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Journal of the Marine Biological Association.

The Director's Report.—No. 1.

The present number of the 'Journal of the Marine Biological Association' forms the first of a new series in which is intended to publish such scientific memoirs as have a direct or indirect bearing upon economic questions. In order that the illustrations, which are indispensable in zoological memoirs, may be conveniently large, the size of the journal has been increased to royal octavo. It is not intended that the Journal should enter into competition with any of the existing zoological or botanical periodicals. It is recognised that the Association is dependent on public support, and that, whilst it is its duty to supply scientific information in an easily comprehensible form to those who are interested in marine fisheries, it should confine itself to shorter accounts of work dealing with those questions in animal or vegetable morphology which are necessarily couched in very technical language. The Journal will be issued from time to time, according to the amount of work ready for publication, and will contain, besides the memoirs alluded to, abstracts of the scientific work done by the naturalists hiring tables in the Laboratory, notes and correspondence from other fishery and marine stations, abstracts of the most important results obtained by the fisheries commissioners of various Governments, and any correspondence addressed to the editor for publication.

In issuing the present number a brief sketch of the condition of the Association may conveniently be given.

Prior to the completion of the Laboratory at Plymouth it was impossible for the naturalists of the Association to do any great amount of practical scientific work; the means and appliances were wanting. A great deal of information on fishery matters and on the local Fauna and Flora was, however, collected and tabulated, and has been printed in the first two numbers of this journal. Mr. Cunningham, the naturalist of the Association, began to work on the development of bony fishes in August, 1887, and the memoir from his pen which appears in this number is for the most part the result of the work done by him under great difficulties, when the Laboratory was still unfinished. Mr. Weldon, of St. John's College, Cambridge, was engaged from time to time before the completion of the building, when his work at Cambridge permitted him, on the study of the Crustacea of the Sound, and the results of his work will be published in due course. The Laboratory was not ready for work, and the tanks in the aquarium were not ready to receive marine animals before the spawning season of the majority of fish and Crustacea of economic value was over, and hence the subject of fish culture, to which great importance is attached, has practically been in abeyance since the apparatus necessary for it has been in place.

Immediately after the Laboratory was opened several inquiries were made by English naturalists as to the work that could be done at Plymouth, and several gentlemen, whose names are given in a Table below, came down to Plymouth for shorter or longer periods, and were engaged in zoological research, some of the results of which are given in the abstracts of this Journal. None of these gentlemen were able to extend their visit beyond September, and they had to experience the inconvenience of working in a new institution in which the necessary routine had not been formed by experience. At the present time, however, the organisation of the Laboratory is far in advance of what it was in September.

It is most unfortunate that the majority of English naturalists are so tied down by professional engagements that they cannot make lengthy visits to what may justly be called the National Marine Laboratory. In working out the life problems of any single animal, a single month's residence near its habitat is not sufficient, and when the research is extended to whole groups, many months, and even years, of patient study are required. Dr. Dohrn's famous station at Naples is tenanted year by year by naturalists from different countries, but chiefly from Germany, who are sent there to occupy one of the tables rented at a fixed annual charge by the different Governments, universities, and learned societies. Were this not the case the Naples Zoological Station, although its assured income is greatly in excess of that of the Marine Biological Association, would not have the means to keep together such a staff of naturalists as is required to produce the admirable scientific memoirs frequently published by that institution.

It is much to be desired that the universities, science colleges, and learned societies of Great Britain will similarly aid the Marine Biological Association by hiring tables at an annual rent,—fixed at

£40 per annum,—and sending their rising naturalists to Plymouth as yearly occupants of such tables. By doing this they will not only aid the progress of the Association and the extension of an accurate and reliable knowledge of all that concerns the denizens of the sea, but they will ensure to themselves a thoroughness and an enthusiasm on the part of those students on their return to scholastic or other duties, which can only be obtained by an extended study of the subject-matter of their science, free from the cares and interruptions of teaching work, and by constant communication with their fellow-workers in kindred branches of study. The effect of the enlightened patronage of the German States on the progress of zoological science in that country cannot be overestimated, and the impetus that has recently been given to the same subject in France, America, Austria, and Holland by the foundation of marine stations in those countries is equally remarkable. It is to be hoped that now that a really efficient laboratory exists on the coast of England, means will be found to enable English naturalists to take advantage of its resources.

The Association is definitely pledged, in consideration of a grant from H.M. Government, to concern itself with economic questions relating to our fisheries. Mr. Cunningham's paper is a sufficient evidence that the pledge is being fulfilled. But it must be observed that practical investigations of this kind, whilst they differ from those which have a purely scientific object only in the end to be obtained, and not in the methods to be employed, require a more comprehensive survey of the phenomena under consideration, and therefore a more extensive experience of their occurrence.

The object of every "scientific" investigation is to trace certain effects to their causes, and whereas in the case of a non-practical question it may be permissible to study the influence of a *single* force upon a fish or other organism, neglecting for the time other forces of equal or perhaps of greater importance, the solution of a "practical" question depends on the sum of many influences, acting, it may be, with varying intensities for various periods on the organism which is being investigated. The organism, its structure, life-history, habits, and abundance is the resultant of many such intermittent, unequal, and sometimes antagonistic forces. A "practical" investigation, then, differs from a "theoretical" only in its greater complexity and in the larger amount of accurate knowledge required for its objects,—practical investigations are nothing but scientific investigations of the highest possible order. A scientific opinion upon fishery questions must be founded upon such a number and variety of observations as to be equivalent to a statement of fact, and those who act upon the opinion, whether legislators, pisciculturists, or fishermen, have a right to expect an immediate advantage as the result of their following it. If a loss instead of a profit accrues, not only is that particular opinion set down as worthless, but the popular voice is apt to pass from a particular to a general statement, and to say that all scientific opinion on such matters is equally without value.

But perfect accuracy in any one detail requires long and laborious work, and many observations require many people to make them. Such work cannot be undertaken by a single man, nor even by two when one of them is subject to constant interruptions, with any prospect of immediate result. Several students are required who will interest themselves in the problems that concern marine life, and will divide the work between them in such a way as to keep a main object in view whilst they are working on separate details. This is being done with great success by the Commission appointed by the German Government for the investigation of the German seas, and may be done with equal efficiency at Plymouth if only the workers are forthcoming. As it is, Mr. Cunningham is fully engaged in the study of bony fishes and their development, and as much of my time as is not taken up with the duties of organisation and secretarial work is devoted to the study of the vast mass of living organisms which inhabit the surface waters of the seas—animals which are of great importance as forming the basis of by far the larger portion of marine life. But in addition to this, statistical, physical, and chemical, as well as other zoological work is required. The action of the tides and currents, the manner in which they are influenced by the weather, the temperature, density, and purity of the sea, are subjects which would take up the whole time of a single investigator, and they are of the greatest importance in the study of the migrations, spawning, and abundance of food-fishes. It is sincerely to be hoped that some gentleman will come forward as a volunteer in this department, and will spend at least a portion of his spare time at Plymouth.

In order that a thorough knowledge of the Fauna and Flora of the Devonshire and Cornish coasts may be obtained, it is requisite that several naturalists should spend long periods in investigating the different groups of the animal and vegetable kingdoms. Little can be done by an individual beyond the mere enumeration of the species with the date and locality of their capture. This work will naturally form part of the researches of renters of tables, but in order that it may be done well it is necessary that tables should be occupied for long periods.

By way of some remarks on the Fauna of Plymouth Sound it may be stated that the dredging and collecting done by the Association during the past year shows that a great change has taken place within the Sound itself. Plymouth Sound is properly included within a line drawn from Penlee Point to the Mewstone. The breakwater divides it into two great areas, of which that lying within the breakwater is nearly a closed basin. During the months of July and August I explored the whole of this inner region very carefully, and extended my researches southward to the imaginary line which limits Plymouth Sound. Previous to my arrival there the same localities had been constantly dredged by Messrs. Heape and Cunningham, so that one may say that the Sound has been carefully explored throughout a whole year. The result is that we find that very many of the animals which were known to be plentiful in the Sound twenty years ago have migrated further out, and are no longer to be found within the breakwater. This is no doubt due to the great increase of the Three Towns, and to the largely increased outfall of sewage, the whole of which is poured directly into what I have already described as a nearly landlocked basin; in many places, indeed, the ground is so foul that no animal would have a chance of subsisting there. This is particularly the case northward of the Breakwater Fort, and along the line of buoys to the north of Drake's Island. It is not advisable to attempt to give a complete list of all the species recorded, but attention may be called to some of the more important forms which occur in the Sound.

The Protozoa have not been worked out. Of the Porifera, *Grantia ciliata* and *G. compressa* are very abundant. *Oscarella lobularis* is not uncommon, and *Clathrina clathrus* is abundant in certain caves beneath the Laboratory. The rocks are covered everywhere with *Halichondria panicea*. *Hymeniacidon suberea* and *Isodictya lobata* are also found, the former in abundance, the latter rarely.

Of the Hydrozoa the most important is *Myriothela phrygia,* which is found on the underside of stones to the east of Drake's Island. *Tubularia indivisa,* common twenty years ago, can rarely be found now. *Clava carnea* and *C. multicornis* occur only in small colonies. *Eudendrium ramosum, Hydractinia echinata, Halecium halecinum,* several species of *Obelia, Clytia Johnstoni,* different species of *Sertularia, Sertularella* and *Plumularia,* with *Antennularia antennina* and *A. ramosa,* nearly complete the list. One hardly ever obtains a fine hydrozoon colony within the Sound, the large specimens come from deeper water and cleaner ground.

The Anthozoa are well represented in number, though not in variety. The most notable species is *Bolocera eques,* which occurs in the Cattewater. *Caryophyllia Smithii,* the common Devonshire coral, is tolerably abundant, and various species of *Sagartia, Bunodes,* and *Tealia* occur in the Sound. One of the most common forms is

Anthea cereus. *Alcyonium digitatum* and *Gorgonia verrucosa* are seldom found within the Sound, though they are common on rough ground in deeper water.

Of the Echinoderms *Antedon rosaceus* may be dredged in abundance close to the Mallard buoy. It appears to congregate in deeper holes during the winter months, and to spread itself along the shore during the summer. Echinids, Holothurians and Ophiurids are tolerably common, and *Asterias glacialis* is ubiquitous, *A. rubens* being common, but less frequent. *Asterina gibbosa* is found on every rock between tide marks.

Several Planarians have been found, but their species have not yet been accurately determined. The most common form is *Leptoplana tremellaris*.

Nemertines are tolerably common. *Lineus obscurus* is the most common form. *Micrura fasciolata, Nemertes Neesii, Amphiporus pulcher* and *lacteus* are not uncommon, and the palæonemertine *Carinella annulata* is found in the Cattewater.

Chætopod worms are found in great abundance and variety. The list given in the second number of the 'Journal' does not nearly enumerate the species which occur within the Sound. As a separate report on the Chætopoda may be expected in a future number, I will not attempt to give a list of the forms which we have collected, but will merely mention the discovery of Pachydrilus by Mr. Beddard in the sand at Jennycliff Bay, and the occurrence of the beautiful little *Gattiola spectabilis* near Bovisand Fort.

A note on Oligochæta by Mr. Beddard will be found at the end of the journal.

The Crustacea will form the subject of a separate memoir by Mr. W. F. R. Weldon, and I need not say more than that we have collected nearly all the species of Decapods enumerated in Mr. Heape's list, and have made some few additions. The Amphipods and Isopods have not yet received sufficient attention, and the same may be said of the Cirrhipedes and Ostracods. No mention is made of *Cladocera* in the list above mentioned, but *Podon* and *Evadne spinifer* are some of the commonest forms taken in the tow-net during the summer.

The Mollusca have received the attention of Mr. Walter Garstang, who gives the following account:

" The common littoral Gastropods are to be found in abundance on the rocks and beds of Fucus left bare by the tides (*Nassa reticulata, Murex erinaceus, Purpura lapillus, Littorina littorea* and *littoralis, Patella vulgata,* and several species of *Trochus*). Five or six species of *Chiton* occur, inhabiting the littoral and laminarian zones. *Helcion pellucidum* is very common on fronds of laminaria, and

Cypræa europæa can always be found. *Natica monilifera* and *nitida* occur on sandy bottoms, whilst their interesting allies, *Lamellaria perspicua* and *tentaculata*, are found on weeds, with colonies of *Botryllus*, *Didemnum*, and other compound Ascidians.

" From deeper water come *Turritella terebra*, *Ovula patula*, *Eulima nitida*, *Emarginula reticulata*, *Aporrhais pes-pelicani*, *Scalaria Turtonis*, *Cerithium* and *Cerithiopsis*, &c. The palliate and non-palliate Opisthobranchs are well represented. *Aplysia hybrida* is fairly common, and especially so in its young stage of *nexa*. *Eolis papillosa* and *Doris tuberculata* can generally be obtained, while smaller species of each of these genera are abundant. *Goniodoris nodosa*, *Polycera quadrilineata*, *Dendronotus arborescens* and *Tritonia plebeia* occur in the Sound. The remarkable *Elysia viridis* is common at the mouth of the Yealm.

" *Dentalium* is rare, but has been taken several times.

" Of the Cephalopoda, *Eledone cirrhosus* has been taken occasionally in the Sound, and so has *Loligo vulgaris*. A specimen of *Loligo media* of Linnæus has been taken from Cawsand Bay, and one of *L. marmoræ* of Verany from off the Draystone. *Sepiola atlantica* (D'Orbigny) is common everywhere. Many Lamellibranchiata require to be specially searched for on account of their habits of life, and this work has not yet been done. *Teredo* is found rarely, while *Saxicava rugosa* excavates the rocks of limestone everywhere. Small species of *Pecten* are very abundant, as also of *Anomia*, specimens of which are found attached to roots and stems of Laminaria. I have found *Crenella marmorata* attached or buried in the tests of *Cynthia tuberosa* and *Styela grossularia*. A single specimen of *Pectunculus glycimeris* has been taken from the Cattewater, but in all probability had been thrown overboard from some trawler. Indeed, all the finer bivalves came from deep water outside the Sound."

Polyzoa are found in great number and variety within the Sound. The most common forms are *Bowerbankia imbricata*, *Crisia eburnea*, *Alcyonidium gelatinosum*, *Flustrella hispida*, *Scrupocellaria scruposa* and *reptans*, *Bugula flabellata*, *Cellaria fistulosa*, *Membranipora pilosa* and *membranacea*, *Lepralia foliacea*, and *Cellepora pumicosa* and *avicularis*. Both *Pedicellina* and *Loxosoma* are taken within the Sound. The former (*P. cernua* and *gracilis*) is very common in tide pools, the latter was brought in once during July.

Although the Brachiopoda *Terebratula* and *Argiope* are recorded in Mr. Heape's list, the Association has been hitherto unable to find either of these forms within or without the Sound.

Of the Gephyrea *Thalassema Neptuni* is sometimes found in holes in stones within the breakwater, but it is much more common near the Eddystone. *Sipunculus nudus,* though recorded from the breakwater, has not been found by us, but a *Phascolion* (sp. incert.) is not uncommon in shells of *Dentalium, Turritella,* and *Aporrhais.*

Ascidians are exceedingly numerous within the Sound, especially the composite forms. Of the simple Ascidians the beautiful *Clavellina lepadiformis* is not uncommon beneath rocks and in tide pools. *Styela grossularia,* a small red Ascidian not mentioned in Mr. Heape's list, covers rocks, stones, and wooden posts. Various species of *Ascidia, Cynthia,* and *Molgula* have been collected, and *Ciona intestinalis* has to be added to the previous list. The Ascidiæ compositæ are ubiquitous, and are being specially investigated by Mr. Garstang. The commonest form, *Aplydium fallax,* which covers stones and wooden piles with red fleshy masses, is not mentioned in the list published in August.

It is not necessary to enumerate over again the fishes given in Mr. Heape's list. The species there recorded have been taken, and most of them are commonly taken in Plymouth Sound, and there is nothing to add, except the occurrence of a peculiar *Siphonostoma,* one of the Lophobranchii, in zostera beds in Cawsand Bay. This little pipe fish is coloured bright green, and has the habit of holding itself upright amongst the waving leaves of the zostera, which it mimics to perfection.

This account does not pretend to be a complete list of everything taken in the Sound during the past year, it is only an indication of the animal forms which can with certainty be procured at a short distance from the Laboratory and in all weathers; for there may be days and even weeks when south-westerly gales prevent any dredging outside the shelter of the breakwater. Further to sea, and along the Devonshire and Cornish coasts, one meets with an abundance of marine life, unrivalled in any other part of the British coast. Were the Association possessed of a suitable steamboat these rich localities could be constantly visited, and what is more important, an enormous mass of evidence relating to the physical conditions of the Channel and to sea fisheries could be collected. A special fund for the purchase of a steamboat was started in July, and has reached the sum of nearly £500, chiefly through the generosity of a few individuals. But a sum of at least £1200 is required to purchase a boat strong and seaworthy enough to resist the heavy weather so frequently experienced in the Channel, and a further annual sum will be required to meet the annual cost of maintaining it. The experience of those resident at Plymouth shows how urgently a steamboat is required, and I would appeal to all those interested in marine biology and in our fisheries to give their assistance to the Association for this purpose.

Some of the most interesting catches of the past year have been made with the tow-net. In the summer months the surface of the sea swarms with minute organisms, many of which are the developmental phases of sand or shore-inhabiting animals. Thus the larva of Balanoglossus, an animal hitherto unknown to the British coast, was taken in August and September, and forms the subject of a memoir in this number. Actinotrocha, the larva of Phoronis, is common, and the larvæ of Echinoderms, Chætopods, Molluscs, Nemertines, and Polyzoa are equally abundant. Several specimens of larval Amphioxus were taken in the tow-net towards the end of October. In the summer months Ctenophora, Medusæ, and other interesting forms afford abundant material for research.

It is needless to say more of the natural advantages of the Devonshire coast. Special facilities for study are afforded by the Laboratory, and as soon as a competent body of naturalists can be established at Plymouth, it will be possible to attack the problems of marine life in a manner hitherto unknown in England, to the great advancement of biological knowledge and to the advantage of practical questions concerned with sea fisheries.

G. C. Bourne.

December 5th, 1888.

Naturalists working at the Plymouth Laboratory during the six months ending December 31st, 1888:

Name.		*Date of arrival.*		*Date of departure.*
W. F. R. Weldon, M.A., St. John's College, Cambridge.	...	June 30	...	Dec. 19
W. T. Hardy, B.A., Caius College, Cambridge.	...	July 17	...	Sept. 15
C. A. MacMunn, M.A., M.D.	...	Aug. 14	...	Sept. 12
F. E. Beddard, M.A., F.Z.S., Prosector of the Zoological Society.	...	Aug. 3	...	Aug. 30
Prof. Burdon Sanderson, M.D., F.R.S. } F. Gotch, M.A. }	...	Sept. 3	...	Sept. 29

In addition to the above, the Resident Director, Mr. Bourne, the Naturalist of the Association, Mr. Cunningham, and Mr. Garstang, Secretary to the Director, have been continuously engaged in zoological research.

Studies of the Reproduction and Development of Teleostean Fishes occurring in the neighbourhood of Plymouth.

By **J. T. Cunningham, B.A., F.R.S.E.,**
Fellow of University College, Oxford; Naturalist to the Association.

With Plates I, II, III, IV, V, VI.

THE following is a detailed account of the results of my investigations concerning the breeding and the development, under natural and artificial conditions, of some of the fishes met with at Plymouth. These researches extended over the period from the beginning of August, 1887, to the end of August, 1888. I have given brief preliminary accounts of some of the results in No. II of the 'Journal,' issued in August, 1888. As I mentioned there, the laboratory work was carried on from August to November in a small room hired for the purpose near the fish quay; from November to June, 1888, in a single room in the Laboratory without a constant supply of sea-water; after that time the Laboratory being finished all its appliances were available.

CAPROS APER.

This fish is abundant off Plymouth in the months of July and August, when it is taken in large numbers by the trawlers, who call it the "cuckoo." At this time it is sexually mature, and evidently approaches the shore for the purpose of spawning.

I obtained and artificially fertilized ova on August 15th, 1887, when on board a trawler which fished on the east side of the Eddystone, and found on my return to shore that the fertilization was successful.

The fertilized ovum of *Capros aper* is of a type which is common to a large number of marine species; it is buoyant, very transparent, and spherical; the perivitelline space is small, the egg-envelope has no markings on the external surface, and there is a single oil-globule which in the normal position of the ovum is at the uppermost pole, *i. e.* the pole opposite to the centre of the blastodisc. But the oil-globule, as is usual in similar ova, is able to move freely at the surface of the vitellus at the early stages of development, that is, until the vitellus is completely enveloped by the blastoderm, and therefore when the ovum is placed on a slide in any position the oil-globule usually rises to the upper pole.

The ovum shown in fig. 1, at the stage when the blastoderm had just begun to spread, measured ·97 by ·98 mm. That shown in fig. 2, when the embryo was fully formed but the tail had not begun to grow out, measured 1·2 mm. in the shortest diameter, 1·5 mm. in the longest. The oil-globule is ·19 mm. in diameter. The ova were measured lying on a slide in sea-water without a cover-glass, the measurements being made by first tracing the outline of the ovum with Zeiss's camera, and then throwing the image of a millimetre scale on the tracing. In the later stage the increase in size is due to an expansion of the egg-envelope, the perivitelline space having increased. But ova of a given species are always, within narrow limits, variable in size.

The development was not carried to a later stage than that shown in fig. 2. At that stage black chromatophores had appeared at the sides of the embryo near the dorsal median line, as black specks.

Trigla cuculus.

I obtained some ova of this species on April 5th and 6th when on board a trawler south of the Wolf Rock, and also some milt, and thought I had effected artificial fertilization, but when I examined the ova on shore I found the fertilization had not succeeded. Another sample, this time successfully fertilized, was brought in by the Laboratory fisherman on April 28th ; they were taken, together with eggs of the common sole and merry sole (*Pleuronectes microcephalus*), on April 27th, about forty miles north of the Longships Lighthouse. On May 13th the Laboratory fisherman returned from a trip on a trawler to the neighbourhood of the Wolf Rock, bringing one bottle of ova of this species fertilized on May 10th, and a bottle of ova of *Trigla gurnardus* fertilized on May 11th. A few more ova of *Trigla cuculus* I fertilized myself at the same locality on May 16th. The natural conditions to which these ova are exposed during development are thus the same as in the case of those of *Pleuronectes microcephalus* (see below), the period of spawning being the same for both species. *Trigla gurnardus* spawns also at the same time.

