (one), 67 (one), 72 (two), and excepting perhaps those recorded without data at 10 and 34 these constitute the only ones obtained.

Tritonofusus propinquus (Alder).

One specimen at Position 58.

Depth, 49 fath.

This species has not previously been recorded from Plymouth, but three specimens were obtained by the *Huxley* at the north side of the Bay of Biscay in 1906 (Rennel, 148, p. 382). The localities of occurrence given by Jeffreys are: Coasts of Yorkshire, Durham, and Northumberland, Berwick Bay, Aberdeenshire, Hebrides, Shetland; New Brighton, Liverpool; Dublin Bay; Cork; Finmark; Kullaberg; Kattegat; cp. Jeffreys (147, iv, p. 339).

MURICIDAE.

Ocinebra erinacea (Linnaeus).

At Positions 59 (spawn only), and 60 (one shell occupied by *Eupagurus cuanensis*).

Depth, 49 fath.

Trophon muricatus (Montagu).

One shell at Position 6, occupied by *Eupagurus cuanensis*.
Depth, 42 fath.

NASSIDAE.

Nassa incrassata (Ström).

One specimen at Position 44.
Depth, 46 fath.

PLEUROTOMIDAE.

Mangilia gracilis, P. Fischer.

At Positions 13 (one living), and 31 (one dead).
Depth, 40–42 fath.

Clathurella linearis (Montagu).

At Positions 7 (one dead), and 11 (one living).
Depth, 42 fath.

OPISTHOBRANCHIATA.

TECTIBRANCHIATA.

SCAPHANDRIDAE.

Scaphander lignarius (Linnaeus).

At Positions 7 (six), 8 (two), 24, 43 (one), 52 (one); all living except that at 52.
Depth, 42–45 fath.

PLEUROBRANCHIDAE.

Oscanius membranaceus (Montagu).

At Position 1 (one specimen, with spawn).
Depth, 40 fath.

NUDIBRANCHIATA.

AEOLIDIIDAE.

Galvina tricolor (Forbes).

At Positions 6 (one), 45 (five), 52 (several).
Depth, 42–47 fath.

Facelina drummondi (Thompson).

At Position 6 (one).
Depth, 42 fath.

DOTONIDAE.

Doto coronata (Gmelin).

At Position 13 (one).
Depth, 42 fath.

Doto fragilis (Forbes).

At Positions 8 (?) (spawn only), 19 (three), 34 (one).
Depth, 44–45 fath.

DENDRONOTIDAE.

Dendronotus frondosus (Ascanius).

At Position 52 (one).
Depth, 43 fath.

DORIDIDAE.

Goniodoris nodosa (Montagu).

At Position 47 (one).
Depth, 47 fath.

Archidoris tuberculata (Cuvier).

At Positions 4 (four), 7 (one), 78 (one).
Depth, 40–49 fath.

TRITONIIDAE.

Tritonia hombergi, Cuvier.

At Positions 4 (one), 52 (two), 60 (one), vii (one), 70 (one).
Depth, 40–49 fath. or over.

Tritonia (Candiella) plebeia, Johnston.

At Positions 4 (four), 7 (one), 11 (one), 45, 46 (one).
Depth, 40–47 fath.

SCAPHOPODA.

Dentalium entalis, Linnaeus.

At Positions 1 (fifteen), 5 (one dead), 6 (one dead), 10 (one living, two dead), 11 (three living, one dead), 13 (one), 36 (one), 37 (five living).
Depth, 40–43 fath.

PELECYPODA.

PROTOBRANCHIATA.

NUCULIDAE.

Nucula nucleus (Linnaeus).

At Position 1 (seven).
Depth, 40 fath.

FILIBRANCHIATA.

ANOMIIDAE.

Anomia ephippium, Linnaeus.

I have thought it best to include under this one species all the specimens of *Anomia* that were recorded. Though it is possible that *A. patelliformis* occurred among them, it was very difficult to distinguish among the extremely irregular forms assumed by the specimens any definite external characters, such as those assigned to the latter form by Jeffreys (147). The shape and moulding of the valves seemed in all cases to be merely dependent on that of the base of attachment.

Specimens were definitely recorded, sometimes in considerable numbers, at Positions 1, 3, 4, 7–15, 19, 31–36, 43, 44, 46, 49, 52, 53, 56, 59, 60, 64, vii, 72.

Depth, 40–50 fath. or over.

Attached to shells of other molluscs, more frequently *Pecten*, and to other bodies, especially stones on the rougher ground, it was one of the commonest and most generally distributed species that occurred.

ARCIDAE.

Pectunculus glycimeris (Linnaeus).

At Positions 6, 7, 10, 14, 16, 17, 19, 32, 33, 36, 37, 43, 44, 46, 51, 53, 58.

Depth, 40–49 fath.

At Position 7, only old valves occurred. Excepting at Positions 10, 14, 16, 17, 19, and 43, the specimens obtained were all of a remarkably small size.

Arca tetragona, Poli.

At Positions 34, 43 (two), 55, vii (one).

Depth, 42–49 fath. or over.

MYTILIDAE.

Volsella modiola (Linnaeus).

At Positions 1 (one dead), 11 (one living).

Depth, 40–42 fath.

Volsella barbata (Linnaeus).

At Position 4 (one).

Depth, 40 fath.

Volsella phaseolina (Philippi).

At Positions 4, 6, 8, 10, 11, 32, 33, 36, 37, 38, 40, 43, 45, 49, 51, 53, 58, 60, 64, vii.

Depth, 40–50 fath. or over.

From one to six specimens were recorded at the several positions, measuring from 3 to 9 mm. in length.

Modiolaria marmorata (Forbes).

At Positions 1 (one), 3 (two), 4 (three), 44 (one), 58 (one), 59 (one), 80 (one).

Depth, 40–51 fath.

Though this species was occasionally found buried in the tests of Ascidians, most of the specimens recorded occurred free. One was attached by the byssus to the base of a colony of *Cellaria*.

PSEUDOLAMELLIBRANCHIATA.

PTERIIDAE.

Pinna fragilis, Pennant.

Pairs of empty valves, or single valves or fragments of such, occurred at Positions 7, 8, 10, 13, 20, 28, 35, 49, 52, 66, 68, vii, 78, 80.

No living specimen was obtained.

Depth, 42–52 fath. or over.

PECTINIDAE.

Pecten maximus (Linnaeus).

At Positions 1 (empty shells), 7 (a few), 8 (one), 10 (one living, a few dead), 11 (one), 12 (three), 14 (one), 20 (a few), 30 (a few), 43 (one young), 45 (two), 47 (one), 52 (one), 59 (two), 60 (three), 62 (one), 68 (three), 80 (several dead).

Depth, 40–51 fath.

Pecten pusio (Linnaeus).

One dead valve at Position 46, and one small living specimen at the doubtful Position vii.

Depth, 47–49 fath. or over.

Pecten varius (Linnaeus).

One young specimen at Position 7.

Depth, 42 fath.

Pecten opercularis (Linnaeus).

The numerical proportion in which this species was obtained may be compared as follows :—

Few or very few specimens at Positions 1, 5 (small), 6, 9, 10, 11, 12, 18, 25, 37, 40, 41, 43, 44, 46 (small), 58 (small), 60 (small), 68 (small).

Fairly plentiful at Positions 3, 14, 20, 30, 31, 35, 52 (about fifty, many quite small), 63 (small), 72.

Abundant at Positions 7, 8, 49.

Dead specimens were obtained for the most part at Positions 10 and 37, and exclusively at Positions 13 (many), 47 (small), 51 and 80 (many).

The variety *lineata* was recorded at Positions 7 (few), 8 (several), 43 (one), 60 (one).

Specimens were recorded with both valves unicolorous at Positions 40 (purple), and 60 (chrome-yellow).

Depth, 40–51 fath.

Pecten tigerinus (Müller).

At Positions 1 (one), 6 (one valve), 7 (one), 13 (one), 31, 32 (several), 33 (one), 34, 43 (few), 44 (one).

Depth, 40–46 fath.

LIMIDAE.

Lima hians (Gmelin).

At Positions 44, 58 (four), vii (one).

Depth, 46–49 fath. or over.

Lima loscombi, G. B. Sowerby.

At Positions 6 (one dead valve, bored), 32 (one), 44 (one), 62 (one), 80 (one).

Depth, 42–51 fath.

EULAMELLIBRANCHIATA.

ASTARTIDAE.

Astarte sulcata (da Costa).

At Positions 9 (one), 11 (one), 15 (one), 16 (three), 19 (one), 32 (a few), 34, 35 (one), 36 (one), 37 (one), 40 (one), 44 (one small), 53 (one), 56 (one).

Depth, 42–49 fath.

CYPRINIDAE.

Cyprina islandica (Linnaeus).

A single living specimen was obtained at Position 39.

Dead specimens occurred at Positions 10 (a few), 12 (several), 13 (one), 20 (several), 44 (one).

Depth, 42–46 fath.

LUCINIDAE.

Lucina borealis (Linnaeus).

One young specimen at Position 1.
Depth, 40 fath.

Montacuta substriata.

At Position 46, attached to *Spatangus purpureus.*
Depth, 46 fath.

LEPTONIDAE.

Kellia suborbicularis (Montagu).

At Positions 1, 11 (two), 32 (two), 38 (two).
Depth, 40–44 fath.

SCROBICULARIIDAE.

Syndosmya prismatica (Montagu).

Three specimens at Position 1.
Depth, 40 fath.

TELLINIDAE.

Tellina crassa (Gmelin).

At Positions 17 (one living), 53 (one overgrown valve).
Depth, 45–46 fath.

MACTRIDAE.

Spisula elliptica (Brown).

At Positions 5 (two), 6 (three dead valves, one bored), 58 (one).
Depth, 42–49 fath.

Lutraria elliptica, Lamarck.

One dead valve bored by *Cliona*, at Position 11.
Depth, 42 fath.

VENERIDAE.

Dosinia exoleta (Linnaeus).

One young specimen at Position 5.
Depth, 42 fath.

Dosinia lincta (Pulteney).

At Positions 1 (one dead), 9 (three single valves), 10 (three living, one dead), 11 (one dead), 13 (one dead).
Depth, 40–42 fath.

Venus fasciata (da Costa).

At Positions 40 (one), 44 (one), 46 (two), 53 (one dead).
Depth, 44–46 fath.

Venus casina, Linnaeus.

At Positions 6 (one dead valve), 9 (four living, one dead valve), 10 (one living, several dead), 11 (one), 12 (one), 13 (one), 16 (two), 17 (three), 19 (one), 34 (a few), 44, 46 (two young), 53.

Depth, 42–46 fath.

Venus ovata, Pennant.

At Positions 1 (one young), 6 (one dead valve), 10 (one), 40 (one), 43 (two), 44 (one).

Depth, 40–46 fath.

Tapes virgineus (Linnaeus).

At Positions 1 (three young living, one dead), 6 (one bored valve), 12 (one dead), 20 (one living), 43 (two dead), 53 (two dead), 56 (one dead).

Depth, 40–49 fath.

Gouldia minima (Montagu).

At Positions 6 (one dead valve), 43 (three), 44 (several).

Depth, 42–46 fath.

CARDIIDAE.

Cardium echinatum, Linnaeus.

At Positions 1 (old valves), 70 (one living).

Depth, 40 fath.

Cardium norvegicum (Spengler).

At Positions 5 (one young), 10 (one), 19 (one), 20 (dead valves), 51 (two large, living).

Depth, 42–45 fath.

Cardium tuberculatum, Linnaeus.

One young specimen, 9 mm. in length, apparently belonging to this species, was obtained at Position 53.

Depth, 46 fath.

GARIDAE.

Gari costulata (Turton).

Single specimens at Position 10, 31, 37.

Depth, 40–43 fath.

Gari ferroensis (Chemnitz).

One dead valve at Position 1.

Depth, 40 fath.

Gari tellinella (Lamarck).

One dead, at the doubtful Position vii.

Depth, between 49 and 53 fath.

SOLENIDAE.

Cultellus pellucidus (Pennant).

Two specimens at Position 1.

Depth, 40 fath.

SAXICAVIDAE.

Saxicava arctica (Linnaeus).

From one to about a dozen specimens were recorded at Positions 3, 4, 7, 11, 14, 32, 33, 37, 40, 43, 47, 53, 59, 62, 64, 72.

Depth, 40–50 fath.

PHOLADIDAE.

Pholas sp.

Old borings of a doubtful *Pholas* occurred in limestone at Position 46.

Depth, 47 fath.

Pholadidea sp.

An unidentified species of *Pholadidea* occurred, boring in sandstone, at Position 34.

Depth, 42 fath.

LYONSIIDAE.

Lyonsia norvegica (Chemnitz).

One pair of dead valves at Position 36.

Depth, 43 fath.

CEPHALOPODA.

LOLIGINIDAE.

Loligo media (Linnaeus).

One specimen at Position 7.

Depth, 42 fath.

SEPIIDAE.

Sepia elegans, d'Orbigny.

At Positions 3 and 60 (one).

Depth, 42–49 fath.

Sepia officinalis, Linnaeus.

At Positions 7 (one), 60 (one).

Depth, 42–49 fath.

Sepia sp.

Two records under the generic name only, of single specimens that were subsequently lost, occurred at Positions 1 and 68.

Depth 40–52 fath.

SEPIOLIDAE.

Sepiola atlantica, d'Orbigny.

One specimen only was recorded at Position 6.

Depth, 42 fath.

POLYPODIDAE.

Moschites cirrosa (Lamarck).

One specimen at Position 8.

Depth, 43 fath.

TUNICATA.

By

Dr. R. Hartmeyer.

CAESIRIDAE [MOLGULIDAE].

Eugyra glutinans (Möller).

At Positions 1 (one), 6 (one), 10 (three), 37 (two).

Depth, 42–43 fath.

Caesira [Molgula] simplex (Alder and Hancock).

At Positions 1 (one), 3 (four), 7 (seven), 8 (one), 10 (two), 11 (two), 12 (three), 31 (one), 32 (two), 34 (one), 49 (six), 70 (one).

Depth, 40–47 fath.

Caesira [Molgula] oculata (Forbes).

At Positions 11 (one), 33 (one), 44 (one).

Depth, 42–46 fath.

PYURIDAE [HALOCYNTHIIDAE].

Pyura [Halocynthia] savignyi (Philippi).

At Positions 3 (one), 4 (one), 8 (one), 15 (one), 34 (four), 43 (three), vii (two).

Depth, 40–49 fath. or over.

TETHYIDAE [STYELIDAE].

Pandocia [Polycarpa] singularis (Gunnerus).

At Positions 1 (seven), 3 (seven), 4 (two very large, many smaller, including a number quite young), 7 (three), 8 (six), 9 (one), 12

(one), 49 (one), 59 (three), 60 (one), 70 (many examples associated with *Ascidiella aspersa*), 72 (two), vii (six, including one young).
Depth, 40–49 fath. or over.

Pandocia [Polycarpa] comata (Alder).
At Positions 1 (one), 4 (one young), 10 (two, including one young?), 31 (two), 53 (one), vii (one).
Depth, 40–49 fath. or over.

BOTRYLLIDAE.

Botrylloides rubrum, Milne-Edwards.
At Positions 3 (one), 4 (one), 8 (one), 38 (one).
Depth, 40–43 fath.

Polycyclus polycyclus (Savigny).
At Positions 3 (two), 4 (one), 7 (one), 8 (one), 49 (one), 60 (one), 64 (two).
Depth, 40–53 fath.

Certain colonies of a *Polycyclus* I refer to the *Botryllus polycyclus* of Savigny, and to the form from the Channel, not to that from the Mediterranean. Herdman has referred colonies from the Irish Sea likewise to this form of Savigny's, but has given them a new name, *P. savignyi*. This new naming seems scarcely justified, even if—as I agree with Herdman in doing—one separates specifically the North-west European form from the Mediterranean form. The latter bears the name *P. renieri*, Lam. *P. polycyclus* (Sav.) is partly a synonym of this species (Mediterranean form). For the North-west European specimens this name *P. polycyclus* (Sav.) still stands. *P. savignyi* (Herdman) is purely a synonym of it. The largest of the colonies (Fig. 1) forms a flattened extended mass, of which the anterior border is divided into a number of blunt lobes, while the posterior end is strongly narrowed with a stalk-like extension. This stalk-like process evidently serves for the attachment of the colony.

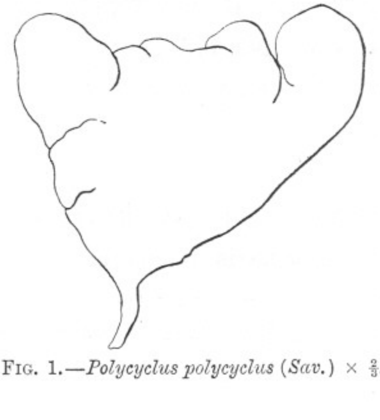

FIG. 1.—*Polycyclus polycyclus* (*Sav.*) × ⅔.

The colony is 67 cm. in maximum breadth, 51 cm. in length, and 1·3 cm. in thickness. To Herdman's description I further add that the meshes contain, counted from the endostyle, ca. 8, ca. 5, ca. 4, ca. 6 stigmata, and the stomach possesses a prominent caecum bent into a hook shape.

RHODOSOMATIDAE [CORELLIDAE].

Corella parallelogramma (Müller).

At Positions 3 (one), 10 (one), 60 (one).
Depth, 40–49 fath.

Corella larvaeformis, Hancock.

At Positions 32 (one), 38 (one).
Depth, 42–44 fath.

PHALLUSIIDAE [ASCIDIIDAE].

Ascidiella aspersa (Müller).

At Positions 1 (three, including a smooth example of the type *virginea*, of which, however, the course of the gut conforms with that of the type *aspersa*), 3 (seven), 4 (eight), 5 (one), 7 (one), 10 (one), 32 (three), 33 (three), 34 (two), 40 (one), 42 (one), 70 (in great abundance in and upon *Pecten* shells, or massed together), 72 (one young).
Depth, 40–44 fath.

Phallusia [Ascidia] virginea, Müller.

At Positions 1 (one), 3 (one), 8 (one), 12 (one), 15 (one), 34 (one), 38 (one), 40 (one), 43 (one), 59 (two), 60 (one), 67 (one), 70 (two), 72 (three), vii (one).
Depth, 40–52 fath. or over.

Phallusia [Ascidia] mentula (Müller).

At Positions 3 (two), 4 (three), 8 (two), 12 (one), 34 (one young), 40 (one), 59 (one).
Depth, 40–49 fath.

Phallusia [Ascidia] conchilega (Müller).

At Positions 1 (one), 4 (one), 8 (one), 10 (three), 32 (one), 34 (two), 36 (one), 37 (two young), 43 (four), 49 (one), 70 (one), vii (two).
Depth, 40–49 fath. or over.

I refer the species *depressa* to the older specific name *conchilega*. Among the material two examples occur which in some characters, especially in the course of the alimentary canal, differ from the typical specimens. That from Position vii (Fig. 2) measured on the body (excluding the test) 3·6 cm. in length and 2·6 cm. in height. The anterior end is narrowed and bluntly rounded; the posterior end, on the contrary, is more than usually broadened. The whole animal has evidently undergone a shortening in the long axis. One consequence of this shortening at least is the almost horizontal position of both loops of the intestine and the situation of the anal opening as high as the upper curvature of the intestine, whereby the unusual course of the latter is occasioned. The test is beset with conspicuously large prominences, which in their form recall those of *Ascidiella aspersa* (Müller). The other specimen (Fig. 3), from Position 8, likewise shows certain peculiarities.

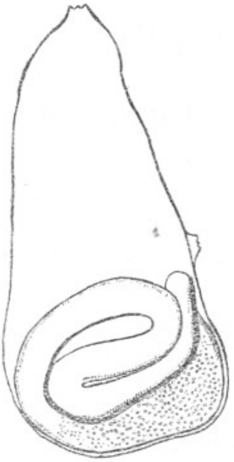

FIG. 2.—*Phallusia conchilega* (Müll.), Interior × 2

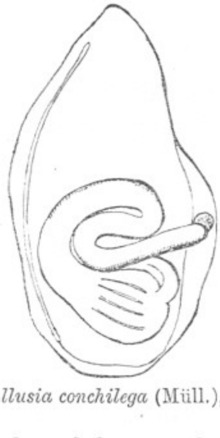

FIG. 3.—*Phallusia conchilega* (Müll.), Interior × 2.

Such are the pronounced oval form, and the likewise very strongly bent loops of the intestine, although the anus retains its position below the upper curve of the latter. The free surface (the animal is attached by the whole left side of the body) is finely cornulated.

CIONIDAE.

Ciona intestinalis (Linnaeus).

At Positions 3 (two), 4 (one), 10 (one), 12 (one), 34 (two), 40 (one), 44 (one), 49 (two), 59 (many massed together), 67 (one), 70 (many on the inner surface of *Pecten* shells or massed together).

Depth, 40–52 fath.

DIDEMNIDAE.

Didemnum [Leptoclinum] perspicuum (Giard).

At Position 3 (two).

Depth, 40 fath.

Leptoclinum [Diplosoma] gelatinosum, Milne-Edwards.

At Positions 1 (one), 3 (one), 4 (two), 59 (one).

Depth, 40–49 fath.

CEPHALOCHORDATA.

Amphioxus lanceolatus (Pallas).

At Positions 5 (one), 11 (one), 21 (one), 48 (five), 50 (one), 57 (eight), 58 (three).

Depth, 42–49 fath.

VERTEBRATA.

PISCES.

The infrequent use of the trawls must be borne in mind with reference to the comparatively few fishes recorded.

ELASMOBRANCHII.

SCYLLIIDAE.

Scyllium canicula (Linnaeus).

One specimen at Position 7.

Depth, 42 fath.

RAIIDAE.

Raia clavata, Linnaeus.

Single specimens at Positions 8 and 66.

Depth, 44–52 fath.

Raia circularis, Couch.

At Positions 49 (one), and 66 (three).

Depth, 47–52 fath.

Raia sp.

Examples of *Raia* not specifically recorded occurred at Positions 3 (one), 7 (three), 8 (one).

Depth, 40–43 fath.

TELEOSTEI.

MURAENIDAE.

Conger conger (Linnaeus).

One specimen at Position 64.

Depth, 53 fath.

GADIDAE.

Gadus luscus, Linnaeus.

At Positions 3, 7 (two), 68 (thirty-two), 78 (six).

Depth, 40–52 fath.

Gadus minutus, Linnaeus.

At Positions 3, and 49 (several).

Depth, 40–47 fath.

Gadus pollachius, Linnaeus.

One specimen at Position 59.

Depth, 49 fath.

Molva vulgaris, Fleming.

One specimen at Position 3.

Depth, 40 fath.

Motella tricirrata, Nilsson.

At Positions 58 (one), and vii (one).

Depth, 49 fath. and (?) over.

SERRANIDAE.

Serranus cabrilla, Linnaeus.

At Positions 8 (one), 49 (three).

Depth, 43–47 fath.

Fishes obtained at Positions 64 (one), and 68 (four), which were not retained, probably also belonged to this species.

CAPROIDAE.

Capros aper (Linnaeus).

At Positions 3 (three), 7 (a few), 8 (one), 49 (a few), 59 (one), 60 (two), 64 (two), 68 (eighty-five), 78 (two).

Depth, 40–52 fath.

The haul at Position 68, where the large number of this species occurred, was one of fifty-five minutes with the otter trawl, taken in 52 fathoms. It was one of the few cases in which the otter trawl was used, with some risk, in the neighbourhood of decidedly rough ground.

PLEURONECTIDAE.

Zeugopterus norvegicus (Günther).

At Positions 52 (one), 59 (one), 60 (one). Length, 6·9, 10·3, and 5·7 cm. severally.

Depth, 43–49 fath.

A *Zeugopterus* which occurred at Position 58, probably also belonged to this species.

Arnoglossus laterna (Walbaum).

At Positions 3 (one), 7 (a few), 8, 49 (eight), 52 (one), 60 (three), 64 (three), 68 (six), 78 (four).

Depth, 40–53 fath.

Arnoglossus megastoma, Donovan.

At Positions 3 (a few), 7 (two).

Depth, 40–42 fath.

Pleuronectes microcephalus, Donovan.

At Positions 7 (one), 49 (one), 68 (three).

Depth, 42–52 fath.

Solea variegata (Donovan).

At Positions 35 (one), 51 (one), 52 (three), 68 (one).

Depth, 43–52 fath.

GOBIIDAE.

Gobius jeffreysi, Günther.

At Position 1 (one), 52 (one).

Depth, 40–43 fath.

Gobius scorpioides, Collett.

At Positions vii (one), 62 (one). Length, 33 mm. and 31 mm. respectively.

Depth, 50 fath. and (?) over.

Mr. Boulenger kindly identified this rare goby. With reference to its occurrence, Holt and Byrne (152, p. 21) state that excepting several specimens obtained from Ballynakill Harbour on the west coast of Ireland, there are only five records of its capture, viz. from the Norwegian coast, the Cattegat, Falmouth, and 30 miles W.N.W.

of Cleggan Head, the depth of occurrence ranging from about 2 to 74 fath.

The two specimens here recorded considerably exceed in length the measurement, "less than 1 inch," given by Holt and Byrne.

AGONIDAE.

Agonus cataphractus, Linnaeus.

At Positions 5 (one), 52 (one). Length of the latter specimen 40 mm.

Depth, 42–43 fath.

Callionymus lyra, Linnaeus.

At Positions 3 (a few), 7 (two), 8 (one), 59 (two), 60 (three), 66 (one), 68 (one).

Depth, 40–52 fath.

TRIGLIDAE.

Trigla pini, Bloch.

At Positions 3 (one), 7 (a few), 8 (one), 49 (four), 60 (three small), 64 (two), 68 (five).