With regard to the experimental conditions I had not time to pay so much attention to this as to other species. My observations are as follows :—The ova fertilized on April 27th were placed on the following day in a glass jar provided with a constant circulation of water, the jar having a layer of gravel at the bottom in which the lower end of a glass cylinder rested, the outflow passing through a siphon which took the water from the inside of this cylinder. The water supplied on this day was taken near the shore on the flood tide three hours before high water, and had a density of 1·025. The ova sank in this. On April 30th I procured some buckets of water from near the mouth of the Sound, at the Duke Rock, and this had a density of 1·026. As it replaced the other water in the circulation jar the ova rose to the surface. The specific gravity of the ova of this species is therefore about 1·0255. The temperature was 9·2° to 8·0° on May 1st, 8·9° on May 2nd, in the water passing through the jar. On May 4th the water brought in had a density of 1·024, and on account of small tides and continuous rain I could not get water any denser. The ova consequently sank to the bottom, and by May 7th all of them were dead. This case seems to show conclusively that death was due solely to the too low density of the water used. The circulation was nearly constant, and therefore the ova must have been sufficiently supplied with oxygen; and the temperature was very little higher than that of the open sea. However, the ova lived nine days. Of the ova brought in on May 13th, I placed the *T. gurnardus* in an apparatus like that described above, and left the *T. cuculus* in a jar of still water taken from the shore, having added common salt to it to cause the ova to float. On May 15th I went to sea on board the trawler "Lola." After my return, on May 19th, I found a single newly-hatched larva of *T. cuculus* in the jar, the rest of the ova being dead. This is somewhat surprising, namely, that an egg should live six days and finally hatch, in a small quantity of unchanged water to which common salt had been added. The temperatures of course had not been noted.

Development and structure.—I have given a figure of the ovum of *Trigla gurnardus* to show the early stage, not having drawn one of *T. cuculus* till the stage shown in fig. 4. The dimensions of the ovum in the two species are exactly the same; the diameter of the ovum is 1·45 mm., of the oil-glouble ·3 mm. There is but a single large oil-globule, which is as usual movable (see under Scomber) in the early stages. The stage shown in fig. 4 in *T. cuculus* was reached in five days three hours. Chromatophores of two colours were present at this stage, some black, the others orange; both kinds are present on the sides of the embryo, only the orange on the yolk-sac. The characters of the larva are shown in fig. 5, but the figure is not coloured. The black dendritic chromatophores are here as usual specially developed along the edges of the median fin-fold, and both kinds are abundant on the surface of the yolk. The notochord is multicolumnar, and the anus immediately behind the yolk. But the most peculiar feature in the larva is the great size of the rudiment of the pectoral fin. As usual the mouth is not open, but there is an opercular opening leading to the gill-slits. The larva was 3·7 mm. in length.

Pleuronectes microcephalus.

I first got the eggs of this species, along with those of the sole and others, on March 5th and 6th, 1888, when I was on board a trawler which was fishing to the south of the Wolf Rock, which lies to the west of the Lizard Point in Cornwall. In the spring and summer, with few exceptions, all the Plymouth trawlers are accustomed to fish in that neighbourhood. They usually leave the port of Plymouth on Monday morning, about 8 a.m., and as a rule it takes about twenty hours to sail to the fishing ground, which is usually spoken of by the fishermen as Mount's Bay, although the fishing actually takes place some distance to seaward of any limit which could reasonably be defined for that bay. Several times I went on board one of the trawlers named the "Lola," and collected eggs of all the species of fish which were in a ripe condition amongst those brought on deck during the week's fishing. Each boat usually returns to Plymouth on Saturday, and starts again the following Monday.

My first trip lasted only from March 5th to March 8th, as we were obliged to return to Plymouth before the end of the week on account of bad weather. On that occasion I found one or two specimens of *Pl. microcephalus* which were partially ripe, and got a few ova and a little milt; but when I examined these ova afterwards on shore I found they were either dead, or still living and floating, but unfertilized. My next trip lasted from April 3rd to April 7th, when I again got some eggs of the same species, and found on my return that they were not fertilized. On April 11th the fisherman engaged for the collecting work of the Association was sent by me to go out in a trawler fishing on the Plymouth ground, and try to procure some fertilized ova. He returned on April 13th, bringing ova of *Pl. microcephalus* but of no other species. These ova I found were fertilized; they were taken four or five miles south of the Eddystone, the trawl being towed east and west. The Laboratory fisherman went out again in a trawler on April 23rd, the boat fished in the Irish Sea about forty miles north of the Longships Lighthouse. He brought back on April 28th ova of *Pl. microcephalus*, and some other species, but those of the former were unfertilized. He went out again on May 8th, this time on board the "Lola," to the Mount's Bay ground, and returned on May 13th, bringing some fertilized ova of this species. I did not stay on shore to study these, as I was anxious to go out myself to procure soles' ova, and went to sea on May 15th for this purpose. On this occasion I did not get ova of *Pl. microcephalus.* On May 26th some healthy fertilized ova of this species were sent up by the captain of the "Lola;" they were taken near the Wolf Rock on May 24th. The Laboratory fisherman, William Roach, obtained more ova of the same species on May 29th on a trawler to the south of the Eddystone, and this was the last lot that I received.

It thus appears that the species we are considering spawns during April and May, the period, no doubt, extending in the case of a few individuals slightly beyond these limits in either direction.

A few data were obtained to indicate the physical conditions to which the ova are normally exposed. The density of the water in the neighbourhood of the Eddystone is 1·0267 to 1·0269 (see under Scomber).

On April 7th I brought a clean sample of sea-water from where we had been fishing, south of the Wolf Rock, in a stoppered bottle, and found its density when tested in the Laboratory was 1·0270. The temperatures observed were as follows:

April 4th.—South-east of Wolf Rock . . .	Surface .	7·5° C.
„ 12th.—5 miles south of Eddystone . .	Surface .	7·2° C.
	Bottom, 40 fms.	6·6° C·
„ 16th.—Ditto	Surface .	7·5° C.
„ 25th.—40 miles north of Longships Lighthouse .	Surface .	7·7° C.
	Bottom, 50 fms.	7·2° C.
May 10th.—10 miles south-east of Wolf Rock .	Surface .	10·0° C.
	Bottom, 45 fms.	8·9° C.
„ 29th.—6 miles south-west of Eddystone . .	Surface .	9·4° C.
	Bottom, 40 fms.	8·8° C.

In describing the artificial conditions under which the ova were kept in the Laboratory, I shall consider first and more fully those obtained on April 12th about five miles south of the Eddystone, as from these all the figures and most of the description given below of the development were taken.

When these ova were brought in I transferred them to some water taken a short distance from the shore opposite the Laboratory; the density of this was 1·026, and the ova all floated in it without difficulty, remaining in a layer at the very surface. They were simply left in jars of the water, with no arrangement for continuous aeration or circulation, but were transferred to clean water every day. On April 14th the temperature of the water in the jars was 12·5° C., more than 5° higher than the surface temperature of the open sea where they were taken. The subsequent temperatures in the jars were: 16th, 11·6° C.; 17th, 13·0° C.; 19th, 11·8° C.

A large proportion of this lot of ova hatched, and some of the larvæ lived five days after hatching. The larvæ after hatching were placed in a jar with gravel at the bottom, supplied with a constant inflow of water, the outflow taking place from a cylinder whose base was inserted in the gravel.

On the 18th I found that water brought up from the shore had a density of 1·023, and in this ova of *Pl. microcephalus* rapidly sank.

The ova fertilized on May 24th were also left in still water, having a density of 1·026, and a temperature on the second day of 13·7° C. These hatched on May 30th. Another lot, fertilized on May 29th, were placed in a Chester apparatus (see under Scomber), made with a square wooden washing tray, and provided with a nearly constant supply of water from the shore. (All this time I was restricted to a single room, all water being carried up by hand.) The temperature of the water was 12·4° C. These ova were all dead on May 31st, the fatality being probably due to the impurity of the apparatus; the washing tray was fastened with white lead, and washed muslin was used over the bottom of the jars containing the ova.

It is thus shown that the ova of *Pl. microcephalus* are extremely hardy, and can be hatched without any difficulty in still water whose temperature and density differs considerably from those to which the ova are exposed under normal conditions. The next step is to make arrangements for collecting and hatching these ova on a large scale, and transferring the hatched young to the sea, in order to find if the supply of merry soles is thereby increased.

The specific gravity of the ovum of *Pl. microcephalus* is about 1·024; they floated in water having a density of 1·025, and sank in that of density of 1·023.

Structure and development.—The ovum of *Pleuronectes microcephalus* resembles that of other species of the same genus, and of many species of Gadus (cod, haddock, whiting, &c.) in having a perfectly homogeneous yolk without oil-globules, and a small perivitelline space. Its diameter is usually 1·36 to 1·44 mm., though individual ova may be a little smaller or a little larger than this. The external surface of the vitelline membrane (egg envelope) is not perfectly smooth, but shows a number of fine raised ridges forming two systems of parallel lines, which cross one another diagonally. Fig. 6 shows the appearance of the ovum under the microscope when the blastoderm has almost entirely enveloped the yolk. In the ova fertilized on April 12th, at 1 p.m., and kept under the conditions already detailed, segmentation was completed on the first day, and on the second the extension of the blastoderm over the yolk took place. On the third day the differentiation of the optic vesicles and of the mesoblastic somites commenced. On the fourth day the lens and auditory vesicles were formed, and the first development of pigment appeared as black dots on the sides of the embryo. Fig. 7 shows the condition on the fifth day: the intestinal tube is formed, the notochord is present and already shows the multicolumnar arrangement of its vacuoles, and the cavity of the heart has appeared as a simple slit in the mesoblast below the neck. The black chromatophores are but little further developed. A number of the larvæ hatched out on April 19th at the end of the seventh and commencement of the eighth day after fertilization. The structure of the larva is shown in fig. 8. It is 3·8 mm. in length. There are now yellow chromatophores as well as black, and both are dendritic. They are present in the median fin-fold, on the sides of the body, and on the surface of the yolk, where they are situated at the surface of the periblast. The mouth is not open, the nasal pit is seen at the anterior end of the head, the heart is more developed and contracts regularly, but there are no red corpuscles. The anus is open and situated immediately behind the yolk. There is a large cavity (the venous sinus) in front of the yolk, between it and the anterior abdominal wall. The notochord is not altered. Besides the median fin-fold there are rudiments of the pectoral fins in the form of a semicircular fold of membrane on each side behind the auditory vesicle. The cavity of the intestine is plainly visible. The larva four days after hatching (fig. 9) is considerably more developed. The mouth is not opened, but its cavity is large and only separated from the exterior by a thin membrane, and three or four gill-slits are open leading from the pharynx to the exterior. The yolk is almost absorbed, and the abdominal region therefore does not protude so much. The venous sinus is still large and its communication with the posterior end of the heart is plainly seen. Red corpuscles are still absent, but white corpuscles or leucocytes are to be seen moving in the venous sinus and passing into the heart. In front of the remnant of the yolk is seen the liver, as a bulbous follicular outgrowth from the wall of the intestine. The urinary bladder is visible behind the rectum. The head is much shortened, so that the auditory vesicle is much nearer to the eye. The pectoral fin is considerably developed, but no fin rays are present in it. The pigment is much more abundant, and has a definite arrangement. The yellow pigment is confined to the body of the larva and the surface of the yolk; on the former it is abundant, especially about the head. The black chromatophores form a fringe at the edges of the median fin, and others are also present on the body and the yolk-sac. The larva is still perfectly symmetrical; no indication of the asymmetry of the eyes and skull is yet apparent. The larva at this stage has a total length of 4·6 mm.

Solea vulgaris.

Observing that the ovaries of soles brought in by the fishermen were approaching maturity, I went out in a trawler on February 6th, 1888, to obtain, and to artificially fertilize, some ripe ova. On this occasion, as on many others when I was similarly engaged, the trawl was brought on deck after darkness had set in, and I had to carry on operations by the dim light of a lantern. From one specimen I got a few ova, but could get no milt. The ova, when examined on shore next day, were found to be unfertilized, though two or three were floating. On this occasion the boat, when the trawl was hauled, was about nine miles west by south of the Eddystone.

My next attempt was on March 6th, when I was on board the "Lola," south-east of the Wolf Rock. At one haul of the trawl I got, out of about thirty-five soles, two or three which yielded a few ripe ova on squeezing, but I could obtain no milt from any of them. On opening those which I judged to be males I found small testes in the usual position, and these I cut out and divided into small pieces, and placed these in the water with the ova, hoping that sufficient spermatozoa for fertilization would thus be obtained. This difficulty in obtaining the milt of the sole, an unexpected obstacle to the investigation of the development of the species, occurred constantly on every subsequent occasion when I tried to obtain fertilized ova. The cause of it I have not yet discovered. There is no such difficulty in the case of other flat-fishes; the ova of the merry sole were fertilized with ease, sufficient milt could almost always be obtained by squeezing males, and at other times I have fertilized the ova of *P. flesus* (the flounder), *P. limanda* (the dab), *P. cynoglossus* (the witch, or pole flounder); but I was not able during the whole of last season ever to squeeze any milt out of a male sole. The probable reason is that the testes of the sole are extremely small.

On March 7th I examined the soles of another haul with the same result. On my return to Plymouth on March 8th I found only about a dozen of the ova floating, and of these only two or three showed a blastoderm, that is, were fertilized. Thus the pieces of the testes placed in the water had effected fertilization only in a few ova of the whole number. The few I had were used up for microscopic examination.

In my next trip to Mount's Bay on April 3rd to 7th, I took some sole's ova as before, using entire testes cut into pieces to fertilize the ova. But on my return I found that this time not a single ovum was fertilized. At this time only a few soles were taken at a haul on the Plymouth ground, and it was necessary to go to Mount's Bay in order to have a chance of getting ripe specimens at all. But after this nearly all the trawlers went round the Land's End and fished on the north coast of Cornwall, so that it was difficult to arrange a trip unless one was prepared to stay out a fortnight, which would have made it impossible to get any results from the material obtained. I sent the Laboratory fisherman on one of these long trips, April 23rd to 28th, but the sole's ova he brought back were unfertilized. He went again to Mount's Bay, May 8th to 13th, and was again unsuccessful. I went myself May 15th to 18th, when I found a good many of the female soles spent, but again failed to get milt; I employed the testes as before, and on my return on May 19th I found a few of the ova fertilized.

The common sole thus spawns in March, April, and May. The temperatures of the open sea during the last two months are given under *Pleuronectes microcephalus*. Off the Wolf Rock on March 6th the temperatures were: surface 7·7° C., thirty fathoms 7·5° C. I found that sole's ova sank in water of 1·026 specific gravity and floated at 1·027, so that their specific gravity is between these numbers.

Structure and development.—The ovum of *Solea vulgaris*, after extrusion and fertilization, is of considerable, size; of two that I measured one was 1·47 the other 1·51 mm. in diameter. It is distinguished from the greater number of the pelagic ova of other genera by two peculiar characters, both connected with the yolk. One is that instead of having a single large oil-globule, or a small number of these, it has an immense number of very minute size. These are arranged in groups of irregular shape, the globules of a given group being all in contact with one another. At the early stages most of these groups are near the edge of the blastoderm, but without any constant arrangement (fig. 10). The other character is that the yolk is not perfectly continuous and homogeneous, but co-extensive with the blastoderm there is a single superficial layer of separate yolk-masses, or yolk-segments, having a somewhat rounded outline, but not spherical (*y. s.* in figs. 10, 11, &c.) This layer of yolk-segments extends with the blastoderm, so that when the latter has enveloped the yolk the layer of yolk-segments also envelops it completely, forming a superficial layer over the whole surface of the yolk as seen in fig. 11. When the embryonic rudiment becomes distinct, and especially after the yolk is completely covered by the blastoderm, the groups of oil-globules are mostly aggregated on each side of the embryo, though there are a few groups at other parts of the surface of the yolk (fig. 11).

I have only, on account of the great scarcity of my material, been able to examine two stages in development from artificially fertilized eggs. Fig. 10 shows a living but unfertilized ovum, drawn on March 8th. The development of a fertilized ovum examined on the same day had evidently been very slow, owing to the low temperature to which it had been exposed; the temperature of the surface sea-water in which the ovum was fertilized was 7·7° C., and as the jar had been kept on board the trawler until shortly before the time when the ovum was examined, the temperature of the water containing the ovum was probably even lower than this during the two days.

Fig. 11 is taken from another ovum fertilized on May 16th, and drawn three days afterwards, the temperature at fertilization having been about 10° C., and in the jar containing the ovum during the time it was on board the boat probably somewhat higher. At this stage the enclosure of the yolk by the blastoderm has been completed, the embryo is distinctly formed, the optic vesicle is present, and the vesicle at the posterior end, known as Kupffer's vesicle, is fully developed; this vesicle is unusually large. Black chromatophores have appeared on the sides of the embryo and on the surface of the yolk, the former being still in the form of dots, the latter dendritic or stellate in shape.

It is evident that the peculiarities of the sole's egg enable it to be easily recognised when taken in the open sea in the tow-net. Twice I obtained specimens in this way. The first time was on March 16th, 1888, from a tow-net worked between the Tinker and the Knap buoys just outside Plymouth Breakwater, just after high water, when the temperature at the surface of the water was 6·6° C. There were three ova altogether, one of which is shown in fig. 12. The diameter of this was 1·47 mm. The individual oil-globules and the vitelline segments were of somewhat larger size than in the artificially fertilized ova, but this is probably a mere individual variation, and there can be little doubt that the ova belonged to *Solea vulgaris*.

The second time was on April 18th from a tow-net worked on the east side of the Sound, when I found only a single ovum, which is figured in fig. 13. This ovum was in the same stage as the artificially fertilized one shown in fig. 11, but it is figured in a different position. It agrees in structure exactly with the ova taken directly from the parent fish, but its apparent size in the figure is greater. It was drawn under a cover-glass, and in this condition measured

1·67 mm. in diameter, the difference being due partly to the flattening caused by the pressure of the cover-glass, and partly perhaps, to individual variation, as the eggs of a given species always vary in size within certain limits. The position of the groups of oil-globules at the sides of and beneath the embryo is clearly shown in this figure.

Historical and comparative.—Imperfect as is the foregoing account of the ova of *Solea vulgaris* and their development, it is the first definite information yet afforded concerning the eggs of this species. Certain facts concerning the structure of the ova in the genus Solea have been published by Dott. Fed. Raffaele in a paper on the eggs and larvæ of Teleostean fishes in the Gulf of Naples,* which appeared in March, 1888 ; but Raffaele has only described fertilized developing ova obtained by the tow-net from the surface of the sea, and did not identify any of these ova with a definite species. He ascertained the peculiarities of the ova in the genus by examining mature ovaries of *Solea impar, vulgaris,* and *Kleinii,* and says that these peculiarities, although distinguishing the ova of Solea from any other pelagic ova, render the ova of the different species so similar that they cannot, when obtained at random (*i. e.* from the open sea) be distinguished easily from one another. These peculiarities are those I have described, namely, the groups of minute oil-globules, and the superficial layer of yolk-segments, which Raffaele calls "vescicole vitelline," speaking of the whole layer as the "zona esterna vescicolare."

Raffaele describes two kinds of ova of Solea obtained by the tow-net, and not having been able to determine their species, he calls them Species A and Species B. Species A was 1·06 mm. in diameter, and was obtained in January. He gives two figures of this ovum, which are both indistinct, and also six figures of the larva at different stages, which are much better. Species B was larger, 1·23 mm. in diameter ; of this he gives no figures of the ovum, but three figures of the larva. Neither of these species probably belonged to *Solea vulgaris,* as the largest of them is ·2 mm. smaller than the ovum of the latter according to my measurements.

Raffaele notices the change in the relative position of the groups of oil-globules as the blastoderm grows over the yolk, attributing it to the fact that they are situated in the cortical protoplasm which divides the vitelline segments, and therefore take part in the movement of the latter. I cannot say whether the oil-globules in the sole's ovum are freely movable at first like the single globule in Scomber, Trigla, &c.

* *Le Uova gallegianti e le Larve dei Teleostei nel golfo di Napoli,* Mittheilungen aus der zoologischen Station zu Neapel, Bd. viii, Heft 1.

The layer of separate vitelline segments is not exclusively confined to the ova of Solea; it is the combination of this character with the peculiar arrangement of the oil-globules which distinguishes this genus. The external segmental layer of the yolk was first noticed by Agassiz and Whitman* in a species of ovum which they ascribe to *Temnodon saltator*, Linn., known in America as the blue-fish. Temnodon belongs to the same family as the boar-fish, *Capros aper*, whose ova have been described above, namely, the Carangidæ. Agassiz and Whitman state that when the blastoderm has enveloped the yolk the yolk-segments are absent immediately beneath the embryo, but I have not verified this in Solea. In the ova described by these authors there is but a single oil-globule of considerable size, and judging from the figures which show the globule in different positions it is mobile at the early stages.

Raffaele describes a perfectly similar superficial layer of segmented yolk in *Mullus surmuletus*, L., the red mullet. He informs us, moreover, that in the ovarian ovum of Mullus when it is approaching maturity the yolk-segments are in the centre of the ovum, and are nothing but a portion of the vitelline segments which at an earlier stage make up the whole mass of the yolk. Most of these segments fuse together to make up the homogeneous part of the yolk; the remainder pass to the surface and take up a position beneath the germ or blastodisc, persisting during development. The partitions enclosing the segments Raffaele believes to be protoplasmic and continuous with the protoplasm of the germ, by which he explains the fact that the yolk-segments are involved in the movement of the blastoderm. The explanation is in all probability correct.

The superficial layer of segments is also described by Raffaele in the ovum of *Callionymus festivus*, and in an unidentified ovum (Species No. 2 in his paper) with a diameter of ·75 mm. which he says resembles that of Callionymus. He states that in *C. festivus* the layer of segmented yolk extends all round the ovum from the beginning, even in the mature ovum before fertilization, and undergoes no movement during the extension of the blastoderm. He refers to a description by McIntosh of the ovum of *C. lyra* (Ann. Mag. Nat. Hist., vol. xvi, 1885), in which it is stated that the surface of the vitelline membrane in this species exhibits a hexagonal mosaic of raised lines, and says that nothing of the kind being visible in the ovum of *C. festivus*, McIntosh probably saw the follicular epithelium attached to the ovum when it was taken from the ovary, and mistook this for a marking of the vitelline membrane.