The small specimens at Position 60 measured 6·4, 5·6, and 5·3 cm. severally, in length.

Depth, 40–53 fath.

Trigla lineata, Gmelin.

Two specimens at Position 49.

Depth, 47 fath.

TRACHINIDAE.

Trachinus draco, Linnaeus.

Only recorded at Position 7.

Depth, 42 fath.

GOBIESOCIDAE.

Lepadogaster bimaculatus, Fleming.

One specimen at Position 1.

Depth, 40 fath.

Lepadogaster microcephalus, Brook.*

One specimen at Position 72.

Depth, 43 fath.

LOPHIIDAE.

Lophius piscatorius, Linnaeus.

One specimen at Position 64.

Depth, 53 fath.

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Some Notes upon the Feeding Habits of Mackerel and certain Clupeoids in the English Channel.

By

G. E. Bullen.

SEVERAL previous authors* have shown that the food of the mackerel, when in coastal waters, is of two different kinds, and that the fish adopts two distinct methods of procuring it. In the first place it feeds by a system of filtration upon planktonic organisms, and secondly upon prey of a larger character which is hunted by sight.

The exact nature of the food taken whilst the fish is in its winter quarters has not as yet been thoroughly investigated; but the present writer, in making examination of the stomach contents of mackerel taken on the ground in March, 1907, 25 miles S.W. of Start Point, found that it consisted entirely of zoo- and phytoplankton of a nature similar to that existing in the water itself.† A close similarity in general character appeared to exist between the nature of these samples and others from fish taken in the Bristol Channel at the surface during the early part of April of the same year.‡

It was also observed that during the three months forming the more important part of the "drifting" season in the western area, viz. April, May, and June, the fish were feeding exclusively upon plankton, and that the nature of this food gradually changed from being largely vegetable to almost wholly animal.

It was not until the middle of June that food of a larger character, but still wholly of the latter type, began to appear in stomach contents, and it is a well-known fact that at about this time every year the drift fishery in the area under consideration begins to decline, and hand-lining commences. This condition is due to the fact that the dense shoals break up, and the system of nutrition, which has hitherto been one of filtration, gives place to one of, what we may term, "selective feeding."

From the evidence before us, in the form of the plankton results for

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* *Vide* Allen, E. J., "Rep. on the Present State of our Knowledge with Regard to the Habits and Migrations of the Mackerel," *Journ. Mar. Biol. Assoc.*, N.S., Vol. V, p. 9.

† "Plankton Studies in Relation to the Western Mackerel Fishery," *Journ. Mar. Biol. Assoc.*, N.S., Vol. XVIII., pp. 285–6.

‡ *Id.* Table No. IV, Nos. 76 to 83, and Table No. V, No. 111.

the stations E5 and E6 (the only two falling within the fishing area), published in the *Bulletins Conseil International pour l'exploration de la Mer*, it would appear that these several changes in the nature of the food of the mackerel, viz. from phytoplankton to general zooplankton, and from thence to zooplankton of a larger character and animal food generally, e.g. young fishes and material offered as bait, is largely, if not entirely, due to seasonal changes in the nature of the food supply itself. Yet, as it has been abundantly shown that certain planktonic organisms are of sporadic distribution, and that there is some fair evidence to show that others occur in shoals of varying extent, it remains to be seen how far the mackerel, exercising these two distinct methods of nutrition, is capable of discriminating between varying types of food during the period that it is feeding by filtration.

The question arises, to begin with, whether in adopting the one system the fish is incapable of using the other, and two important points in this connection may be considered. In the first place, the Newlyn drifters state emphatically that it is impossible to take mackerel, when closely shoaling, upon a hand-line; and secondly, it is a matter of common knowledge amongst fishermen that, when late in the summer mackerel are caught (in drift nets), when feeding heavily upon copepods, they are very liable to rapid decomposition in the region of the stomach, and that this is due to the "soft" condition of the fish themselves, and not to the increased warmth of the atmosphere. Now, with respect to this matter it may be stated that the present writer, in making examination of the stomach contents of several hundreds of mackerel taken at various times of the year, has invariably found that the walls of the stomach appeared to be contracted and thickened in cases where phytoplankton formed the bulk of the food, whereas the organ in question was distended and the walls extremely thin when zooplankton occurred. Moreover, although no careful histological comparison was made between the two types, it was found possible to distend, by means of an air-pump, to a great extent an empty stomach of the latter type without undue pressure, whereas one of the thickened type would not respond to such treatment. Again, throughout an observation extending over nearly six years upon fish in many cases from not exactly determined sources, the writer has found that, with very few exceptions, the thinning of the stomach walls is developed to the greatest extent as the western drift fishery approaches its highest point of productiveness, viz. in May and June in the case of large mackerel, and in June and July with those of smaller size, which latter, as Dr. Allen* has

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* *Op. cit.*, p. 25.

pointed out, appear to be solely on feeding migration. Moreover, in all of the early spring "hooked" mackerel that the writer has examined, the walls of the stomach have been of fair thickness.

The evidence before us is certainly insufficient to warrant an assertion that a physiological change is brought about in the nature of the stomach by reason of a change of diet, but the fact remains that the writer has found it possible invariably to determine the *general* nature of the food contained in the stomach of a mackerel or a pilchard from an external examination of the organ itself, before it is opened.

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With reference to the transitional stage from the one type of feeding to the other, the following note, received in the autumn of 1911 from Mr. Mathias Dunn, of Newlyn, is of considerable interest. This observer states:—

"I sent you yesterday some specimens of a rare Crustacean *Macropsis*, which has been very abundant on our coasts this summer. The mackerel have been feeding ravenously on these animals, and at times have pursued them into the harbour, where they have been so numerous as to appear like thick porridge. We have had some excellent opportunities of seeing mackerel feed, during the visit of these little creatures. They have been hunting up and down the back of the pier, like a pack of hounds, going the whole length, turning and returning again and again. They were swimming about ten to twelve feet off the pier in company with a number of scads, about twenty to thirty in each shoal, the scads in every case swimming close to the pier and the mackerel just outside. The mackerel were swimming in open order, closing in, rising and falling in graceful undulations, by which means they either drove their prey on to the surface, where there was no escape, or turned it to the centre of the shoal, where it was also promptly despatched."

Upon examination, the sample sent by Mr. Dunn was found to consist almost entirely of the Mysid Crustacean *Macropsis stabberi*, Van Beneden,* together with a few young Herring (surface-swimming stage), and a slight number of fish ova and the Copepod *Centropages typicus*, Kröyer.

Unfortunately no stomach material was examined, but the foregoing observations tend to show amongst other things that the fish were feeding by sight, and were exercising discrimination in the selection of their prey. At the time when these observations were

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* For the determination of this species the writer is indebted to Mr. W. M. Tattersall, M.Sc.

made, however, viz. in July, the heavy summer drift fishery was far on the decline* and line fishing had commenced, an indication that the fish had begun to take prey of larger type.

With further reference to the feeding habits of mackerel and herring, in this instance kept in captivity at the Brighton Aquarium, the writer is indebted to Mr. E. W. Cowley, the Superintendent, for the following note.

This observer states: "The herring and mackerel are usually taken from the sea in October and November with the seine net, which is drawn on to the beach. They are then conveyed to the Aquarium in cans the size of an ordinary sanitary bin, about 20 or 30 in each can. Special care is taken to see that the cans are not overcrowded, the fish are not handled in any way, and conveyed to the tanks with the greatest possible speed. Even with these precautions we consider ourselves fortunate in saving 10% of the original catch. After they are placed in the tanks great care has to be exercised to see that the fish are in no way disturbed until they are acclimatized; but we have not found it necessary to darken the tanks.

"In the case of the herring and mackerel we find that the placing of a rock in the centre of the tank assists them considerably, unless of course a tank 120 feet long is provided.

"We feed both species upon sand-hoppers and small shrimps, alive if possible, and vary the diet from time to time with whiting cut up into small pieces. Of course great care has to be used not to overfeed them.

"The feeding is done at regular times, viz. 12 noon and 4 p.m. I have repeatedly noticed that the fish seem to know the time of feeding, for at these hours they are always on the alert. Before the food falls to the bottom of the tank it is devoured, and even when only a few shrimps or sand-hoppers are left, the fish will dart hither and thither after them.

"Usually we keep the herring and mackerel in separate tanks, but since last month (i.e. October, 1911) we have had them mixed, and I notice that they are swimming intermingled.

"During the summer months they both swim nearer to the surface than in the winter, but they never seek the bottom, being continually in motion, night and day. Otherwise there is no difference in their summer and winter movements. The temperature of the water in the tanks, which hold about 3000 gallons, is not so variable, I should think, as that of the open sea.

"Usually the mackerel live about two to three years, but we have kept herring from four to five years. No examples have ever been

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* *Vide* "Weekly Market Reports," *Fish Trades Gazette.*

measured or weighed, but certain of both species appeared to have reached sexual maturity before they died. The greatest mortality with both herring and mackerel takes place during the summer, and this may be due to the small quantity of water in the tanks, which are furnished, however, with air tubes, which continually circulate the water, day and night."

From personal observation of some mackerel which had recently been installed in one of the tanks at the Brighton Aquarium in October, 1910, the present writer would estimate the average length to be not more than 9 inches. In this connection it may be noted that Cunningham* states that the smallest ripe specimens which he had examined were 11·6 in. to 12·9 in. long.

In specimens measuring about 9 in. in length, seined at Sidmouth in 1911 towards the end of July, the writer observed no sexually mature fish, and the same condition obtained in several shoals taken by the seine at Brighton in October, 1909–10. It is fair to suppose, therefore, that the mackerel forming the subject of Mr. Cowley's observations were not sexually mature fish when placed in the tanks, and according to Cunningham† about a year old.

Now, although it may be urged that observations taken upon fishes acclimatized to the abnormal conditions obtaining in an aquarium are open to question, certain points of interest present themselves when Mr. Cowley's remarks are considered. In the first place, it will be seen that mackerel and herring *can* exist, for a reasonable period, all the year round upon food of a type similar to that which is hunted by sight—we may almost say food of a more solid character than plankton. Secondly, although the mackerel is known to be an active swimmer and voracious feeder, its appearance as it moves leisurely round the tank at a pace of not more than two miles an hour when no disturbing influence is present, might suggest that it is either aware of the fact that the tank water does not support sufficient plankton to form a good meal, or that it is indifferent to it in view of the fact that it knows that food of a more solid nature is offered to it at regular intervals.

Returning to the opening question raised in the first paragraph, it may be suggested that here is further evidence to show that mackerel, feeding by sight upon prey of a large character, are incapable of taking nourishment by means of filtration.

Mr. Dunn's observations tend to show that the larger plankton organisms are hunted by the mackerel by sight, the fish thereby exercising a selective capability.

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* Cunningham, *Mark. Mar. Fishes*, p. 315.

† *Id.*

To what extent this power, on the part of the fish, to discriminate between food of a wholesome character and that which is otherwise—what we have termed "selective feeding"—is carried, may now be considered.

The writer, in a previous paper,* has remarked upon the finding of alternating layers of certain species of zooplankton, in almost pure condition, in stomach material. The same thing has been recorded in the case of the Irish mackerel.†

The explanation of this condition originally suggested was to the effect that the fish might have been feeding first in a shoal of plankton organisms of one type and then in another, or else in different layers of water.

Prof. Ehrenbaum, of Heligoland, upon hearing of this theory, informed the writer that he had on certain occasions observed herring and mackerel, which were kept alive in tanks, showing unmistakable signs of feeding by selection upon individual copepods and other plankton organisms.‡

Further, it may be mentioned that the present writer, in making exhaustive examination of several hundreds of stomachs of mackerel and pilchard (of the former for the purposes of the paper already cited), was never able to detect any sign of the presence of medusae. Dr. Allen, however,§ in summarizing published information regarding the food of the mackerel, states: "In the first place, it feeds upon the smaller forms of the plankton, e.g. copepods and other crustaceans, larvae of crustaceans, molluscs, echinoderms and worms, diatoms and even *siphonophores* and *medusae*."‖ That this may be food of a somewhat exceptional character is evidenced by the fact that mackerel and

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* *Op. cit.*, p. 274.

† Farran, *Rep. on Sea and Inland Fisheries, Ireland*, 1901, Pt. II, p. 122.

‡ In reply to an enquiry respecting this statement Prof. Ehrenbaum wrote: "With reference to your enquiry, I desire to state that in the Heligoland aquarium mackerel, and at certain times also young herring, are kept alive for months, and both species have often been observed feeding in the manner described.

"Personally (and in this statement I think I have the support of many biologists), I consider that it cannot be doubted that all fish, which prey upon plankton, *feed by selection*. This can easily be demonstrated by an investigation of the stomach contents. Such material is never found to consist of all the various plankton components occurring within the area from whence the fish have been taken, but includes only certain species, which have been selected by the feeding fish.

"In my opinion it is a fallacy that certain fish, e.g. the mackerel, habitually swim round with an open mouth. The filtering apparatus of the gill arches is not intended to collect the plankton about to be swallowed, but serves to protect the tender gill-leaflets from possible damage caused by spurious forms of the plankton, which might occasionally be taken in the act of breathing into the mouth."

§ *Op. cit.*, p. 9.

‖ The italics have been inserted.

pilchard drift-fishermen at Newlyn, Mevagissey and elsewhere contend that good catches are seldom made in water which "brimes" considerably. On one occasion at Mevagissey an old fisherman, on seeing several *Hormiphora plumosa* drop from the first net of a fleet shot for pilchard, informed the writer that he knew that there would be a poor catch, which subsequently proved to be the case. The explanation, however, which was given, was to the effect that these ctenophores, becoming caught up on the meshes, rendered the nets conspicuous by their phosphorescence.

It may be mentioned, moreover, that boats fishing further out to sea made fair catches, and it is possible that these ctenophores occurred abundantly, as is often the case, in the estuarine water flowing out of the harbour, and in the fairly still water in the immediate vicinity.

The above statements constitute our sole direct evidence of the extent to which the theory of selective feeding in mackerel and certain other drift fishes can be carried. We may therefore summarize some other points which may lend further support to the suggestion.

There is a fair amount of evidence to show that mackerel, herring, and pilchard are continually in a state of voluntary movement when engaged upon inshore migration.

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With mackerel, the opinion is generally held by fishermen that once fish are known to be congregated in certain areas, unproductive fishing is due to the fact that the fish are not at the surface. The continued prevalence of N. and N.W. gales is well known to have a marked effect upon the western fishery, even at its height. The slight knowledge which we now possess respecting this fish's winter habitat* would strengthen the idea that it would naturally seek deeper layers of water, when the surface was subject to inclement conditions of atmosphere.

Mr. Cowley's statement, already cited, that mackerel and herring kept in captivity are continually in motion night and day, is quite in accordance with the views held by several intelligent fishermen, questioned on the subject by the present writer.

Moreover, the bare fact of the gradual progression shoreward of mackerel spread over a wide area at the beginning of the fishing season, resulting in a concentration of many thousands of shoals within the comparatively limited area afforded by the most productive fishing waters of May—i.e. within a 50-mile radius to the S. and S.W. of Scilly—would, to a great extent, preclude the suggestion that the fish are much affected in their inshore movements by the influence of currents.

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* *Vide* A. Cligny, "*Les pretendus migrations du maquereau.*" Ann. Sta. Aquicole, Boulogne-sur-mer, Nouv. Ser., Vol. I, 1905.

In the present state of our knowledge with regard to the winter habitat of the species, it is impossible to even hazard a suggestion as to how far many of these fish, caught in the height of the season, have travelled, yet the fact remains that productive fishing is carried on nearer and nearer to land as the season continues.

It is a somewhat difficult matter to obtain precise information with regard to the rate of progression of a single shoal of drift fish. Mathias Dunn, senior, stated that this in the case of pilchards, when on migration, was about 1½ miles an hour.*

Some information gathered at Sidmouth in 1911, moreover, may be worthy of record. The writer was informed by two boatmen who were constantly sailing over the area under consideration, that a shoal of small mackerel was first observed off Start Point at the beginning of July. It passed too far out from Dartmouth and Exmouth to be taken in a seine, but was fished for by certain drifters within a few miles from land. The shoal finally came close inshore to the west end of the sea-front at Sidmouth, where the greater part were taken in a seine, the remnant passing farther to the east. The time occupied in covering the total distance (which in a straight line is about 33 miles) was stated to be about nine days.

From a consideration of the above statements, several questions pertinent to the question of selective feeding naturally arise. In the first place, it may be suggested that when once distinct migration commences, whether it be a "spawning" or a "feeding" migration, mackerel make more or less regular daily progress towards inshore waters in the area under discussion, their movement being undeterred by the influence of currents. If this be the case, it naturally follows that were the fish to swim vigorously forward in the indiscriminate pursuit of plankton, at a pace sufficient to enhance the catching power of the mouth, their progress toward the land would be considerably more rapid than it appears to be from the slender evidence before us.

The speed, at which the small mackerel already mentioned crossed Torbay and the adjacent water, appears to have been about three to four miles a day. From observations made at Sidmouth by the present writer upon fish of this type in the years 1910–11, the food consisted for the greater part of caradid larvae with a few copepods, certainly, on the whole, organisms which might have been hunted by sight. How did these fish, therefore, take so long in covering the distance cited, unless whilst maintaining a shoal formation they were continually rounding up their prey in ceaseless movement, similar to that

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* Dunn, M., "Some Habits of Picked Dogs, Herrings and Pilchards," 54*th Ann. Rep. Royal Cornwall Polytechnic Soc.*, p. 5.

described by Mr. Mathias Dunn, whilst at the same time travelling by almost imperceptible stages toward land?

Again, if it can be suggested with any degree of certainty that a plankton organism such as a caradid larva, which is considerably smaller than the mysid *Macropsis*, is hunted by sight—by a system of selective feeding—it is a difficult matter to determine how small an organism may be before a mackerel ceases to feed upon it with discrimination.

The present writer in a former paper* has shown that a marked correlation appears to exist between the extent of the inshore migration of mackerel during the three months constituting the more important period of the drift-fishing season in the western part of the English Channel, viz. April, May, and June, and the paucity or abundance of the zooplankton occurring in the same area.

These observations, considered collectively, would tend to show that mackerel prefer an animal to a vegetable diet, and that it is probable, with a thorough understanding of the seasonal changes occurring in the pelagic plankton of the area under consideration, it may be demonstrated that shoaling mackerel frequent, in greater numbers, those areas supporting a food supply most suited to their taste. There is considerable evidence, moreover, in support of a theory that shoals of mackerel, when entering swarms of wholesome planktonic organisms, feed ravenously upon them while they last, whilst refraining from food to a great extent when swimming in water containing, what we may suppose to be, organisms of a distasteful character. It naturally follows that in years when the coastal waters support in greater proportion food of an inferior type, the extent of the inshore migration of mackerel is largely retarded.

The question naturally arises—Can this condition be traced to the fish's own capability of discrimination in question of food? Can it also be urged that if mackerel are capable of hunting, presumably by sight, the larger forms of the zooplankton, they are also able to discern when in sufficient numbers dense shoals of the more minute forms such as the copepod *Calanus finmarchicus* Gunnier and others, thereby still exercising a system of selective feeding, though in this case in a more expansive sense, viz. the obtaining of large mouthfuls of suitable plankton by a selection of the type of water supporting such prey, whenever possible.

. . . . . .

To summarize briefly the deductions which may be drawn from a consideration of the above observations, it may be stated—

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* *Op. cit.*, p. 278 and onward.

(*a*) That not only mackerel, but herring also can exist for a reasonable period of time, whilst exercising a system of nutrition by selective feeding, irrespective of season.

(*b*) That this system of selective feeding in mackerel and scad may extend to the larger forms of the plankton.

(*c*) That whilst it is impossible to determine how far the mackerel is assisted in its search for food by its power of vision, there is strong presumptive evidence to show that a capability for selective feeding, in a wider sense, may be extended to comparatively minute organisms, when they are present in sufficient numbers.

(*d*) And that this capability on the part of the fish to discriminate between food of a wholesome and that of a presumably unwholesome nature, would cause it to seek in greatest numbers water supporting the most suitable type of food, the extent of inshore migration thereby being largely dependent upon the planktonic condition of the coastal waters.

(*e*) Finally, that there is a by no means negligible amount of evidence to show that, when feeding upon the minor forms of the plankton, mackerel are incapable of assimilating other larger prey—which theory, if more fully established, would lend further support to the deduction that there is necessity for a suitable and abundant supply of plankton in the inshore waters before the shoals are induced to approach the land in sufficient numbers to form a profitable fishery.

In the preparation of this paper the writer's thanks are due to Mr. Mathias Dunn and Mr. E. W. Cowley for their valuable observations, also to Dr. E. J. Allen for much assistance and advice.

On the Occurrence of a Northern Hydroid *Halatractus* (*Corymorpha*) *nanus* (Alder) at Plymouth.

By

Dr. E. Stechow, München.

With Plate VII and Figure 1 in the Text.

ON looking over some hydroid material, for which I have to thank the Biological Station at Plymouth, I found upon an alga that was thickly covered with *Eudendrium album*, Nutting,* between the stalks of the Eudendrium a single specimen of the rare *Halatractus* (*Corymorpha*) *nanus* (Alder), which has until now been considered an Arctic species. The specimen is of special interest owing to the fact that this form has only been exceptionally met with in subarctic waters, and has only been recorded in England as a special rarity from the colder coast of Northumberland [Hincks, 1868; Allman, 1872; Pennington, 1885]. As far as can be gathered, it has only been found once even there. Its discovery now at Plymouth, on the warm southern coast washed by the Gulf Stream, is therefore the more surprising. In the comprehensive list of the Marine Fauna of Plymouth in this Journal (N.S., Vol. VII, pp. 155–298, 1904) the species is not included.

Corymorpha nana. Alder, Catalogue of Zoophytes of Northumberland and Durham. Trans. Tyneside Nat. Field Club, Vol. III, p. 108, Pl. 9, Figs. 7–8. 1858.

Corymorpha nana. Hincks, A History of the British Hydroid Zoophytes, p. 130, Pl. 22, Fig. 3. 1868.

Halatractus nanus. Allman, Monograph Tubularian Hydroids, p. 391. 1872.

Corymorpha nana. Pennington, British Zoophytes, p. 78. 1885.

Corymorpha nana. Bonnevie, Hydroida, Norske Nordhavs Expedition, p. 22, Pl. 1, Fig. 7. 1899.

Corymorpha nana. Bedot, Matériaux, 2^me^ période. Revue Suisse de Zoologie. Tome 13, Fasc. 1, p. 63, 1905.

Corymorpha nana. Broch, Hydroiden der arktischen Meere. Fauna Arctica, Bd. 5, Lfg. 1, p. 194. 1909.

Halatractus nanus. Bedot, Matériaux, 3^me^ période. Revue Suisse de Zoologie. Tome 18, Fasc. 2, p. 304. 1910.

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* *Jour. Mar. Biol. Assoc.*, N.S., IV, p. 146, 1896, and *Ann. Mag. Nat. Hist.*, 7 ser. Vol. I, p. 362, Pl. 14, Fig. 1, 1898.

The specimen agrees fairly well with the descriptions of Alder, Hincks, and Allman as completed by Bonnevie (1899). Nevertheless, I give here an accurate drawing (Plate VII), since it differs from the *figure* given by Hincks in many details, and the species has, indeed, never been adequately figured. The base is unfortunately broken off. The whole individual has a length of 3·5 mm.; the lower diameter of the hydranth, measured between the bases of the tentacles, is 0·8 mm.; the aboral tentacles are about 1·5 mm. long. The specimen is a young one, as can be seen by the immature condition of the gonophores. These show the beginning of the invagination of the Entocodon ("Glockenkern"), with as yet no trace of a differentiation into the characteristic medusoid organs (Fig. 1). The gonophores are simple and *unbranched;* they do *not* hang in bunches, as is characteristic of *Corymorpha nutans*, the only species of *Corymorpha* previously found at Plymouth. There is also no indication that these gonophores could be transformed at a later stage of their development into branched blastostyles. Besides, they stand in their circle not singly and uniformly distributed, but for the most part crowded near together in small groups. The hydranth has eighteen aboral and sixteen oral tentacles; but the number of the aboral tentacles especially is still increasing, as is shown by four very small tentacles, which I found in addition to those enumerated above between the large ones.