* *Pelagic Stages of Young Fishes*, Memoirs of Museum of Comp. Zoology, vol. xiv, No. 1, pt. i, Cambridge, 1885.

But I am able to confirm entirely McIntosh's statement with regard to *C. lyra.* I examined ripe ova squeezed from a mature female, and saw the hexagonal reticulum figured by McIntosh, and further, I took in the tow-net in the Firth of Clyde in 1886 an ovum well advanced in development, which showed exactly the same marking, and which agreed in all characters with the ripe ovum of *C. lyra.* Moreover, I saw no layer of yolk-segments in this species. At Plymouth I again met with the same ovum on February 1st, 1888, inside the Sound; two views of it are shown in figs. 26 and 27; the former shows an optical section, the latter the surface of the vitelline membrane. This ovum measured in one case ·90 mm., in another ·97 mm. Raffaele gives as the diameter of the ovum of *C. festivus* ·56 to ·60 mm. The Italian author speaks as if he had taken the ova directly from the parent fish, and thus it would seem that there are great differences between the ova of these two species of the same genus, but they agree in having no oil-globules.

The other kind of ovum with a peripheral layer of yolk-segments is briefly described by Raffaele (No. 2 of his undentified species). This has a diameter of ·75 mm., and has a number of rather large oil-globules scattered separately over the yolk; it was obtained by the tow-net in January.

As it seems not quite certain that the identification of the ovum of Temnodon by Agassiz and Whitman is correct, and there is some doubt about *Callionymus festivus* and the other species, Mullus and Solea are left as the only genera whose ova undoubtedly have the peripheral layer of yolk-segments. It is interesting to notice that these ova present a condition of the yolk intermediate between that characteristic of non-pelagic ova and that seen in typical pelagic ova. Oil-globules occur equally, either singly or in numbers, in both kinds of ova, but in all adhesive ova the yolk is made up of a number of minute yolk-spheres, and in nearly all pelagic ova the yolk is one mass, continuous and homogeneous, a single yolk-sphere. The adhesive ova are characteristic of nearly all shore fishes from the large Cyclopterus to the minute Goby, and also of the greater number of Physostomi, *i. e.* of the more primitive fishes with an opening to the air-bladder. But certain Clupeoids, *e. g.* the pilchard, although belonging to the Physostomi, have pelagic ova, and in these ova the subdivision of the yolk is retained at all stages; then in Solea and Mullus the central part of the yolk is fused into one mass, while a peripheral layer continues segmented; and finally in most pelagic ova the segments disappear altogether, and there is no subdivision of the yolk at all. It is possible that the peculiar character of the ovum of Solea indicates that there is no close affinity between this genus and Pleuronectes; the adaptation to the habit of lying on one side may have brought about a superficial similarity in fishes originally derived from distinct families. I hope to decide this question by a careful comparison between soles and other kinds of flat-fish in all points of adult structure.

Solea variegata.

I did not devote much attention to this species, as my time was occupied with others; the following notes are therefore very meagre. Until May 30th I had not been able to find any of this species in a ripe condition. On that day the Laboratory fisherman brought me a few ripe ova which he had taken from a fish on board a trawler six miles south-east of the Eddystone. He had not been able to get any milt. When I examined the ova they were all at the bottom of the jar apparently dead, and all I could make out was the size and a large group of numerous oil-globules, individually larger than those of *Solea vulgaris.* These all collected at the highest point of the ovum when placed on a slide. The diameter was 1·36 mm. The appearance of the ovum is shown in fig. 14.

On July 17th, I obtained from a tow-net worked by the Laboratory fisherman from a mackerel boat south-east of the Eddystone a peculiar kind of pelagic ovum which is shown in fig. 15. This had a superficial layer of yolk-segments, like *Solea vulgaris,* but the oil-globules, though rather numerous, were of rather large size, and were scattered singly at nearly equal distances over the surface of the yolk. The diameter measured 1·36 mm. Thus the size of the ovum and of the individual oil-globules agreed closely with the dimensions noticed in the unfertilized ovum of *Solea variegata.* I conclude provisionally that the ovum shown in fig. 15 belongs to this species. Raffaele examined the ovarian eggs of only three species, *S. impar, vulgaris* and *Kleinii.* Impar is considered by Day in his Fishes of Great Britain and Ireland as synonymous with lascaris, which is Couch's lemon sole, and occurs occasionally on the coast of Devonshire; Kleinii occurs only in the Mediterranean. Thus there is nothing to show that *Solea variegata* may not have separate oil-globules; and although in the dead unfertilized ovum I observed them all in one group, this does not prove that they are not in the later stages of the living egg fixed at a distance from one another. Moreover, Raffaele describes and figures among his undetermined species an ovum which agrees in all respects with that shown in fig. 15 except that it is 1·4 mm. in diameter instead of 1·36. This difference may be due to the conditions of measurement or to individual variation. Raffaele thinks his ovum belongs to another species of Solea; it seems to me probable that it belongs to *Solea variegata.*

Other species of Pleuronectidæ.—It will be useful here to summarise the present state of our knowledge concerning the reproduction of other species of the flat-fish family. I have already mentioned that Day considers *Solea lascaris* and *Solea impar* of Günther's British Museum Catalogue to be one and the same species, and that Raffaele has examined the mature unfertilized ovum and finds it has the same peculiarities of structure as *Solea vulgaris.* The species occurs occasionally at Plymouth, but I have never met with a specimen, and it is too rare to be of any importance for practical hatching. Day also unites *Solea lutea* and *Solea minuta* of Günther. This is a very small and practically unimportant species which also is rare at Plymouth, and I have not seen a specimen.

Of Pleuronectes I have previously* described the ova and development of *P. flesus,* the flounder; *P. limanda,* the dab; *P. platessa,* the plaice, and *P. cynoglossus,* the witch, or pole flounder. These, with *P. microcephalus,* are the only British species of the genus. The eggs and larvæ of all these species are closely similar and differ only in size. The eggs and larva of *P. Americanus* described by Agassiz and Whitman in Pelagic Stages, &c., have the same characters.

Rhombus maximus, the turbot, and *R. lævis,* the brill, both occur at Plymouth. I have not been able to get ripe ova of either, but Raffaele considers certain ova which he obtained from the tow-net, which had a diameter of 1·33 mm., a homogeneous yolk, and a single large oil-globule, as belonging to *R. lævis.* He also figures larvæ of this species. Wenckebach describes the mature ova of *R. maximus* as having a diameter of ·75 mm.

Arnoglossus includes two species which occur at Plymouth, of which *Arnoglossus laterna,* the small scald-fish, is of no importance in the fish market. Concerning this species I have some incidental remarks to make. It is very common at Plymouth, and inside the Sound, especially in Cawsand Bay, young specimens of all sizes from three quarters of an inch long up to the full size of about six inches, are taken in numbers by the small trawls used for catching shrimps. It is constantly reported by fishermen that the shrimpers catch numbers of young soles, but the report is simply founded on a mistake, these young scald-fish being erroneously taken for soles. On August 15th, 1888, I went, with Mr. Bourne, on purpose to test this matter, and after trawling for a long time in Cawsand Bay we got large numbers of young scald-fish, but only one young specimen

* *The Eggs and Larvæ of Teleosteans,* Trans. Roy. Soc. Edinb., vol. xxxiii, pt. 1, 1887.

of *Solea vulgaris*. In one point the descriptions and figures of *Arnoglossus laterna* given by Day in his British Fishes, and by Günther in his Catalogue of the British Museum Collection are a little too vague. The latter author does not of course give a figure for each species, and he speaks of the anterior curve of the lateral line in this species is subsemicircular. The former describes it as almost semicircular, and figures it as a rounded curve much like that of Zeugopterus. The anterior part of the lateral line in reality forms almost three sides of a square, and has another smaller curve still farther forwards, as shown in outline in fig. 39.

Raffaele states that the mature ova of Arnoglossus are ·60 to ·70 mm. in diameter, with a homogeneous yolk and a single oil-globule, and cannot be distinguished from those of Rhomboidichthys and Citharus, genera of Pleuronectids occurring in the Mediterranean, but not in Britain. It would seem therefore that the ova of Arnoglossus only differ from those of Rhombus in size.

Two species of Zeugopterus occur at Plymouth. I have met with a specimen of *Z. punctatus* taken in a lobster pot. They have no value in the market and their ova are not known.

SCOMBER (the Mackerel).

My first examination of living mackerel was made on board a boat called the "Prima Donna," on May 24th, 1888. On this occasion the nets were shot on the east side of the Eddystone, about fourteen miles from Plymouth Sound; and when they were hauled at daybreak in their whole length of nearly two and a half miles only abont fifty mackerel were taken. Several of these were males in a perfectly ripe condition, but only one ripe female was found, from which a number of ova were taken and fertilized. The skipper and the men having seen performed the simple operations necessary to obtain and fertilize the eggs, I left a basket of collecting bottles on board, and they supplied me with fertilized ova almost every time they went to sea. In fact, by this skipper and another, who was also taught how to collect them, more ova were sent to me than I could deal with, and I had to tell them not to send any until I gave them notice. The spawning continued from the end of May till the middle of July, and throughout this time I was studying and making experiments with mackerel ova. I received the last of the season on July 17th. It follows from this that mackerel in the neighbourhood of Plymouth spawn principally in June and the first half of July, that the ovaries and testes of all the adult fish become ripe within this period, and that all the reproductive products in a given fish are matured and shed within a short space of time. The process of spawning, that is to say, as usual in species of fish that swim in shoals and have migratory pelagic habits, is approximately simultaneous in all the specimens in a given locality, proceeds very rapidly when once begun, and is limited definitely to one short period of the year.

Physical conditions during development.—I have collected a few data concerning the density and temperature of the water at the surface of the sea, some miles from the Sound, that is where mackerel ova are shed under natural conditions.

March 23, 1888.—Water brought in from 2 miles outside the breakwater		
	Density . .	1·0268
	Temp. when tested	8·2° C.
April 7.—Water from 7 miles south of Wolf Rock .	Density . .	1·027
	Temp. when tested	7·5° C.
June 1.—Water in which mackerel ova were floating when brought in; that is, water taken from the surface at the place where the mackerel were caught.		
	Density . .	1·0267
June 2.—Water in which mackerel ova were brought in from sea.		
	Density . .	1·0268
July 17.—Ditto	Density .	1·0269
	Temp. when tested	15·0° C.
May 31st.—Temperature of the sea 2 miles outside the breakwater.		
	Surface . .	9·44° C.
	Bottom, 12 fms. .	10·0° C.
June 12.—Temperature of sea at 7 miles south-west of the Eddystone, taken with Casella's reversing thermometer in the "Scottish" frame.	Surface .	11·6° C.
	Bottom, 40 fms. .	10·0° C.
July 10th.—Temperature of sea in middle of Plymouth Sound, Melampus Buoy.		
	Surface .	13·3° C.
	Bottom, 7½ fms. .	12·7° C.

With regard to the temperature of the sea at places where spawning mackerel were caught, that is in the neighbourhood of the Eddystone, it is certain that it could not have been higher than the temperature in the Sound and a short distance south of the breakwater. This temperature therefore between June 12th and July 10th rose from the temperature observed at the mackerel ground on the former date, namely, 11·6° C., to something less than that observed in the Sound on July 10th, namely, 13·3° C. With regard to density, the specific gravity of water from the mackerel ground was ascertained on shore three times, and was 1·0267 on June 1st, 1·0268 on June 2nd, and 1·0269 on July 17th. The temperature of the sample at the time when the density was observed was only once ascertained, on July 17th, when it was 15·0° C. The temperature of a small quantity of water in a bottle carried on a fishing boat, and examined in the Laboratory in June and July, must of course be somewhat higher than its temperature when taken from the sea, but we see that the greatest difference of temperature between the sea and the observed sample of sea-water was that between 11·6° C. and 15·0° C., or 3·4°. Thus the density of the water at the surface of the sea was slightly greater than that observed in the samples, allowing for the expansion of the water caused by a rise of temperature of two or three degrees. But this difference of density would be scarcely appreciable, and we may therefore conclude with certainty that the density of the surface water of the sea was not less than 1·0267 and very little higher than 1·0269. The temperature on June 12th, seven miles south-west of the Eddystone, was 11·6° C., and on July 10th less than 13·3° C.

The following data of the conditions of temperature and density to which the ova were exposed during the Laboratory observations are to be compared with the natural conditions ascertained above. The first lot of ova I got, namely, those taken on May 24th, I placed in a glass jar of water provided with a slow circulation; at the bottom of the jar was a layer of gravel, and a glass cylinder with its base in the gravel surrounded the siphon through which the outflow took place. Thus the ova were prevented from approaching the exit siphon, while the water passed through the gravel up into the inside of the cylinder. This apparatus was arranged at 10 a.m. on May 24th, and on the following day I found that all the ova had sunk to the bottom of the jar, and were in a dead or dying condition. A few of the ova which had been left in the water brought in from the sea were still alive and developing. The water supplied to the circulation apparatus was brought up from the shore, as at this time I was restricted to my single room in the Laboratory, and the aquarium apparatus was not built. The result showed that the water from the shore, although constantly supplied in a pure condition to the eggs in the circulation apparatus, was rapidly fatal, while in the water from the open sea, although perfectly still and unchanged, the ova lived.

On May 26th more ova were sent up by the crew of the "Prima Donna." I had some clean water brought up from the shore, and found that its density was 1·0260, and its temperature 13·7° C. In this water the mackerel ova slowly sank, although the ova of *Pleuronectes microcephalus*, which I had at the same time, rose to the surface in it as soon as they were introduced. It is remarkable that there should be so considerable a difference in the specific gravity of the ova of the two species, the more so as the mackerel ovum has a large oil-globule, and the merry sole none, and yet the former is a good deal the heavier. As these mackerel ova were in perfectly clean water when brought in I did not transfer them to the water from the shore, but only added a little of the latter to the water containing them, taking care not to decrease the density so much as to cause them to sink. I discarded the circulation method this time, and left them in bottles of still water.

On the 27th I was obliged to transfer them to shore water, in which they sank, but I brought them to the surface again by adding common salt. I found on testing I had raised the density to 1030, which was excessive.

On the 28th I found the temperature of the water containing the ova was 12·1° C. I changed them again into clean water made denser with salt. Many of them were still doing well.

On the 29th the water was again changed, and the temperature of the old water was 12° C., of the new 11° C.

On the 30th I fitted up an apparatus on the principle invented by Captain Chester, of the Fish Commission of the U.S.A., and described by A. Ryder in the Commissioner's Report for 1885, p. 499 (Washington, 1887). I procured a wooden washing tray with a hole bored in one side near the top, in which hole, by means of a cork, I fitted a glass siphon with its shorter leg inside the tray. In the tray I placed a glass cylinder open both at the top and the bottom; over the lower opening a piece of muslin was fastened. The eggs were placed in the cylinder, and a supply of water allowed to run at a constant rate into the tray. In consequence the water rose in the tray and the glass cylinder to the height of the hole in the side of the tray when the siphon commenced to act, and the water was drawn off until the level was lowered below the short leg of the siphon, when it commenced to rise again. Clean water in such an apparatus is thus constantly flowing over the eggs, while the latter are only subjected to very gentle motion.

But it would have been better if I had not been tempted to try circulation again. On the 31st a great number of the ova were dead, and by the evening of this day I could find none alive, and they all had to be thrown away. The damage may have been partially or wholly due to impurities derived from the wooden tray or the muslin, but the probable meaning of the result is that density is an essential condition; the ova lived and developed four days in still water in which they floated without motion at the surface, although the water for three of these days was shore water made denser with common salt, and when placed in a current of shore water to which no salt was added they died in twenty-four hours.

In this case the temperatures to which the ova were exposed during the first four days as observed were 13·7° C., 12·1° C., 12° C., and 11° C. The densities were 1·0267 to 1·030. The temperature of the open sea on May 31st was not more than 9·44 C., and the density 1·0267 or a little more. The temperature of the water on the last day in the Chester apparatus was 12·4°, while its density was not greater than 1·0260. Thus the ova were not injured during the first four days by a temperature more than 4° higher than that of the open sea, and a density increased on one occasion by ·0033, but they died on the fifth day in a circulation in which the temperature was the same as before, and the density decreased by ·0007 or somewhat more. Unless the motion or impurities from the apparatus killed them, it must be concluded that they died because they sank in the water.

My next experiment was still more unsuccessful. Ova were brought in on June 1st, and I transferred them to water fetched from near the breakwater; the density of this was 1·0255. I added salt to it till the density was 1·0265. On June 2nd the temperature was 14° C. I then changed the water, and placed half the ova in a glass jar provided with a circulation, the outflow being protected by muslin; but on June 3rd both halves, that in the still water and that in the circulating, were dead.

On June 12th I received a number of healthy fertilized ova from the "Prima Donna," taken seven miles south-west of the Eddystone. I placed these in a Chester apparatus, made with a perfectly clean wooden tub instead of the tray formerly used, and placed them in the tank-room, as the aquarium apparatus was all but complete and the pumps were working. By placing the tub under one of the jets I expected to obtain a constant supply of water to the apparatus, which was impossible in my single room, where each bucket of water had to be carried up by hand. But the pumps had to be stopped and all the ova died.

On June 29th I received a fresh supply, and as the aquarium pumps were now working continuously I kept these in a Chester apparatus on the shelf below the small tanks in the main laboratory, water being supplied to the tub by means of a siphon from the tank above. Some of these ova lived well for some days, but they sank in the water because its density was not great enough. And as some of the ova died the living and dead were all mixed together in a mass lying on the muslin at the bottom of the jar, a condition which was obviously unhealthy. The water in circulation in the aquarium system of the Laboratory varied somewhat in density, because frequently some water had to be run off from one of the large reservoirs to allow some slight defect in the arrangements to be attended to, and then more water was pumped up from the shore to make up the loss. On June 8th the density of the circulating water was 1·0260, on August 15th it was 1·0250; it varied between these two limits. On July 4th the temperature of the water in the tanks in the main laboratory was 14·5° C. The temperature of the open sea at this time was not much above 12° C. Thus, in this last experiment with mackerel ova the temperature was only about 2° higher than that of the open sea, and the density was 1·0250 or 1·0260 instead of 1·0267.

Some of these ova hatched on July 4th, on the sixth day after fertilization, but these were few in number, all the rest being dead; the larvæ were also half dead and had not strength enough to survive more than a few seconds when placed on a slide; consequently I was unable to get a drawing of them. On July 5th there were neither larvæ nor ova left alive. I got another sample of mackerel ova subsequently, but they were only partially fertilized and soon died.

It is difficult to say whether the death of the ova in the experiment conducted from June 29th to July 5th under the most favorable conditions, was partially due to the presence of impurities derived from the new apparatus, but it has generally been observed that in a new aquarium the animals die in considerable numbers notwithstanding all care. It was so to a certain extent in ours,—there were more deaths at first than subsequently; and the fact of the system having been so newly arranged may have had an unfavorable effect on the mackerel ova; but I believe the chief cause of failure was the insufficient density of the water. Apart from the question whether buoyant ova will develop normally in water of such low density that they sink in it, it is certain that in the apparatus used for floating ova the conditions become unfavorable if the ova sink. They are insufficiently supplied with oxygen, and it is impossible to separate the dead ova from the living. Some pelagic ova have been found near or on the bottom in the Baltic, where the density of the water is below that of the open seas. The observations I refer to were made at Kiel by V. Hensen,* a member of the Commission for the Investigation of German Seas, and they refer only to plaice, flounder (*Pleuronectes flesus*), dab (*Pl. limanda*), and cod. By fishing with a fine net attached to a dredge at the bottom, at a depth of nine fathoms, about eighteen miles from Kiel, at the mouth of Kiel Bay, he obtained ova of the three species of Pleuronectes mentioned, and these afterwards hatched in captivity. The specific gravity of the water at the place mentioned has an average for the year of 1·0128, and the maximum observed during several years was 1·0201, and the average temperature in April, when the ova were taken, was 6·11° C. Hensen found that the ova of the plaice, after having been shed into sea-water had a specific gravity of 1·01496;

* *Ueber das Vorkommen und die Menge der Eier einiger Ostseefische*, 4ter Bericht der Commiss. zur Unters. der deutschen Meere, IIte Abtheil., 1883.

and found that in eleven years, in March three times, in April three times, in May seven times, the maximum specific gravity of the water off Kiel Bay was lower than that of the plaice ovum. Thus in these years the ova of Pleuronectes species would have to develop on or near the bottom. Hensen does not give any details of the apparatus in which he hatched the ova artificially, but I infer from his remarks that he hatched them when they sank in the water of the vessels containing them.

But of course it does not follow that mackerel ova will develop healthily in water of less specific gravity than themselves. And it is certain that it was a constant result in my experiments that mackerel ova floating at the surface in still water, even when the density was artificially increased with common salt, lived some days, while those provided with a circulation of water in which the ova sank died in a much shorter time. The same thing was observed also with the ova of *Pleuronectes microcephalus* and others. But these experiments are not sufficiently rigid to prove that the too low density of the water, *i. e.* the sinking of the ova, was the sole cause of the death of the ova in unsuccessful experiments. It may, however, be pointed out that in my experiments the ova were first fertilized in water much denser than themselves, and remained in this some time before they were transferred to water of less specific gravity in which they sank, and a change of density like this after fertilization may possibly be fatal, when if the ova were shed and fertilized at the beginning in water in which they sank they would live and develop normally. This can only be decided by further experiments directed specially to this point.

The specific gravity of mackerel ova fertilized in the water of the open sea where the parents were captured is 1·0265 at the maximum. In water of a specific gravity of 1·0263 a few out of a large number of ova remained at the surface; at a specific gravity of 1·026 the ova remained suspended at various depths for some time, and one or two rose to the surface, while at 1·0257 all the ova sank rapidly. Thus the specific gravity of different individual ova varies slightly within narrow limits; a few were observed to have a specific gravity of less than 1·026, but the great majority are heavier than 1·0263, and none are heavier, at least at early stages of development, than 1·0265, or lighter than 1·0259.

Development.—The ovum of the mackerel after fertilization is spherical and transparent, and has a diameter of 1·22 mm. In the early stages of segmentation the ovum is not perfectly spherical, because the principal diameter, passing through the centre of the blastoderm, is a little longer than the others, owing to the slight pressure of the prominent blastoderm on the envelope (fig. 16). The yolk is homogeneous and colourless; at its surface is a large oil-globule, also colourless, having a diameter of ·32 to ·33 mm. The blastodisc, and the blastoderm at the commencement of segmentation, has a slightly yellow colour, which disappears later. The envelope is thin, and I have not noticed any sculpturing or inequalities on its outer surface. The perivitelline space is small, at the stage referred to, consisting as usual of only a ring-shaped cavity in the depression between the blastoderm and the yolk; the rest of the ovum is in contact with the inner surface of the envelope.

The oil-globule moves with perfect freedom at the surface of the yolk, which proves that the latter substance is a liquid of very slight tenacity. When the ovum is floating freely in water the blastoderm is at the lowest pole, and the yolk at the uppermost. When the ovum is placed upon a slide, whatever be the position of the blastoderm, the oil-globule rises to the uppermost pole; the blastoderm is the heaviest portion of the ovum, the oil-globule the lightest. On the slide the position of the blastoderm is proved to be fixed in relation to the position of the egg envelope, but the oil-globule remains free and rises to the pole which is vertically highest under the action of gravity. Even when the blastoderm is placed uppermost the oil-globule passes freely beneath it and rests below its centre. Thus it is evident that the yolk is to be regarded as a liquid enclosed within a layer of protoplasm continuous with the blastoderm, and at the surface of this liquid next to the protoplasmic layer moves the oil-globule.

The blastoderm spreads out, and the segmentation cavity, embryonic rudiment, and embryonic ring are formed in the usual way. At the temperature of about 13·5° C. the sixteen-cell stage is reached in about seven hours, and the segmentation cavity is formed before the end of the first day (twenty-four hours). On the second day the growth of the blastoderm over the yolk takes place. During all this time until the envelopment of the yolk is completed the oil-globule remains movable (figs. 17 and 18), but as soon as the yolk is completely covered by the blastoderm the oil-globule becomes fixed in a position ventral to the posterior end of the embryo (figs. 19, 22, 24). This fixture is effected by the periblast, and is a fact which deserves the greatest attention. The oil-globule seems to belong entirely to the yolk, and the periblast grows with the blastoderm outside the yolk. Why then should it grow in between the oil-globule and the yolk, separating the two and fixing the former in one position? In its new condition the oil-globule projects slightly beyond the general surface of the yolk, which is depressed in its immediate neighbourhood. Thus there is a cavity round the projecting part of the oil-globule. This projecting part comes into contact with the blastoderm, which is here composed only of epiblast; the cavity belongs, of course, to the segmentation cavity. The question arises whether the periblast furnishes a covering to the outer surface of the oil-globule as well as to the deeper side. It probably does, but I cannot say with certainty.

The time when the enclosure of the yolk is completed varies of course with the temperature, but in my experiments it was effected before the end of the second day. The differentiation of the organs in the dorsal part of the embryo begins before it is complete, and proceeds rapidly during the third day. Fig. 20 shows the stage reached about the middle of the third day; seven mesoblastic somites are distinctly seen, the eyes are indicated, and Kupffer's vesicle has appeared. On the fourth day (figs. 21, 22, 23) the crystalline lens, the auditory vesicle, the heart, the intestine, and the notochord are formed, and pigment appears in the skin. This pigment is confined to the sides of the embryo, and to the deep surface of the oil-globule; there is none on the surface of the yolk; the pigment consists entirely of black dendritic chromatophores. The development of these chromatophores in the periblast covering the oil-globule on its deeper surface is another fact in connection with the oil-globule which deserves special attention. I have described the development of chromatophores in the periblast covering the anterior part of the yolk in *Pleuronectes microcephalus*, and these connected with the oil-globule in the mackerel are in homologous relations, but it is curious that they should be confined to the surface of the oil-globule and absent from the rest of the yolk.

Fig. 24 shows the condition reached on the fifth day; all the organs are more developed, and the notochord is seen to be multi-columnar. Pigment is still absent from the periblast covering the surface of the yolk, except over the surface of the oil-globule. But green chromatophores have appeared in addition to the black, and are confined to two small groups on each side, one behind the eye, the other at the base of the tail. The latter organ has begun to grow out at the posterior end of the embryo.

Some ova fertilized on June 29th, hatched on July 4th, the sixth day, at a temperature of 14·5° C. I have not been able to give a figure of the larva for reasons stated above, and can only give a few notes of its characters. The distribution of the pigment is much the same as in fig. 24; the notochord is multi-columnar, the mouth not open, the anus is immediately behind the yolk.

The special development of chromatophores round the oil-globule is not a peculiarity of the mackerel, but seems to occur to a great or less extent in all ova which contain oil-globules, especially if there is only a single one present. But so far as I am aware, attention has not hitherto been called to the peculiar position of this pigment on the deeper side of the oil-globule, though it probably has the same relative position in other species.

Historical and Comparative.—Some valuable information and deductions concerning the life-history of the mackerel are contained in a report made by Prof. G. O. Sars to the Department of the Interior of the Norwegian Government. Prof. Sars carried on investigations of the Norwegian fisheries for a series of years from 1864 to 1878, at the request of the Government, and his reports have been officially published from time to time at Christiania. The whole series was finally published in one volume in 1879. But to the English reader they are more easily available in the translations published in the Report of the United States Commissioner of Fish and Fisheries for 1877. In the report of Prof. Sars for 1875 he states that he made some preliminary investigations of the spawning of the mackerel during a zoological tour in the summer of 1865. He says that this fish spawns at the surface of the water, near or far from the coast, and that the roe floats near the surface and there goes through all the stages of its development; that the spawning period is as a general rule the first half of July; that the ova when shed are small beads as clear as crystal, which float near the surface as long as they are alive; that the ova are of about the same size as those of the cod or a little larger, but are distinguished from these by a large and very distinct and clear oil-bladder near the upper pole; that he obtained the fertilized ova from the sea by means of a fine net, and was able to keep these during development until they hatched. He believes that by the end of one year the young fish are about as long as the finger, that in two years they grow to the size of a common herring, and at the end of three years are full-grown and spawn themselves; that during the first two years they remain near shore, roaming about in the open water.

With regard to the habitat, the home of the mackerel, Prof. Sars, rightly no doubt, considers that it extends in the eastern part of the North Atlantic along the whole western coast of Europe from the Orkney Islands and the north coast of Scotland to the Metiterranean and southward to the Canary Islands. It occurs on the southern and western coasts of Norway, on all the other coasts of the North Sea, on the western coast of Great Britain, round Ireland, in the Channel, on the coasts of France, Spain, and Portugal, and in the Mediterranean as far as the Black Sea. It also occurs on the Atlantic Coast of North America from Labrador to Cape Hatteras (see: *Materials for a History of the Mackerel Fishery,* U.S. Fish. Comm. Report for 1881). Prof. Sars rightly condemns the erroneous notions that have been held concerning the habits of the mackerel. Some have supposed that there is an enormous annual migration for spawning purposes from the sea round the North Pole; others, especially the fishermen, that the fish in winter remained at the bottom in a torpid condition, and, what is still more strange, blind. Prof. Sars believes, as is now generally held for all pelagic fish, that they approach the coast chiefly in order to spawn, and at other times are scattered at greater distances from the shore, or in the ocean, but always in an active pelagic condition. He thinks it probable that not all the mackerel taken on the coasts of the North Sea pass their whole life in that area, but that many enter it from the north or through the Channel. It is certain that in the neighbourhood of Plymouth mackerel are often caught in greater or less numbers all the year round, though there is generally little fishing immediately after the spawning time, *i. e.* at the end of July and the beginning of August.

It is stated in the paper already referred to, "Materials for a History of the Mackerel Fishery," that the spawning season on the Coast of New England coincides with that observed on the British Coasts, occurring in May and June in Massachusetts Bay, and in June in the Gulf of St. Lawrence. As we have seen, Professor Sars states that the spawning of the mackerel does not begin on the west coast of Norway until the beginning of July, and that it is finished about the middle of that month. He may not have been able to make sufficient observations, as at Plymouth the spawning period lasts more than one month.

It may well be that the season is a little later off Norway, for I find that the surface temperature on July 22nd in the Foldenfjord, 64° 34′ N. latitude., in 1880 was 11·4° C., which is slightly less than the temperature off the Eddystone on June 12th, 1888. Thus the spawning season of the mackerel is doubtless inseparably connected with a certain range of temperature, though the connection may be an indirect one, through the relation of the temperature of the sea to the mackerel's food.

In the family Scombridæ, besides the mackerel are included the various genera of tunnies, which are mostly of very large size, and the tropical sucking-fish, *Echeneis remora*. Of these, so far as I know, the ova and development have not been investigated, but in all probability their ova are buoyant and pelagic. On the Atlantic coast of North America another species of the family besides the common mackerel occurs, and is the object of a regular and valuable fishery in Chesapeake Bay, at Sandy Hook, Southern Long Island, and Narragansett Bay. This species is the *Cybium maculatum* (Mitchel), Agass. It is chiefly captured in fixed gill-nets, not in drift-nets or seines to so great an extent. Its spawning and development have been investigated by J. A. Ryder, a naturalist of the United States Fish Commission, and an account of its fishery is given by R. Edward Earll. Its ova are pelagic and closely similar in all respects to those of *Scomber scomber*, but somewhat smaller. On the coast of Virginia (Mobjack Bay, Chesapeake Bay) it spawns in July. Ryder does not mention the mobility of the oil-globule; he states that it is fixed and to its position ascribes the buoyancy of the egg, and the position of the egg when floating. Probably the oil-globule is movable nevertheless, and there are several floating eggs which have no oil-globule. Ryder describes the subsequent formation of a mantle of cells, "apparently of hypoblastic origin," round the oil-globule, and says that by the time the young fish is ready to hatch, the covering of the oil-sphere is found to be more or less covered with pigment which seems to have been developed in the cellular mantle. This refers to the same processes in the history of the oil-globule as I have described in the mackerel, but the mantle round the globule is certainly not made of hypoblastic cells, but of the periblastic syncytium, from which the pigment-cells are developed. The development in Cybium is extremely rapid, hatching taking place about twenty-four after fertilization; the temperàture of the water in which the eggs were kept artificially, or of the sea in which they are shed naturally, is not stated by Ryder. The mouth was formed about twenty-four hours after hatching, by which time the yolk was almost entirely absorbed. Some of the larvæ were kept alive till the sixth day after hatching.

Blennius ocellaris.

On July 10th I received at the Laboratory a large hollow bone, probably the femur of an ox, affixed to the sides of the cavity of which was a single layer of adhesive ova of an orange-red colour; this was forwarded by Mr. Dunn, of Mevagissey, who had obtained it from some fishermen. It was brought up by a long line fifteen miles south of Deadman Point, Cornwall, having been caught by one of the hooks. In the letter sent at the time Mr. Dunn stated that the fishermen said that when the bone was taken there was a fish in the cavity of the bone, supposed to be guarding the eggs, but that the fish had escaped and fallen overboard. The next day, however, Mr. Dunn forwarded a fish which he said was the one that had been seen in the cavity of the bone, the fishermen having found it at the bottom of their boat and recognised it as the same. This fish was a specimen of *Blennius ocellaris,* L., and in all probability the ova belonged to it.

The character of the ovum is shown in Fig. 25. Its diameter, measured in a direction parallel to the surface of attachment, is 1·2 mm. The embryo was distinctly formed and somewhat advanced in development, the heart having begun to beat; but this organ lying on the surface of the yolk anterior to the embryo is not shown in the figure. The yolk is of an orange-red colour and made up of separate minute yolk-spherules; it also contains near the tail of the embryo a number of oil-globules of different sizes. The tissues of the embryo were very transparent. The chromatophores are limited in number, intensely black in colour, and confined to the dorsal portion of the yolk-sac near the tail of the embryo.

Blennius galerita, and *Blennius pholis* are stated by Day to have adhesive ova, the former depositing them on stones, the latter in holes in rocks, on the authority of Couch (Zoologist, 1846). *Centronotus gunnellus* has adhesive ova which adhere together and form a free round mass. *Zoarces viviparus* hatches its ova in its ovary and produces about fifty young at a time all alive and similar to the parent except in size (see my paper in Trans. Roy. Soc. Edin., 1886). Shore fishes, like fresh-water, fishes have usually adhesive ova, or in some cases heavy ova which sink to the bottom. Such ova usually have oil-globules, either a single one or several, and the yolk is always made up of minute yolk-spherules.

CALLIONYMUS LYRA (the Dragonet).

I have already referred to the ova of this species in connection with my observations on *Solea vulgaris*, and have stated that I identified the ova taken by the tow-net shown in figs. 26 and 27 as the ova of *Callionymus lyra*. I also mentioned that Raffaele denies altogether the existence of the hexagonal marking of the vitelline membrane in the Mediterranean species *C. festivus*. On the other hand, Raffaele found an exactly similar reticular marking of hexagonal meshes on the vitelline membrane of the fertilized ova of *Uranoscopus scaber*, and in the ovarian ova of *Saurus lacerta*. It is certainly somewhat inconsistent on the part of the Italian zoologist that he should assume that McIntosh mistook an epithelium for a marking of the vitelline membrane in *C. lyra*, and should affirm the existence of the marking in Saurus on evidence exactly equivalent to that on which McIntosh relied. Saurus is a genus of the Scopelidæ, which family belongs to the order Physostomi.

Leaving the question of *Saurus lacerta* entirely aside for the present, the similarity between the ova of *C. lyra* and Uranoscopus suggests some interesting possibilities with regard to the true systematic affinities of these two genera. Callionymus belongs to a group, Callionymina, which is classed by systematists in the family Gobiidæ, but which certainly forms an aberrant group of that family. Callionymus is extremely different from any of the typical Gobiidæ; it has a depressed form, no ventral sucker, has the eyes close together at the top of the head, in accordance with its habit of lying always on the sea-bottom on its flat ventral surface, and has a multiradiate spine resembling a riding spur directed backwards from its preoperculum. Uranoscopus similarly belongs to an aberrant group of the Trachinidæ, to which our common weevers, *Trachinus draco* and *vipera*, belong. All the Trachinidæ with few exceptions have a backward-pointing spine on the operculum. Uranoscopus possesses this spine, but whereas most Trachinidæ are compressed from side to side, Uranoscopus, as its name implies, is depressed from above downwards and has the two eyes directed upwards and placed on the upper flat surface of the head. The families Trachinidæ and Gobiidæ are widely separated by Günther, the former being placed among the Gobiiformes, the latter among the Cotto-scombriformes. Yet considering that the eggs have a rare peculiarity in common, and that there are several similarities of adult structure, it seems probable that Callionymus and Uranoscopus are closely allied, and that either the Callionymina ought to be included among the Trachinidæ instead of among the Gobiidæ, or that the Callionymina and Uranoscopina together form a single family, distinct both from the Gobies and the Weevers.

In support of this suggestion it is to be noted that the ova of typical Gobiidæ are adhesive, not pelagic like those of Callionymus, and that, although the ova of both Uranoscopus and Trachinus are pelagic, those of the former have the reticulate marking and no oil-globules, those of Trachinus have no marking and numerous oil-globules. The ova of Trachinus have been described and figured by George Brook in Lin. Soc. Journ., vol. xviii, 1884, and also by Raffaele in the paper so often cited.

CLUPEA PILCHARDUS (the Pilchard) AND CLUPEA SPRATTUS (the Sprat).

The ovum of the pilchard has never yet been obtained directly from the parent fish and artificially fertilized, and therefore the absolutely certain knowledge based on the examination of ova so obtained is still wanting. But it will be shown in the following that a definitely characterised ovum is known, which I have traced with all reasonable certainty to this species. The history of our knowledge on this subject is of much interest, and is an excellent example of the difficulty which may unexpectedly occur in the attempt to solve an apparently simple problem.

The question of the ova of the pilchard is closely connected with that of floating Clupeoid ova in general, and I will therefore give a brief summary of the history of this larger question. Some years ago the only species of Clupea whose eggs were known with certainty was the herring, *Clupea harengus.* The eggs of the herring are heavy and adhesive, and when expelled from the body of the fish they stick fast to anything they happen to fall upon. A detailed account of their structure and development was published by Prof. Kupffer in 1878 in the Jahresbericht der Commission zur Untersuchung der deutschen Meere for 1874–76. But before that herring spawn had been dredged from the sea-bottom near the Isle of May in the Firth of Forth. I myself studied the ova in the years 1883 and 1884, and published a paper on them in 1885.* In 1882 Alexander Agassiz described† a pelagic ovum (*i. e.* a floating one) which had a yolk entirely divided into small segments, and which produced a larva 5 mm. long, having a great resemblance to a larval herring. Agassiz at first thought these eggs must belong to some Clupeoid, but afterwards identified the larva as the young of *Osmerus mordax,* Gill. But the American *Osmerus mordax* is the same as the British *Osmerus eperlanus,* and this species was discovered by myself‡ to have adhesive ova with a peculiar method of adhesion, and to spawn in almost fresh water in the upper parts of estuaries. V. Hensen§ in 1883 described a similar ovum, which he took in the tow-net in the Baltic near Kiel. This ovum, like that of Agassiz, had a segmented yolk and no oil-globules; its diameter was 1·24 mm., and the larva which hatched from it resembled a herring larva and had a length of 3·7 mm. In 1886‖ I described a very similar ovum taken by the tow-net in the Firth of Forth; this likewise had a segmented yolk, and produced a herring-like larva. The dimensions of the ovum were ·94 by ·97 mm. diameter, and the larva was 3·63 mm. long. I concluded that this ovum came from the same species as Hensen's. The latter informed me by letter that he believed the ovum to belong to the sprat, *Clupea sprattus,* but I did not succeed in obtaining fertilized ova of the sprat for

* *On the Significance of Kupffer's Vesicle, &c.,* Quart. Journ. Micr. Sci., 1885.

† *Young Stages of Osseous Fishes,* part iii, Proc. Amer. Acad. Arts and Sci., vol. xvii.

‡ Proc. Zool. Soc. Lond., 1886.

§ Vierter Bericht der Comm. Unters. deutschen Meere, II Abtheilung, Berlin, 1883.

‖ Trans. Roy. Soc. Edinb. for Session 1885–86.

comparison. Lately, in 1887,* Hensen has stated that he obtained ova taken from the sprat and artificially fertilized, and found they agreed in all respects, both in size and structure, with the ova he got in the tow-net. There can be little doubt that my ova from the Firth of Forth were of the same species as Hensen's; my measurement of the ovum was somewhat smaller than his, but the length of the larva was almost exactly the same in the two cases. And it is also pretty certain that Agassiz' ovum found off the American coast belonged to some species of Clupea.

With regard to *Clupea pilchardus*, Couch long ago in 1865, in his Fishes of the British Islands, stated that the pilchard spawned at the surface of the sea. His account is as follows: "In April and May they are habitually prepared to shed their spawn, which they now do at a further distance from land and over deeper water than is the case at the warmer season of autumn, when again, early or later, they perform the same function, although we do not feel assured that they are the same fishes which thus perform the duty of procreation on both occasions." "I have reason to suppose that the spawn is shed at the surface, and mingled with it a large quantity of tenacious mucus in which it is kept floating while it is obtaining the vivifying influence of the light and warmth of the sun. My notes on this subject are that presently, after spawning, a sheet of jelly, enclosing myriads of enlarging grains of spawn, has been seen to extend several miles in length, and a mile or more in breadth over the surface of the sea." We shall see how far Couch was from a knowledge of the real spawn of the pilchard.

In a Report by Frank Buckland and Spencer Walpole, Commissioners for Sea-Fisheries, on the sea-fisheries of England and Wales, presented to Parliament and officially published in 1879, evidence concerning the spawning of the pilchard, given by Mr. Dunn, of Mevagissey, is recorded. In Appendix No. III to that Report, by Frank Buckland, the following quotation is given from a letter from Mr. Dunn: "On the 28th of May, 1871, I took a pilchard alive, and in the act of spawning, about twenty miles from land. With the help of my hands the fish deposited the remaining spawn into a bucket of sea-water. Immediately the spawn rose to the surface of the water with the buoyancy of cork, and instantly the eggs separated from each other. By the candle-light the globules appeared bright and almost transparent. After a few minutes they lost their buoyancy save just dipping under the surface, others floating an inch or two further down. In this state they continued for two hours, then a white speck showed itself in each globule,

* Fünfter Bericht der Comm. Unters. deutschen Meere, Berlin, 1887.

and all sank to the bottom of the vessel." The eggs in this experiment were unfertilized, no milt was added to them.

In Day's work, Fishes of Great Britain and Ireland, 1880–1884, it is stated that Mr. Dunn observed that the pilchard appears to breed at two seasons of the year, May and June, and also in December, and the young are first seen in September, three or four inches in length. On January 16th, 1882, Mr. Dunn observed the fish returning to the bays shotten.

On the 15th October, 1887, in reply to inquiries of mine, I received a courteous letter from Mr. Dunn, in which he said he was certain that some pilchards spawn late in December and early in January, and even up to March, the winter spawning extending thus over some months. He said that in summer some pilchards spawn in May, the majority in June, and others in August. He also said that in some seasons spawn, which he believed to come from the pilchard, was seen floating in immense tracts on the surface of the sea.

This continuous sheet of spawn mentioned by both Couch and Mr. Dunn, can only be the spawn of *Lophius piscatorius*, the angler or devil-fish, whose spawn is known to be contained in an extended sheet of gelatinous material. It is fully described by Agassiz and Whitman in their memoir already cited, on the Pelagic Stages of Osseous Fishes. I have not myself met with this spawn of Lophius off the coast of Devon and Cornwall, but as the angler is common enough in the neighbourhood, I have no doubt that it has been seen by fishermen and erroneously identified by Couch and Mr. Dunn as the spawn of the pilchard.

Meanwhile, before any naturalist had identified ova of the pilchard the eggs of another species of the family Clupeidæ, namely, the anchovy, *Engraulis encrasicholus*, were examined and found to be pelagic. This discovery was made by K. F. Wenckebach, of Amsterdam,* and published only in 1887. I have not seen the original paper, but the Italian zoologist Raffaele gives a description, with figures, of the ova of the anchovy and the young stages of the fish, from studies he was able to make upon them at the Zoological Station at Naples. Fortunately, there is no danger of confounding the eggs of the anchovy with those of the pilchard or sprat. The egg of the anchovy, like the others, has the yolk divided into segments, but instead of being spherical like the others it is much elongated, so as to have the shape of a sausage.