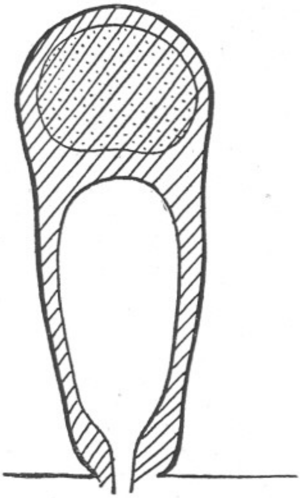
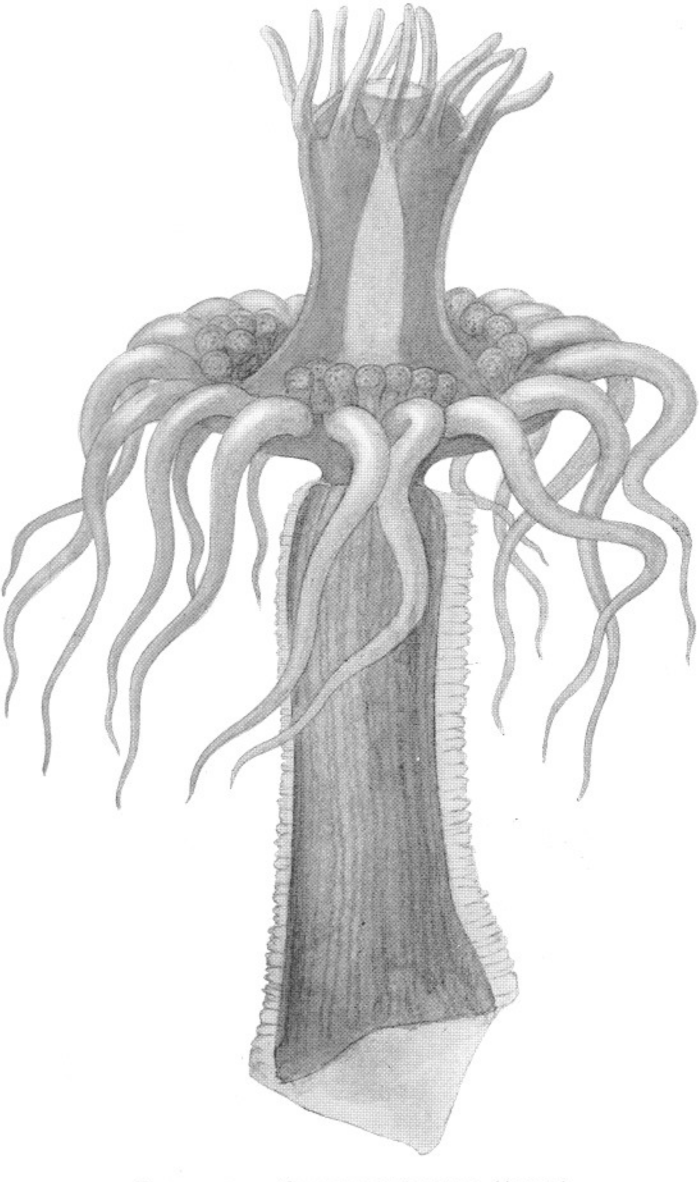


FIG. 1.—*Halatractus nanus* (Alder). Blastostyle (Diagrammatic, with outline drawn from actual preparation. The "Glockenkern" is dotted).

The hydranth is very sharply separated from the hydrocaulus. This is not accurately represented in Hincks's figure, which shows incorrectly a gradual transition at this place. Below the hydranth there is a deep *constriction;* the hydrocaulus which follows this begins with a slight thickening, which causes the constriction above it to appear still more obvious. I find it difficult, therefore, to understand how this characteristic constriction could have escaped the older authors. This is the chief point of difference which I find as compared with Hincks's figure, but it does not seem to me sufficient to found a new species.

The periderm is membranous, and encloses the hydrocaulus to the top; in this upper part however it is not closely attached, but lies loosely around it. In the interior of the hydrocaulus below the surface a longitudinal striation can be clearly recognised, due to the longitudinal canals present in all the *Corymorphas.*

In spite of certain differences when compared with the accounts of previous authors, I think that this form may certainly be identified as *Halatractus nanus* (Alder). Its transportation by a ship, under the circumstances in which it was found, is also improbable. There remains, therefore, only the supposition that its normal distribution really extends as far south as Plymouth, and that it is only on account of its rarity that it has not been previously found.



HALATRACTUS (CORYMORPHA) NANUS (ALDER).

List of Nemerteans collected in the Neighbourhood of Plymouth from May–September, 1910.

By
Dr. Gerarda Wȳnhoff.

With Figure 1 in the Text.

THE following list is one of the results of my work during a stay of nearly four months at the Plymouth Laboratory of the Marine Biological Association. I desire to express my thanks to the Director and the Staff of the Laboratory for the interest they took in my work and for their kind assistance.

A few of the Nemerteans, recorded in the list of the Plymouth Marine Invertebrate Fauna, published in 1904, were not found. For example, *Cephalothrix linearis,* which was dredged by Riches outside the Breakwater, has never been found again, notwithstanding all the trouble taken in searching for it. *Amphiporus bioculatus, McIntosh,* known from one specimen only from a dredging in Millbay Channel, I have not seen, nor the two new species of the genus *Oerstedia* described by Riches as *O. nigra* and *O. immutabilis.* To the forms missing in my list I must add *Malacobdella grossa, Baseodiscus curtus, Oxypolia beaumontiana, Micrella rufa,* and *Cerebratulus pantherinus.* With the exception of the two *Oerstedia* species each of the above species has been found in single specimens on rare occasions. Instead of these nine species however, I can add nineteen which have not yet been recorded from Plymouth; the greater part of these are new to England or the Atlantic Ocean, and four are new species.

As to the system accepted in this list, I have followed neither Bürger nor Coe. Bergendal's investigations on *Carinoma* and my own studies on the family *Cephalotrichidae* resulted in the breaking up of Bürger's ordo *Mesonemertini.* Bergendal's work has revealed many peculiarities in *Carinoma,* which prove its near relationship to the *Tubulanidae.* Moreover certain anatomical features remind us very much of the *Heteronemerteans.* The *Cephalotrichidae* are quite typical *Protonemerteans,* but do not possess any character suggesting an intermediate position between the other members of this group and the *Metanemerteans.* Both genera have therefore been replaced in Bürger's ordo *Protonemertini,* which means the restoration of Hubrecht's *Palaeonemertini.*

Certainly *Hetero-* and *Palaeonemertini* are much more closely related to each other than the *Metanemerteans* with either of them. The position of the mouth behind the brain, the structure of the alimentary canal, the tendency to a complicated structure of the body wall, the development of an outer longitudinal muscle layer, the presence of an inner circular muscle layer of which traces may be found at least in every family, the structure and position of the cerebral organs and the position of the nervous system, which only secondarily migrates through the outer circular muscle layer, together with the absence of any structure in the proboscis, which reminds us of its peculiar complication in the ordo *Metanemerteans*, are so many points of resemblance, that I do not hesitate to join *Palaeonemertini* and *Heteronemertini* together in one order, the ordo *Anopla* of Max Schultze.

Bürger's *Metanemertini* = Hubrecht's *Hoplonemertini* constitute my second order, for which Max Schultze's name *Enopla* ought to be restored. They are characterised by the situation of the mouth in front of the brain, the presence of an oesophageal diverticulum, the structure of the body-wall, the peculiar structure of the proboscis and the presence of stylets, the position of the nervous system in the parenchyma of the body, the situation and structure of the cerebral organs, the uniformly built vascular system.

Palaeonemertini and *Heteronemertini* have been reduced to the rank of suborders. The nomenclature of "Das Tierreich" has been adopted.

As iconographical works I have everywhere referred to:

1. *Bürger, O.* Die Nemertinen des Golfes von Neapel. Fauna und Flora. Monogr. 22, 1895.
2. *Joubin, L.* Les Némertiens. Faune française par R. Blanchard et J. de Guerne. Paris, 1894.
3. *McIntosh.* A Monograph of British Annelids. Part I. Nemerteans. Ray Society, London, 1873–1874.

ORDO I. ANOPLA.

In addition to the outer circular and the inner longitudinal muscle layers an outer longitudinal and an inner circular muscle layer may be present. The nervous system is situated in the body wall. Mouth always behind the brain. No diverticulum of the oesophagus. No stylets and no peculiarly built proboscis.

SUBORDO I. PALAEONEMERTINI.

Lateral nerves and brain nearly always situated outside the muscular body-wall. The body-wall consists of an epithelium, a circular muscle layer and an inner longitudinal muscle layer; the inner circular muscle layer may be absent.

I. Fam. TUBULANIDAE, Bürger.

Cerebral organs nearly always present; the cephalic furrows merely consist of epithelial grooves. Often with lateral sense-organs. Nervous system situated between the epithelium and the basal membrane or between the basal membrane and the outer circular muscle layer. The epithelium is very thick and contains many clusters of secretory cells. Inner circular muscle layer present. A median dorsal blood-vessel is not present.

Genus **Tubulanus.**

The nervous system is situated between the basal membrane and the muscular body-wall. Cerebral organs present.

1. **Tubulanus polymorphus** (*Ren.*). (Bürger. Monogr. Taf. I, Fig. 4; Joubin. Les Némertiens, Pl. I, Fig. 8 et 9.)

Locality: Eddystone and Rame-Eddystone Grounds; once off the Breakwater.

A few specimens of this Nemertean were always dredged in the deep water near the Eddystone or on the Rame-Eddystone Grounds, at a depth of 45 m. or more. No external markings are present; the body has a uniform orange colour and is rather soft. The head is separated from the body; it is much broader and rounded. Lateral organs are present.

Geographical distribution: Norway, England, France (both coasts), Mediterranean coasts.

2. **Tubulanus linearis** (*McIntosh*). (Bürger. Monogr. Taf. I, Fig. 2.)

Locality: Several specimens known from different localities inside the Breakwater (Queen's Grounds, Asia Shoal, Millbay Pit, Duke Rock). Shallow-water form.

The head and oesophageal region of this Nemertean are milk-white; the other part has an orange-brown tint. This is due to the intestine. The head is very flat, and in the living animal very often makes a burrowing movement. Notwithstanding the perfect transparency of this part I have not been able to distinguish the cerebral organs or cephalic slits. The rhynchodaeum is conspicuous as a milk-white line in front of the brain commissures, which are very long; the brain lobes are but small and do not approach each other at all. The proboscis sheath does not extend into the hinder part of the body; it is, however, present at the beginning of the intestinal region.

Geographical distribution: Southern coast of England, Wimereux, Naples.

3. **Tubulanus miniatus** (*Bürger*). (Bürger. Monogr. Taf. I, Fig. 8.) Three individuals of a Nemertean which I consider identical with the one specimen described by Bürger from Naples, were dredged on the Rame-Eddystone Grounds on July 11th. Depth 45–55 m.

By its size this species is easily distinguished from *T. polymorphus*, the length of the biggest specimen being 3 cm., at a breadth of 1½ mm. Moreover, the colour of the body is a darker orange than *T. polymorphus* possesses at Plymouth; the rounded head is not so broad, and is not so sharply separated from the body; it has a white patch at its tip. Generally the dorsum has a more intense colour than the ventral side; the dorsal and ventral regions are sharply separated by a line which is particularly well seen in preserved specimens. Alcohol specimens do not take the peculiar marking described by Hubrecht for *T. polymorphus*. Side organs are probably present.

Geographical distribution: One specimen known from Naples (Bürger).

4. **Tubulanus nothus** (*Bürger*). (Bürger. Monogr. Taf. I, Fig. 12.) Locality: Rum Bay, Bridge and Queen's Grounds, each one specimen; from Asia Shoal and Millbay Pit, each three specimens.

This species, which resembles *T. annulatus* very closely, but is of smaller size, is a shallow-water form at Plymouth. The colour is darker, especially on the back. The ventral side has an orange-brown tint, which continues in a dirty yellow at the head and the tail. On the dorsum a black pigment seems to be developed, which gives the whole animal a dirty brown appearance. The head is colourless with two characteristic black, semicircular pigment spots. It is not broader than the body. The first white ring is present directly behind the colourless head; the median dorsal line takes its origin from it; it is one of the broader belts which very often quite characteristically break up into two thin rings. The lateral lines originate from the second belt; a ventral longitudinal line was present in most of my specimens. Side organs exist; they are to be found as small orange pits at the dorsal side of the lateral lines, just in front of the fourth circular line. Forty rings or more are present, which show in part the arrangement described by Bürger.

The presence of a median ventral line is the only difference between the Naples specimens and my species. Sometimes the ventral line, however, was very inconspicuous, even invisible in the living specimens, while all alcohol material, even those specimens I collected as undoubtedly *T. nothus*, show clearly the presence of this line. Therefore I do not hesitate to regard my species as identical with *T. nothus*, Bürger.

Geographical distribution: It has only been described from Naples by Bürger.

5. **Tubulanus superbus** (*Köll*). (Bürger. Monogr. Taf. I, Figs. 5, 7, 9, 11.)

Locality: On the Eddystone and Rame-Eddystone Grounds; often met with. One specimen from Asia Shoal.

This Nemertean seems to be common on all grounds outside the Breakwater at a depth of 45 m. or more. A small number of individuals has been recorded from more shallow water; both Punnett and Beaumont found it in a sandbank in the river Yealm. Joubin and Bürger give a depth of 30–80 m., which agrees with the ordinary habitat of this worm at Plymouth. The colour of this big Nemertean is a reddish brown. There are four longitudinal white lines and a great number of white rings. The head is broader than the body. Pigment spots are not to be seen. The median dorsal line continues to the tip of the snout, which itself is surrounded by white lines. The cephalic grooves are situated at a short distance behind the first transverse dorsal line. Side organs are present.

Geographical distribution: Mediterranean coasts, Sweden, Great Britain, French coasts of the Channel.

6. **Tubulanus annulatus** (*Mont.*). (Joubin. Les Némertiens, Pl. I, Fig. 2 et 3. McIntosh. Monogr. Pt. I, Pl. 8, Fig. 1.)

Locality: This Nemertean has been recorded from nearly all dredging grounds inside and outside the Breakwater; more commonly it is met with near the Mewstone and the Eddystone, at a depth of at least 18 m.

T. annulatus can easily be distinguished from *T. superbus* by the absence of a median ventral line, its much smaller size and the bright orange-red colour. The white median dorsal line continues on the head and bifurcates at the tip, enclosing a patch of the same colour as the body. The head is coloured both on its dorsal and ventral side; the lateral lines originate from the first white belt, which is situated at a short distance behind the cephalic grooves and just behind the mouth. The cephalic grooves reveal exactly the same features as in *Carinella aragoi, Joubin.* "Ils occupent le fond du cou, et sont, non en creux, mais en relief; ils sont teintés en jaune. Sur la face ventrale, ils commencent audessus de la bouche, de chaque côté, mais sans se rejoindre sur la ligne médiane. Ils sont, dans toute cette portion, à peu près droits. Arrivés sur le bord latéral, dans le prolongement des lignes blanches dont il a été question plus haut, on aperçoit un petit orifice. Au delà, ils passent sur la face dorsale et forment des sinuosités tout à fait caracteristiques. La terminaison des deux sillons forme deux lignes séparées par la bande blanche dorsale" (Joubin. 1890. "Archives de Zoöl. expér. Ser. II, T. VIII, p. 495).

As far as I can judge from the description and the figures given, *T. annulatus, Montagu*, which is doubtless the same species which I found at Plymouth, agrees completely with *C. aragoi, Joubin*, in external features. However, we cannot at present consider the species identical, as their anatomy is not at all the same. This seems to be a case like the one described by Bergendal for *Carinella linearis* and *C. groenlandica*. Neither do the Plymouth specimens agree with the description and figures of Bürger's species in the Naples monograph.

C. annulata, Bergendal, however, seems to exhibit the same internal structure as the Plymouth specimen; but this species differs externally from *C. aragoi* as Bergendal states. This complicates the question still more. Only the study of sections of all these Nemerteans can throw more light on this interesting question. At any rate there can be little doubt as to the identity of *T. annulatus* (*Mont.*) with the Nemertine described above.

7. **Tubulanus albocapitatus.** *Nov. spec.*

Locality: Rame-Eddystone Grounds.

Fig. 1.
Tubulanus albocapitatus.

In 3 different dredgings, each time one specimen of this small Nemertean, which can easily be mistaken for a young *T. annulatus*, was collected. On closer inspection it differs considerably from that form. A complete individual had a length of 1½ cm. and was ½ mm. broad in the oesophageal region. The head is not sharply separated from the body, nor is it much broader. Pigment spots are absent. The perfectly white head is followed by a brown-red belt of the same breadth, which is the darkest part of the whole body. A yellow pigment is distributed all over this region. The cephalic furrows are situated in this ring; they are rather deep and reach half-way to the dorsum; they are not lined with white or yellow, as is the case in *T. annulatus*, and are quite differently shaped. The first circular white line separates this region from the body. The median dorsal line, which is white too, passes through this belt into the dark region described above, but does not reach the white head. At both sides of this median longitudinal line, separated from it by a translucent region, a reddish-brown stripe of a fainter tint is present. These stripes do not even reach the lateral lines, as a transparent region is developed between them too; the white pigment patches, which are dispersed at the sides, constitute a very inconspicuous and incomplete lateral line. The ventral side is also transparent. Eleven white belts are present; the first constituting the separation between the intense coloured and the oesophageal region. Just in front of the second ring one pair of white patches is conspicuous; they are connected with this belt and are situated in the dorsal red stripes. I have not found any trace of side organs.

II. FAM. CALLINERIDAE.

Cerebral organs absent. Nervous system situated between the basal membrane and the outer circular muscle layer. A thick nervous layer is present in the head. Inner circular muscle layer present. A median dorsal blood-vessel fails; four blood-vessels in the head. Rhynchodaeum with a separate layer of longitudinal muscle fibres. Proboscis anteriorly, with four longitudinal muscle bundles, followed by a diaphragm.

GENUS **Carinesta.**

No composite gland cells in the epithelium. Oesophageal nerves paired; no lateral sense organs. Diagonal muscle layer absent. Proboscis attached behind the mouth. Proboscis sheath without any peculiarities of musculature.

1. **Carinesta anglica.** *Nov. spec.*

Locality: one specimen was collected from the river Yealm at low tide by digging in a muddy sandbank; and one fragment crawling about in sand from Whitsand Bay.

This white nemertine somewhat resembled Punnett's description of *Oxypolia beaumontiana*. The snout is elongated and pointed; when contracted the wrinkling is obvious. Colour a watery milk-white anteriorly; the gonads give the posterior part a rosy-brown tint. The mouth had been protruded obviously in the fragment from Whitsand Bay. No sense organs are present, nor could I distinguish the proboscis pore. The proboscis itself and the intestinum are easily visible because of the transparency of the animal.

The posterior part of the body was much swollen and contracted at irregular intervals when the animal was first examined; on touching it broke into pieces.

Sectioning revealed the very interesting structure of this animal, which I was able to identify as a *Carinesta* species. From Punnett's type specimen, however, which was collected at New Britain, it differs in the total absence of that part of the inner circular muscle layer, which is already disappearing in *C. orientalis*. Moreover, a head gland exists in *C. anglica* and fails in Punnett's specimens. I could not find any traces of a dorsal decussation of fibres, nor is there any special longitudinal muscle sheath at the ventral side of the oesophagus.

III. FAM. CEPHALOTRICHIDAE.

Bodywall composed of an epithelium in which a separate layer of gland-cells does not exist, the basal membrane, the outer circular and the inner longitudinal muscle layer. The inner circular muscle layer often fails. The nervous system is situated in the middle of the inner longitudinal muscle layer. Sense organs are not developed. Four thick cephalic nerves. Vascular system consisting of a pair of lateral blood-vessels only. A great number of nephridial organs.

GENUS **Cephalothrix.**

Mouth widely separated from the brain. Body thread-like. No sense organs. The oesophageal nerves are not paired. No bifurcation of the continuation of the dorsal brain lobes. An inner circular muscle layer fails. The genital sacs are not developed in the oesophageal region.

1. **Cephalothrix rufifrons** (*Johnston*). (Bürger. Monogr. Taf. II, Fig. 24.)

Locality: Common between tidemarks at Rum Bay, Mount Edgcumbe, Drake's Island, the Mewstone; in clean sand, between corallines, under stones, etc. Very thin, colourless or white species, with two small red or orange spots on the tip of the head. Length, 30–40 mm.; breadth, $\frac{1}{2}$ mm.

Geographical distribution: Coasts of Norway, Denmark, Great Britain, France, and Italy.

SUBORDO II. HETERONEMERTINI.

The body-wall is composed of the epithelium, cutis, outer longitudinal, outer circular and inner longitudinal muscle layers. The nervous system is situated between these muscle layers. The lateral nerves are always found outside the circular muscle layer.

I. FAM. BASEODISCIDAE (= Eupolidae, Bergendal).

Proboscis pore near the tip of the snout. The inner muscular layers are not developed in the head. Cerebral organs large, close to the brain. A thick layer of connective tissue separates the epithelium with its gland cells from the outer longitudinal muscle layer. Proboscis with two layers, an outer circular and an inner longitudinal. Proboscis without muscular crosses. The proboscis sheath is short. Head more or less rounded; usually with eyes.

GENUS **Poliopsis.**

Head sharply separated from the body by a deep furrow. A dorsal and a ventral median longitudinal cephalic furrow are present.

1. **P. lacazei,** *Joubin.* (Joubin. Les Némertiens. Pl. I, Fig. 15 et 16.)

Locality: One specimen from the Eddystone.

On the 26th of May I got this single specimen, together with *Tubulanus superbus* and *T. polymorphus,* from the Eddystone Grounds. As the position of the eyes, the bright pink colour and the two cephalic slits agreed perfectly with Joubin's description, I did not hesitate to identify my specimen as *P. lacazei.* The internal structure proved the correctness of this identification.

Geographical distribution: Joubin found this species at Banyuls, Bürger at Mauritius, Hallez near Calais.

II. FAM. LINEIDAE.

Usually with a pair of deep horizontal cephalic furrows. Proboscis with three muscular coats and mostly with two muscular crosses. Cephalic gland consisting of very slender tubes, situated anterior to the brain.

SUB-FAMILY A. LINEINAE.

Without caudal cirrus. Proboscis sheath usually much shorter than the body.

GENUS **Lineus.**

Body rounded or flattened, unusually long, very contractile. Head mostly somewhat broadened and spathulate. The worms are not able to swim; as a rule they coil themselves up and make knots. Ocelli present in most species. Proboscis sheath short.

1. **Lineus longissimus** (*Gunn.*) (McIntosh. Monogr. Pl. IX.)

Locality: Rather common in dredgings from the Sound, Mewstone, and the Yealm.

The colour is a blackish brown relieved throughout by the fine purplish "iridescence of the cilia." With darker and lighter stripes on the head and part of the body. Eyes numerous, arranged in a marginal row on each side of the head, which is somewhat broadened and spathulate, not separated from the body.

Geographical distribution: Atlantic and Baltic coasts of Europe.

2. **Lineus bilineatus** (*Ren.*). (Joubin. Les Némertiens, Pl. II, Fig. 26 et 27.)

Locality: Very common, especially in dredgings from the Sound; from the Rame-Eddystone Grounds, the Mewstone neighbourhood, but also from the Cattewater and between tidemarks at the Yealm and Rum Bay.

Colour a pale brown, sometimes with a reddish shade, or nearly white. With a pair of longitudinal white streaks, passing on from the tail to the tip of the head, where they usually join together in a broader white patch. Head ending bluntly, somewhat spathulate. Eyes wanting.

Geographical distribution: Sweden, Great Britain, France, Italy, Madeira.

3. **Lineus lacteus** (*H. Rathke*). (Joubin. Les Némertiens. Pl. II, Fig. 23; and McIntosh, Monogr. Pl. V, Fig. 3.)

Locality: Two specimens from Asia Shoal, on one occasion.

Body slender, threadlike, white, anteriorly pinkish. Head broadened, spathulate, not distinctly separated from the body. Eyes about fifteen, arranged in a row on each side of the snout. Mouth removed from the brain. Length 100 mm., breadth 1 mm.

Geographical distribution: The Channel, Sweden (?), Mediterranean, and Pontic coasts.

4. **Lineus ruber** (*Müll.*). (McIntosh. Monogr. Pl. V, Fig. 2.)

Locality: Between tidemarks very common in Cawsand and Rum Bay, at Drake's Island; from New Grounds in dredgings.

Body flattened, 3 mm. broad, diminishing towards the tail. Colour usually bright red. Head spathulate, separated from the body. With four to twelve eyes. Length 150–200 mm.

Geographical distribution: Coasts of the Northern Atlantic, with Baltic, Mediterranean, and Madeira coasts.

GENUS **Euborlasia.**

Body very thick, biconvex in section and usually not flattened ventrally. Lateral margins absent after preservation. Head not separated from the body. In animals not perfectly extended the posterior part of the body is much thicker (3–6 times) than the anterior region. Proboscis sheath short. Without eyes.

1. **Euborlasia spec.**

To this genus I refer two fragments of Nemerteans, which were collected from a sandbank in the river Yealm. As in both fragments the anterior portion of the body is wanting, I have not been able to identify the species, or even the genus with certainty. One fragment came living into my possession. It had been dug up in the sandbank, high up the river Yealm, at a place where the water is nearly fresh. A great deal of sand has been removed from this sandbank during the last ten years, and it is now very muddy. This Nemertean, which was formerly rather common at this place, has since become quite rare. The other fragments, which also lack a head, were collected at the same place in 1898. After preservation the body is deeply furrowed and wrinkled, much as in *Cerebratulus corrugatus.* The anterior part of my specimen got very thin by preservation (breadth 5 mm.); the following region suddenly broadens till it has a breadth of 16 mm. The living specimen had a brownish colour, with more whitish margins. No markings were present.

The sections revealed some features which decided my classification of this species as a *Euborlasia;* I regard it, however, as a separate species from both *E. elisabethae* and *immaculata.*

The proboscis sheath is very short, as already in the thinner portion of the body it is devoid of its muscular coats. The intestinal caeca are richly developed and branched. The gonads are placed in rows between the caeca, alternating with their diverticula. They all open dorsally. Muscular septa are entirely absent. The intestinum with its diverticula and the gonads are surrounded by a thick layer of connective tissue, in which a great number of very narrow blood-vessels are imbedded. The structure of the epithelium agrees perfectly with Bürger's description; the large gland cells are especially conspicuous (Bürger. Monograph Naples, T. 22, Fig. 39).

SUB-FAMILY B. MICRURINAE.

Caudal cirrus present; proboscis sheath usually extends nearly or quite to the posterior end of the body.

GENUS **Micrura.**

Small, thin, mostly flattened and soft nemertines; head spathulate, ending bluntly, not separated from the body. Lateral margins of the body not remarkably thin; incapable of swimming. Often with a great many eyes. The mouth is circular. Proboscis sheath short.

1. **Micrura fasciolata** (*Ehrbg.*). (McIntosh. Monogr. Pl. VI, Fig. 2.)

Locality: Common in the dredgings from the Sound, Eddystone, Mewstone, and from the Rame-Eddystone Grounds.

General colour red or red-brown, head and ventral side white. 10–24 slender white transverse stripes across the dorsum. With 4–6 small eyes. Length 120–200 mm., breadth 1–2 mm.