Raffaele gives a description and figures of two other kinds of floating eggs, which, having a segmented yolk, are recognised by him as belonging to species of the herring family; he obtained these

* *De embryonale ontwikkeling van de Ansjovis* (*Engraulis encrasicholus*), Verh. Akad. Amsterdam, Deel 26, 1887.

from the open sea by means of the tow-net, and has not taken directly from the fish, eggs that could be identified with them. He therefore speaks of them as Clupea species A, and Clupea species B. The first of these he believes to be the ovum of the pilchard. It is well known that the pilchard and the sardine are the same fish at different sizes, and sardines are common enough in the Gulf of Naples. This species, A, is an ovum of spherical shape varying from 1·50 to 1·70 mm. in diameter. Compared with the majority of floating ova, it has this peculiarity, that the space between the egg proper and its envelope is exceedingly large; the egg itself inside this space has a diameter of only ·80 to ·90 mm. In the yolk is a single oil-globule ·16 mm. in diameter. The segments of the yolk have a polygonal form due to their mutual pressure. The egg hatched in four or five days at a temperature of 9° to 12° C., and the larva resembled that of other pelagic Clupeoid ova, *e. g.* the sprat, but its length is not given.

The ovum of species B differs very slightly from that of species A. It is a little smaller in the diameter of the egg envelope, which is 1·20 to 1·40 mm. It has, like the other, a segmented yolk containing a single oil-globule which is ·121 mm. in diameter, slightly smaller than in the previous case. The oil-globule has a slightly yellow colour, the yolk and embryo have a faint smoky tint, which colours are absent in species A. The only other difference is that in the newly-hatched larva of species B the oil-globule is in the centre of the lower margin of the yolk, in species A it is at the posterior end of the yolk. Species A was found in the winter, Species B in summer and autumn.

My own Inquiries.—From the beginning of September, 1887, I examined at Plymouth the pilchards landed by drift-net boats from time to time, but never found any generative organs which were quite ripe or very nearly ripe from that time till the following summer. In October, 1887, the ovaries and spermaries seemed to be about half developed in a few specimens, and it is possible, even probable, as will be seen, that some individuals spawn late in the autumn. I found no change in the condition of the fish up till the end of January: the fish were usually 7½ to 8½ inches in length. In the early part of 1888 I was too much occupied with other fish to pay a great deal of attention to pilchards, but there was no regular fishing for them going on, and scarcely any were caught. I was told by a pilchard fisherman that these fish were found in spawning condition in April and May, but he did not think at any other time of the year. Afterwards I was told by mackerel fishermen that they often in summer got large pilchards which were meshed along with mackerel in their mackerel drift-nets, and that these were always soft and ripe, with spawn and milt running out of them. I found by actual experience that this was perfectly true. On June 2nd, 1888, two pilchards were brought up to me from a boat which had caught them in mackerel nets five miles south-west of the Eddystone. These were perfectly ripe, the whole ovary, as in the herring, containing nothing but ripe eggs which escaped on the slightest pressure. These eggs were, of course, dead, and as these were the only two pilchards taken it was impossible to fertilize any of them at the time of capture. But the eggs were fresh enough to show in some degree their structure, and I made a drawing of one which is shown in fig. 28. This shows that there is but a single oil-globule, and that the yolk is made up of spherical vesicles. The diameter measures ·98 mm., that of the oil-globule ·16 mm. Of course the envelope in the ovarian egg is everywhere in contact with the yolk. Several times in June and July one or two pilchards were taken by mackerel fishermen who were endeavouring to get fertilized pilchard spawn for me, but they never succeeded in getting ripe males and ripe females at the same time. Sometimes they got a single ripe male, at others two or three ripe females. One boat shot at my request two pilchard nets, which have a smaller mesh, with its fleet of mackerel nets, but even this did not succeed. One of these occasional ripe specimens, a female, was caught as late as October 17th, and the skipper who took it pressed the ripe ova into a bottle of clean sea-water, and gave them to me the next day when he returned to port. But when I got them the ova were already dead and lying at the bottom of the jar, and on examination I found that the yolk was decomposed. I could form no conclusions from these as to the normal extent of the perivitelline space.

In 1887 I had taken pelagic ova in the tow-net, which, from the probability of the ovum with segmented yolk taken in the Firth of Forth being that of *Clupea sprattus*, I guessed were those of the pilchard. The structure of these ova is shown in fig. 29. I took some in Whitsand Bay, August 11th, and did not meet with them again till November 9th, when I found a few in a tow-net worked from a trawler to the south-east of the Eddystone. On both occasions there were only five or six specimens of this particular ovum. Its diameter measured in one case 1·72 mm., in another 1·65, including the envelope. The space between the latter and the yolk was extremely large, and the yolk itself measured ·85 mm. in diameter in the first case, ·95 mm. in the second. The yolk was composed of polygonal segments divided by curved surfaces, and contained a single oil-globule ·16 mm. in diameter. This ovum, therefore, agrees in every respect both of size and structure with

Raffaele's Clupea species A. Of those taken on November 9th I was successful in hatching some, and the appearance of the larva produced is shown in fig. 30. This larva was 3·8 mm. in length, and the oil-globule was at the posterior and lower side of the yolk, thus also agreeing with the larva of Raffaele's species A. There can be no doubt that these ova of mine and those described by Raffaele as species A belong to the same species of fish, and the character of the unfertilized ovum taken directly from the pilchard, having a diameter corresponding to that of the yolk in the tow-net specimens, and an oil-globule of exactly the same size as that in the latter, is sufficient evidence that these ova from the tow-net are the ova of *Clupea pilchardus*. Fig. 30, then, shows the structure of the larva of the pilchard. Like that of the herring and sprat it has a unicolumnar notochord, that is, a notochord with a single linear series of cubical vacuoles. At the time of hatching, pigment, as in the herring, is altogether absent, even in the choroid of the eyes. The intestine extends far behind the yolk, and the anus is near the end of the tail. A comparison of figs. 28 and 29 shows that the ovarian ovum of the pilchard is more closely similar to the fertilized ovum of the herring than the pilchard ovum in its pelagic state after fertilization ; in the ovarian ovum the yolk elements or segments are still spherical vesicles as in the herring, while in the fertilized ovum these segments have come into close contact with one another, and so become more polygonal.

These observations show, as was previously stated by Mr. Dunn, that pilchards spawn far out at sea, and that the pilchard fishery consists exclusively in the capture of fish which are not spawning, of fish in which the generative organs are not even approaching the ripe condition. The shoals of pilchards which are caught in drift-nets not far from shore in autumn, winter, and spring, approach the coast to feed and not to spawn ; they are either shotten fish or young fish which have never spawned. It is otherwise with the mackerel and the herring ; mackerel are, as I have shown in this paper, caught as abundantly during their spawning period as at any other time, while the winter fishery for herrings near Plymouth and all the other great herring fisheries that I know of consist chiefly in the capture of spawning shoals, although there are productive fisheries of immature herring which remain some time in shore waters for the purpose of feeding.

My evidence, as far as it goes, does not favour the theory that there are two separate periods in the year at which pilchards spawn ; it shows that ripe specimens occur to the south of the Eddystone occasionally from the beginning of June to the middle of October, and as it is reasonable to suppose that the pilchard, like the herring, spawns in shoals, we must conclude that these shoals of ripe fish are to be sought at greater distances from shore than the region a few miles south of the Eddystone where the isolated individuals were taken. This conclusion is supported by the paucity of the pilchard ova taken in the tow-net, and it does not permit very sanguine hopes of the practicability of artificially propagating the pilchard on a large scale. But it must be mentioned that, according to the positive statements of the mackerel fishermen, the number of spawning pilchards taken in their nets was extraordinarily small last season; that it is not unusual for fifty or more ripe specimens to be taken among a single catch of mackerel.

Another kind of buoyant Clupeoid ovum occurs near Plymouth. This is shown in fig. 31. It is 1·01 or 1·02 mm. in diameter, and has the small perivitelline space characteristic of the majority of pelagic ova. The yolk has the same segmented structure as that of the pilchard ovum but has no oil-globule. At the stage shown in fig. 31 black chromatophores were conspicuous near the dorsal median line of the embryo. The larva hatched from one of these ova is shown in fig. 32. Its length was 3·07 mm., which is less than that of the pilchard larva and less than that of the larva previously described by Hensen and myself. But as the length of a hatched larva probably varies, I think that in all probability this ovum and larva belong to *Clupea sprattus*, the sprat, which regularly occurs in Plymouth Sound in winter. This kind of ovum was taken in small numbers just outside the Sound, to the east of Penlee Point, on January 28th and 30th, 1888.

Pelagic Ova taken in the Tow-net.

Some of these, identified as those of the pilchard, sprat, sole, and dragonet, have already been described, but besides these many other kinds were obtained which could be identified with more or less certainty from the descriptions and figures already published by myself and others of artificially fertilized ova taken directly from the parent fish. Some ova taken near the Rame Head on February 6th, 1888, measuring 1·36 in one diameter, 1·44 in another, and having an entirely homogeneous yolk, were probably the ova of *Pleuronectes microcephalus*, of which some specimens probably begin to spawn in February.

Pleuronectes platessa (the Plaice).

An ovum of Pleuronectid type of very large size, obtained January 21st, 1888, eight miles south of the Mewstone, probably came from this species. It measured 2·13 mm. in diameter, had a number of dendritic black chromatophores on the body of the embryo; the tail was fully developed and the larva almost ready to hatch. The ovum of the plaice was described in my paper in the Trans. Roy. Soc. Edin., vol. xxxiii, part 1; the measurement I there gave was 1·95 mm., but 2·13 mm. is not beyond the limit of individual variation.

Gadus merlangus (the Whiting).

Ova obtained February 6th, 1888, off the Rame Head at the entrance to Plymouth Sound. Their size was 1·23 mm. in diameter, they had a homogeneous yolk without oil-globules. I gave a description of the ova of this species in 1885* from artificially fertilized ova, and stated their diameter as 1·25 mm. I did not figure the hatched larva in that paper, and therefore now give figures of one stage of the ovum, and of the larva which hatched from one of these tow-net specimens. The larva is 3·67 mm. long, and the dendritic chromatophores are confined to the body of the fish absent from the median primordial fin, and from the surface of the yolk. The rectum, as in all species of Gadus, does not extend to the edge of the ventral part of the median fin, but ends blindly close to the body. Figs. 33, 34.

I found the whiting perfectly ripe at Mount's Bay on March 7th, although I did not take any artificially fertilized ova, and there is no doubt that off Plymouth the species spawns also in February.

Gadus luscus (the Pouting).

Another ovum similar to the previous, but measuring 1·13 mm. in diameter, was obtained eight miles south of the Mewstone on January 20th. From it a larva hatched on January 23rd, which obviously belonged to a species of Gadus, having similar characters to the one assigned to the whiting. It is represented in fig. 35. Its length was 2·97 mm. I have identified it provisionally as the larva of *Gadus luscus,* the eggs of which species I have never taken directly from the fish.

Motella, sp.? (the Rocklings).

The ova and larvæ shown in figs. 36, 37 I find it difficult to identify, but they probably belong to the genus Motella. The blind rectum,

* *Relations of Yolk to Gastrula in Teleosteans,* Quart. Journ. of Micr. Sci., 1885.

terminating before reaching the edge of the primordial fin, shows that the larva is one of the cod family. The hake, *Merluccius vulgaris*, has been found to have a single oil-globule, but the present ovum has a diameter of ·78 mm., that of the hake is larger, ·94 to 1·03 mm. *Motella tricirrata* has, according to Raffaele, an ovum measuring ·74 mm., while the ovum of *Motella mustela*, according to George Brook (Journ. Linn. Soc., 1884), measures ·65 to ·73 mm. Another feature characteristic of Motella and present in the ovum under consideration is the presence in the earliest stage of several oil-globules which afterwards fuse into one. This ovum was obtained in considerable numbers to the east of Penlee Point on January 28th and 30th, 1888. Some of those taken on the latter date hatched on February 2nd. The length of the larva was 1·98 mm., and it had black pigment only which was confined to the body of the fish, and absent from the fin and the yolk-sac. It is not unlikely that these ova really are those of *Motella tricirrata*; the difference between their size and that given by Raffaele is very slight. On May 31st I obtained in the tow-net two specimens of a young fish 17 mm. long, which agrees with descriptions given of the young *Motella tricirrata*. The chief characteristic of this young fish (fig. 39) is the great length of the ventral fins which extend back to the anus, and the intense black colour of their terminal third. Another curious point is that the caudal fin, although it has apparently attained its final form, is almost completely homocercal, being supported by fin rays which have a symmetrical relation to about eight terminal vertebræ. The sides of these little fish had a very bright silvery glitter. There was a small barbel on the symphysis of the lower jaw. This young fish is identical with that described by Couch (vol. iii, p. 113) as Thompson's Midge, which together with the *Couchia argentata* of Günther (Catalogue, vol. iv, p. 363), is identified by Day as the young of the three-bearded rockling *Motella tricirrata*. Agassiz (Young Stages of Osseous Fishes, pt. 3) describes stages of a young fish very similar to the one I have described, and identifies it as *Motella argentea*, Rhein., but I do not know if this species is the same as *Motella tricirrata*. The young of *Motella mustela*, the five-bearded rockling, is known as the mackerel midge, which has already five barbels, but its younger stages may well be indistinguishable from those of *Motella tricirrata*. These young Motella are said to form the principal food of the mackerel in May, but I have not verified this at Plymouth.

I found one specimen of hake perfectly ripe on July 6th, so that this species spawns at Plymouth in summer; Raffaele found it spawning at Naples in May.

I have taken other kinds of ova in the tow-net, but have not been able to identify them with any certainty. The ova most difficult to identify are those which have a homogeneous yolk with a single oil-globule, because there are so very many species which have ova of this character differing only, in the early stages, in size, and sometimes not even in that respect. Further and more minute study of the larvæ will probably enable us to distinguish the species to which they belong, but before hatching this is almost impossible. It has been seen already in this paper that this type of ovum is common to the families Scombridæ (mackerel), Carangidæ (cuckoo), many Gadidæ (hake, rockling), many Pleuronectidæ (Arnoglossus, Rhombus). And Raffaele describes ova of the same kind from the bass, *Labrax lupus* (Percidæ), and from some of the sea-breams *Pagellus erythrinus*, &c. (Sparidæ) ; some of the wrasses (Labridæ), namely, Coris and Julis, have also similar ova.

It is evident that a great deal still remains to be done before an adequate knowledge of the development and growth of the Plymouth fishes is obtained. But the researches I have described in this paper have been, and future work will be, greatly facilitated by Raffaele's admirable memoir so often quoted in the preceding pages. The extent to which the Italian naturalist's results apply to the fish-fauna of Plymouth, shows how closely connected faunalogically are the south coast of Britain and the Mediterranean.

A Hypothesis concerning Oil-Globules in Pelagic Teleostean Ova.

In considering the question why some pelagic ova have separate oil-globules in their yolk while others have none at all, I have noticed a connection between the presence of these separate masses of fatty matter and the normal quantity of oil in the body of the parent fish. Whenever the adult has a large quantity of oil in its tissues the ova possess one or more oil-globules in the yolk. At least this seems obvious in some cases. In both the herring and the pilchard the yolk is completely vesicular ; this is a character common to all species of the genus *Clupea ;* but the pilchard ovum has a large oil-globule, the herring ovum has none ; and it is certain that the adult pilchard possesses more oil in its tissues than the herring. The mackerel also is a rich oily fish, and its ovum has an oil-globule, while the species of Pleuronectes and Gadus have comparatively dry flesh, and their ova have no oil-globules. The sole is richer in oil than the plaice, and the former has oil-globules while the latter is destitute of them.

There are two ways of regarding this fact if it be one. We may suppose that the excess of oil runs over as it were into the ova, without having any great importance to the latter; or we may suppose that as the tissues of the adult are oily, it is necessary that the tissues of the embryo should be supplied with abundance of oil in order to develop normally. But perhaps the truth lies in the union of these two suppositions, that the excess of oil in the tissues of the parents extends into the ovum, and during the development of the latter supplies the embryo with an abundance of fat which is necessary to its constitution. But none of these hypotheses explain why in many cases ova provided with oil-globules have a greater specific gravity than those that are without them; a difference which must depend on a greater density of the protoplasm and of the yolk.

The Development of the Vascular System and Cœlom in Pelagic Ova of Teleostei.

In a great many pelagic Teleostean embryos at the time of hatching the heart consists of a tube which opens posteriorly out of a wide space between the yolk, or more accurately between the surface of the periblast and the wall of the yolk-sac, which wall consists solely of a layer of epiblastic cells. The heart itself is surrounded by another cavity which is separated from the space first mentioned by a thin membrane, which passes on the one hand into the lips of the posterior aperture of the heart, and on the other into the body wall ventrally, into the tissue beneath the pharynx dorsally. The space out of which the heart opens contains blood, *i. e.* a colourless fluid containing at first colourless corpuscles, which at a later stage become red corpuscles. The blood is carried by the pulsations of the heart out of the space round the yolk into the cavity of the heart.

The cavity round the periblast, which communicates with the heart, exists at an earlier stage, before hatching, as a space between the epiblast of the anterior part of the yolk-sac and the periblast. And this is the same space which exists at a still earlier stage before the yolk has been enveloped by the blastoderm, between the epiblast and the periblast in the central part of the blastoderm, that is, over all the region of the latter which is not occupied by the embryonic rudiment and the embryonic ring. This space, in fact, is the earliest to appear in the ovum, and is nothing more or less than the segmentation cavity.

To consider now the space which surrounds the heart, and which is entirely separated from the space which communicates with the heart. This cavity round the heart is simply a portion of the true body-cavity or cœlom. The heart with this cavity develops shortly before hatching out of a solid mass of mesoblast cells situated below the pharynx, and continuous on either side with the lateral mesoblastic plates which lie on either side of the notochord. I have not studied the histological process by which the heart itself is formed. Suffice it to say that it is produced by the formation of the central mesoblastic cells into a tube, which, as soon as it has a lumen, communicates with the space between the ventral epiblastic body wall and the periblast. The cavity in which the tubular heart is contained is due to a splitting of the mesoblast, and is continuous superiorly and posteriorly with the cavity formed on each side of the embryo by the splitting of the lateral mesoblastic plates. The cavity containing the heart is in reality the first part of the ventral region of the body-cavity to be formed. A section farther back, through the centre of the yolk-sac at the stage immediately after hatching, shows a cavity on each side of the embryo in the mesoblastic plates; the splanchnic mesoblast forms the roof of the cavity between the periblast and the wall of the yolk-sac. The mesoblast only extends a little way from the embryo, so that laterally and ventrally the wall of the yolk-sac is formed solely of epiblast. The lateral body-cavities communicate anteriorly with the ventral body-cavity which contains the heart.

What then does the blood space between periblast and wall of yolk-sac correspond to in those Teleostean ova which possess a vitelline circulation? Obviously the vitelline veins and their tributaries communicate with the posterior end of the heart, just as does the single extensive blood space in pelagic ova. This blood space corresponds, and in a sense is homologous with the cavities of the vitelline veins. Suppose the vitelline veins and their capillaries to open out sufficiently so as to coalesce, and we have a single space extending over the surface of the yolk and communicating with the posterior end of the heart. This supposed continuous space would then correspond with the venous space in the pelagic ovum in a general way; but would it correspond exactly? The vitelline veins, where they exist, are canals running through a layer of splanchnic mesoblast covering the periblast. Now, in a pelagic ovum the mesoblast is, as far as we can judge from our present knowledge, limited to the embryo and the embryonic ring, and at a later stage to a narrow region at the sides of the embryo, which region is derived from the embryonic ring after the latter has disappeared as such. The space, therefore, over the rest of the yolk between the periblast and the epiblast, *i. e.* the segmentation cavity, can only close at these early stages by contact occurring between the epiblast and periblast. Now, such contact seems to occur at the stage immediately after the enclosing of the yolk has taken place, but it is certain that at a slightly later stage the space is again open beneath the anterior end of the embryo, between the yolk and the epiblast forming the wall of the yolk-sac; and this space becomes the venous sinus out of which the heart opens. Thus it would seem that the venous sinus in the pelagic ovum, which corresponds to the vitelline veins in other ova, is bounded internally by the periblast, and externally by a layer of epiblast, and that it is a persistent segmentation cavity.

But if we look at the living newly-hatched larva of *Pl. microcephalus* (fig. 8) we see over the surface of the yolk black and yellow dendritic chromatophores. As these are continued over the anterior surface of the yolk-mass, and are not visible in the wall of the yolk-sac in front of the yolk, it follows that these chromatophores exist on the surface of the periblast and not on the inner surface of the epiblastic wall of the yolk-sac. Chromatophores are of course mesoblastic, and these in particular are, in all probability, developed *in situ* from the periblast, the nucleated protoplasm surrounding the yolk. It has been shown in various Vertebrate ova that the nucleated protoplasm of the yolk at early stages buds off cells which join the mesoblast. At this later stage in the Teleostean ovum the periblast forms mesoblastic pigment-cells, and also, as shown by Ryder and others, *blood-corpuscles.* But there is no evidence that there is any mesoblast on the internal surface of the wall of the yolk-sac; the venous sinus is bounded internally by periblast with a few chromatophores on its surface, externally by a layer of epiblast. It is obvious, on reflection, that all the yolk, with its periblast, after the formation of the definite hypoblast, is a part of the splanchnic mesoblast. But the interesting morphological peculiarity about the venous sinus in the Teleostean embryo is that it is the persistent segmentation cavity. The segmentation cavity may partially disappear by the contact of its walls, but it is not, as usually represented in the frog, obliterated by the growth of the mesoblast; and thus, when the sinus venosus appears it is not as a cavity or system of veins entirely surrounded by splanchnic mesoblast, but is the old segmentation cavity between the epiblastic ventral wall of the yolk-sac and the periblast. This periblast develops chromatophores on its surface, a process which is peculiarly well illustrated by the formation of pigment-cells round the oil-globule in the mackerel; and at a later stage, no doubt, the sinus venosus acquires mesoblastic walls all round it, but this is not till the yolk has been absorbed.

The opening of the posterior end of the heart into the cavity round the yolk looks very surprising at first sight, and as it is very conspicuous has attracted the attention of all who have studied the development of pelagic Teleostean ova. I have figured it myself in my paper on Teleostean eggs and larvæ published in the Transactions of the Royal Society of Edinburgh. Ryder described it in the cod larva (Ann. Rep. Comm. of Fisheries of U.S. for 1882), but gave what was a very natural but erroneous interpretation of it. He called the space ronnd the heart the pericardiac space, which is true if taken etymologically but not morphologically. The venous cavity he called the segmentation cavity, which is partially true, and stated it was the same as the body-cavity, which is erroneous.

Lastly, Mr. A. E. Shipley has described the development of the heart in Petromyzon (Quart. Journ. Micros. Sc., Jan., 1887). His description of the development of the heart from mesoblast beneath the pharynx agrees with what I have described in Teleostei. He also states that the heart communicates posteriorly with the space beneath the ventral yolk-cells and the epidermis, and that such a space would be equivalent to part of the segmentation cavity. Thus the condition of things in Petromyzon is similar in these respects to that in pelagic Teleostean ova. But when Mr. Shipley says, " From the fact mentioned above that the mesoblast behind the heart has not split into somatic and splanchnic layers nor united ventrally, it will be seen that the cavity of the heart communicates posteriorly with the space between the ventral yolk-cells and the epidermis," I do not follow him. It seems to me to be a *non sequitur*,—the heart might remain closed posteriorly until the ventral mesoblast had developed in the region behind it.

Moreover, although in Petromyzon it may be true that the mesoblast behind the heart has not split into somatic and splanchnic layers, my preparations show that the proposition is not true for Teleostean larvæ, for I find that the mesoblastic plates behind the heart have split so as to form a cœlom, and the splanchnic layer forms a horizontal partition dorsally between the cœlom on each side and the blood space surrounding the yolk. And although it may be true in Petromyzon that the yolk-cells form the immediate boundary of the venous sinus internally, it is also possible that some mesoblastic cells exist on the surface of the yolk in that form, for Mr. Shipley has drawn his conclusions from the study of sections, and I was not at first able to perceive in sections the dendritic chromatophores I have described in the larva of the pelagic Teleostean ovum. My observations concerning this subject have been chiefly but not exclusively made on the ova and larvæ of *Pleuronectes microcephalus*.

DESCRIPTION OF PLATES I—VI,

Illustrating Mr. J. T. Cunningham's paper on the "Reproduction and Development of Teleostean Fishes occurring in the neighbourhood of Plymouth."

Reference Letters.

au. Auditory vesicle. *p.* Body-cavity. *e.* Eye. *ht.* Heart. *int.* Intestine. *k. v.* Kupffer's vesicle. *n.* Notochord. *s. v.* Sinus venosus. *o. g.* Oil-globules. *y. s.* Yolk-segments.

All the figures, except figs. 38 and 39, are drawn from living ova or larvæ, with the help of Zeiss's camera lucida, and, except where otherwise stated, with Zeiss's objective A and ocular 2. Sometimes the object was, when drawn, covered with a cover-glass, sometimes not, as specified in the description of each figure.

FIG. 1.—Ovum of *Capros aper*, fertilized August 15th, 1887, 6 p.m. Drawn August 16th, 10 a.m. (16 hours).

FIG. 2.—Same species, fertilized same time. Drawn August 17th, 1 p.m. (1 day 19 hours), without cover-glass.

FIG. 3.—Ovum of *Trigla gurnardus*, fertilized May 11th, 1888. Drawn May 13th, without cover-glass.

FIG. 4.—Ovum of *Trigla cuculus*, fertilized April 27th, 1 p.m. Drawn May 2nd, 4 p.m. (5 days 3 hours); cover-glass.

FIG. 5.—Same species, fertilized May 10th. Hatched and drawn May 19th (9 days). Zeiss a_3, oc. 2, camera, no cover-glass.

FIG. 6.—Ovum of *Pleuronectes microcephalus*, fertilized April 12th, 1 p.m. Drawn April 14th, 4.30 p.m. (2 days 3½ hours).

FIG. 7.—Same species, fertilized same time. Drawn April 17th, 6 p.m. (5 days 5 hours); cover-glass.

FIG. 8.—Same species, fertilized same time. Hatched and drawn April 19th (7 days). Zeiss a_3, oc. 2, camera, without cover-glass.

FIG. 9.—Same species, fertilized and hatched same dates. Drawn April 23rd (4 days after hatching), Zeiss a_3, oc. 2, camera, cover-glass.

FIG. 10.—Ovum of *Solea vulgaris*, living but unfertilized. Drawn March 8th, 5 p.m.; cover-glass.

FIG. 11.—Same species, fertilized May 16th, 4 p.m. Drawn May 19th (3 days), without cover-glass.

FIG. 12.—Same species, taken in tow-net at surface outside the end of Plymouth Breakwater, March 16th; cover-glass.

FIG. 13.—Same species, taken in tow-net on the east side of Plymouth Sound, April 18th; cover-glass.

FIG. 14.—Ovum of *Solea variegata*, pressed from the fish May 29th, unfertilized. Drawn after death, May 30th, without cover-glass.

FIG. 15.—Probably the same species, taken in tow-net south-east of Eddystone Light, July 17th; without cover-glass.

FIG. 16.—Ovum of *Scomber scomber*, fertilized May 24th, 3 a.m. Drawn same day, 10.30 a.m. (7½ hours; 13·5° C.), without cover-glass.

FIG. 17.—Same species, fertilized June 1st, 3 a.m. Drawn June 2nd, 11 a.m. (1 day 8 hours), without cover-glass.

FIG. 18.—Same species, fertilized May 26th, 2 a.m. Drawn May 27th, 5 p.m. (1 day 15 hours); no cover-glass.

FIG. 19.—Same species, fertilized May 24th, 3 a.m. Drawn May 25th, 1.30 p.m. (1 day 10½ hours); no cover-glass.

FIG. 20.—Same species, fertilized May 26th, 2 a.m. Drawn May 28th, 11.30 a.m. (2 days 9½ hours); no cover-glass.

FIG. 21.—Same species, fertilized same time as above. Drawn May 29th, 11 a.m. (3 days 9 hours), without cover-glass.

FIG. 22.—Same species, fertilized same time. Drawn May 29th, 5 p.m. (3 days 15 hours), with cover-glass.

FIG. 23.—Same species, fertilized same time. Drawn May 29th, 1.30 p.m., with cover-glass.

FIG. 24.—Same species, fertilized same time. Drawn May 30th, 5 p.m. (4 days 15 hours), with cover-glass.

FIG. 25.—Ovum of *Blennius ocellaris* adhering to ox-bone. Drawn in living condition, without cover-glass, July 10th, 1888.

FIG. 26.—Ovum taken in tow-net in Plymouth Sound, February 1st, 1888; no cover-glass. Optical section. Probably *Callionymus lyra.*

FIG. 27.—Same ovum, surface view, showing the marking of the vitelline membrane.

FIG. 28.—Ovum pressed from a ripe female pilchard when the fish was dead.

FIG. 29.—Ovum of the pilchard at an advanced stage of development, from tow-net August 11th, 1887.

FIG. 30.—Newly-hatched larva of same species, from an ovum taken in tow-net November 9th, 1887.

FIG. 31.—Ovum of the sprat, taken in tow-net January 28th, 1888.

FIG. 32.—Newly-hatched larva of same species, from an ovum taken in tow-net January 30th, 1888.

FIG. 33.—Ovum taken in tow-net February 6th, 1888. Drawn February 9th, 1888. Zeiss a_3, oc. 3, camera; no cover-glass. Identified as *Gadus merlangus.*

FIG. 34.—Larva hatched from same kind of ovum on February 8th. Zeiss a_3, oc. 3, camera; no cover-glass.

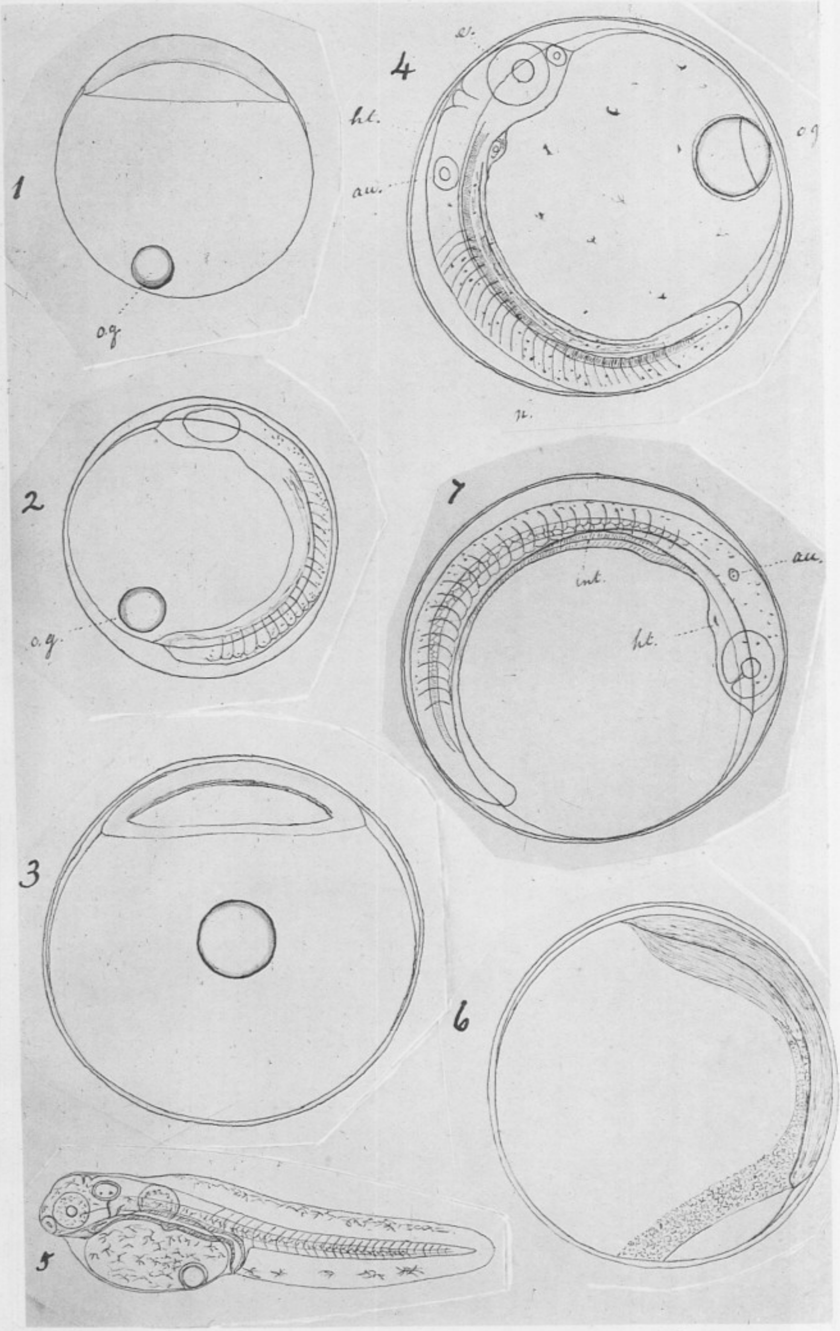
FIG. 35.—Gadoid larva hatched from ovum, taken in tow-net January 20th. Probably *Gadus luscus.*

FIG. 36.—Ovum tken in tow-net January 28th; 8-cell stage.

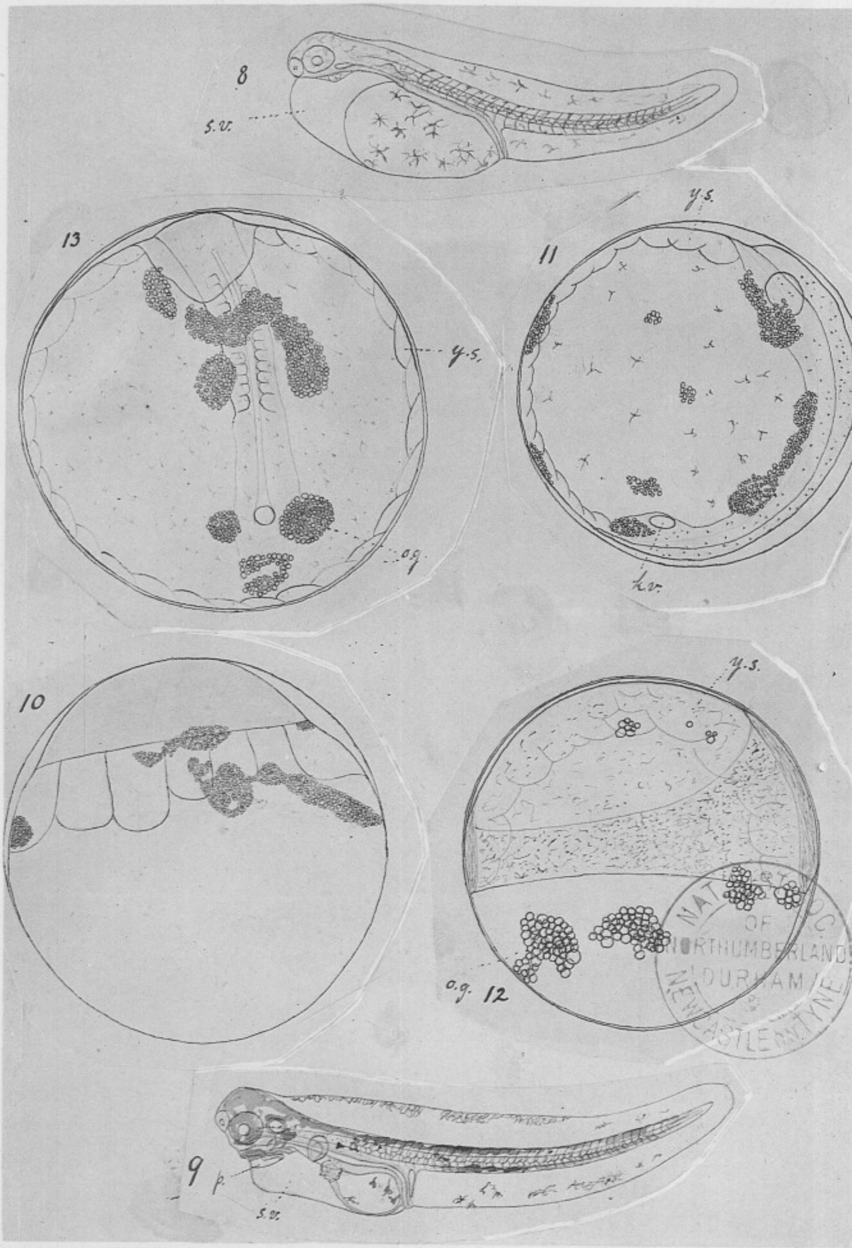
FIG. 37.—Larva hatched from ovum of same species, collected January 30th. Hatched and drawn, February 2nd, without cover-glass.

FIG. 38.—Young Motella, 17 mm. long, from tow-net, May 31st. Drawn without the microscope.

FIG. 39.—Outline sketch of *Arnoglossus laterna.* Natural size. February 9th.



G. C. Bourne del. *Glyptographie Silvestre et Cie, Paris.*



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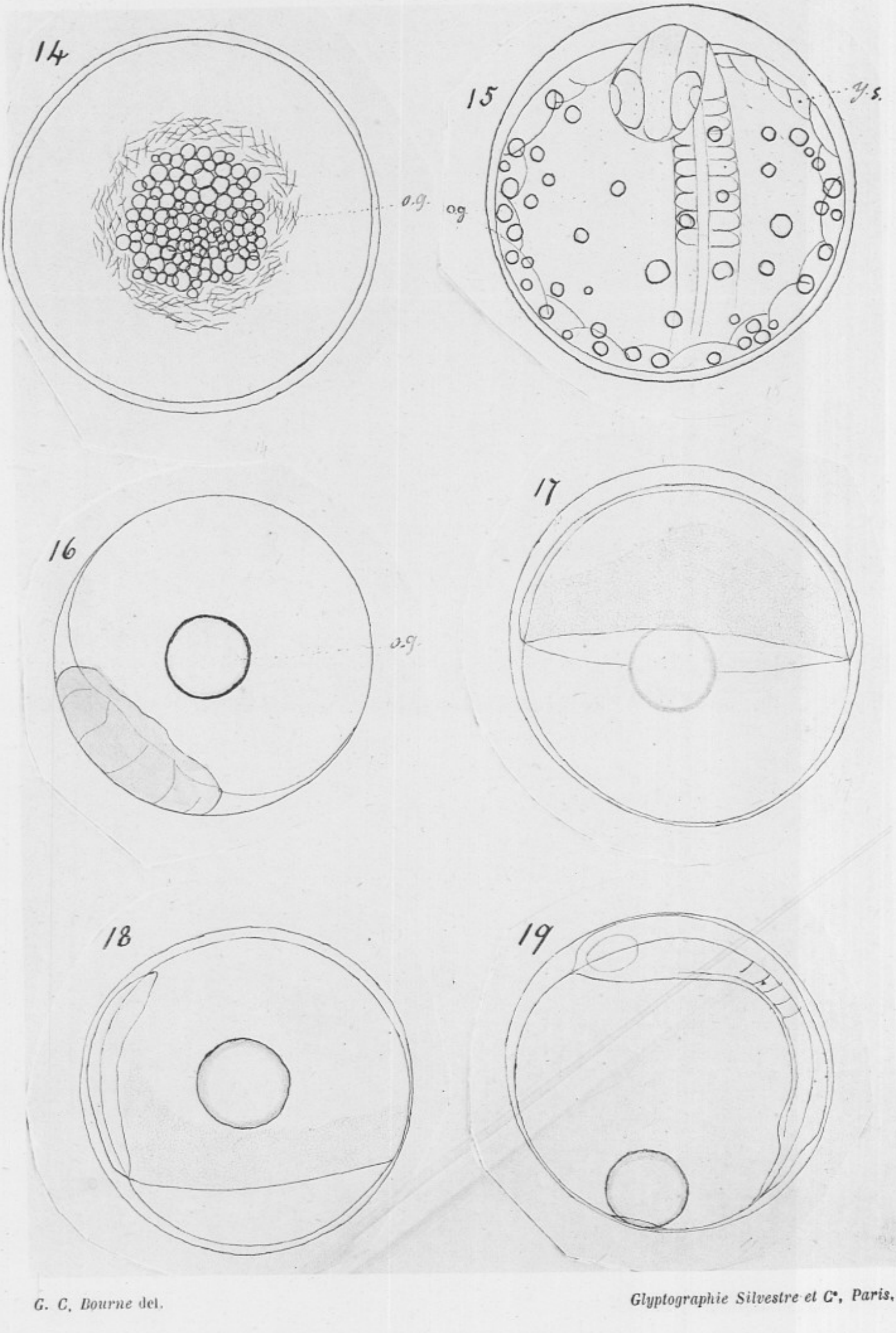

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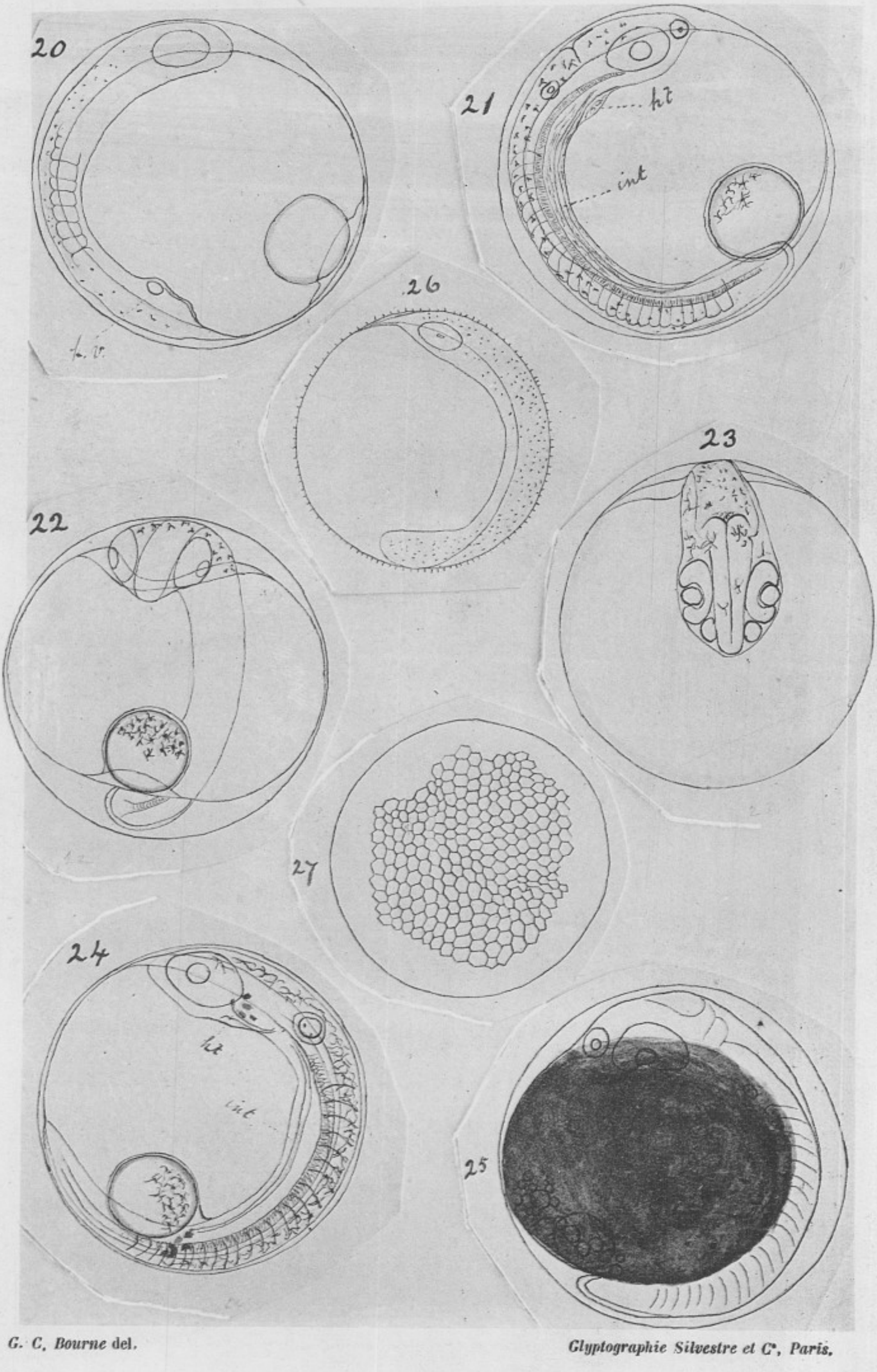