Geographical distribution: Sweden, Great Britain, Northern coast of France, Mediterranean.

2. **Micrura aurantiaca** (*Grube*). (McIntosh. Monogr. Pl. VII, Fig. 4.)

Among some tubes of preserved nemertines I found one containing two nemertines from the Breakwater. They were supposed to belong to the same species, and must therefore have been very much alike in the living state. After preservation, however, the difference was very obvious, the one being rather flattened with lateral margins and the other being circular anteriorly and showing no margins even at the more flattened and weaker posterior part of the body. The colour of the more rounded nemertine was moreover brownish, while the bright yellowish colour of the flattened specimen at once proved it to be a small specimen of *Cerebratulus roseus.* So I suppose the colour of the other specimen to have been a very faint red or rose. The internal structure, however, makes it quite certain that this specimen must have been an abnormally faint coloured and rather large individual of *Micrura aurantiaca.* All traces of the original colour or of any markings had disappeared. Eyes are absent. The cutis is as thick as the epithelium. There are no traces of a connective tissue layer separating the cutis from the external longitudinal muscle layer, which is much thicker than the circular or inner longitudinal muscle layer. The latter layer has been very much reduced. The cerebral organs are placed above the lateral nerves. The dorsal part of the dorsal brain lobe is situated laterally to the ventral part ; it ends anteriorly to the cerebral organs. The cephalic slits end where the cerebral canal originates from them. They reach as deep as the brain. The mouth is situated beneath the hinder end of the cerebral organs.

Geographical distribution : Both coasts of France and the Mediterranean.

3. **Micrura purpurea** (*Dalyell*). (McIntosh. Monogr. Pl. VII, Fig. 3.)

Locality : Rather common in dredgings from the Sound ; occasionally a specimen from the Rame-Eddystone and the Mewstone Amphioxus Grounds.

Colour brown ; head white, with a bright yellow transverse bar ; eyes absent. Length 100–200 mm., breadth 2–3 mm.

Geographical distribution : Sweden, Great Britain, North coast of France, and Mediterranean.

4. **Micrura candida,** *Bürger* (= *Micrura lactea, Hubrecht*). (Joubin. Les Némertiens, T. 2, Fig. 23 bis.)

Locality : Two specimens from the Mewstone and two from the Mewstone Ledge.

Perfectly white. Eyes absent.

Geographical distribution : Channel and Mediterranean.

Two specimens are known from England, one from Stoke Point near Plymouth, and one from Halfway Rock.

GENUS **Cerebratulus.**

Body usually long and ribbon-like, much flattened, with very thin lateral margins; well adapted for swimming. Head pointed, lancet-like. Eyes are usually absent. Mouth mostly a long slit.

1. **Cerebratulus fuscus** (*McIntosh*). (McIntosh. Monogr. Pl. VI, Fig. 3.)

Locality: In dredgings from Asia Shoal, Queen's and New Grounds, Millbay Channel, and once from Mewstone Ledge.

General colour usually pale yellow, only pigmented on the head; sometimes, however, especially in bigger worms, a brown pigment was distributed all over the dorsum. Brain transparent. No eyes. Head spathulate, not separated from the body.

Geographical distribution: Sweden, Great Britain, France, Portugal, Mediterranean.

2. **Cerebratulus roseus** (*Chiaje*). (Bürger. Monogr. Taf. VI., Fig. 12.

Locality: Specimens were collected from the Breakwater, May, 1910; from Salcombe (Millbay) by Mr. Potts, in 1908; from the sand under Batten Castle, May, 1902; each time one complete specimen. A fourth specimen, collected from the Breakwater, was found in a tube of preserved specimens with *Micrura aurantiaca*.

The colour of the only living specimen I have seen was a dirty flesh colour; this individual was a female, which whilst being brought in broke into several pieces; however, no parts, not even the appendix, had been lost. The uncoloured margins were very conspicuous. The centre of the body probably took its darker colour from the eggs, which had an orange-brown tint and were partly deposited through the genital pores, situated in two rows on the dorsum. The mouth is large; the cephalic slits even reach the region of the mouth. The preserved specimens show the bright yellowish tint characteristic of *Cerebratulus roseus*. Bürger's figure moreover leaves no doubt as to the identity of my specimen with his *C. roseus*.

Geographical distribution: The French coast of the Channel and the Mediterranean.

3. **Cerebratulus alleni.** *Nov. spec.*

Locality: Yealm sandbank.

This Nemertine was collected on the 7th of November, 1907. The single specimen was given to me last summer. It had been preserved in corrosive sublimate and was then in alcohol. The only description I could get of the living animal was: colour, light flesh with white snout. It was supposed to belong to the same species as the individual described as *Micrura aurantiaca* and a small specimen of *Cerebratulus roseus*. From both, however, it differs in the shape of the head, which is conspicuously swollen at its hinder part and not separated from the body, so that it is best described as fig- or pear-like. The colour is a greyish brown anteriorly, which is replaced by a yellowish grey in the greater part of the body. These two colours are sharply separated from each other, just as in *Tubulanus polymorphus*. Sections revealed the following peculiarities, which made me create a new species for this single individual.

The cephalic slits are rather long, extending nearly to the beginning of the mouth, and farther than the cerebral organs themselves. They are not very deep, and reach only half-way to the brain. The cerebral pit, however, is deeper. The cerebral canal originates behind the dorsal brain lobe; this bifurcates into two lobes, the dorsal of which ends quite free in the longitudinal musculature in the region of the cerebral canal, separated from the ventral lobe by a thick band of tissue. The ventral lobe continues directly as the cerebral organ. This is never in contact with any blood-vessel, but lies internally to the circular muscle layer. The dorsal lobe of the dorsal brain, the cerebral organ, and the ventral brain lobe are situated above each other. The blood-vessels form one large dorsal anastomose in the head; the very short cephalic blood-vessels unite again within the brain; from this ventral anastomose an unpaired oesophageal blood-vessel takes its origin. This unpaired vessel divides into two in the region of the oesophageal nerve commissure. These two communicate often with the lateral blood-vessels situated on both sides of the proboscis sheath. In this region large gland cells are also conspicuous. They are buccal glands, which are enormously developed all round the mouth and the oesophagus. They are placed in clusters, and freely protrude into the blood-vessels, both into the lateral and into the oesophageal vessels, which frequently communicate with each other and form a network all round the oesophagus. They are even more richly developed than in *Micrura alaskensis, Coe;* they do not, however, extend outside the circular musculature.

The epithelium is not very thick. A separate cutis layer cannot be distinguished. The cutis glands are situated in the outer longitudinal muscle layer. A small layer of longitudinal muscle fibres, as thick as the epithelium itself, and traversed by the gland ducts, separates the layer of glands from the epithelium. These are themselves surrounded by muscle fibres, and do not form a compact layer. They are some two or three times as high as the epithelium. The bases of the cutis glands are situated not quite half-way between the outer bodywall and the circular muscle layer, laterally at a third of that distance only. The circular muscle layer is separated from the outer longitudinal by a thick nervous layer. Diagonal muscle fibres are absent. The circular muscle layer is rather feebly developed, and has twice the thickness of the epithelium, while the inner longitudinal muscle layer is twice to three times as thick as the circular layer in the oesophageal region. Longitudinal muscle fibres are not present between the oesophagus and proboscis sheath.

The gonads alternate regularly with the intestinal caeca; the genital pores are situated above the proboscis sheath. In the intestinal region the outer longitudinal and circular muscle layers are very much reduced. This is especially the case with the outer longitudinal muscle fibres which form a layer of the same thickness as the cutis glands dorsally and ventrally, so that the latter reach the circular muscle layer; laterally, however, the layer of longitudinal fibres is thicker. The circular muscle layer is as thick as the epithelium, but the inner longitudinal muscle layer, which is five to six times as thick as the circular, has the same breadth as in the oesophageal region.

On the 1st of June part of a Nemertine was collected in dredging materials from the New Grounds. It turned out to be the posterior part of a very thin (1 mm.) nemertine, completely white, and long in comparison with the uniform breadth. The head failed, but an appendix was present. The structure of the body-wall reveals the characteristics of a Heteronemertean, as the outer longitudinal muscle layer is present. As with all the layers of the body-wall, this longitudinal muscle coat is very much reduced in size when compared with other nemertines. There are no traces of a cutis nor of any clusters of composite gland cells. Epithelium and outer longitudinal muscular coat have about the same breadth and are separated by the thin basement membrane only. The epithelial cells constitute a single layer. The circular and inner longitudinal muscle layers together have but one-third of the thickness of the outer muscular coat. They have about the same breadth. The longitudinal muscle fibres surround the wide enteron and the proboscis sheath, which ends just before the point where the tail is attached. The intestinal pouches are very shallow, and I have not been able to discern any septa. The gonads alternate with the intestinal pouches, or perhaps they are the cause of the appearance of these unreal diverticula. The position of the lateral nerve cords is the usual lateral situation. I have not been able to detect a median dorsal blood-vessel.

The point of greatest interest is the structure of the tail, which differs widely from any structure of this kind yet described. The epithelium has about the same height as in the body; many gland cells are present. I have not found any traces of the outer longitudinal muscle layer. Circular and inner longitudinal muscle coat are present as a single layer of muscle fibres. In the tail itself I have not been able to trace the nervous system; from the posterior commissure of the body, however, nervous tissue is seen to reach the basis of the tail. The centre of the tail is occupied by the intestine, which is seen to communicate widely with the intestine of the body and opens to the exterior by the anal aperture at the tip of the appendix. There are no intestinal pouches, nor gonads nor rhynchocoelom in the tail, which moreover lacks all connective tissue. Even the basement membrane could not be distinguished. If any nervous tissue is present it must be still epithelial.

As to the vascular system, I have not been able to find the anal anastomose nor anything like vessels in the appendix.

Certainly there can be no doubt that this specimen belongs to the sub-family Micrurinae. Had it not been for the tail, I should have felt inclined to identify the fragment as *Lineus niveus, Punnett*, which lives at the much greater depth of 100–140 m. near Bergen in Norway. As, however, Punnett describes the total absence of a tail in half a dozen specimens he collected, and as I can only judge their relationship by the hinder part of the body, I do not feel justified in considering them identical. If my supposition is right, I am inclined to think that a new genus ought to be created, on account of the structure of the appendix and the very primitive features which *Lineus niveus* reveals. The presence of an appendix certainly would approximate *Lineus niveus* still closer to *Zygeupolia* and *Micrella*.

ORDO II. ENOPLA.

The body-wall consists of a single-layered epithelium, a basal membrane, the outer circular and the inner longitudinal muscle layer. Mouth anterior to the brain, or the oesophagus opens into the rhynchodaeum. An oesophageal diverticulum is present. The nervous system is not situated in the body-wall, but in the central connective tissue.

SUBORDO A. PRORHYNCHOCOELOMIA.

Worms with a very long and slender body; they like to coil themselves up and to form knots. The proboscis is much shorter than the body. The proboscis sheath never extends into the posterior third part of the body, and exists usually in the anterior third only. Neurochords or neurochord cells fail.

I. Fam. EMPLECTONEMATIDAE.

Mostly very long and flat forms. Proboscis short and rather stout, with one very differently shaped central stylet only. Very often with many small eyes; seldom two or four eyes. No statocysts.

Genus **Emplectonema.**

Very long and slender. Alimentary tract and proboscis open together. Cerebral organs very small, generally situated a long distance in front of the brain. Mostly with many small eyes. The proboscis sheath does not quite extend to the second third of the body. Sexes separate.

1. **Emplectonema gracile** (*Johnst.*). (McIntosh. Monogr., Pl. II, Fig. 5.)

Locality: In dredgings from the Mewstone; between tidemarks at Breakwater, Drake's Island, Cawsand Bay. Far less common than the next species.

The colour of this Nemertean is usually a more greyish green than the figure in McIntosh's monograph indicates; ventral surface white. The head is lined with white and possesses a faint yellow transverse bar. It is broader than the body, but not sharply separated. Cerebral organs a long distance in front of the brain. 20–30 eyes in two groups at both sides of the head. The handle of the central stylet is twice the length of the stylet itself; all stylets are curved. With two pouches each containing 5–6 accessory stylets. Length 20 cm. or more, breadth 1 mm.

Geographical distribution: This species is widely distributed. It is known to occur on the West coast of North America as well as in Chile and the Aleutian Islands, the coasts of France and Germany, Madeira and the Mediterranean.

2. **Emplectonema neesi** (*Oerst*). (McIntosh. Monogr. Pl. III, Fig. 6; and Joubin, Les Némertiens, Pl. III, Figs. 77–80.)

Locality: Common between tidemarks in the Sound; from Breakwater and the Mewstone; occasionally met with in dredgings at a depth of 10–15 fathoms.

This Nemertean is much more abundant than *E. gracile.* However, it is not so widely distributed. *E. neesi* has been recorded only from the Atlantic coasts of Europe. It ranges from Iceland to the Channel.

Head broadened and of a yellowish colour, paler than the body. The dorsum has a brown hue in which flesh-coloured stripes occur;

sometimes these stripes are broken up into patches, which give the animal a speckled appearance. The ventral surface is white. Cerebral organs at a great distance in front of the brain. Numerous small eyes arranged in four clusters. The oesophageal diverticulum sends two pouches to the brain. Both the central stylet and its basis are short and stout; they are of the same length. Two pouches, each with three accessory stylets. Length to 46 cm., breadth ½ cm.

3. **Emplectonema echinoderma** (*Mar.*). (Bürger. Monogr. T. II, Fig. 3.)

Locality: One specimen from Millbay Pit.

Bürger's figure gives a very good idea of the Plymouth specimen; the head shows the same form and markings. The colour is generally a more orange-red. A number of very small eyes, arranged in a row, are situated on the margins of the head; they do not show very much, which is probably due to the want of clearness of the tissues of the head, and they certainly were not so numerous as those described by Bürger. The transparent hooks are quite characteristic. Length 120 mm., breadth 1½–2 mm.

Geographical distribution: Mediterranean, Madeira, and Plymouth.

Genus **Carcinonemertes.**

Head without distinct lateral grooves, not demarcated from the body. Ocelli 2. Mouth and proboscis open together; oesophagus extremely short, opening broadly into the intestine through a large muscular chamber. Proboscis but little developed, very small in size and extremely short, without lateral pouches of reserve stylets, but armed with a central stylet and basis only.

1. **Carcinonemertes carcinophila** (*Köll*). (Joubin. Les Némertiens, Pl. III, Fig. 81. McIntosh. Monogr. Pl. I, Fig. 5.)

This parasitic Nemertean lives in self-secreted tubes between the egg masses of *Carcinus maenas* and *Portunus depurator*. Only two out of a great number of *Carcini* I examined were inhabited by this worm; one specimen in each. On *Portunus*, however, it was more common, especially in specimens from dredgings. If the crabs had been collected on shore I never found them inhabited by this parasite. The tube, in which the orange or pale reddish animal folds itself together, is attached to the axis of the feet that bear the eggs. I have not been able to find any nemertine on the gills either of *Portunus* or of *Carcinus* or *Galathea*.

This species was with certainty known only to occur on *Carcinus maenas;* probably *Galathea strigosa* and *Xantho floridus* may also be infected with them. In New England they live on *Platyonychus ocellatus.*

Geographical distribution: *C. carcinophila* has not been found previously in England; it has been recorded from the Atlantic coasts of Belgium and France, from the Mediterranean and from New England.

GENUS **Nemertopsis.**

As *Emplectonema,* but instead of many, only four eyes, situated in a rectangle. The distance between the eyes of one pair is smaller than that between the eyes of one side.

1. **Nemertopsis flavida** (*McIntosh*), *Beaumont.* (McIntosh. Monogr. Pl. IV, Fig. 1; and Joubin, Les Némertiens, Pl. II, Fig. 61.)

Locality: Common in the Sound, both from dredgings and between tidemarks. Once from a dredging near the Mewstone.

Under this name I unite both the *Nemertopsis* species, described by Beaumont (1900, p. 817 and 818). It seems to me very doubtful whether *N. tenuis* must be distinguished from *N. flavida.* The only difference between the two so-called species is to be found in the colour, which is quite white in *N. flavida* and a very faint pink in *N. tenuis.* This, however, might be due to the colour of the blood, which is decidedly red in the last species and cannot be seen in the first. Moreover, the colour of *Tetrastemma flavida, McIntosh,* is pinkish or pale peach, which agrees with *Nemertopsis tenuis,* not with *N. flavida.* Beaumont states a difference in the extension of the proboscis sheath. This I have not been able to ascertain. A difference in body length of the animals might have caused this just as well, especially as the worms very easily break into pieces. No other difference between *N. flavida* and *tenuis* has been described. As to the value of the red-blood colour, this is not a character on which alone to base a new species. As long as no other difference between these two forms is known, we cannot regard them as separate species. Perhaps they are only varieties of one species, but even this seems questionable to me.

Moreover, Beaumont does not seem to be quite certain himself as to the value of his distinction. "The doubtful status of *Nemertopsis tenuis* as a species distinct from *N. flavida,* and the fact that they have rarely been distinguished with certainty, make it expedient to consider them together (W. I. B.)." (Plymouth Marine Invertebrate Fauna, 1904. Nemertea.)

In this case the name *Nemertopsis tenuis, Bürger,* has to be dropped; it must be replaced by *Nemertopsis flavida* (*McIntosh*), *Beaumont,* which species is not to be regarded as synonymous with *Tetrastemma flavida, Bürger*.

Head attenuated; reddish or pale pink to white. With four minute eyes. The very small cerebral organs are situated in front of the brain. The central stylet and its base have nearly the same length. All stylets are slender. With two accessory pouches, containing each three accessory stylets. Length 4–5 cm., breadth ½ mm.

Geographical distribution: Mediterranean, Channel coasts, Scotland.

SUBORDO B. HOLORHYNCHOCOELOMIA, Bürger.

Body usually short and stout; most species do not show any tendency to coil themselves up. Proboscis at least as long as the body. The proboscis sheath ends usually just in front of the anal aperture, and always extends into the last third part of the body.

I. FAM. AMPHIPORIDAE.

Worms of a length of some centimetres, even of 10 cm. sometimes; the smaller species are very stout, and the larger are rather stout too. The gonads do not alternate with the intestinal diverticula. They bifurcate. The oesophageal diverticulum sends long pouches to the brain. Proboscis sheath without lateral diverticula. Proboscis with one central stylet and conical handle. Cerebral organs large. Nearly always with many large eyes. Number of proboscis nerves variable.

GENUS **Amphiporus**.

Extremely contractile; in contraction the head is invisible as a rule. They cannot swim. Usually numerous eyes, sometimes failing, never four. One central stylet, but often many pouches, each containing a few accessory stylets. The handle is always conical. Mouth and proboscis pore join together. Proboscis sheath without pouches. Sexes separate.

1. **Amphiporus lactifloreus,** *McIntosh*. (McIntosh. Monogr. Pl. I, Fig. 1).

Locality: In shallow water, near the coast, and between tidemarks. From all dredging grounds in the Sound, and once from a dredging at the Mewstone Ledge (18–27 metres).

A flattened, very soft nemertine of a pale pink or white colour. The head is not sharply separated from the body. Cerebral organs in front of the brain. A number of small eyes present on the head; they are arranged in two groups on each side, "the posterior group generally forming a triangle, with one eye-speck (that most remote from the snout) much larger than the rest."

Geographical distribution: North Atlantic and Mediterranean coasts.

2. **Amphiporus dissimulans,** *Riches.* (Joubin. Les Némertiens, Pl. III, Fig. 42, and p. 129, Fig. 16.)

Locality: Dredged from all grounds in the Sound and near the Mewstone.

Length 5 cm. The colour is variable, most frequently a very pale pink. Head broadly spathulate, pointed, sharply separated from the body. The eyes are never divided into groups and are very numerous. Cephalic grooves as in Joubin's *A. roseus.* Tail oar-like.

I should not be surprised if the anatomy of the specimens described by Riches and Beaumont under the above-cited names proved them to belong to the same species, in this case *A. lactifloreus.*

As far as the internal structure is known every evidence of a difference fails. "The shape of the head and of the tail, the number and arrangement of the eyes, the position of the cephalic grooves, and the difference of habitat, *A. lactifloreus* being a shallow-water form, and these specimens being never obtained in less than 15 fathoms, are the distinguishing characters," says Riches.

As to the difference of habitat I cannot agree with Riches. Both *A. dissimulans* and *A. lactifloreus* have been recorded in dredgings from the same spot, as Asia Shoal, Queen's Grounds, Millbay Channel; moreover, *A. lactifloreus* proves not to be a shallow-water form alone, as I got quite a typical specimen from the Mewstone Ledge, at a depth of 10–15 fathoms; *A. dissimulans,* on the contrary, has been collected at Drake's Island between tidemarks (I cite from the Invertebrate list). But even if a difference in habitat exists, as Riches supposes, the distinguishing characters might be due simply to this. Certainly it is remarkable that both species are distributed alike in the neighbourhood of Plymouth. If *A. dissimulans* occurs in the deeper parts of the Sound, *A. lactifloreus* occupies the shores of the same parts (according to Riches). On the Mewstone it is the same; in shallow water *A. lactifloreus,* from the Mewstone Ledge *A. dissimulans.* To these spots both species seem to be confined.

As a distinguishing character the arrangement of the eyes does not hold good either. I met with several specimens of so-called *A. dissimulans,* the eyes of which were arranged in two groups as in *A. lactifloreus.* Other specimens had the *lactifloreus* habitus, but the eyes formed a continuous series on each side of the head. The characters of habitus and arrangement of eyes proved to be quite insufficient to distinguish between the two species. As to the only remaining character, the position of the cephalic grooves, I can only agree with

Beaumont, that their arrangement in *A. lactifloreus* is very similar to that in *A. dissimulans* (1895, p. 360). In fact, I have not been able to see the slightest difference between them; in both species the cephalic furrows are arranged as described by Beaumont.

All distinguishing characters given by Riches between *A. lactifloreus* and *A. dissimulans* fail. The varieties as described by him and by Beaumont certainly exist, but they are connected by a series of variations of their characters, which makes it very probable that they themselves are to be looked upon as varieties of one single species, in this case *Amphiporus lactifloreus.*

3. **Amphiporus allucens** (*Bürg.*). (Bürger. Monogr. Pl. IV, Fig. 35).

Locality: One specimen from the Mewstone Ledge (10–15 fathoms) and one from the Rame-Eddystone Grounds.

The specimens recorded by me under this name fully resemble *A. pulcher var. allucens, Bürger*. Colour bright salmon, as in *A. pulcher* described by Beaumont; the head is more yellow, with the central nervous system showing through as a pale pink-coloured spot. Head not separated from the body. The eyes are large and black and were arranged in a double continuous row on each side of the head. The last eye of the shorter row is larger and lies just in front of the brain. The cephalic grooves join ventrally in front of the brain. The absence of secondary cephalic grooves and of a reserve central stylet decided me to separate this species from *A. pulcher, Bürger*. As to its relations to *A. pulcher, McIntosh*, the number and arrangement of the eyes, the shape of the head and the whole habitus of the worm are so different, that it seems impossible to confuse them.

Geographical distribution: Naples.

II. FAM. DREPANOPHORIDAE.

GENUS **Drepanophorus.**

Broad and ventrally flattened worms of some centimetres length. Intestinal diverticula not bifurcated; the oesophageal diverticulum sends pouches in the direction of the brain. Gonads alternating regularly with the intestinal diverticula. Numerous eyes. Cerebral organs at the sides of or posterior to the brain. Proboscis sheath with metamerically arranged lateral pouches. Proboscis with many central stylets, situated on one crescent-shaped handle.

1. **Drepanophorus spectabilis** (*Quatr.*). (Bürger. Monogr., Taf. III, Figs. 28 and 28A.)

Locality: Queen's and New Grounds (5–6 fath.) and Mewstone Ledge (10–15 fath.).

The colour is yellowish pink, interrupted on the dorsal surface by six longitudinal brown stripes; the outer lines are confined to the body; they cease just before the cephalic furrows. On the head, which is narrower than the body and well separated, four dorsal stripes continue. Many eyes are present, arranged centrally in two rows on each side. The cephalic grooves are conspicuously branched and show a brown pigment on the transverse ridges.

Geographical distribution: Plymouth is the most Northern habitat of this species; it has not been recorded for any other place in England. *D. spectabilis* occurs on the Atlantic coasts of France and at the Cape Verde Islands as well as in the Mediterranean.

III. Fam. PROSTOMATIDAE.

Usually short and slender, somewhat flattened Nemertines with four eyes. Gonads alternating with the intestinal diverticula which are not bifurcated. The oesophageal diverticulum has no pouches. Cerebral organs anterior to the brain. Proboscis with ten nerves.

Genus **Prostoma.**

Usually nearly cylindrical, ventrally somewhat flattened, soft worms. Head sometimes sharply, often however slightly or not at all separated from the body; spathulate or rounded, and often somewhat broader. Nearly always the head shows a characteristic pigmentation. Proboscis with ten nerves. The central stylet and its handle are of equal length; in the middle the base is narrowed. Only two stylet sacs, containing two to three accessory stylets each. Cerebral organs situated in front of the brain.

1. **Prostoma melanocephalum** (*Johnston*). (McIntosh. Monogr. T. 2, Fig. 1.)

Locality: In dredgings from Queen's Grounds and between stones from the Cattewater.

This species can be distinguished easily from all other Prostomas by the large, intense black spot on the head; this and the yellow colour of the body, in which no traces of brown are to be seen, make it quite impossible to confuse them with *P. coronatum*, as Beaumont and Riches have done. Moreover, a great difference in habitus exists between both forms, mature specimens of *melanocephalum* having a length of 30–60 mm. with a breadth of 2 or 2½ mm., while *coronatum* is one of the slender species of this genus.