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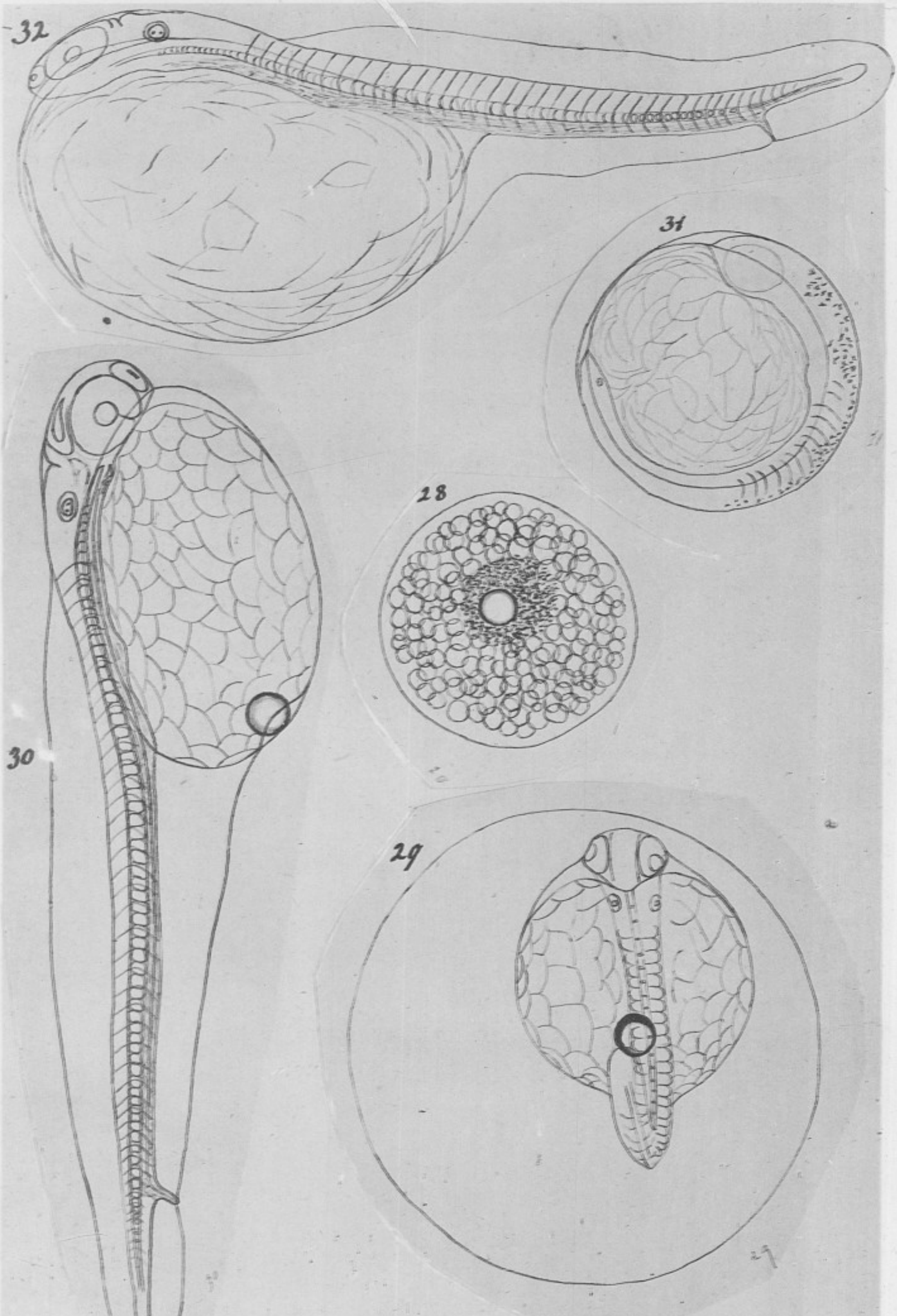

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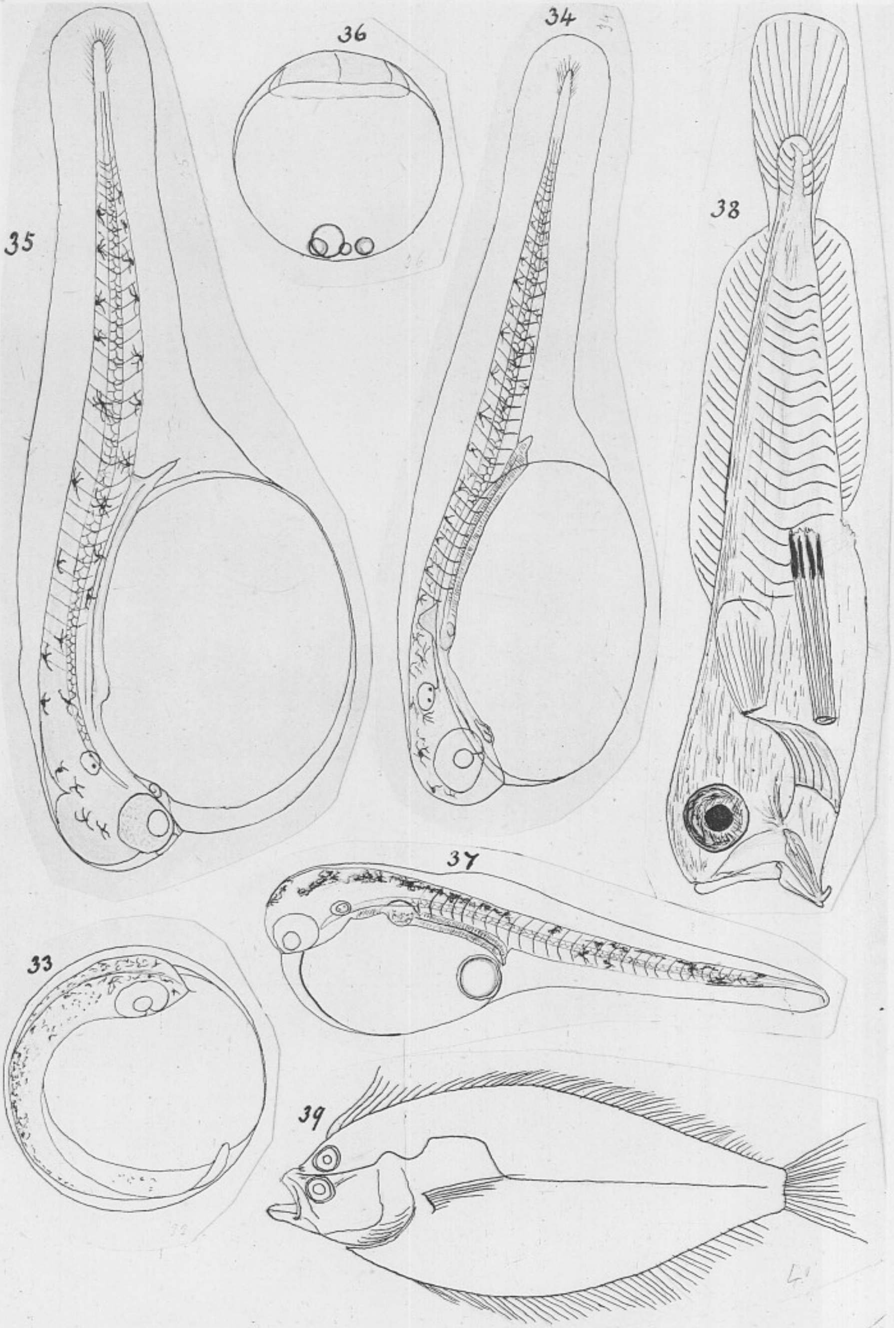


G. C. Bourne del. *Glyptographie Silvestre et Cie, Paris.*

Notes on some Animal Colouring Matters examined at the Plymouth Marine Biological Laboratory.

(*Brief Abstract.*)

By

C. A. MacMunn, M.A., M.D.

The following is a list of the Invertebrates which I had an opportunity of examining. Their pigments were not in all cases thoroughly studied, partly because the Laboratory had been opened but a short time before my arrival, and was not yet fully provided with the necessary chemical apparatus, partly through want of time.

Cœlenterates.

Chrysaora hysocella.
Tubularia indivisa.
Corynactis viridis.

Echinoderms.

Antedon rosaceus.
Asterias glacialis.
Goniaster equestris.
Solaster papposa.
Asterina gibbosa.
Holothuria nigra.
Ocnus brunneus.

Vermes.

Arenicola piscatorum.
Terebella.
Cirratulus.
Nereis.
Pontobdella.
Polynoe.
Chætopterus insignis.
Nemertes neesii.
Phyllodoce viridis.

Tunicates.

Styela grossularia.
Botryllus violaceus.
Botrylloides.
Ascidia virginea.
Clavellina lepadiformis.

Bryozoans.

Lepralia foliacea

And one Mollusc—*Doris.*

The results arrived at will be published *in extenso* in the Quart. Journ. Micros. Sc., but I may here briefly refer to the most important facts which I came upon.

Does the spectroscope support the supposition that symbiotic Algæ are present in Antedon rosaceus? The answer is decidedly no, as neither chlorophyll nor chlorofucin is present in any of the extracts of this Echinoderm. I found that if the stomach with its contents was removed before the extraction with alcohol, ether, &c., the above result was obtained, but if allowed to remain then chlorophyll (from the food) was present. This decides the question. Krukenberg has figured a chlorophyll band in his map of the alcohol extract of *Antedon* which led me to suppose that I should also find it, but the result was as described. Dr. P. Herbert Carpenter* has come to the same conclusion, by studying the morphology of the supposed algæ and the pyriform oil-cells of Wyville-Thomson, which Vogt and Yung† took to be the amœboid spores of these algæ. Apart from spectroscopic proof the latter were found neither to possess a cellulose wall nor to contain starch, and as they are easily seen to grow out from the surface of the integument, being attached to it by their narrower parts, it is not easy to see how they can have been mistaken for anything else but what they are. The red pigment of *Antedon* I found not to be identical with Moseley's antedonine, and in the complete paper the points of difference are referred to at length.

The ether extract was found to contain a lipochrome‡ probably allied to Kühne's xanthophan.

The red pigment itself easily goes over into glycerin, alcohol, and partially into water. It gives no well-marked bands; its colour is destroyed by acids, and more or less changed by alkalies.

Krukenberg's paper, *Ueber die Farbstoffe von Comatula mediterranea,* will be found in his Vergleichend-physiologische Studien, zweite Reihe, dritte Abth., 1882.

Other Echinoderms.—The fine violet colour of *Asterias glacialis* can be extracted by fresh water, but the solution gives no bands; the colour is diminished by ammonia and by caustic potash, and is not much affected by hydrochloric acid. Alcohol extracts from the integument a lipochrome allied to Kuhne's rhodophan,§ but ether

* *Notes on Echinoderm Morphology,* Quart. Journ. Mic. Sci., Jan., 1887.

† Traité d'Anatomie Comparée Pratique, Livr. 7, 8, pp. 519—572.

‡ The lipochromes (Krukenberg), or fat-pigments, include those formerly known as luteins, also tetronerythrin and the chromophanes of the retina, &c. They give bands in the violet half of the spectrum, and become in the solid state blue or green by H_2SO_4 and HNO_3, and in some cases blue or green with I dissolved by means of KI. The last test often fails in the case of animal lipochromes. All lipochromes are soluble in such solutions as ether, chloroform, bisulphide of carbon, &c.

§ Kühne, Unters. a. d. physiol. Inst. d. Univ. Heidelberg, Bd. i, 1878; Bd. iv, 1882.

fails to extract it. The violet colouring matter could not be extracted by glycerin, and no hæmatoporphyrin could be obtained by extracting the integument with alcohol and sulphuric acid, whereas in *Uraster rubens,* especially in brownish specimens, that pigment is present as I have shown.* Nor was any found in *Goniaster, Solaster, Asterina,* nor in *Holothuria nigra* and *Ocnus brunneus.* The integuments of the first three yield lipochromes, which are described in the full paper. *Holothuria nigra* contains within it, and colouring its ovaries, its blood, its digestive gland, &c., one or more lipochromes. The polian vesicle contains what may be described as a lipochromogen, and in the blue ovaries of *Ocnus brunneus* a similar substance is found which, under the influence of alcohol, ether, &c., as in the case of the beautiful blue pigment of the larval lobster and the "cyano-crystals" of other Crustaceans, becomes changed into a reddish lipochrome. Enterochlorophyll† is present in *Goniaster, Solaster,* and *Asterina,* and in these, as well as in many other Echinoderms, notably in *Holothuria nigra,* there is reason for supposing that its yellow or red lipochrome-constituent is built up in the digestive gland, from whence it is carried to the integument. In the last-mentioned species it is present in the blood. It may be remembered that Dr. Halliburton‡ has detected a lipochrome in the blood of various Crustaceans, in which also it is prepared in the "liver." So that we may consider the digestive gland of these animals not only an organ in which digestive ferments are prepared, but also as discharging a chromatogenic function. In *Holothuria nigra* a yellow pigment can be extracted from the integument by alcohol, which possesses a magnificent emerald-green fluorescence. This has been described by Krukenberg§ as a "Uranidine," and it has also been described by Prof. Jeffrey Bell.|| To the latter I am indebted for a solution of the colouring matter which I have described in full in the paper referred to.

Cœlenterata.—The discovery of polyperythrin (which I have shown to be identical with hæmatoporphyrin) in many Cœlenterates by Prof. Moseleyl,¶ led me to hope that in the brown pigment of *Chrysaora* I might see a banded spectrum, but I could not see any bands whatever, and my further results have confirmed exactly those of Prof. McKendrick,** who examined this jelly-fish.

In the beautiful little *Corynactis viridis,* when it has a red colour,

* Jl. Physiol., vol. vii, No. 3; see also vol. viii, No. 6.

† See Proc. Roy. Soc., vol. xxxv (1883), p. 370, *et seq.*; also Philos. Trans., Pt. i, 1886.

‡ Jl. Physiol., vol. vi, No. 6.

§ Vergl. physiol. Stud., II Reihe, 3 Abth., 1882, S. 53.

|| Proc. Zool. Soc., Dec., 1884, p. 563.

¶ Quart. Journ. Mic. Sci., vol. xvii, N.S., 1877.

** Journ. Anat. and Physiol., vol. xv.

I find actiniohæmatin present, differing in no essential respect from that colouring matter as I have described it elsewhere.*

In *Tubularia indivisa* the bright red colour of the polyp heads was found to be due to a lipochrome.

Vermes.—In *Arenicola,* as in *Lumbricus terrestris,* the glandular tissue surrounding the intestine was found to contain a lipochrome, as well as the integument. From the latter situation the black pigment could be extracted by caustic potash, but in solution it gave no bands. Hæmoglobin is present in this worm, as is known by Prof. Ray Lankester's researches.

In *Terebella,* besides the hæmoglobin (Lankester), to which, and not to tetronerythrin the colour of the tentacles is due, the integument contains a lipochrome. In *Cirratulus* the tentacles also owe their colour to oxyhæmoglobin, but they also yield a lipochrome to solvents, as does the integument.

In *Nereis* a lipochrome is also present besides the hæmoglobin. The blood of *Nereis Dumerilii* showed one broad band like that of reduced hæmoglobin. In some parts of the worm only one band like the first one of oxyhæmoglobin was seen. An aqueous solution of the blood, however, gave two bands, but on adding ammonium sulphide they disappeared, and did not seem to be replaced by the single band of reduced hæmoglobin.

In *Pontobdella* an undescribed colouring matter bearing a remote resemblance to chlorophyll can be extracted from the integument by absolute alcohol. This comes from the large green-coloured corpuscles situated in the deeper parts of the integument.† The green solution showed no red fluorescence, nor did it show all the chlorophyll bands. With hydrochloric acid it became a deeper blue colour, but did not show the phyllocyanin spectrum.

In *Polynoe* a phosphorescent area was noticed surrounding the head ganglion, which latter was of a red colour, and gave a band situated approximately in the same part of the spectrum as that of reduced hæmoglobin, but in no part of the worm could I see the spectrum of oxyhæmoglobin. In one specimen the cerebral ganglion showed one band like the first of oxyhæmoglobin, and in another this ganglion was yellow and showed no band.

I have examined the green colouring matter of *Chætopterus insignis* (Baird) and can confirm Professor Lankester's statement that it is chlorophyll. The alcohol solution possesses a fine red fluorescence and gives all the chlorophyll band and yields "modified" and "acid" chlorophyll as well as phyllocyanin by suitable treatment.

* Philos. Trans., Pt. ii, 1885.

† See A. Gibbs Bourne's paper, Quart. Journ. Mic. Sci., July, 1884.

I could detect no hæmoglobin in *Nemertes Neesii*, nor did the integument yield hæmatoporphyrin to acidulated alcohol.

In *Phyllodoce viridis* a special green pigment occurs which is not chlorophyll. This pigment is described at length in the complete paper. It may be remembered that P. Geddes* exposed this green polychæte Annelid to sunlight and failed to get any evolution of oxygen. Of course the above result explains why.

Tunicates : In *Styela grossularia* the brilliant red pigment surrounding the exhalent and inhalent orifices was found to be a red lipochrome, which by Merejkowski† would doubtless be taken for tetronerythrin, but in this, as well as in many other instances, it is more closely related to Kühne's rhodophan than to anything else. The ether solution was at first a fine red colour, but soon changed to greenish, and although it did not show a red fluorescence it gave a chlorophylloid spectrum. But the pigment present was not chlorophyll ; it seemed to possess characters, however, which should class it among the lipochromes and which show that the step from one to the other is not a great one.

Botryllus violaceus yields to solvents such as alcohol and ether a yellow lipochrome, which in a deep layer of alcohol solution showed a band in red like that of chlorophyll. It is probable that in this instance also a colouring matter is present possessing some of the characters of chlorophyll and being yet a lipochrome.‡

In *Botrylloides* an allied pigment is present.

In *Clavellina lepadiformis* some bluish colouring matter occurs which showed some shading at the blue end of green and a feeble shading at D, but I was unable to examine it further.

In *Ascidia virginea* a reddish pigment was noticed which gave two shadings in the green and strongly absorbed the violet end of the spectrum, but I failed to get it into solution. It is probably, however, related to the lipochromes.

Bryozoans : The examination of *Lepralia foliacea* yielded interesting results. It contains abundance of chlorophyll mixed with a lipochrome, to which latter the fine orange of this species is due. The chlorophyll is also accompanied by a second pigment, probably chlorofucin,§ if so, the latter must be due either to symbiotic algæ or to brown marine algæ. The ether solution shows the bands of the latter pigment well marked, and has a red fluorescence, which is

* Proc. Roy. Soc. Edin., vol. xi, 1881–82.

† Bullet. de la Société zoolog. de France, 1883, p. 81 *et seq.;* cf. Dr. W. Wurm in Jahreshefte des Vereins für vaterl. Naturkunde in Württ., 1885, S. 262—265.

‡ Cf. Krukenberg, Verg. physiol. Stud., 2 Reihe, 3 Abth., 1882, Tafel v, 7.

§ Sorby, Proc. Roy. Soc., No. 146, vol. xxi, 1873 ; see also my paper in Quart. Journ. Mic. Soc., vol. xxvii.

not so well marked in the case of the alcohol solution. Water extracted from *Lepralia* a little reddish yellow colouring matter, showing some shading at the blue end of green, and glycerine a little yellow. The acetic acid solution was brownish yellow, and in deep layers absorbed all the spectrum except the red, while in a thin layer it showed a band at the blue end of green.*

I formerly found chlorophyll in *Flustra foliacea*, where it is evidently due to the presence of the brown bodies, the remains of the atrophied Zooids.

The only mollusc which I had time to examine roughly was *Doris*, but in this I found evidence of the presence of a hæmochromogen-like spectrum, resembling exactly that of the pigment which I have named enterohæmatin, and which Sorby found in several snails and slugs, and I found in *Patella* and *Astacus*.† This pigment is, as I have shown, connected with the histohæmatins, which have a very wide distribution throughout the animal kingdom.

Remarks.—It was evident to me that every pigment which I met with, in this somewhat rough and unfinished series of observations, could be classified under groups which have already been described by others and myself; but they are not on that account the less interesting, as the distribution of these pigments is of great importance.

To morphologists the study of animal chromatology may seem trivial, but the pigments are of great importance from a physiological point of view, and the discovery of hæmoglobin, hæmocyanin, the histohæmatins, echinochrome, and other respiratory colouring matters, has thrown much light on the respiratory processes in animals.

With regard to the lipochromes, it is difficult to understand what *rôle* they play. I cannot think that they can be of much use in respiration, as they are unaffected by oxidizing and reducing agents as are other respiratory substances. And I therefore differ from Merejkowski with regard to tetronerythrin being respiratory, as it—as I said before—has been shown to be a lipochrome. It is significant that such widely separated structures as the eye-spot of a starfish and the rods of the Vertebrate eye should each yield lipochromes; it would seem that in such cases they are concerned in the absorption of light-rays.‡ Probably their simple chemical constitution, as they all consist of only three elements, carbon, hydrogen, and oxygen, has been taken advantage of for such purposes, as they can be built up with the minimum expenditure of energy. It is interesting also to note that they have a very strong absorptive power for the violet end of the spectrum.

* Cf. Krukenberg, Verg. physiol. Stud., 2 Reihe, 3 Abth., S. 29.

† Philos. Trans., Pt. i, 1886, p. 239, and Ibid., p. 268.

‡ Cf. Sir J. Lubbock in The Senses of Animals, Internat. Sci. Series, p. 3, *et seq.*

Their very intimate association with chlorophyll, and the actual change of that substance into them, which I have sometimes observed, teach that the step from one to the other colouring matter is not a great one. When we also consider that they are widely distributed throughout the vegetable kingdom, it no longer becomes difficult to understand why chlorophyll should be built up by animals. I am quite convinced that Prof. Lankester's contention that true animal chlorophyll exists can no longer be contradicted.

Krukenberg* has shown that the lipochromes are connected closely with the lipochromoids and melanoids, and through the latter with the melanins; if so, they furnish the radicals for the construction of many black and brown pigments (such as we find in *Holothuria nigra*, whose interior is, as said before, pigmented, to an extraordinary degree, by lipochromes).

The narrow view that all or nearly all the pigments of the vertebrate body are formed from hæmoglobin, held by many human physiologists up to a very late period, is shown to be erroneous by a study of the chromatology of the lower forms. Thus there are other mother-substances such as the histohæmatins, which are of as great importance to many Invertebrates as hæmoglobin is to the higher forms, and it is only by a knowledge of this fact that we can explain the occasional occurrence of such pigments as hæmatoporphyrin in the integument of a starfish, in slugs, and in *Solecurtus strigillatus*,† as I have shown, or of biliverdin in *Actinia mesembryanthemum*, as I have also shown, or in the shells of various molluscs, as Krukenberg has pointed out.‡

These histohæmatins and others, such as the enterohæmatin of snails, slugs, the common limpet, the crayfish and *Doris*, actinohæmatin, and Lankester's chlorocruorin, may possibly, and probably do, represent immature kinds of hæmoglobin on their way, as it were, to form that complex body, but they certainly are not metabolites of hæmoglobin.