P. melanocephalum is a shallow-water form, not at all common near

Plymouth. I got it twice from Queen's Grounds, once from the Cattewater, on each occasion a few specimens.

Geographical distribution: Sweden, the Atlantic coasts of England, France and Madeira, the Mediterranean and the Pontic coasts.

2. **Prostoma coronatum** (*Quatr.*). (Bürger. Monogr. T. 3, Figs. 2, 8.)

Locality: Fairly common in all dredgings from the Sound; Mewstone and Cattewater; once between tidemarks at Rum Bay.

To this species must be referred the greater part of the nemertines described by Riches as *Tetrastemma melanocephalum*. *P. coronatum* never attains the size of *P. melanocephalum*, its average length being 12 mm. with a breadth of 0·5–1 mm. (even in sexually mature specimens). The shape of the *brown* pigment on the head, as indicated in Bürger's figure, is quite characteristic. It is the same as in *P. diadema*, *Joubin* (Les Némertiens, Pl. III, Fig. 66).

Geographical distribution: The Atlantic coasts of Norway and France and the Mediterranean are known as its habitat.

3. **Prostoma vermiculus** (*Quatr.*). (Joubin. Les Némertiens, Pl. III, Fig. 64.)

Locality: Rather common in dredgings from Asia Shoal; from some other dredging grounds in the Sound, near the Mewstone and Mewstone Ledge, and once between tidemarks at Rum Bay.

Joubin's figure gives by far the best idea of this species. However, the individual reproduced is a small one, as ripe specimens of *vermiculus* are very large in comparison with *P. coronatum*. They have the same size as *P. melanocephalum* and can be distinguished readily from both *coronatum* and *melanocephalum* by the shape and the colour of the pigment spots, constituting a pair of longitudinal brown stripes, connecting the eyes.

Geographical distribution: *P. vermiculus* has been recorded from several spots on the English coasts, and is distributed all over the Northern part of the Atlantic, from North America to Norway and Madeira and the Mediterranean.

4. **Prostoma peltatum** (*Bürger*). (Bürger. Monogr. Taf. III, Fig. 6.)

Locality: Two specimens from the Bridge.

This species is characterised by the presence of two pairs of eyes, of which the anterior pair is at least twice as large as the posterior. A transverse band of brown pigment is situated between the eyes; it does not hide them. Colour deer-brown. Both specimens were ♀. Length 40–50 mm., breadth 2 mm.

Geographical distribution: Naples.

5. **Prostoma longissimum** (*Bürg.*). (Bürger. Monogr. Taf. III, Fig. 15.)

Locality: One specimen in a dredging from the Mewstone.

The single individual which I describe under this name is identified only with hesitation with the Neapolitan species. The description Bürger gives in his Monograph agrees completely with the external features of my specimen, and so does the figure cited. The most striking characteristic is the transverse bar of bright red pigment on the head. However, a great difference of habitat exists between the Mediterranean and English forms, the latter living at a depth of 10 fathoms at least, the Naples specimens being very common on the beach together with *Emplectonema gracile.*

Geographical distribution: Naples.

6. **Prostoma robertianae** (*McIntosh*). (McIntosh. Monogr. Pl. III, Fig. 1, and p. 167, text Fig. 8.)

Locality: Rame-Eddystone.

Head separated from the body by a brown pigment ring, from which a pair of longitudinal brown stripes proceed towards the tail. A median white line is also present on the dorsum. Colour brownish pink. The anterior pair of eyes is decidedly larger than the posterior pair, which was not covered by the brown collar. Length 8 mm., breadth ½ mm.

This rather characteristic Nemertean seems to live at a greater depth than most of its relatives. McIntosh describes it from the Hebrides and the Shetland Islands at a depth of 6–8 fathoms; Beaumont from the Isle of Man at 15 fathoms, and from Valencinia Harbour at 1–2 fathoms; Bergendal from Kristineberg at 15–20 fathoms; while the Plymouth specimen lived at a depth of 25–30 fathoms.

7. **Prostoma candidum** (*Müller*). (Bürger. Monogr. T. III, Figs. 13 and 19.)

Locality: Asia Shoal and Queen's Grounds.

A few specimens of this Nemertine were met with in dredgings from Asia Shoal and Queen's Grounds. A characteristic brown pigment is present at the cephalic grooves. The colour of my specimens was not as green as in Bürger's figure; it agreed better with that of McIntosh's figure, in which, however, the cephalic grooves have not been represented. These cephalic grooves, the shape of the head and the bright yellow colour distinguish *P. candidum* (*Müll.*) from the next species, to which probably the majority of *P. candidum*, *Riches*, belongs. He describes, however, a specimen from Redding Point which seems to be identical with *Prostoma candidum* (*Müll.*). Length 12 mm., breadth ½ mm.

Geographical distribution: All coasts of the Northern part of the Atlantic, including the Channel, the North Sea and the Baltic, North America, Madeira, and the Mediterranean.

8. **Prostoma flavidum** (*Ehrbg.*). (Bürger. Monogr. Taf. III, Fig. 20.)

Locality: From Queen's and New Grounds, Cattewater and Rame-Eddystone in dredgings; between tidemarks at Rum Bay.

This species includes one of the most common Nemerteans of Plymouth Sound. The colour is a pale yellow or reddish tint, which may even be quite pink, as in a specimen dredged from the Rame-Eddystone Grounds. It can be distinguished from *P. candidum* by the colour and by the total absence of any pigment on the head. The reddish and yellow variety of *P. candidum*, *Riches*, probably belongs to this species, which is *not* synonymous with *T. flavidum* of McIntosh, Riches, and Beaumont. Length 12 mm., breadth ½–1 mm.

Geographical distribution: Sweden, Belgium, coasts of France, Madeira, Mediterranean, and Red Sea.

9. **Prostoma cephalophorum** (*Bürg.*). (Bürger. Monogr. Taf. III, Fig. 22.)

Locality: A few Nemertines belonging to this species have been found in dredgings from New Grounds and the Bridge, Asia Shoal, and Queen's Grounds.

Head rhomboid, broader than the body, sharply separated from it, with four rather large eyes. No markings. The general colour is brown; the head and the margins of the body, however, are less darkly coloured. My specimens agree fully with the description given by Beaumont (1900).

Geographical distribution: Ireland, Isle of Man, coast of Cornwall and Naples.

10. **Prostoma ambiguum**, *Riches.*

Locality: Common at all dredging and trawling grounds in the Sound, in the neighbourhood of the Mewstone, and on the Rame-Eddystone Grounds, at a depth of 25–30 fathoms.

My specimens perfectly resemble those described by Riches. Length 10–15 mm., breadth 1 mm. Four brown eyes, the anterior pair of which is at least twice as large as the posterior. Colour pale yellow, with a reddish brown pigment developed on the dorsum. Head broadened and separated from the body.

Geographical distribution: Plymouth.

11. **Prostoma helvolum** (*Bürg.*). (Bürger. Monogr. Taf. III, Fig. 16.)

Locality: Mewstone Ledge and Rame-Eddystone Grounds. Depth 10-30 fathoms.

This yellow Nemertine reminds one very much of *Prostoma candidum;* it is very slender, however, attaining a length of nearly 2 cm., at a breadth of less than 1 mm. This, the presence of a shining white glandular area on the tip of the head in which the anterior pair of eyes is situated, and of a similar very conspicuous glandular spot in the anal region, characterize *P. helvolum.*

Geographical distribution: Naples.

12. **Prostoma quatrefagesi,** *Bürg.*

Locality: One specimen from New Grounds.

This species has no external markings. The colour is a bright yellow and the animal was quite transparent. On account of these characteristics it reminds one very much of *P. candidum.* However, the proboscis sheath does not extend into the posterior third part of the body. Moreover the number of the stylet sacs is quite unique amongst English *Prostoma's.* Four pouches, containing at least twelve accessory stylets, are present.

Geographical distribution: Sicily and Naples.

13. **Prostoma herouardi,** *Oxner.* (Bull. Inst. Océanogr. Monaco, 1908, No. 127. Pl. I, Fig. 1.)

Locality: From hulks in Plymouth Sound.

Once I got quite a number of these Nemertines from between Laminaria roots. Their length did not exceed 5 mm. and they certainly were not broader than $\frac{3}{4}$ mm. The colour is a light flesh colour, with a dark wine-red stripe on the dorsal surface, which extends from the tip of the head to the end of the tail. Four eyes, arranged so as to form a trapezium if the head is contracted, are situated in front of the brain. Cephalic grooves are not present on the dorsal surface of the head. The cerebral organs, however, are in front of the brain and are funnel-shaped. The proboscis sheath continues to the end of the body; proboscis with two stylet pouches, each containing two reserve stylets. Central stylets as long as the handle, which is not narrowed in the middle. The median dorsal red stripe is due to epithelial pigment.

Geographical distribution: Roscoff en Finistère.

GENUS **Oerstedia.**

Body cylindrical; head perfectly continuous with the body. Four small eyes.

1. **Oerstedia dorsalis** (*Abildg.*). (Bürger. Monogr. Pl. III, Figs. 30 and 36.)

Locality: Abundant everywhere in Plymouth Sound; Rame-Eddystone Grounds, and between weeds in Whitsand Bay.

I found several varieties of the species in dredgings; of these *O. dorsalis var. marmorata* was the most common; I found it everywhere in Plymouth Sound, at Whitsand Bay and in the Rame-Eddystone dredgings. From the last spot, however, I several times collected the variety *viridis* (Bürger, Monogr., Pl. III, Figs. 34 and 34a), and on one occasion a single specimen of var. *cincta* (Bürger, Monogr., Pl. III, Fig. 27).

Geographical distribution: Atlantic Ocean, with the Baltic, North Sea, the Channel and the Mediterranean.

UTRECHT, September, 1911.

On a Method of Rearing Larvae of Polyzoa.

By

Dr. M. Hasper, Darmstadt.

COLONIES of *Bowerbankia pustulosa*, collected in July and August, 1911, in and near Plymouth Sound, contained a great many ovicells and produced numerous larvae, when kept in a flat glass trough and put under circulation during the night. The small yellowish larvae have a decidedly positive phototropism. They gather on the surface of the water on that side which is turned towards the light, from which position they sink to the bottom of the glass. Their movements slacken gradually in the course of a few hours, and at last are limited to revolving in a small circle until they fasten on the sides of the glass. Here they complete their metamorphosis, and in a few days the primary polypides are expanding their ciliated tentacles. The result was better when the just-hatched larvae were brought into a jar sterilised by hot water and filled with so-called outside water, i.e. water from beyond the Breakwater. This jar was fitted with a glass stand carrying a number of cover-glasses. When the larvae settled on these, it was easy to make total preparations of them without detaching them.

But this method is not sufficient when sections of a just-settled larva or a young primary zooecium are to be made without injuring it by its separation from the substratum. In this case the larvae must be induced to fasten to a material which can easily be cut with the object. For this purpose egg-shells proved useful. They were washed with water, then kept in alcohol of 70 per cent. for about a day, and the coagulated albumen was mechanically removed. The alcohol was afterwards extracted by sea-water. Prepared in this way, the egg-shells were filled with outside water, charged with a number of swimming larvae and kept cool by running water underneath an inverted bell-glass. As long as the larvae were still active, the water was renewed with a pipette twice a day. When the metamorphosis was accomplished and the young polypide began to come out of its cell, it was necessary to add some well-adapted food. I made use of two cultures of algae in sterilised water, kept in stock in the laboratory and kindly placed at my disposal: *Pleurococcus mucosus* and *Nitzschia* *closterium forma minuta.* In other cases the egg-shells were put into a larger jar fed with water from the tanks by means of a siphon.

When the animals are in the stage required, they can be fixed in a very simple manner. To the younger stages the fixing fluid was added directly after having poured out the water. If the individuals were further developed and were to be fixed with expanded polypides, they were paralysed by some crystals of menthol floating upon the surface of the water for some six hours and killed by a pipetteful of the fixative, squirted out directly upon them in order to prevent them from collapsing when the water was removed. As most of the fixatives contain some percentages of acid more or less, the innermost layer of the calcareous shell is dissolved and so the inner skin is spontaneously detached. When a mixture of a hundred parts of a saturated solution of corrosive sublimate and five parts of glacial acetic acid was used, the inner skin was lifted up by bubbles of carbonic acid in a few minutes, so that it is easy to detach the membrane after having washed the objects in the shells, and cut the latter into small pieces. The pieces of membrane with the attached polypides are then treated in the usual way. The membrane becomes very transparent in xylol or cedarwood oil, and the object cannot be lost in the paraffin. The egg-skin serves as a means of orienting the object too, and can be sectionised so excellently that it is not in the slightest degree an impediment.

I employed this method for the larvae of several species of Polyzoa and a Tunicate of the family of Didemnidae. It is especially useful, of course, when the larvae are of a dark colour, as, for instance, those of *Bugula neritina* Oken (= *Cellularia neritina* Pallas), which contrast with the white ground most excellently. These larvae settle in numbers just below the edge, or even on the free surface of the water taking advantage of the surface-tension.

An Account of the Natural History of the Slipper-Limpet

(*Crepidula fornicata*),

With some remarks on its occurrence on the Oyster Grounds on the Essex Coast.*

By

J. H. Orton, B.Sc.

THE American limpet, or slipper-limpet, known to naturalists as *Crepidula fornicata*, was introduced into England about 1880, being recorded at that time by Mr. B. S. Dodd in the Proceedings of the Malacological Society for 1893. Dodd, it is interesting to note, sounded even at that early time a warning note against the possible spread of this animal, and the probability of its becoming an enemy to the oyster farmer. There is no doubt that this limpet has been, and is probably still being introduced along with American oysters, on which it fixes itself. I have myself seen it unshipped along with oysters, but all the specimens I found had died recently. The spread of the limpet appears to have been very rapid on some grounds, as, for example, at West Mersea, where, since its appearance about eight years ago (from information obtained from local oyster fishermen), it has spread so that it is now more common than oysters.

The rapid spread of Crepidula on this coast is probably due chiefly to the abundance of the kind of food which the animal likes, and I am able to show that Crepidula feeds on exactly the same food as oysters. Thus the suitability of the Essex coast for the culture of oysters rendered it equally suitable for the spread of Crepidula. The mode of feeding of Crepidula is the same in principle as that of the oyster. Water is drawn in and expelled at the front end of the shell; the ingoing current entering on the left side, passing over the back of the animal, and out at the right side, as indicated in the accompanying diagrams (see† page 447, Figs. 1 and 2). Between the ingoing and outgoing currents the gill of the animal acts as a strainer, which collects all the food material that occurs floating in the

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* Printed by the Kent and Essex Sea Fisheries Committee, January, 1912, for distribution amongst the Committee.

† These figures are incorporated in another and fuller account of the mode of feeding of Crepidula (see pp. 444–78 of this number) which was written subsequently to the printing of this Report.

water. The collected food material is washed towards the mouth in two main batches, according to whether it is coarse or fine. The coarse particles on being drawn in with the water can be seen to be washed forwards along the left side of the animal towards a pouch which hangs down in front of the mouth. (See Figs. 1 and 2 A.) In this pouch the particles collect, and Crepidula can feed when it wants. The greater part of the fine particles, however, are treated differently. These, on being drawn against the gills, are washed towards the tips of the gills, which just roof in a deep groove on the right side of the animal. (See Fig. 1 B and Fig. 2 B.) In this groove the fine particles are collected, and every now and then are shot forward towards the mouth in a cylindrical mass. (See Fig. 1 B.) As the food mass passes forward, the animal seizes it in its mouth and eats it. I have fed Crepidula on diatoms, and watched it feeding in this way, and if very fine coloured particles be added to the water, a coloured cylindrical mass may be seen collecting on the right side of the animal just behind the "head," and the action of swallowing easily observed. Examination of the gut contents of Crepidula and the oyster shows that the same kinds of diatom are found in both animals, and moreover, that the commonest diatoms are the same in both animals. The fæces of slipper-limpets fed on a culture of diatoms consist wholly of diatom shells embedded in mucus. Thus it will be seen that Crepidula can be fed on diatoms. A chain of six individuals lived for nine months in a large-sized jam jar which contained sterilised water, to which supplies of diatoms and other small organisms were added at intervals. At present there are in our tanks a large number of living chains which have already been there nearly a year, and several other chains which I have had about seventeen months. These are all undoubtedly feeding on the floating substances in the tanks. A more detailed account of Crepidula's mode of feeding and of the gut contents of Crepidulae and oysters will be published shortly in the Journal of the Marine Biological Association.

In accounting for the spread of Crepidula in its new environment, some allowance must also be made for the probable absence of some of the enemies which it had in its original home, and also for the probability of an invigorating effect of the new environment. With regard to this latter suggestion may be noted the apparently early spawning of English Crepidulae. I am informed by Prof. Conklin that American Crepidulae begin to spawn in May and possibly in April, while English Crepidulae begin to spawn in early March.*

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* Since this Report was written, Crepidula spawned in the tanks at Plymouth in early February.

The direct factor in the spread of Crepidula, however, lies in connection with the spawning habits, as may be gathered from what follows. Crepidula spawns during the period from early March to the beginning of November, but the greater number of individuals appear to spawn about May. This limpet takes special care of its spawn. It constructs about 50 to 60 membranous bags, into each of which it passes about 250 eggs, and as the bags are made and filled with eggs they are closed and fastened together by short cords. These cords are finally all stuck on to the surface on which the slipper-limpet happens to be sitting, so that when by taking away the spawning individual the spawn is uncovered, it looks like a bundle of balloons, each containing a number of eggs. Each spawning individual, therefore, lays about 13,000 eggs, which are carefully protected beneath the shell of the mother until they are hatched. It is unlikely that individuals would spawn more than once a year, but beyond the fact that May seems to be a maximum spawning period, I have as yet no definite information to offer.

* To return to the fate of the eggs of Crepidula after they are laid: the eggs are protected by the mother Crepidula for about a month, but about the end of the month holes appear in the egg-bags, and the developing Crepidulae escape by swimming away from their parent. At this stage the Crepidulae resemble tiny shore sea-snails (*Littorina*), having, however, a transparent shell. In this condition they swim about at the surface of the sea, according to Prof. Conklin, for about two weeks. Towards the end of that time the young limpets begin to seek the bottom, and soon afterwards slipper-limpet spat having the typical flat shell may be found on the various objects on the sea-bottom. Thus young Crepidulae develop from the egg in about six or seven weeks.†

* The rapid spread of Crepidula along the Essex coast is now seen to be easily possible, for young swimming forms could easily have been carried by currents to the various parts of the coast, where they have settled down and formed new centres for a wider distribution. It will be an interesting problem to observe how far this species will spread in the future.

Besides the remarkable rate at which Crepidula is over-running the oyster beds, the species presents another feature which the oyster

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* These paragraphs were inadvertently omitted from the original Report.

† The information given of the development of Crepidula has been drawn largely from Prof. Conklin's work on Crepidula (see *Journal of Morphology*, Vol. XIII, pp. 17, 18). By observations similar to his I judge also that the period of development from egg to spat is about six or seven weeks. More definite information, however, is to be desired on this point.

dredgers find very troublesome, namely, the curious habit of sticking together in long chains by one individual sitting on the back of another. These chains are without doubt permanent collections of individuals, as can be seen from the following facts:—

(1) The accurate fitting of the edge of the shell of each animal into the crevices and irregularities of the surface or shell upon which it is seated; hence, only short periods of separation could be possible. Thus the animal has, so to speak, grown in the position.

(2) In cases where a chain is attached to soft rock, the proximal individuals wear in the rock itself a deep impression of the edge of the shell by a lateral movement, probably executed in the search for food. In this way the animal becomes seated on a boss of the rock with a pit all around it.

(3) Experiments on separating the members of chains, and giving the animals an opportunity of re-chaining, indicate that the older animals can only re-attach themselves to anything with difficulty, but attach themselves most easily to a smooth surface. If a number of such animals be left in a dish, they make no attempt to re-chain in their previous order, and indeed large specimens appear unable to move about, or move only with great difficulty.

By supporting dismembered individuals of a chain in the same relative positions which they occupied before being separated, I have succeeded in re-forming a number of chains, but in order to effect this it is necessary to place the animals close together, and to keep a close watch on them, so as to replace them should they fall out of position. In many cases, however, even with such care, the animals are apparently unable to re-attach themselves.

(4) Prof. Conklin states that old individuals sometimes become permanently fixed by a calcareous secretion of the foot, and recently I have observed several old individuals which appeared to be just beginning to form such a calcareous attachment.

(5) I have kept a number of chains of Crepidula alive for as long a period as a year without the members of a chain separating, except in one or two cases, which may thus be regarded without doubt as exceptional.

Thus there would appear to be no doubt that the chains are permanent. The chains, however, are composed of almost entirely middle-aged or elderly Crepidulas, so to speak. But the very young ones are motile, and move about from place to place. I have shown elsewhere that Crepidula is a protandric hermaphrodite, that is to say, that all the individuals are born as males, and, passing through an apparently hermaphrodite stage, change into females. Consequently, chains are formed in the following manner:—

The young male individuals creep about from place to place, and eventually settle down either on shell or some similar surface, or on the end of a chain. Suppose an individual to settle on an oyster shell. The young male grows larger, and at the same time the edge of its shell takes on the contour of the surface to which it is attached, so that they fit accurately together. As the individual increases in age, it begins to change into a female, but meanwhile another young male may creep on to its back and settle down. This latter individual in turn begins to change into a female, another young male in the meantime having crept on to its back. With a repetition of this process, longer and longer chains are formed, until in odd cases as many as thirteen individuals may be found in chain. In this way it will be seen that in any chain the bottom individuals will be females, and the end individuals males, while between these may occur individuals of all intermediate sex forms between male and female.

Regarding, therefore, the fact established that Crepidula is protandric, the occurrence of a graded series of sex forms from the outer to the attached ends of the chains is further evidence that the chains are permanent.

With regard to the age of chains, I have not yet finished my investigations, but judging from reports I have received from different stations along the Essex coast, it would seem that the number of individuals in a chain will give also the number of years the chain is old. The longest chains contain about as many individuals as years have elapsed since the first appearance of the species. Thus, at West Mersea, the longest chains are composed of thirteen or fourteen individuals, and I estimate that Crepidula would first appear on those grounds about fourteen years ago. Local fishermen will almost certainly underestimate the length of time Crepidula has been present in their locality.

With regard to the destruction of Crepidula on the oyster grounds, it does not seem at all possible to make any sweeping attack on this pest. However, an attempt might be made to make Crepidula saleable by trying various methods of cooking it to make it palatable. In this way Crepidula might come to be rather a desirable acquaintance than an enemy. There would appear to be every likelihood of Crepidula being equal in value to the common Whelk as an article of food. But no doubt the animals should be taken out of their shells before being cooked. After a little practice it is quite easy to take the animal out whole. Fishermen at West Mersea say that Crepidula eats rather tough and bitter, but I was told the limpets were cooked in their shells, so that a good result could not be expected.

Another suggested means of combating the spread of Crepidula is one which might be put into practice at once, if it has not already been adopted, namely, that of encouraging dredgers to bring in the whole of their catches of Crepidula and to destroy them. Possibly, also, something might be done by transplanting enemies of Crepidula into the oyster district, but great care should be taken that the enemies of Crepidula should not turn out to be also enemies of oysters.

The slipper-limpet, however, is not the only animal on the dredging grounds which is an enemy to the oyster. Sea-squirts, other bivalves than the oyster, many worms, barnacles, and all other animals which feed on the material found on or floating near the sea bottom, are likewise enemies of the oyster, enemies in the sense that they compete for food and space. On the other hand, there may be quite enough food on the sea bottom to support all these animals and many more, but at present we have no definite information as to how much of this kind of food there is, although there would seem to be plenty for all.

In the question of how to treat Crepidula, therefore, it would be of great value to have some precise information as to how much oyster food there is on or near the sea bottom, and it is to be hoped that before long the desired information will be obtained.

It has been stated that the presence of Crepidula on oyster grounds is evidence that the grounds are healthy, and there can be no doubt now that this is true, since Crepidula takes the same food as oysters. An interesting confirmation of this statement lies in the fact that inshore Crepidulae at West Mersea are much finer than the specimens obtained on the outer grounds, and it is well known that the inshore oyster grounds are much healthier than those outside.

The substance of this report may now be summed up as follows:—

Crepidula feeds on the same kind of food as oysters, and its presence on oyster grounds may therefore be taken as evidence of the grounds being healthy.

Crepidula takes special care of its spawn. Since all the male Crepidulae change into females, every individual produces in its later life at least 13,000 eggs per year.

The eggs develop into free swimming larvae, which may be scattered far and wide.

Whether Crepidula is harmful to oysters cannot be determined until some measurements have been made of the actual amount of food on the sea bottom, excepting in cases where it occurs in such quantities as to smother the oysters. Crepidula as an enemy to oysters must be put in the same class as the mussel.

There are two main problems to be attended to.

(1) To keep up the food supply of the oysters.

(2) To destroy, besides the oysters' active enemies, as many as possible of those animals which take the same food as oysters, as, for example, the slipper-limpet, mussels, most tube-dwelling worms, other animals similar to the oyster, barnacles, and all the different kinds of sea-squirts.

It should be borne in mind that sea-squirts are nearly as common on some grounds as Crepidula, and that they are just as likely to take away the oyster's food as is Crepidula.

The mode of feeding of Crepidula, with an account of the current-producing mechanism in the mantle cavity, and some remarks on the mode of feeding in Gastropods and Lamellibranchs.

By

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Assistant Naturalist at the Plymouth Laboratory.

With Figures 1–20 in the text.

TABLE OF CONTENTS.

I. INTRODUCTION.

The manner in which the slipper-limpet, *Crepidula fornicata*, feeds has apparently puzzled all the naturalists who have interested themselves in this animal, as may be gathered from what follows. Crepidula—like its allies the whelks and other pectinibranchiate Gastropods—has a well-developed radula, a fact which leads one to infer that the animal lives a marauding life. But both Conklin and myself have shown that Crepidula settles down permanently at an early age to a sedentary life, so that after settling down the animal must feed on whatever food happens to be in its immediate neighbourhood.

From my studies of the habits and anatomy of this sluggish animal I had formed a hazy idea that, since the gut is very strongly ciliated throughout, food was probably drawn in at the mouth in a current of water. As a result of this idea, I concluded that the radula in later life was an obsolete organ which the animal possessed merely as a heritage from its ancestors. On my expressing this opinion to Dr. Allen, he pointed out that if Crepidula possessed an obsolete but well-developed radula, then the phenomenon appeared to be a new one, which required to be carefully investigated. Subsequently a careful examination was made of the gut contents of Crepidula, and a comparison established between these and the ingested food of the native oyster, *Ostrea edulis*, taken from the same grounds, namely, off the Essex coast in the Blackwater near West Mersea. It may be here remarked that as Crepidula has spread so rapidly on the oyster grounds off the Kent and Essex coasts as to become a nuisance, it has become a matter of much importance to oyster farmers to have definite information about its food. The examination made of the gut-contents of these two animals revealed a close similarity in the kind of food-material, as far as skeletal remains indicate, and the identity of the most common forms of diatoms found in both animals. The contents of the gut of both these animals are mainly:

1. Sand-grains.
2. Sponge-spicules.
3. Diatom shells.
4. Vegetable debris, Radiolarian, Foraminiferan, and Peridinian tests.

The most common diatoms* present in both animals are:

† *Actinoptychus undulatus*, Bail.
† *Paralia sulcata* (Ehr.).
Navicula aspera, Ehr.
Cocconeis scutellum, Ehr. and a var. parva?
Hyalodiscus stelliger, Bail.
Actinocyclus ralfsii (Wm. Sm.).

Among the less common, but, in the case of some of the larger, equally important forms are several species of †Coscinodiscus, Nitz-

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* For the identification of diatoms, works by Van Heurck (3) and Gran (4) were consulted.

† It is not surprising to find these plankton forms amongst the food of these animals. Both Crepidula and oysters were taken from depths of only a few fathoms and not far from the shore. In such a situation as this the plankton will doubtless be much mixed up with bottom-living organisms.

schia, Navicula, and Grammatophora, and occasional specimens of a few other species. As the majority of these forms were found living in the washings from the shells of Crepidula and the oyster, there is no doubt that the animals were feeding on at least most of the forms mentioned. A species of Prorocentrum, probably *P. micans,* was however the organism found in the greatest numbers in the gut of these animals at the time they were examined, i.e. about the month of October, 1911.

It therefore became evident that Crepidula takes the same kind of food as oysters, and as the oyster has no radula, I appeared to have gained my point about the radula of Crepidula, namely, that it is a useless organ. However, while examining Crepidula one evening I detected a current in the mantle cavity, and subsequently observed the mode of feeding, which established beyond doubt both the nature of the food-material and the use of the radula, as will be shown in the following account.

II. THE MODE OF FEEDING IN CREPIDULA.

Crepidula feeds in the same way in principle as the oyster—that is, an ingoing and an outgoing current of water is established in the mantle cavity along a definite pathway, while between the two currents the gill acts as a strainer, retaining even very fine particles of suspended matter which may eventually reach the mouth. The gill consists of a row of free filaments—more than four hundred filaments were counted in the gill of an adult specimen—placed parallel to one another, midway between the dorsal and ventral surfaces. The filaments stand out in a line along the left side of the mantle cavity, extending almost in a horizontal line across this cavity; their tips rest along the edge of the right epipodium anteriorly, but posteriorly on the dorsal surface of the visceral mass. The gill thus forms a sheet across the mantle cavity, which it divides into a left ventro-lateral inhalent chamber, and a right dorso-lateral exhalent chamber. Fig. 1 gives a ventral view of the animal in the act of feeding; the arrows indicate the direction of the food-current. In feeding, the front end of the shell is raised slightly and a current is set up in the mantle cavity by the cilia on the gill-filaments. Water is drawn in along the anterior half of the edge of the shell on the left, passed through spaces between the gill-filaments, and is expelled along the front half of the edge of the shell on the right (see Fig. 1).

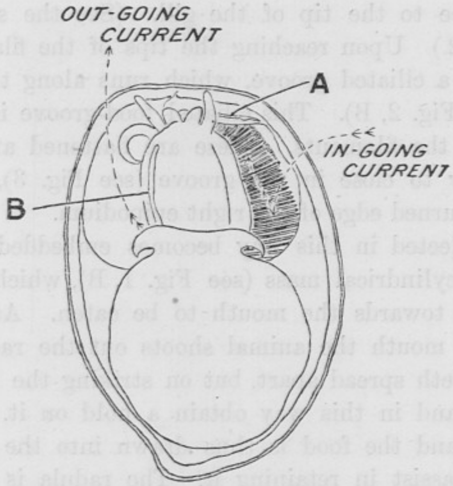

FIG. 1.—Ventral view of Crepidula. The arrows indicate the direction of the food-current. (Drawn from life. × 2.)

A. Food-pouch for the coarse food-particles: the main part of the pouch is hidden from view by the animal's "head."

B. Cylindrical mass of food in the food-groove; seen through the translucent body-wall.

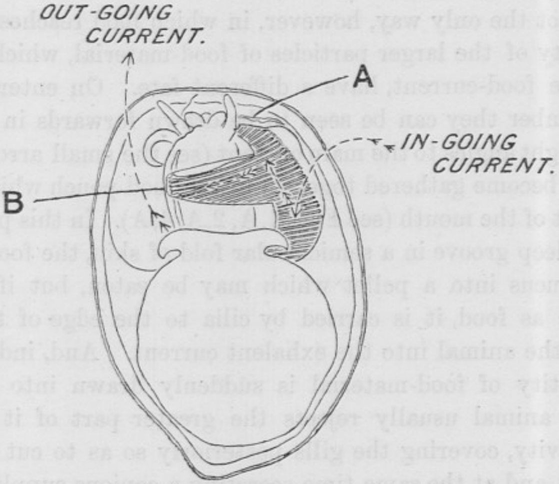

FIG. 2.—Ventral view of Crepidula with a part of the "neck" region supposed to be cut away to show the gill lying over the back of the animal.

A. Food-pouch.

B. The pointer points at the exposed tips of a few gill-filaments, just in front of which can be seen the food-groove in section.

The little arrow between the cut surfaces of the animal indicates the direction in which the fine food-particles travel.

Most of the fine particles of suspended matter are carried by the current against the gills, and being caught by the cilia of the gill-filaments or in the mucus secreted by the gill, are hurried along the ventral face to the tip of the gill. (See the small transverse arrow in Fig. 2.) Upon reaching the tips of the filaments the food is deposited in a ciliated groove, which runs along the right side of the body (see Fig. 2, B). This ciliated food-groove is just roofed in by the tips of the filaments. These are flattened at this point the more effectively to close in the groove (see Fig. 3), and just meet the slightly upturned edge of the right epipodium.

The food collected in this way becomes embedded in mucus and formed into a cylindrical mass (see Fig. 1, B), which is at intervals passed forward towards the mouth to be eaten. As the food-mass approaches the mouth the animal shoots out the radula at it with the marginal teeth spread apart, but on striking the food-mass these teeth close in, and in this way obtain a hold on it. The radula is now retracted and the food is thus drawn into the pharynx where the mandibles assist in retaining it. The radula is then freed and again shot out at another part of the food-mass, grasping and drawing back another length. These operations are repeated until a length of the food-material is broken off from the main mass. The detached piece is then swallowed.

This is not the only way, however, in which food reaches the mouth. The majority of the larger particles of food-material, which are drawn in with the food-current, have a different fate. On entering the inhalent chamber they can be seen to be drawn forwards in a direction almost at right angles to the main current (see the small arrow in Figs. 1 and 2), and become gathered together in the food-pouch which is placed just in front of the mouth (see Figs. 1, A, 2, A, 4, A). In this pouch, which is really a deep groove in a semicircular fold of skin, the food is worked up with mucus into a pellet which may be eaten, but if considered undesirable as food, it is carried by cilia to the edge of the shell or pushed by the animal into the exhalent current. And, indeed, when a large quantity of food-material is suddenly drawn into the mantle cavity, the animal usually rejects the greater part of it by backing into the cavity, covering the gills posteriorly so as to cut off most of the current, and at the same time secreting a copious supply of mucus, in which the intruding material becomes caught, and carried in the current forwards. But instead of passing into the food-pouch, it is carried further forward into a ciliated path which is situated immediately in front of and parallel with the food-pouch and deposited at the extreme front of the shell (see Fig. 4, A). It has been noticed that the food-material gathered in the food-pouch is often rejected, while that in the food-groove is almost always eaten. Thus the food-pouch and forwardly directed current are a means for separating and transferring to the region of the mouth the larger food particles, and at the same time they may be utilized by the animal for getting rid of such heavier undesirable particles as may be taken into the inhalent chamber.

The mode of feeding may be easily observed by inducing individuals to attach themselves to glass, so that if fine particles of some coloured substance be added to the water, the whole of the details of the operations can be seen through the glass. Carmine powder suspended in a solution of methylene blue in seawater gives a good result, as the latter stains the mucus a little, and makes its presence the more easily detected. From the foregoing account of the mode of feeding of Crepidula there remains no doubt that Crepidula takes the same kind of food as the oyster.

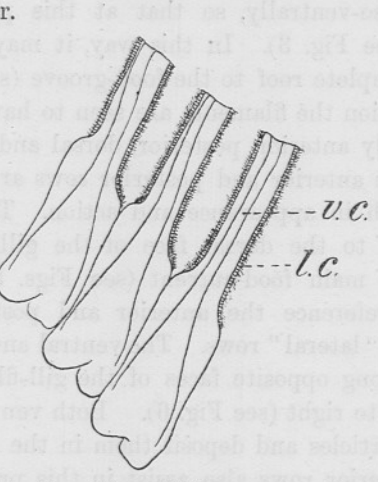

FIG. 3.—Ventral view of the tips of three gill-filaments from the anterior region. (Drawn from the living animal. × about 90.)

v.c. Ventral edge of the filament: the cilia are not represented.
l.c. Lateral cilia.
The notch in the tip of the filament permits the passage of food-particles to the ventral surface.

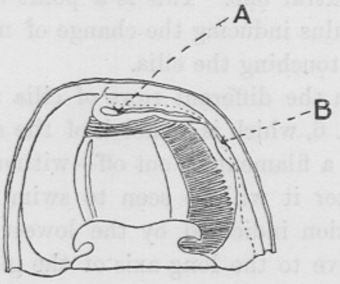

FIG. 4.—Ventral view of the anterior half of Crepidula with the "head" of the animal supposed cut away in order to show the food-pouch.

A. Food-pouch.
B. The ciliated path is represented by the dotted line.

III. MECHANISM CAUSING THE FOOD-CURRENTS IN CREPIDULA.

The main food-current is produced by the lashings of rows of cilia on the anterior and posterior faces of the gill-filaments. The filaments, it has been noted, stand out in a row from the left side of the mantle (seen in Figs. 1 and 2 below the small arrow), being each supported internally by a pair of chitinous rods (see Fig. 5, C). They are free, and placed a little distance apart so that water can pass between them. When examined separately they are seen to be flattened antero-posteriorly (see Fig. 5), except at the tips, where they are flattened dorso-ventrally, so that at this part they touch the adjoining ones (see Fig. 3). In this way, it may be noted, the filaments form a complete roof to the food-groove (see Figs. 1 and 2, B). In transverse section the filaments are seen to have four rows of cilia (see Fig. 5), namely anterior, posterior, dorsal and ventral rows (compare Fig. 6). The anterior and posterior rows are formed by far the stronger cilia both in appearance and action. These lash the water from the ventral to the dorsal face of the gill, and are the chief producers of the main food-current (see Figs. 5 and 6, l.c.). For convenience of reference the anterior and posterior rows may be referred to as the "lateral" rows. The ventral and dorsal rows of cilia lash the water along opposite faces of the gill-filaments towards the tips, i.e. from left to right (see Fig. 6). Both ventral and dorsal rows gather the fine particles and deposit them in the food-groove, but the anterior and posterior rows also assist in this process, as may sometimes be seen when examining a living filament under the microscope, or even when examining the living animal with a lens. Therefore, when cilia of the anterior and posterior rows wash food towards the food-groove, the direction of their lashing is changed from a ventro-dorsal to a laevo-dextral one. This is a point of some interest, and apparently the stimulus inducing the change of motion is supplied by the particles merely touching the cilia.

The way in which the different rows of cilia act may be gathered from a glance at Fig. 6, which is a sketch of the end of a gill-filament.

If such a piece of a filament be cut off—without the flattened tip—and observed in water it will be seen to swim, when unimpeded by mucus, in the direction indicated by the lowest arrow in the figure. This direction, relative to the long axis of the gill, gives some idea of the relative strength of the lateral rows of cilia as compared with the dorsal and ventral rows, for the direction is, of course, the resultant of the action of the two sets of cilia. Hence it is apparent that the lateral cilia are by far the stronger, just as one would expect to find, seeing that they have to draw a current of water through the mantle cavity, while the other rows merely pass on the food-particles.

The ventral rows of cilia lash in a direction from left to right, and, as has already been remarked, are the main collectors of the fine food-particles. The dorsal rows of cilia lash in the same direction as the ventral rows, but on the opposite face of the gill; whatever particles are passed on to them by the lashings of the lateral cilia they wash along the dorsal face of the filament, through a notch in the tip of the latter (see Fig. 3), and round to the large cilia on the ventral surface (see Fig. 6). The dorsal cilia, however, also assist in maintaining the food-current, and in modifying the direction of the current formed by the "lateral" cilia, for a glance again at Fig. 6 will show that the resultant direction of the water current produced by all the cilia on the gill is in a direction opposite to that in which the free filament swims. Thus, in the living animal the effect of the dorsal cilia on the current on its passing through the gills is to turn it towards the right, namely, towards the exhalent aperture (see Figs. 7 and 8). The groups of large cilia on the ventral tips of the filaments are probably the chief agents in pushing the collected food forwards towards the mouth, being assisted in this by the cilia in the food-groove. The tips of the filaments are covered all over with cilia; those on the anterior and posterior faces doubtless assist in interlocking the filaments.

In connection with the gill-filaments, there still remains to be considered the action of those cilia which occur on the floor of the posterior part of the mantle cavity, that is, on that part of the mantle lining the dorsal surface of the visceral mass. In this region the cilia wash particles from left to right into a ciliated path on the right side, which path is continuous with the food-groove (see Fig. 2, B) in the anterior region. The mantle to the right of the ciliated path bears cilia which lash particles into the same path, working however in a direction mainly dorso-ventral.

The cause of the forwardly-directed current at the anterior end of the inhalent chamber is found in the presence of strong and active cilia on the lips of the food-pouch, on the inner side of the mantle, and especially those on the dorsal surface of the left epipodium. The food which is washed forwards by these groups of cilia is directed into the food-pouch chiefly by the cilia on the dorsal lip of the latter, but it is pushed along inside the pouch by cilia, being assisted in this, however, by slow, wave-like pulsations of the side-walls. In the capture of food-particles there is no doubt that the secretion of mucus for entrapping the particles is a very important factor, and a more correct

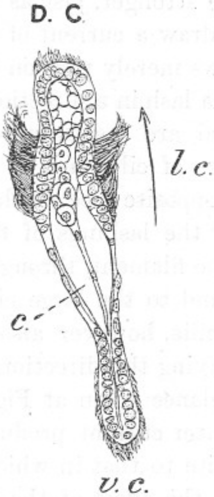

FIG. 5.—Transverse section of a gill-filament of Crepidula from the visceral region. (× about 67.)

D.C. Dorsal cilia; l.c. Lateral cilia, which lash in the direction indicated by the arrow; v.c. Ventral cilia; c. Gill-filament supports.

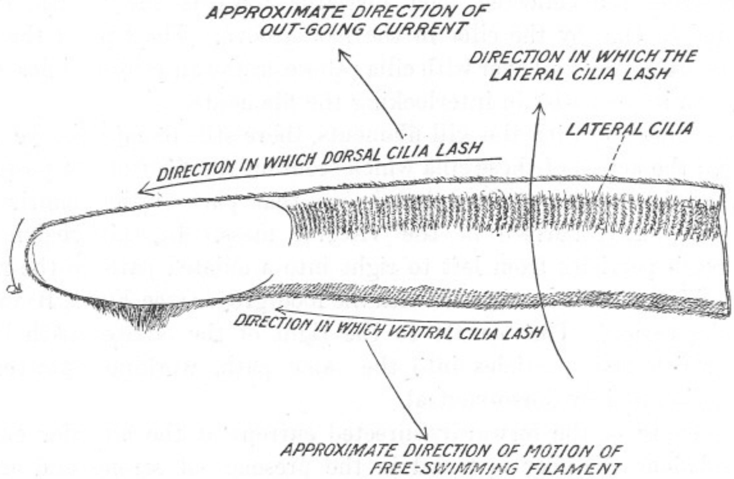

FIG. 6.—Posterior view of a gill-filament of Crepidula. (Drawn from a living filament of Crepidula. × 50.)

idea of the forward movement would be conveyed if one imagined a sheet of mucus bearing the food-particles being both drawn and passed onwards into the food-pouch.

The question now arising as to why the larger food-particles should be caught in mucus and carried forwards, while the finer particles travel onwards to the gill, is easily answered, but it is necessary first to obtain a fair idea of the spacial relation of the inhalent chamber. Fig. 7 is a transverse sectional diagram of the inhalent chamber, and Fig. 8 a longitudinal sectional diagram, A in both figures indicating the position of the forwardly directed stream in the inhalent chamber.

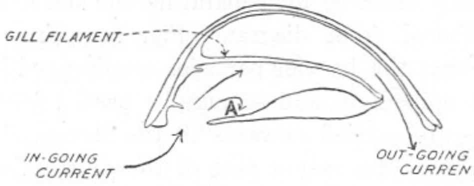

FIG. 7.—Diagram of the special relations of the mantle cavity of Crepidula in transverse section, taken just anterior to the propodium.
A indicates the position of the forwardly directed stream.

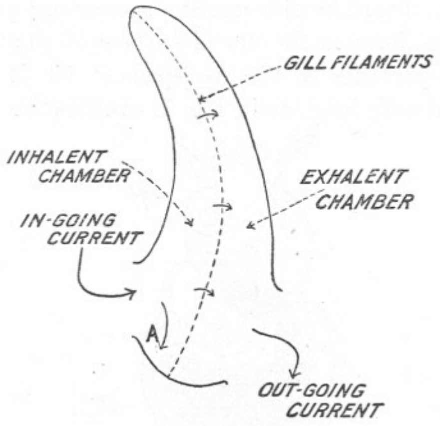

FIG. 8.—Diagram of the general spacial relations of the mantle cavity of Crepidula in median longitudinal section. The inhalent and exhalent apertures are represented, although not actually occurring in the section.
A indicates the position of the forwardly directed stream.

It will be seen that the area of the inhalent aperture is relatively small, and that there is a sudden widening out at this point of the path of the inhalent stream. Consequently, when a current is passing through the mantle cavity the velocity of the stream must fall just inside the inhalent chamber, and as a result the larger particles tend to lag behind and sink in the stream. As they sink they come within the influence of the forward stream caused by the cilia on the food-pouch, mantle and left epipodium, and becoming eventually caught in this stream (see the small arrow A in Figs. 7 and 8) are carried forwards into the food-pouch. From the disposition of the cilia causing the forward stream, it is possible for the coarser food-particles always to be carried forward, no matter whether the animal be placed upside down or any other way, but if the animal be upside down a fairly copious secretion of mucus becomes necessary to capture the particles. In the normal position of the animal, however, that is, with the ventral surface downwards and facing a little to the left, the disposition of the parts is beautifully effective for separating the heavier food-particles, as may be gathered from diagram (Fig. 7). From this diagram it will be seen that the heavier particles are dropped into the ciliated path on the left epipodium, and so may be passed forwards while the lighter particles are carried onwards in the stream above. The cilia on the left epipodium are only a part of the uniform covering of cilia on the dorsal surface of the animal's "head" and "neck." The disposition of the cilia on the remaining parts, and the directions in which these lash, may be gathered from a glance at Fig. 9. It will be noticed that the cilia on the right side assist in washing particles into the food-groove, while those on the dorsal surface of the "head" assist in transferring food-particles to the food-pouch; for it will be remembered that the animal's head, as in Fig. 1, overlies the food-pouch.

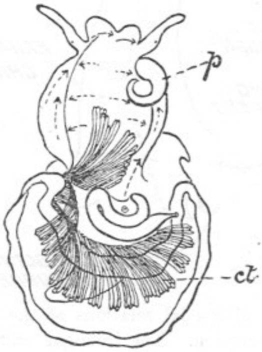

FIG. 9.—Dorsal view of a male Crepidula taken out of its shell and drawn from life, with the mantle turned back. The arrows indicate the directions in which the various groups of cilia lash. (Natural size.)
ct. Gill filaments.

IV. SUMMARY OF ACCOUNT OF CURRENT-PRODUCING MECHANISM, AND MODE OF FEEDING IN CREPIDULA.

The mode of feeding in Crepidula is thus seen to be as follows:—A main food-current is produced through the mantle cavity by the lashings of rows of cilia on the anterior, posterior, and dorsal surfaces of the gill-filaments; the current entering the mantle cavity on the left at the front of the shell passing between the gill-filaments and out at the front of the shell on the right. On entering the inhalent chamber, however, the velocity of the stream falls owing to the widening out of its path, so that while the heavier food-particles tend to be dropped out of the current, the lighter particles travel onwards towards the gill. On coming in contact with the gill these particles are either caught by the cilia or in mucus secreted by the gill, and swept by the rows of cilia on the ventral and dorsal faces of the gill-filaments towards the tips of the latter, and deposited in a ciliated groove on the right epipodium, which groove is efficiently roofed in by the flattened tips of the filaments. In the groove the food becomes worked up with mucus into a cylindrical mass which at intervals is passed forwards towards the mouth to be eaten. In the process of eating the food is seized and drawn into the buccal cavity by means of the radula, and there retained by means of the mandibles prior to being swallowed. The heavier food-particles, however, reach the mouth by a different route. On falling out of the main stream they are caught in the forwardly directed stream caused by the combined lashings of several groups of cilia, namely, those on the left dorsal region of the animal's "head" and "neck," those on the face of the food-pouch, and those on the left anterior border of the mantle. This stream is directed into the pocket of the food-pouch by the cilia on its dorsal lip where the captured food becomes worked into a pellet and deposited in front of the mouth for eating. If, however, the animal is not wanting food, the entrance to the food-groove is closed, and the stream is directed out of the mantle cavity by way of a ciliated path parallel to the left anterior edge of the mantle. In front, this ciliated path runs parallel with the pocket of the food-pouch (see Fig. 4, B), but behind, it is placed on a fold of skin somewhat similar to that forming the food-pouch. If a large quantity of foreign material be drawn into the mantle cavity, the ciliated path may be formed into a channel by the infolding of the edge of the fold on which the path lies posteriorly, but in front by the raising up of the mantle along the sides of the path. At the same time, the animal shuts off the food-current by closing the mantle cavity, and by covering the gill by the body, confines the intruding material to the forwardly directed stream, and is then able to reject it. Should large bodies get into the mantle cavity, the animal tries very hard to get behind them, and when it does so, pushes the intruding material bodily in front of the lips and extended tentacles out of the apparently sacred precincts of the inhalent chamber into the exhalent chamber, or even right outside the mantle cavity. Intruding air-bubbles have often been seen to give the animals great trouble in this way. In trying to clear the chambers the animal shows some ingenuity in trying different plans, but apparently also some stupidity in not widening the exits by raising the shell, and so making its task an easy one.

V. FUNCTION OF THE RADULA IN CREPIDULA.

In the process of feeding it will now be seen that the radula plays a very important part; it is used for seizing and conveying to the pharynx all the food that the animal takes; while the mandibles, it may be noted, assist in retaining the food temporarily in the pharynx.

Thus the radula of Crepidula, far from its being, as I thought, an obsolete organ, is one which is in constant use and of the first importance in the life of the animal, but, instead of its being used for rasping, as in its allies and presumably in its ancestors, it is now used for grasping. The function of the radula in Crepidula has therefore changed, and the failure to imagine the probability of such a change led me to a wrong conclusion with regard to its present importance to the animal. The change in function is, however, interesting, as it adds one more instance to the economy practised by nature in making use of the material that is to hand. Signs of degeneration in the radula are nevertheless appearing, as may be gathered from the following independent observations by Haller (5): "Die Auffallende kurze Radula (*of species of Crepidula*) liegt in einem sehr dickwandigen Radularsacke. Der Munddarm und die Buccalmasse ist bei allen von mir un tersuchten Calyptraeiden ungemein klein." Hence one might expect to find among the allies of Crepidula some forms which are evolving out of their radular apparatus a more efficient organ adapted to the present needs; and such a change is the more to be expected as the radula is a specific variant in the group to which the animal belongs.

VI. RESEMBLANCE OF THE FUNCTION OF THE GILL OF CREPIDULA TO THAT OF THE LAMELLIBRANCH GILL.

A change in function—or rather an additional function—has also been taken on by the gill of Crepidula. The ancestral gill was probably mainly an organ of respiration, but now the gill serves also as a food-collector. The gill of Crepidula has, therefore, exactly the same function as that of typical Lamellibranchs. The phenomenon is thus apparently presented of two independent trends of evolution arriving in principle at exactly the same result: both groups of animals having utilized the respiratory organ in a similar way as a water-pump and as a food-sieve.*

VII. THE MODE OF FEEDING IN THE OYSTER AND OTHER LAMELLIBRANCHS.

The mode of feeding in Lamellibranchs has been described by several writers. Stenta (6) described a number of forms fairly fully. Kellogg

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* If, however, the gill of the ancestors of Lamellibranchs and Gastropods were already a food-collecting organ—as seems possible from the observations here made on the gill of Nucula and many Gastropods (see pp. 467–73)—then the "convergence" is homogenic and not homoplastic.

(7 and 9) has treated other forms in more detail; and about the same time Herdman and Hornell (10) described the mode of feeding in the Ceylon pearl oyster.

The following description of the mode of feeding in the European oyster contains little that has not already been noted by these writers in similar forms. The native oyster (*Ostrea edulis*) draws a food-current into the mantle cavity between the mantle lobes antero-ventrally. The current does not enter along the whole of the ventral surface, however, when the animal is feeding normally, but only in a small restricted part such as is indicated in Fig. 10. It is only in this part that the ventral edges of the mantle lobes are not apposed, and the opening thus produced forms practically an inhalent aperture. The outgoing current leaves the mantle cavity postero-dorsally (see

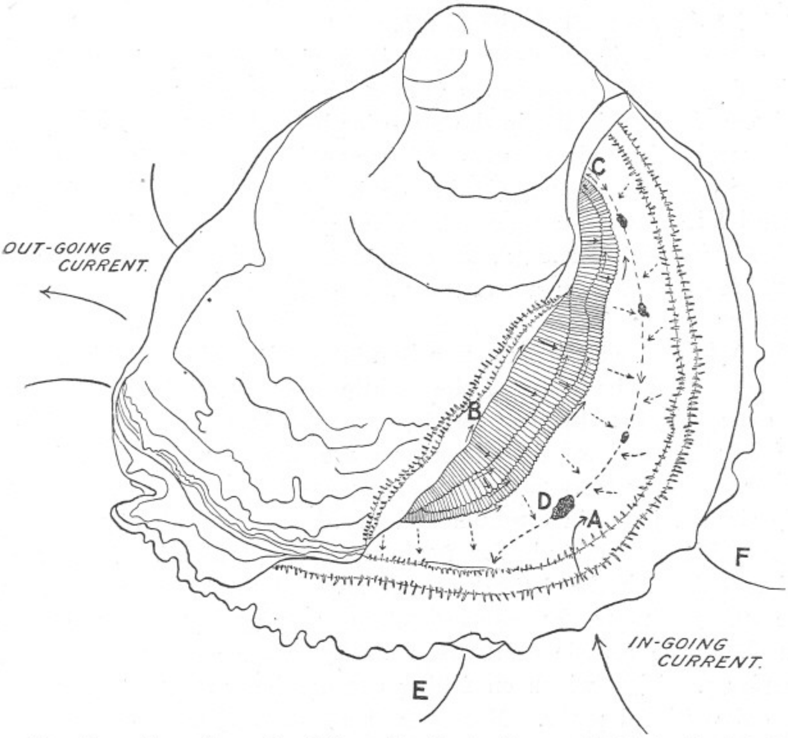

FIG. 10.—View of mantle cavity of the native Oyster (*Ostrea edulis*) from the right side to show the food currents. (Drawn from life, natural size.)

The ingoing current enters the mantle cavity between the points E and F.

The dotted arrows indicate the directions in which the mantle cilia lash.

The arrows on and at the edges of the gill-lamellae indicate the paths of the main food-streams.

A. Point at which the heavier particles begin to fall out of the main food-stream.

B. Minor food-stream at the base of a gill-lamella.

C and D. The ciliated path on the mantle which carries away food-material rejected by the palps and the particles collected from the mantle.

E and F. Region in which the oyster commonly takes in its main food-stream.

Fig. 10). On entering the mantle cavity the path of the ingoing stream is suddenly widened (see Fig. 14) and, as is the case in Crepidula, the heavier particles drop out of the current. These particles, however, are collected by the mantle cilia into a definite ciliated path, the cause of the "untere Rückenström" of Stenta, which conducts them posteriorly to a point in about the middle of the inhalent chamber (see Fig. 10), whence the intruding material is expelled at intervals by sudden flappings of the shell-valves. This stream is protected, or rather rendered possible, by the infolded mantle edges, which shield it from the main stream. Those particles which fall on the mantle in the posterior part of the inhalent chamber are washed ventrally, and are either shot out of the mantle cavity at any point, as indicated by the arrows in Fig. 10, or are caught up by the gill and carried forwards towards the mouth.

In the American oyster there is a similar, posteriorly-directed ciliated path on the anterior half of the mantle, but according to Kellogg (7) there is also in the posterior half of the inhalent chamber a forwardly-directed current, which carries intruding bodies forward to the point where the current in the anterior part deposits whatever material it may have collected. The whole of the foreign particles collected by the mantle are then expelled at the point where the two paths meet, that is, in about the middle of the edge of the inhalent chamber.

In Mytilus and Cardium (see Stenta, 6) the ciliated path collects particles from the whole of the mantle and washes them posteriorly into the exhalent chamber, but here, as also in *Glycimeris glycimeris*, the inhalent and exhalent apertures are more definite than in the oyster, both apertures, however, being posterior (see Figs. 11 and 12). The ciliated paths in Cardium and Mytilus are excellently arranged for expelling intruding bodies, for in the natural feeding position these animals lie with the ventral surface apposed to the substratum, and the current enters the mantle postero-ventrally. Hence the whole length of the mantle cavity is utilized for the weeding out of the heavier particles, which on falling out of the current drop straight into the ciliated paths. Moreover, there is in Mytilus in the dorsal angle of the inhalent aperture a fold of epidermis forming a sort of curtain (see Fig. 11, B) which prevents the ingoing current from impinging directly on to the gills by directing it ventrally. In this way there doubtless results a more effective selection of the coarser particles. In Cardium a semicircular fold of the mantle between the inhalent aperture and the posterior ends of the gills (see Fig. 12, B) doubtless assists in the automatic selection of the heavier food-particles in the same way as the "curtain" in Mytilus. In Pecten water is drawn into the mantle cavity along the whole of the ventral and part of the anterior surface, but chiefly in two restricted areas. One of these areas is indicated by the large arrow pointing to B in Fig. 13, and the other is shown approximately by the large arrow passing near A, Fig. 13. The ciliated path on the mantle in Pecten collects particles from the whole of the ventral region of the mantle (see the dotted line C A B in Fig. 13) and washes them anteriorly to the edge of the mantle (see Fig. 13, B), whence they are expelled along with the material rejected by the palps.

While the heavier particles are dropped out of the current just inside the mantle cavity in the oyster, the finer particles travel onwards in the stream until they reach the gill, which retains them while allowing the current to pass onwards into the exhalent chamber. The food-particles drawn against the gill-filaments are caught in the mucus secreted by the gill and washed to the distal edges of the gill-lamellae, where they are formed into a cylindrical mass. This mass is then pro-

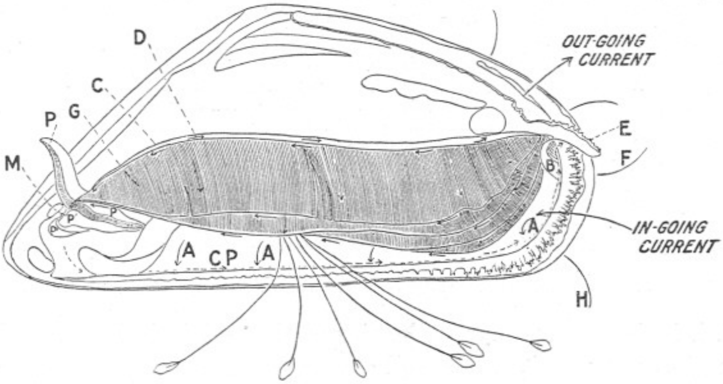

FIG. 11.—View of the mantle cavity of the common mussel, *Mytilus edulis*, from the left side to show the food-currents. (Drawn from life, about natural size.) The arrows on and at the edge of the gill-lamellae (G) indicate the paths of the main food-streams.

C.P.	The dotted arrows and line at the ventral edge of the mantle indicate the ciliated path which carries the material rejected by the palps and that collected from the mantle to the point indicated by the arrow above B in the figure. Here the rejected material is pushed into the exhalent current.
A.	Arrows indicating the paths of the heavier particles settling out of the main food-stream.
B.	A sort of curtain hanging from the dorsal part of the inhalent aperture.
C.	The line of attachment of the mantle to the body-wall.
D.	Arrows in the supra-branchial chamber indicating the direction of the exhalent current.
E.	Uplifted left border of the inhalent aperture to show the curtain, B.
F.H.	Points between which the main food-current is drawn into the mantle cavity.
G.	Left outer gill-lamella.
P.P.	Left palps between which the edges of the left gill-lamellae may be seen to end.
P^1P^1	Right palps.
M.	Locus of the mouth.

pelled along its somewhat precarious journey towards the palps by the cilia in the open food-groove which is found along the distal edges of the gill-lamellae of the oyster, and indeed of most other Lamellibranchs (compare Figs. 14 and 15).

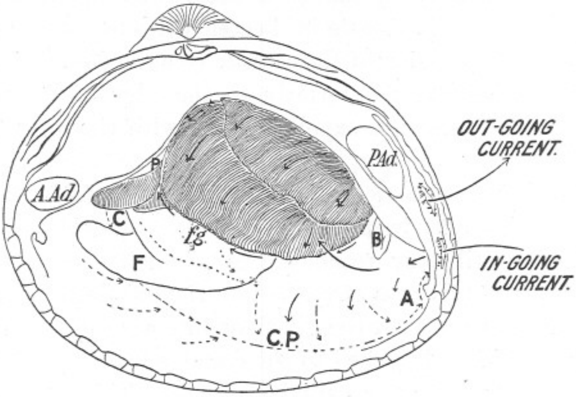

Fig. 12.—View of the mantle cavity of the common cockle, *Cardium edule*, to show the respiratory current and the currents connected with the mode of feeding. ($\times \frac{3}{2}$.)

C.P. Ciliated path on mantle which carries away the material rejected by the palps and that collected from the mantle.

A. Point at which heavier particles begin to drop out of main stream on to mantle, and also the region on the mantle whence the material collected by the ciliated path is finally shot out of the mantle cavity.

B. Gill-shield directing the ingoing current ventral-wards.

C. Point at which material is passed from the palps to the mantle.

fg. Food-groove at the ventral edge of the inner gill-lamella.

P. Left outer palp, below the base of which lies the mouth.

A. Ad. Anterior adductor. P. Ad. Posterior adductor.

The dotted arrows on the mantle and foot indicate the directions in which the cilia lash.

The arrows on and at the edge of the gill indicate the paths of the food-streams.

Such food-streams occur at the tips of the four lamellae, at the bases of and between the lamellae, and also between the outer lamellae and the mantle (see Fig. 14). The particles in the basal streams are mostly washed to the tips of one or other of the gill-lamellæ before reaching the palps, but in any case the streams on each side of the body eventually pour their burdens on to the palps, whence they are conveyed either to the mouth or directed into the ciliated paths if deemed undesirable as food (see Figs. 10 and 14). If the food is accepted, the palps separate so as to allow it to pass between. The cilia on the inner surfaces of the palps then quickly wash the food into the mouth. If the food is rejected, the palps remain apposed, and the cilia on their outer surfaces direct the food-mass on to the ciliated path on the mantle whence it is conveyed outside the mantle cavity.

In Pecten and Mytilus the upturned edges of the outer gill-filaments touch the mantle during feeding, and in this way form at this point a temporary food-groove. Otherwise the food-streams in these forms are similar to those of the oyster. In Cardium the frontal cilia on the outer gill-lamellae lash towards the edge of the gill on the outer faces

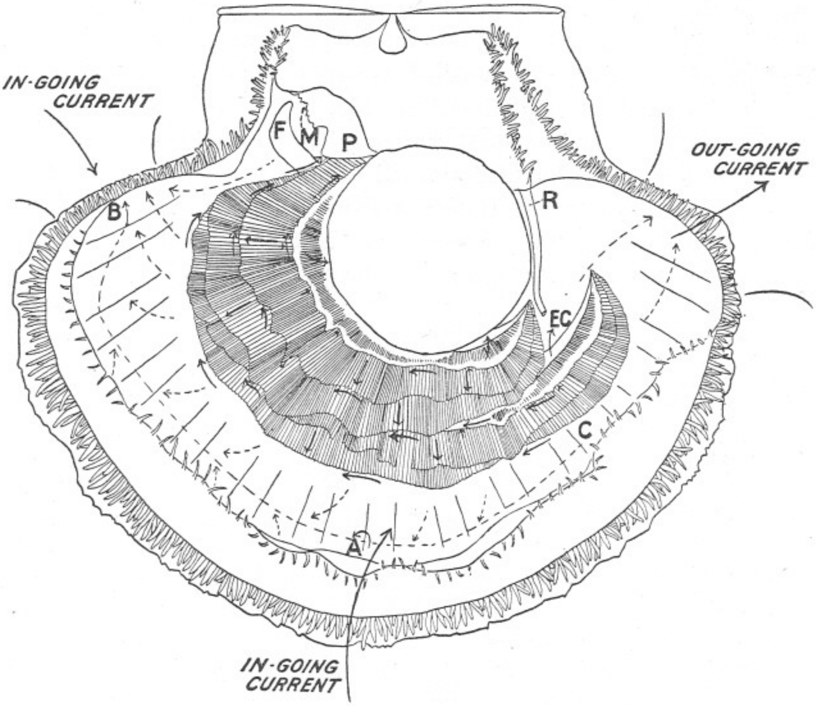

*Fig. 13.—View of mantle cavity of the scallop, *Pecten maximus*, to show the food-streams, seen from the left side with the mantle supposed to be cut away. (Drawn from life, natural size.) The posterior ends of the gills are somewhat retracted. In feeding, these spread across to the edge of the mantle and divide the cavity into inhalent and exhalent chambers.

The *dotted arrows* indicate the directions in which the mantle cilia lash, and the dotted line on the ventral part of the mantle between A and B indicates the ciliated path.

The *small arrows* at the edges of the gill-lamellae and of the reflected filaments indicate the paths of the main food-streams which lead to M, the region of the mouth. The arrows at the proximal ends of the gills, as at E C, indicate the direction of the exhalent current.

A. Point at which the heavier particles settle out of the main food-streams.
B.C. The ciliated path on the mantle.
E.C. Exhalent currents.
F. Foot.
M. Region of mouth.
P. Left outer palp.
R. Rectum.

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* I am indebted to Mrs. Orton for this drawing, for assistance in the drawing of the oyster (Fig. 10) and also Fig. 14.

but towards the base of the gill on the inner faces. On the inner lamellae the frontal cilia on both faces lash particles towards the free edge of the gill into a well-defined food-groove. In Pecten, Kellogg has described that in the troughs of the gills particles are lashed towards the base of the gill, while on the crests particles are lashed towards the edge. On the other hand, Stenta has shown that in Anodon food-particles are washed towards the bases of the outer lamellae but to the tips of inner lamellæ. All these different modes of food collection and transportation may be indicated in diagrammatic form as in Fig. 14. This diagram will also indicate the mode of food-collection and food-transportation in Nucula. I find that in Nucula the gills divide the posterior region of the mantle cavity into infra- and supra-branchial chambers as in the higher Lamellibranchs. The

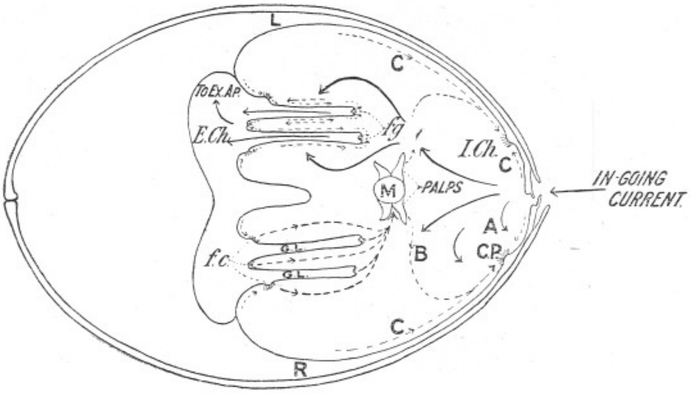

FIG. 14.—Diagram of the general mode of feeding in Lamellibranchs.

The large thick-lined arrows indicate the paths of the main respiratory and food-current.

The dotted thin-lined arrows indicate the directions in which the mantle and gill cilia wash the food-streams. The dotted thick-lined arrows leading from the right gill-lamellae indicate the paths of the main food-streams towards the mouth.

Food-collection is indicated on the left gill-lamellae, and food-transportation on the right gill-lamellae.

A. Point at which the heavier particles begin to settle out of the current.
B. The ciliated path on the mantle which carries away material rejected by the palps, and that collected from the mantle.
C.P. The ciliated path seen in section on the mantle.
C. The subsidiary mantle streams.
L. & R. Left and right valves of shell, and the beginning of the left and right mantle lobes.
f.g. Main food-grooves.
f.c. Food-channels at bases of gills.
I.Ch. Inhalent chamber.
E.Ch. Exhalent chamber.
G.L. Gill-lamellae.
M. Mouth.
To Ex. Ap. To exhalent aperture.

inner edges of the inner leaflets are apposed and kept interlocked by groups of large cilia (see Fig. 18, I.c.d., p. 468). The outer edges of the outer leaflets and the posterior ends of the gills effect similar ciliary junctions with the mantle by means of groups of large cilia (see Fig. 18, O.c.d.). In this way a complete partition of the mantle cavity is effected, and the ventral surface of this partition is utilized as in the higher Lamellibranchs for food-collection. Food-particles brought to the gill in the main current are arrested by the gill and washed along the edges of the leaflets from the outer leaflet to the inner (see Fig. 18). At the ventral end of the inner leaflets of both sides the collected food is washed anteriorly towards the mouth. Food-particles collected from the gill in this way appear to be gathered up by the appendages of the palps and transferred to the palps, which pass it along into the mouth. Food-particles may be rejected by the palps in Nucula in the same way as in other Lamellibranchs. Rejected food is pushed off the posterior end of the palps on to the foot, and off the posterior face of the foot on to the mantle. The mantle cilia in Nucula collect particles into anterior and posterior ciliated paths which converge at the middle ventral edge of the mantle just as in the American oyster. The observations on the mode of feeding in Nucula are still being carried on. In the light of the observations already made on Nucula, and especially of those on the ciliation of the gill (see page 467), it would be worth while to re-examine the mode of feeding in Yoldia. Drew (11, pp. 15 and 16) was unable to find out whether Yoldia uses its gills otherwise than for pumping water. If, however, the whole gill be examined alive while feeding it with carmine, the secret would soon be out. It is possible that the gill in this form may not be used for food-collecting, and if not, the condition is more interesting than if it is so used. However, from one of Drew's figures of the gill of Yoldia, although a general view (11, Fig. 20), there is good reason for believing that food-collecting occurs in the same way as is described here for Nucula.

VIII. AN EXPLANATION OF THE DIRECTION OF EVOLUTION IN LAMELLIBRANCHS.

The mode of feeding in Lamellibranchs, it will now be seen, necessitates the sedentary habits which are exhibited by most members of this group. Moreover, there can be no doubt that adaptation to the mode of feeding has been at least one of the main factors in determining the direction of evolution in Lamellibranchs. From the foregoing account of the gill of Nucula, it is clear that the gill in this form presents an early stage in the adaptation of the original respiratory organ to a food-collecting organ; and further, recent work (see Pelseneer, 12, pp. 253–4, and Ridewood, 13) has confirmed the conclusion that the higher Lamellibranchs have evolved mainly on the principle of folding and consolidating the originally simple free gill-filaments to form gill-lamellae. It will now be seen to be highly probable that this complication and fusion of the gill-filaments is an adaptation for the purpose of obtaining a more efficient feeding organ. Folding of the gill-filaments dorso-ventrally into demibranchs and—incipiently—antero-posteriorly into crests and troughs has increased the food-collecting surface, while fusion of the filaments first by ciliary junctions and afterwards by organic connections has rendered the food-collecting organ less liable to derangement. In the Filibranchs there is much danger of the gill-filaments becoming separated, whereby the continuity of the food-grooves at their tips is broken. As a result the animal may have difficulty in feeding, and its nourishment be thus seriously interfered with. Hence adaptations which ensure a firm gill would undoubtedly be advantageous—other things being the same—in preventing interference with the feeding process. The folding of the gill in an antero-posterior direction is also an adaptation in perfecting the feeding process, for by this means the food-collecting surface of the gill is further increased (see various figures by Ridewood, 13, pp. 242–263); moreover, greater opportunity is thereby given for effectively sieving the food-current, which has necessarily to pass more obliquely over the surface of the filaments to pass onwards into the exhalent current, thus giving the frontal cilia of the gill-filaments a better chance of capturing food-particles. It will also be seen that this folding results in the formation of secondary food-channels, thus the principal and apical filaments which occur in the troughs and crests respectively of the folds of the gills of many Lamellibranchs (see Ridewood, 13, p. 163) probably function mainly as the bearers of subsidiary food-grooves.

Along with the evolution of a more efficient food-collecting gill in Lamellibranchs there have occurred a gradual fusion of the ventral edges of the mantle lobes and a development of inhalent and exhalent siphons. It is highly probable that this fusion of the mantle lobes is primarily an adaptation of the same nature as the gill folding, that is, tending towards perfecting the mode of feeding. For in Mytilus, Glycimeris, and Ostrea, and doubtless also in many other forms, there is an attempt to limit the ingoing current to a definite area, and the effect obtained is that of limiting the area over which the heavier particles settle out of the food-stream to a part of the mantle adapted for expelling the undesirable material. In siphonate forms with the mantle fused ventrally such as the higher Eulamellibranchs, the whole of the ventral region of the mantle lobes may be utilized as a settling area from which undesirable material can be removed without interfering unduly with the normal feeding process.

IX. THE CURRENT-PRODUCING MECHANISM IN LAMELLIBRANCHS.

With regard to the cause of the main food-current in Lamellibranchs most writers are vague. Herdman and Hornell (10), however, have investigated *Margaritifera vulgaris* and state cautiously that in this species "the respiratory current is apparently due to the normal rhythmic lashing of the cilia on the large cells at the edges of the filaments; while the collection or the rejection of particles in the water seems to be the result of special action stimulated apparently by the irritation. Particles arrested by the branchial filter are caught up by the nearest cilia, which by local reversed lashing carry them outwards to the free ventral edge of the lamella."

In Crepidula it is easy to make out with certainty the direction in which the several rows of cilia are working, as the filaments—relative to those of Lamellibranchs—are large. In Nucula, Anomia, Mytilus, Glycimeris, Arca, Modiola and Pecten, I also find that it is fairly easy to make out that, as in Crepidula, the lateral cilia which lash across the length of the filaments (see Figs. 15 and 16) are the chief cause of the inhalent current, and that the "frontal" cilia which lash towards the free edge of the gill, collect the food-particles and wash them onwards towards the food-grooves at the edge of the gill (see Figs. 15 and 16).

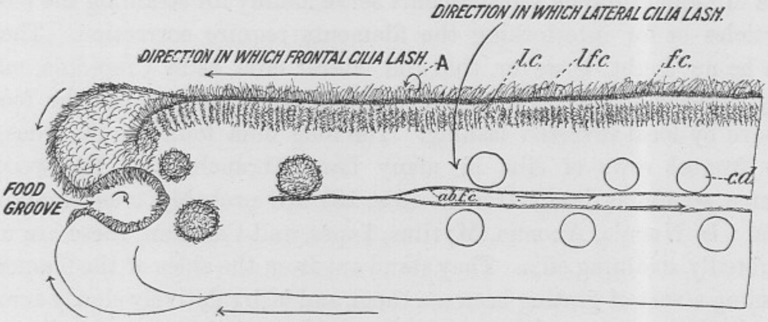

FIG. 15.—Lateral view of a living filament of the left outer lamella of the gill of *Mytilus edulis*. (× about 84.)

l.c. Lateral cilia. l.f.c. Latero-frontal cilia. f.c. Frontal cilia.
ab.f.c. Ab-frontal or inner cilia. c.d. Ciliated disc.
A. Arrow indicating roughly the direction in which the latero-frontal cilia lash.

In Mytilus there are also on the "inner"* or ab-frontal side of the filament cilia which lash in a direction opposite to that of the frontal cilia; they therefore help in producing the main current as in Crepidula. These cilia doubtless also assist in keeping clean the inner surfaces of the gill-filaments. The examination of living filaments of Mytilus revealed inaccuracies in the existing figures of the gill-cilia in this form (see Peck, 14) and Ridewood (13, Fig. 11, c, p. 201). Sections were therefore prepared from well-preserved material, and a drawing of one of these made for Fig. 17 (p. 467).

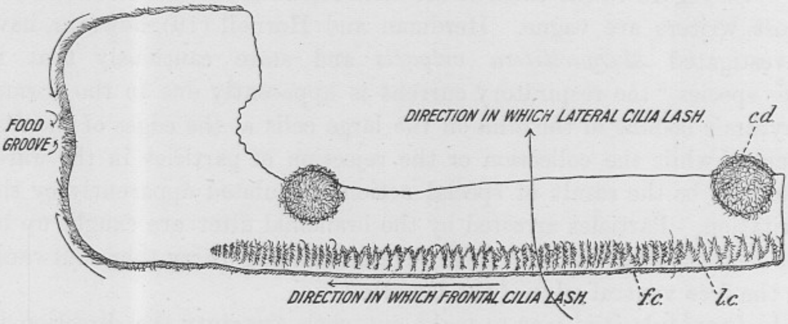

FIG. 16.—Lateral view of living filament of left outer lamella of gill of *Pecten maximus*. (× about 130.)
l.c. Lateral cilia. f.c. Frontal cilia. c.d. Ciliated disc.

On now comparing the ciliation in Ostrea, Tapes and Cardium, with that in the aforementioned forms, there can remain no doubt that the lateral cilia here also produce the main current by lashing across the length of the filament, while the frontal cilia collect the food-particles by lashing towards the free edge of the gill. Therefore the statements by Kellogg (9, pp. 416–423, see also 7, p. 36), and Pelseneer (12, p. 230) that the lateral cilia in Lamellibranch gill-filaments serve mainly for straining the food-particles or for interlocking the filaments require correction. There can be no doubt, however, that the lateral cilia, as in Crepidula, may help occasionally if necessary in washing particles towards the food-groove by local reversed lashing. The long cilia found at the sides of the frontal rows of cilia in many Lamellibranchs (see Ridewood's figures *passim* as latero-frontal cilia, 13) are probably true straining cilia. In Nucula, Anomia, Mytilus, Tapes, and Cardium, these are undoubtedly straining cilia. They stand out from the sides of the filament, forming a sort of grating between them, and lash relatively slowly across the length of and towards the middle of the frontal face of the filament (see Figs. 15, 17, and 18). Thus Nucula and Mytilus have four kinds of cilia, the lateral cilia producing the main current, the frontal for

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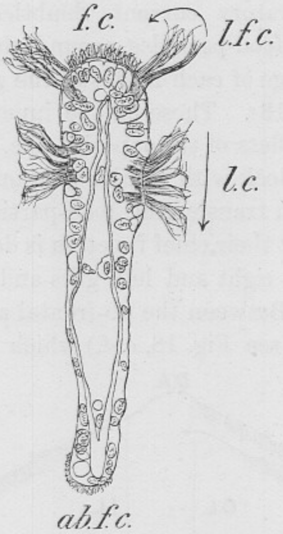
* That is, the side away from the exposed face of the gill-lamella.

collecting and transporting the food, the fronto-lateral, which assist in food-collecting, and the ab-frontal or inner cilia, which help in producing the main current, in collecting food, and in cleaning the filaments.

Since the ciliation of the gill-filaments in all Lamellibranchs is essentially the same (see Ridewood, 13, p. 163) doubtless in all Lamellibranchs the main food and respiratory current is caused by the lateral cilia, while the collecting and transporting of food-material is done mainly by the frontal cilia, assisted by the latero-frontal cilia when these are present.



* Fig. 17.—Transverse section of gill-filament of outer left gill-lamella of *Mytilus edulis* taken near the free end of the lamella and between the ciliary junctions. (× 418.)

l.c. Lateral cilia which lash in the direction indicated by the arrow alongside.
l.f.c. Latero-frontal cilia which lash in the direction indicated by the arrow.
f.c. Frontal cilia.
ab.f.c. Ab-frontal cilia.

X. CILIATION OF THE GILL OF NUCULA.

The ciliation of the gill-plates of Nucula is, I find, essentially the same as that of the gill-filaments of Mytilus (compare Figs. 15 and 18). The lateral cilia are well developed, and, as in the other Lamellibranchs examined, produce the main current through the mantle cavity. The frontal cilia collect and lash food-particles from the tip of the outer towards the tip of the inner leaflet on both gills. The larger frontal

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* This section was obtained from material preserved in Bouin's Picro-formol (see 19, p. 76) and stained in borax-carmine and picro-nigrosin solutions. Picro-nigrosin after picroformol or corrosive-acetic is an excellent stain for cilia.

cilia on the tips of the inner leaflets lash the collected food anteriorly towards the mouth. The latero-frontal cilia are also well developed and, as in Mytilus, stand out between the filaments, acting as strainers and lashing across the length of the filament away from the inter-filamentary spaces. These cilia are very large, and, *as in the case of all the cilia on gill-filaments, it is necessary to see them living to obtain an accurate idea of their size and function. And indeed all figures of gill-cilia ought to be corrected where necessary by comparison with the living object.* The ab-frontal cilia lash mainly towards the tip of each leaflet as indicated in Fig. 18, and besides helping in producing the main food and respiratory current, doubtless also assist in food-collecting, by lashing food-particles around the tips of either leaflet. On the outer dorsal edge of each leaflet of the gill of Nucula is a group of large cilia (see Fig. 18). Those on the inner leaflets interlock with similar cilia on the leaflets of the opposite side, while those on the outer leaflets doubtless interlock with similar cilia on the mantle. Probably these large cilia help in transferring food-particles from the dorsal to the ventral surface, but their chief function is doubtless that of effecting a junction between the right and left gills and between the gills and mantle respectively. Between the ab-frontal and lateral rows of cilia occur patches of cilia (see Fig. 18, *c. d.*) which are more numerous on

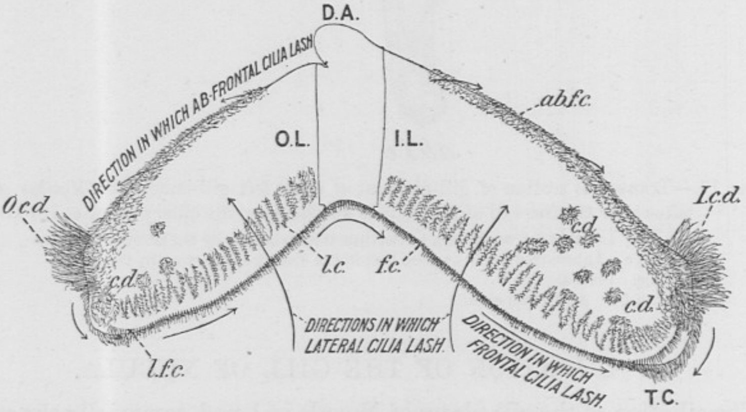

FIG. 18.—Anterior view of a living pair of leaflets of the right gill of Nucula. (× about 65.) The leaflets anterior to the pair depicted were cut away.

ab.f.c. Ab-frontal cilia.
c.d. Patches of cilia on the inner and outer leaflets.
D.A. Dorsal surface of gill about the 30th pair of leaflets from the posterior end of gill.
f.c. Frontal cilia.
I.c.d. Cilia effecting a junction with similar cilia on the left gill.
I.L. Inner leaflet of gill.
l.c. Lateral cilia.
l.f.c. Latero-frontal cilia.
O.L. Outer leaflet of gill.
O.c.d. Cilia effecting a junction with the mantle.
T.C. Cilia which transport collected food forwards.

the inner than on the outer leaflets, and indeed are apparently often absent from the outer leaflets. These cilia arise from little spurs of tissue and have the same curious rotary motion as those which occur in patches on the gill-filaments of the Filibranchs. The action and distribution of these patches of cilia leave no doubt that they effect ciliary junctions between the leaflets in the same way as those of the Filibranchs effect junctions between filaments. There are also similar patches of larger cilia immediately below and to the side of the groups of the inter-locking cilia on the tips of each leaflet (see Fig. 18, c.d. below O.c.d. and I.c.d.). Doubtless these have also the function of interlocking the leaflets, and are similar to those occurring on the tips of the gill-filaments of Yoldia (see Kellogg, 9, Fig. 78) and *Anomia aculeata.* It is therefore evident that the gill of Nucula is undoubtedly less primitive as compared with the gill of other Lamellibranchs than has formerly been thought. A fuller investigation of this gill is being made.

XI. THE BEARING OF THE GILL CHARACTERS OF NUCULA ON THE RELATIONSHIPS OF THE PROTOBRANCHIA.

It is clear from the foregoing description that the gill of Nucula—and indeed those of Yoldia and Solenomya may be included—cannot now be regarded as being so primitive and unique as to justify the classification of the Protobranchia as a group co-equal with the Filibranchia. Ridewood has shown that the gill of *Anomia aculeata* consists on each side of two rows of filaments whose only difference from the leaflets of Nucula lies, I find, in their being narrow and filamentous instead of broad and lamellate. This obviously constitutes only a minor difference. Indeed, the occurrence of ciliated discs on the gill-lamellae of Nucula might fairly be advanced as evidence of higher specialization —along orthodox Lamellibranch lines—than occurs in the gill of *Anomia aculeata,* since the filaments of this species of Anomia appear to be without ciliated discs excepting at the tips. Further, the ciliated discs at the tips of the Anomia filaments are matched by similar ones in the gill-leaflets of Nucula, and the action and function of the various rows of cilia is, I find, the same in both animals. Moreover, the frontal cilia on the filaments of Anomia occur on the ventral surface as in Nucula, and those on the outer filaments lash in the same direction as in Nucula (see Fig. 18). Ridewood (13, p. 194) has shown that in this species of Anomia the posterior end of the gill on each side is free and that the inner filaments of each side interlock, and that the outer filaments form a junction with the mantle by means of cilia. All these features are found in the gills of Nucula (see Fig. 18).

Thus the one feature of Protobranchia regarded by Pelseneer as unique—the occurrence of gill-leaflets—is undoubtedly robbed of its glamour—and cannot now be reasonably regarded as of such great taxonomic value as formerly. Another supposedly unique feature of the Protobranchs, namely, the absence of a subdivision of the mantle cavity (see Sedgwick 15, p. 345), must be abandoned, for Drew has already shown that in Yoldia (11, p. 14) there is a subdivision of the mantle cavity into inhalent and exhalent chambers, as is here described for Nucula, and as will no doubt be found in all the Protobranchs. With regard to the other primitive or special features of Protobranchs, such as the occurrence of distinct pleural ganglia, a plantar surface to the foot, free communication between the cavities of the gonad, pericardium, and kidneys, and other features—with regard to these, Pelseneer has already shown (12, *passim*) that they are matched in some adult members of the Filibranchs with the exception of separate pleural ganglia, which at present are only known in the developmental stages of other forms (as Modiolarca, Dreissensia, etc. See Pelseneer 12, p. 234). It is therefore clear that the Protobranchs cannot now be classified as a group equivalent to the Filibranchs. We must therefore be prepared to degrade —or rather elevate—the Protobranchia to a subordinate position in the Filibranchia of Pelseneer, or in the Eleutherorhabda of Ridewood. It is a matter of much interest that Palaeontologists (16, p. 359) should already have classified together the Protobranchia and the remainder of the Filibranchs into the order of Prionodesmacea, whose diagnosis is concerned mainly with shell characters. As we may now take for granted that Lamellibranchs have evolved mainly on the principle of perfecting the gill as a feeding organ, it is clear—from the closely similar results attained by Palaeontologists and modern zoologists—that there is a close correlation between shell characters and gill characters. Whether the shell characters are capable of any functional explanation, similar to that of the gill characters, my knowledge of the group does not yet enable me to say. It is probable that such an explanation may now be possible.

XII. A COMPARISON OF THE MODE OF FEEDING IN LAMELLIBRANCHS AND CREPIDULA.

In Lamellibranchs, as in Crepidula, it has been noted that there is an arrangement whereby an automatic selection of the heavier particles takes place just inside the inhalent chamber. Thus the forwardly directed stream in the inhalent chamber in Crepidula is equivalent to that caused by the ciliated path on the mantle of Lamellibranchs; the purpose of the stream in both animals being that of expelling undesirable material from the inhalent chamber. There is this difference, however, that Crepidula, unlike the oyster, has the option of ingesting the automatically selected heavier particles. On the other hand, in the oyster and other Lamellibranchs the fringes of tentacles on the edge of the mantle form a coarse sieve by interlacing at the entrance to the mantle cavity, and in this way prevent the entrance of coarse particles; it is possible, however, that the particles collected on the mantle in Lamellibranchs might be picked up by the gill and conveyed to the mouth, as probably happens in the posterior region of the inhalent chamber of the oyster and the scallop. Both animals have still another opportunity for selecting their food-material, namely, by refusing the food-masses which are brought by the gills to the mouth. It has been observed that both animals do at times refuse such food, so that selection of food-material is undoubtedly exercised in this way. From my preparations of the gut contents of these two animals, I received the impression that those of the oyster were the finer, but as I have examined comparatively few specimens, it is doubtful whether that observation has any significance. It would be necessary to examine and compare a larger number of individuals to obtain a significant result. The fine food-particles are collected on the gill in both Crepidula and Lamellibranchs, and conveyed along food-grooves to the mouth, but Crepidula may be regarded as having gained an advantage over Lamellibranchs by closing in its food-groove, and thus ensuring the capture of the food. If disturbed while feeding an oyster would be much more liable to lose its food than Crepidula.

There is, however, an interesting difference in the position of the lateral cilia on the filaments in Crepidula and Lamellibranchs. In Crepidula these cilia are nearer the exhalent chamber (see Fig. 6, l.c., p. 452), while in Lamellibranchs they are nearer the inhalent chamber (see Fig. 18, l.c., p. 468). An explanation of these phenomena will probably be offered when more Gastropod gills have been studied.

It will now be apparent how remarkably similar Crepidula, its allies, and Lamellibranchs are in the details of their modes of feeding. The closeness of the resemblances they offer may fairly be regarded as an expression of the similar tendencies they have derived from their common origin.

XIII. THE MODE OF FEEDING IN THE ALLIES OF CREPIDULA.

The nearest allies of Crepidula doubtless all feed as Crepidula itself does. Such a deduction may fairly be drawn at once from the similarity in the mode of life of those animals and the general similarity of their organs in the region of the mantle cavity. I have examined *Calyptraea chinensis* alive, and find that it feeds in exactly the same way as does Crepidula, collecting food both in its epipodial food-groove and in a food-pouch.

Capulus hungaricus exhibits an interesting variation of the same manner of taking food. In this animal there is no epipodium nor food-pouch. But instead of the former the lips have become elongated in the form of a grooved proboscis, which appears to be held along the right side of the animal to collect the food-particles from the tips of the gills when the animal is feeding. The forwardly-directed stream is present on the edge of the mantle in the inhalent chamber, but the stream is relatively weak. There is an outgrowth of the foot between the propodium and the "neck" region, known as the "operculum," which appears to be used partly for side-tracking the food-current into the exhalent stream when the animal is not feeding, but I have not yet had the opportunity for investigating Capulus fully, and so must defer a detailed account until later.

The Hipponycidae are so similar in structure to the Capulidae as to have been placed with them at one time in the same Order, and as they live a sedentary life, it is almost certain that they will be found to feed in some similar manner to that of Capulus. There is, therefore, little doubt that all the Calyptraeidae feed in the same way as Crepidula, and that the Capulidae feed in a similar manner: thus there is good reason for suspecting that all sedentary Pectinibranchs may obtain their food in the same or in a similar manner.

XIV. THE CURRENT-PRODUCING MECHANISM IN OTHER GASTROPODS.

After seeing the gills of Crepidula, Calyptraea, and Capulus, and especially the latter, whose gill is very similar to that of most Gastropods, I was stimulated to examine all the sedentary forms to be had. But, on seeing Pelseneer's figures of sections of the gills of some Aspidobranchs (17, Figs. 99 to 104), I was induced to examine all the Gastropods available. It was found that in all the forms examined, namely, Fissurella, Haliotis, Calliostoma, Gibbula, Murex, Purpura, Nassa, Buccinum—in all these—the gill-filaments are ciliated in essentially the same way as those of Crepidula. There are generally present lateral, frontal and ab-frontal cilia, and the gill-filaments, or rather gill-leaflets, closely resemble those of the Protobranchs. The lateral cilia in all the forms examined produce the main current in the mantle cavity. The occurrence of frontal and ab-frontal cilia in all these forms is a matter of much interest. In all cases these cilia collect plankton from the ingoing current, but whether such collected food is eaten I am not yet able to say. It seems probable that all these forms may be found to feed partly on plankton. A research into this matter is being made. In some cases (namely, Fissurella and Buccinum) the gill undoubtedly divides the mantle cavity into inhalent and exhalent chambers as occurs in Crepidula and its allies. At the tips of the filaments in all these forms there are interlocking cilia similar to those at the tips of the gill-leaflets of Nucula. These cilia doubtless serve to effect a junction between the gill and the opposite wall of the mantle. Thus there can be no doubt that most Gastropods on further investigation will be shown to have the mantle cavity divided by the gill into two chambers.

A point of some interest presents itself at once on comparing the gill-filaments or gill-leaflets of the Aspidobranchs and many Pectinibranchs with the gill-filaments of Crepidula and Calyptraea, namely, that the gill-leaflets of the former bear the same relation to the filaments of the latter that the gill-leaflets of Nucula bear to the gill-filaments of the Filibranchs. Thus the Pectinibranchs already present the same range of gill-features that I propose should be united in the Filibranchiate Lamellibranchs. It may here be remarked that the similarity in the structure and function of the gills in Gastropods and Lamellibranchs shown by the foregoing observations, emphasizes that close relationship between these groups, which Pelseneer has already pointed out (17).

A cursory examination of the gills of Chitons indicates that rows of lateral cilia on the gill-leaflets produce the main current through the mantle cavity in a manner similar to that in Gastropods and Lamellibranchs.

XV. SIGNIFICANCE OF CHAIN FORMATION IN THE MODE OF FEEDING OF CREPIDULA.

It is well known that Crepidula has the curious habit of forming long chains by one individual settling on the back of another; as many as fourteen individuals may be found holding together in such a manner, and usually there is a gradation in size from the largest at the bottom to the smallest at the top.* Each individual does not sit in the *middle* of the back of the one immediately below, but with the right anterior edge of the shell touching the same part of the shell next below. As a result each animal topples over a little to the right of the one below it, so that the chains really form spirals (see Fig. 19). This arrangement has some relation to the mode of feeding, for by the toppling over to the right each individual is given a maximum area of water to draw on from the left side for its food-current, which it will be remembered is drawn in at the left. Moreover, the approximation of the right sides of all the individuals of a chain results in a combination of the exhalent currents, which must give excellent results in removing effete products from the chain. The combined exhalent currents will doubtless also assist the smaller individuals in the chain by reducing the pressure of the water in the region of the exhalent aperture, and thus enabling them to pass a greater volume of food-bearing water through their mantle cavities than they otherwise could.

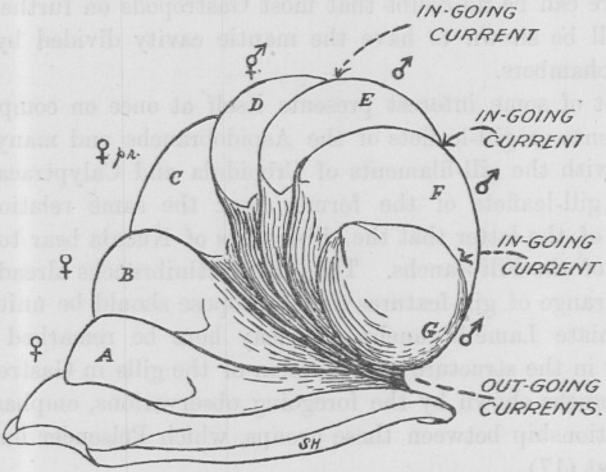

Fig. 19.—Postero-lateral view of a chain of seven individuals of Crepidula to show the separate ingoing and the combined outgoing current of all the individuals in the chain. (Natural size.)

These advantages of chain formation are to be added to those already noted (2, p. 479), and it may be remarked that the copulation of the smaller with the larger individuals there suggested as probable has now been observed a good many times, and contrary to what Prof. Conklin has suggested (1, p. 16), several times by the same individuals, and by individuals separated from each other by one or two of their fellows. These observations, however, are still being carried on.

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* See (2) pp. 469–80 for a fuller description of chain phenomena.

In connection with the feeding habits of whole chains, an interesting adaptation has many times been observed: when a number of chains have established themselves on a surface of limited extent, as on a valve of an oyster-shell, the chains are to be found with their anterior ends towards the edge of the oyster-shell and their posterior ends all converging on the middle. Thus the animals are again found to be making the best use of the space at their disposal for ensuring an equally good respiratory and food-current to each member of the group.

From a consideration of the mode of feeding of Crepidula its habits are easily explained, and it is now easy to understand why all individuals but small ones run a great risk of death if they become disenchained, or detached from their surface of attachment. A detached individual with its mantle cavity exposed is unable to produce an effective respiratory and food-current, which along with some unknown cause which gives rise to the general discomfort usually exhibited eventually results in death. Moreover, if a new surface of attachment is offered, it is necessary for the animal to be able to fit its shell fairly well to it in order to have a chance of living. If, however, an animal be offered a surface to which it is able to accommodate its shell, I find that it is usually able to accept it, especially if the surface offered is smooth.

XVI. THE MANDIBLES OF CREPIDULA.

The location of the mandibles of Crepidula appears to have given so much difficulty that even Troschel confesses (18), "Die beiden Kiefer habe ich nur einmal bei *Crepidula fornicata* gefunden. Sie Können also leicht übersehen werden. Der eine Fund beweist dass sie vorhanden sind, und dass die Meinung diese Familie sei kieferlos welcher ich lange Zeit gehuldigt hatte, irrthumlich war."

During the foregoing research, however, a clue was given from the mode of feeding as to the probable position of the mandibles, so that it was possible to make a preparation to demonstrate them at once. As Crepidula in eating takes food into the mouth between the roof of the mouth and the dorsal surface of the radula, one would expect to find the mandibles in the dorsal wall of the buccal cavity. If this region be exposed after dissecting out the radula and its muscular apparatus, the mandibles are to be found lying transversely on a prominence near the mid-dorsal line and just behind the mid-dorsal anterior edge of the buccal cavity as in Fig. 20. They are easily found by following the above directions after soaking the head region in glycerine.

Troschel describes the mandibles and gives a drawing of them in the work cited. They are very small, being about ·7 mm. long and ·16 mm. wide in the widest part.

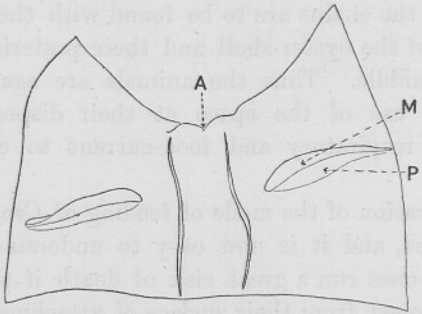

Fig. 20.—Ventral view of the roof of the mouth of Crepidula. (× 25.)

A. Middle part of anterior edge of the roof of the mouth.
M. Mandible.
P. Prominence on which the mandible is situated.

SUMMARY.

The gut-contents of Crepidula and the English oyster are similar with regard to skeletal remains, and the commonest diatoms found in both animals are the same.

Crepidula is a marine Pectinibranch which settles down at an early age to a sedentary life.

Crepidula feeds in the same way, in principle, as the oyster, i.e. a food-current of water is set up in the mantle cavity, while between the entrance and the exit of the current the pectinate gill acts as a food-sieve. The food-particles arrested in the inhalent chamber reach the mouth in one of two ways: the fine particles by way of a food-groove on the right side of the body, the coarse particles by way of a food-pouch placed in front of the mouth.

The radula is used for grasping the food-masses and conveying them into the mouth; its function has therefore changed from a rasping to a grasping organ, hence adaptational developments of the radula may be expected to occur in the allies of Crepidula.

The mode of feeding may be easily observed in detail by inducing animals to fix on glass and feeding them with carmine granules suspended in methylene blue solution in sea water.

The main food-current is caused chiefly by rows of cilia, the lateral cilia, on the anterior and posterior faces of the gill-filaments: the food-streams are caused by rows of cilia on the dorsal and ventral faces of the gills, by cilia on the dorsal surface of the animal, and by cilia on the inside of the mantle.

The gill of Crepidula, like that of Lamellibranchs, is at the same time a respiratory organ, a water-pump and a food-sieve.

The food-streams of Crepidula are comparable to those of Lamellibranchs.

A partial selection of the coarser food-particles is effected in the oyster—and Lamellibranchs generally—in the same way in principle as in Crepidula.

There are special morphological arrangements in Mytilus and Cardium to assist in the automatic selection of the finer food-particles.

The main food and respiratory stream in Lamellibranchs is caused by the "lateral" cilia on the gill-filaments, while the collection and transportation of food is effected mainly by the frontal cilia of the filaments. The latero-frontal cilia in Nucula, Anomia, Mytilus, Tapes, and Cardium, and therefore probably in all the Lamellibranchs in which they occur, are true straining cilia.

The gill-leaflets of Nucula and most Protobranchia possess similar cilia having a similar function to those on the gills of higher Lamellibranchs, and those of *Nucula nucleus* have also ciliated discs.

The gill of Nucula divides the mantle cavity into infra- and supra-branchial chambers, and the ventral surface of the gill is used for food-collection in the same way as in higher Lamellibranchs. Thus the gill of Nucula is essentially similar to that of some Filibranchs—for example, some species of Anomia and Dimya.

Hence the Protobranchia cannot now be considered as a group co-equal with the Filibranchia, and should be elevated to a sub-division of the Filibranchia.

Evolution in Lamellibranchs, which has occurred mainly on the principle of folding and consolidating the gill-filaments, comprises a series of adaptations tending towards a more perfect mode of feeding.

Calyptraea chinensis feeds in exactly the same way as Crepidula, and *Capulus hungaricus* feeds in a similar way.

Doubtless, therefore, all the Calyptraeidae, all the Capulidae, and there is reason to suspect that all sedentary Pectinibranchs, feed in the same or in a similar manner.

Most Gastropods have gill-filaments essentially the same in structure and function as those of Lamellibranchs, i.e. lateral cilia occur generally and produce the main current in the mantle cavity; frontal and ab-frontal cilia are found, and these collect food-particles from the ingoing current. In many Gastropods, and probably in most branchiate forms, the mantle cavity is divided by the gill into inhalent and exhalent chambers.

The manner of chaining in Crepidula is adapted to securing a good food and respiratory current.

The mandibles in Crepidula are to be found just behind and a little to either side of the middle of the anterior border of the roof of the mouth.

The author wishes here to express his thanks and indebtedness to the Government Grant Committee for a grant out of which some of the expenses of the foregoing work were defrayed. He is also grateful to Dr. Allen for useful criticism.

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