The view that modified myohæmatin from pigeon's muscle is hæmochromogen, which Herr Ludwig Levy holds, and endeavours to prove in a recent paper,§ cannot be maintained by anyone who extends his observations to invertebrate animals. Levy further states that it is derived from hæmoglobin, but where is the hæmoglobin from which it comes in a bee, a wasp, a butterfly, a slug, a snail, a crayfish, or a lobster, or in many others in which not a single trace of hæmoglobin can be detected by the most careful spectroscopic

* Centralb. f. d. medic. Wissensch., 1883, S. 785—788.

† Jl. Physiol., loc. cit.

‡ Centralb. f. d. medic. Wissensch., loc. cit.

§ *Über den Farbstoff der Muskeln*, Inaug. Dissert. Strassburg, 1888.

observation ?* I am quite aware of the near relationship of these pigments to hæmatin, and I know that modified myohæmatin and enterohæmatin are very like hæmochromogen : it was for that reason that I gave them their present names; but apart from the fact that, as I have just stated, no hæmoglobin can be found in some animals where they occur, there remains the no less important one, that they do not behave chemically, as they ought to do, if they were metabolites of hæmoglobin.

* Philos. Trans., loc. cit.

On a Tornaria found in British Seas.

By

Gilbert C. Bourne, M.A., F.L.S.,

Fellow of New College, Oxford, and Resident Director of the Association.

With Plates VII, VIII.

Before 1888 no specimen of Tornaria, the well-known pelagic larva of Balanoglossus, had been taken off the English Coast. But on August 9th of the past year Mr. Weldon, using the surface net near the Eddystone Lighthouse, took several young specimens of Tornaria, and subsequently the same gentleman, during a cruise of a week's duration towards the end of August, captured many larger and more mature specimens of the same larva. Other specimens were taken by us up to September 21st, and in the month of August Mr. Rupert Vallentin found several specimens in the vicinity of Falmouth.

The specimens taken on these occasions form the subject of the present memoir, and their anatomy is detailed at some length, both because of the interest attached to a form hitherto unknown to England, and because it is in some respects of morphological importance.

The specimens taken by us came from the offing, and were not taken within four miles of the shore; Mr. Vallentin's Tornaria were found close to the shore at Falmouth. As he was able to bring his back alive and preserve them at leisure in his laboratory, they are better preserved than those taken by us, since we were obliged to preserve our catch in a somewhat rough manner out at sea. An examination of Mr. Vallentin's specimens leaves me no doubt that the larva is *Tornaria Kröhnii*, a species found in the Mediterranean. The different forms of Tornaria have not been with certainty referred to their adult forms, but *T. Kröhnii* must belong to one of the Mediterranean species of Balanoglossus, that is to say, to *B. Kowalevskii*, *B. minutus*, or *B. claviger*, species which have not hitherto been recorded from the English Channel, unless we suppose that the larva of *B. salmoneus v. sarniensis*, which occurs in the Channel Islands and at Roscoff, is identical with *Tornaria Kröhnii*.

The larvæ found on August 9th were of minute size, the largest measuring not more than ·33 mm. in length. In the same surface net I found a few specimens of a younger larva which is identical with Johannes Müller's figure of the youngest Tornaria found by him. One of these larvæ is shown in fig. 1. It has a pre-oral ciliated band and a longitudinal band, but the circumanal band is not developed. The anus is terminal and the mouth opens on the ventral surface. A longitudinal section of this larva is shown in fig. 2. The segmentation cavity is large, and in its anterior portion are several scattered amœboid cells, which will form the walls of the anterior body-cavity. The mouth leads into a stomodæum which is not yet in communication with the gut. The gut is divided into two regions, an anterior mid-gut and a posterior hind-gut, the latter opening to the exterior by the anus. The opening of the anus is shown in fig. 3. It seems probable from the condition of the larva that the posterior division of the gut is not a proctodæum, as might be supposed from an examination of the perfect Tornaria, and that the blastopore persists as the anus without being pushed further inwards by a secondary invagination of ectoderm, *i. e.* a proctodæum.

The next stages observed have all the characters of a Tornaria. The circumanal ciliated ring is now fully developed, but has not the same importance that it acquires at a later stage. The pre-oral and longitudinal bands retain the same arrangement, but are more marked than they were in the earliest stage (fig. 4). The gut is increased in size and is more distinctly differentiated into a mid-gut and a hind-gut. The anterior body-cavity is formed, probably from the amœboid cells described in the earlier larva, and is connected by a muscular thread with the now conspicuous apical sense organ. It opens on the dorsal surface by a pore, which eventually becomes, as Spengel* has shown, the proboscis pore of the adult. Anticipating its fate I shall refer to this pore as the proboscis pore. Fig. 12 shows a longitudinal section through a Tornaria of this age. It can be seen that the œsophagus opens into the gut, the point of junction between the two being sharply defined. The cells of the œsophagus are columnar and richly ciliated. In larvæ of this age the opening from the mid-gut into the hind-gut is very small and difficult to find in specimens contracted by reagents. At first I was led to believe that no communication between the two exists at this stage, but further examination showed me that an opening exists as shown in fig. 5. No traces of the so-called heart (the proboscis sac of Bateson) nor of the collar- and body-cavities are to be found at this stage. The third stage shown in fig. 13 represents the perfect Tornaria. The larva has increased greatly in size, the specimen from which the figure was drawn was as much as a millimetre in

* *Bau u. Entwicklung von Balanoglossus,* Tagebl. d. Naturf. Vers. München, 1877.

length; but in this respect there is great variety among individuals. The pre-oral and longitudinal bands have undergone considerable changes both in their arrangement and in histological characters. In the earlier larva the pre-oral band was triangular, the base overhanging the mouth, and the apex touching the apical sense organ. In this stage the external angles of the triangle are drawn out on either side into long loops which are turned upwards towards the apex, the remainder of the figure appearing as a third median loop which touches the sense organ. The lower edge overhanging the mouth has not undergone any change. The longitudinal band forms a sort of cross the head of which touches the sense organ, the arms are turned upwards like those of pre-oral band. Ventrally the angle beneath the mouth is larger and more sharply defined, but otherwise no important change has taken place. In section, both the pre-oral and longitudinal bands are seen to be composed of numerous densely-crowded, deeply-stained nuclei, the cell outlines of which are not distinguishable. In the earlier stage the cells of the bands were columnar and fewer in number. The cilia have nearly disappeared in the later stage, but a few fine patches may be distinguished. The circumanal band on the other hand has increased in size and importance, and is now the chief if not the only organ of locomotion. Its long and powerful cilia are borne on long columnar cells arranged in oblique rows of three, as is shown in fig. 11. Above and below the ciliated cells are supported by packing cells, and numerous spots of bright brown pigment mark the course of this as well as of the pre-oral and longitudinal bands. Each ciliated cell is long and columnar, slightly contracted in the middle of its length, with a large nucleus. The cilia can be traced as fine fibrillæ inwards as far as the nucleus, but I could not determine whether they entered the nucleus or not.

The alimentary tract does not require a detailed description. The chief distinction between this stage and the last consists in the large circular aperture between the mid-gut and hind-gut. The anus remains relatively small.

The anterior body-cavity, which from its fate may conveniently be spoken of as the proboscis cavity, shows the same relations as in the previous stage. The whole cavity is larger, and its walls are further differentiated, the anterior wall being considerably thickened. Between the thickened portion and the point of insertion of the œsophagus on the mid-gut a few scattered cells may generally be distinguished.

The "heart" of Agassiz, Metschnikoff, and Spengel makes its appearance at this stage as a vesicle lying just above and to one side of the proboscis pore. Figs. 6—10 are a series of sections through the region of the proboscis pore in a perfect Tornaria. In fig. 6 two canals may be seen lying side by side. Of these, one marked *ant. b. c.* is the canal of the proboscis cavity leading to the proboscis pore. The other, marked *v.*, is the heart in question. An examination of figs. 7 and 8 shows that it is formed as an invagination of the ectoderm just above and to one side of the proboscis pore (*d. p.*). Prof. Spengel, who has investigated the whole development of many species of Tornaria, has been good enough to send me proofs of the illustrations of his forthcoming monograph on Balanoglossus, and from his figures and from the account given in his preliminary paper (*d*) it appears that this vesicle is destined to form the "heart" in the adult animal, the proboscis sac of Bateson.

By permission of Mr. Weldon I reproduce a drawing (fig. 19) of the proboscis gland in a later stage of the Tornaria found by him in the Bahamas. In this the heart or proboscis sac (*v.*) is seen as a sac lying in the proboscis gland. It is completely closed, and does not communicate with the blood system nor with the proboscis cavity. The most plausible explanation of this structure is that the anterior body-cavity of Balanoglossus may primitively have been a paired structure, and that this sac may be a member of the pair and the degenerated fellow of the proboscis cavity. But the development of a mesoblastic pouch as an invagination of the ectoderm lands us in a great morphological difficulty.

The development of the posterior mesoblastic pouches can be followed up to a certain point in this stage. It has already been shown by Metschnikoff and Agassiz that a plate is budded off from the posterior region of the gut on each side, which subsequently undergoes division, and forms, as shown by Spengel, the collar-cavities and body-cavities of the adult. My sections show that right and left of the body a plate of cells is budded off from the upper edge of hind-gut on either side. At first continuous with the hind-gut (fig. 14), each plate subsequently separates from it, and becomes so closely applied to the mid-gut as to look as if it had originated from it (fig. 15). The cells composing these plates multiply, and a cavity is formed in them, as shown in fig. 16. No later stages were observed in our Tornaria, but in other forms these pouches become each divided into an anterior and a posterior portion, the anterior moiety on each side giving rise to the collar-cavity of the adult, the posterior moiety to the general body-cavity. This further development is figured in the drawings which Prof. Spengel has sent me, and I was able to follow it in the series of preparations of the Bahamas Tornaria lent me by Mr. Weldon.

Bateson, in his account of the development of *Balanoglossus*

Kowalevskii, describes the collar- and body-cavities as arising from separate pairs of archenteric pouches. The account given above, which was first given by Metschnikoff and has since been proved by Spengel, is in accordance with Bateson's observations, if I am right in considering that the hind-gut is in reality a portion of the true gut and not a proctodæum. But although I believe that the evidence at my disposal is opposed to the view that this region of the alimentary tract is a proctodæum, Prof. Spengel informs me that he is inclined to think that it is, and should he prove to be correct, the origin of the mesoblast from such a source would be without parallel in the animal kingdom. I expect to find that my view is correct, because a widely different origin of the mesoblast in two species of the same genus is in itself hardly credible, and would present most serious morphological difficulties.

The apical sense organ in our Tornaria is shown in section in fig. 18. Its central portion is composed of columnar sense-cells bearing cilia. Outside of these are larger cells, with large nuclei surrounding a pair of deeply pigmented pits. These pits are the "eye-spots" of previous authors, the large cells surrounding them are probably ganglion-cells. Beneath the sensory cells is a thin layer of nerve-fibres. The structure of the sense organ and its relation to the muscular band which connects it with the proboscis cavity can readily be seen in fig. 18. The paired invaginations forming sense pits, suggest a comparison with similar organs in the unarmed Gephyrea.

Unfortunately, the account of the British Tornaria must stop here. No specimens older than that described were taken during the year. Possibly if we had brought back our Tornaria alive we might have succeeded in rearing the further stages as was done by Metschnikoff and Agassiz, but owing to the distance we had to traverse in a small sailing-boat, and that often in calm weather, we found it always expedient to preserve our catch on board. Very probably the Tornaria ceases to lead a pelagic life, sinks to the bottom, and undergoes its further development there, which would explain our taking no later stages in the tow-net.

In conclusion, I have to thank Prof. Spengel for his kindness in sending me proofs of his forthcoming illustrations of the development of Balanoglossus. From these it appears that he has already anticipated anything that is new in this paper, such as the formation of the "heart" and the structure of the sense organ. I am also indebted to Mr. Weldon for lending me numerous drawings and preparations of the two forms of Tornaria found by him in the Bahamas, and to Mr. Rupert Vallentin for the specimens taken by him at Falmouth.

DESCRIPTION OF PLATES VII, VIII,

Illustrating Mr. G. C. Bourne's paper on "A Tornaria found in British Seas."

FIG. 1.—Lateral view of a very young Tornaria (?).

FIG. 2.—Longitudinal section through the same specimen, showing the relation of the stomodæum to the gut.

FIG. 3.—Posterior part of the next section to 2, showing the blastopore persisting as the anus.

FIG. 4.—Young Tornaria, older than fig. 1. Actual size ·33 mm.

FIG. 5.—Frontal section through the posterior region of a Tornaria of the same age as fig. 4, to show the communication between the mid-gut and the hind-gut.

FIGS. 6, 7, 8, 9, 10.—Five consecutive sections through a perfect Tornaria in the region of the proboscis pore, showing the opening of the latter (*d. p.*) and the canal (*ant. b. c.*) which connects it with the proboscis cavity. In figs. 6, 7, 8, the mode of origin of the so-called heart (*v.*) may be seen.

FIG. 11.—Surface-view of the circumanal ciliated ring, showing the nuclei of the ciliated cells, the supporting cells, and the pigment spots.

FIG. 12.—Sagittal section through a Tornaria of the same age as fig. 4, showing the proboscis cavity and pore.

FIG. 13.—Lateral view of a perfect Tornaria, showing the complication of the ciliated bands. Actual size 1 mm.

FIG. 14.—Longitudinal section through the posterior region of a Tornaria of the same age as fig. 3, showing the origin of the mesoblast from the hind-gut.

FIG. 15.—Longitudinal section through a somewhat more advanced larva, showing the mesoblast separate from the hind-gut, and closely applied to the wall of the mid-gut.

FIG. 16.—Transverse section of a larva somewhat older than fig. 15. A cavity has been formed in the mesoblast.

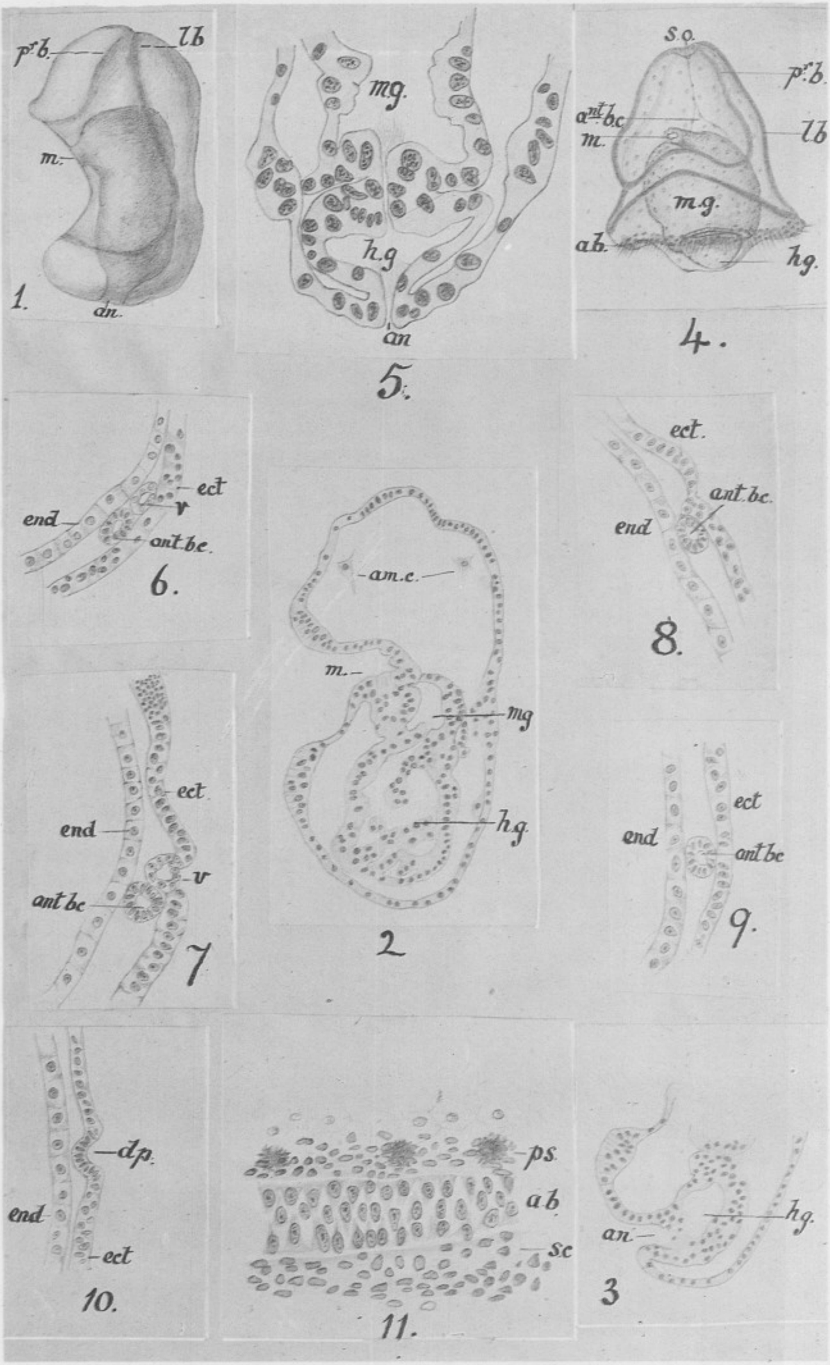
FIG. 17.—Surface view of the ectoderm in a perfect Tornaria.

FIG. 18.—Frontal section through the apical sense organ, showing the sense pits (*s. p.*), the ganglion-cells and layer of nerve-fibres, the proboscis cavity, and the muscle band connecting the latter with the sense organ.

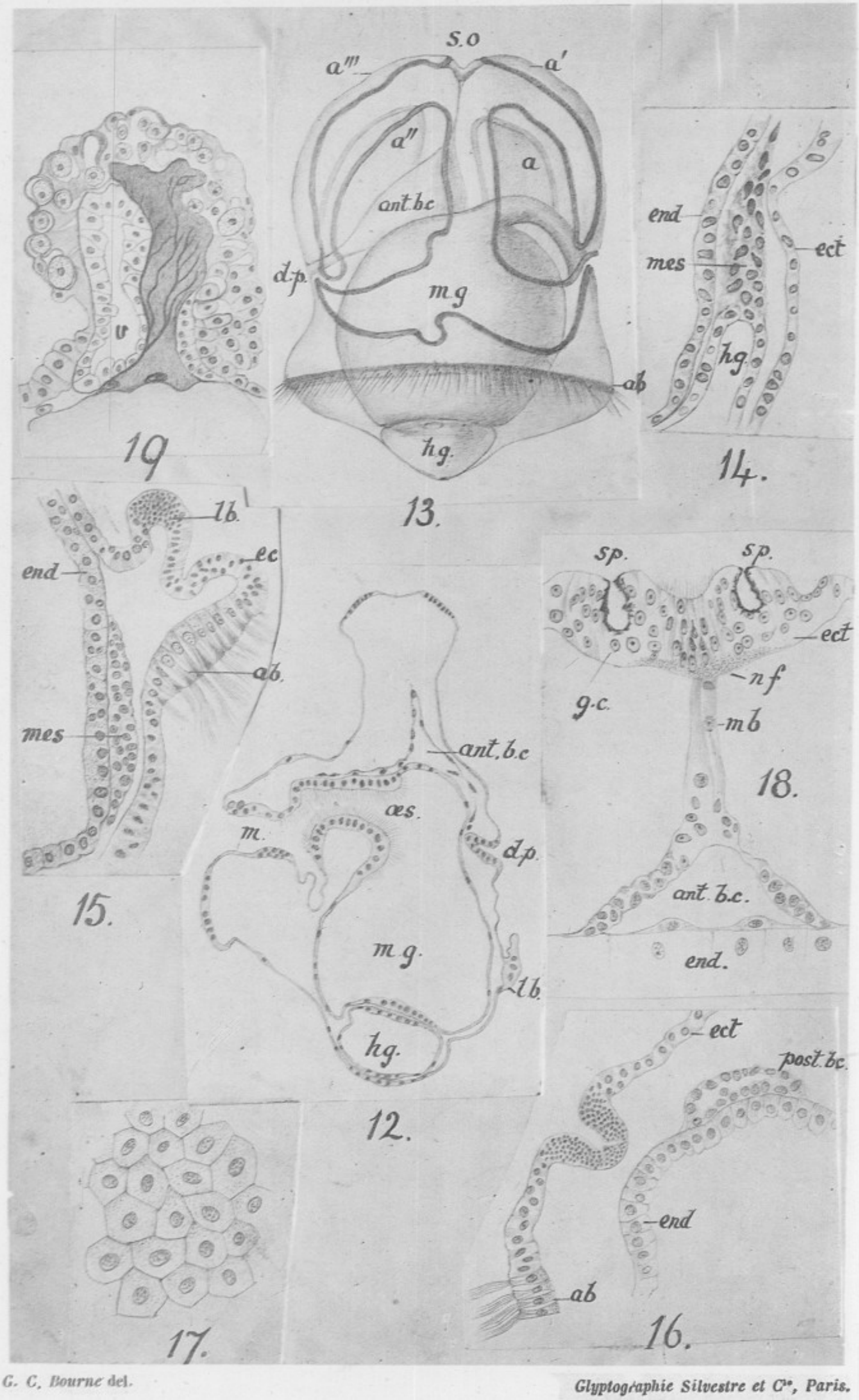
FIG. 19.—Section through the proboscis gland of an advanced larva of a Balanoglossus from the Bahamas, showing the relations of the so-called heart (proboscis sac) to the proboscis gland. Copied from a drawing by Mr. Weldon.

Lettering in the above figures.

a. Lateral loop of the pre-oral band. *a'.* Median loop of the pre-oral band. *a''.* Lateral loop of the longitudinal band. *a'''.* Median loop of the longitudinal band. *a. b.* Circumanal ciliated band. *am. c.* Amœboid cells. *an.* Anus. *ant. b. c.* Proboscis cavity. *d. p.* Proboscis pore. *ect.* Ectoderm. *end.* Endoderm. *g. c.* Ganglion-cells. *h. g.* Hind-gut. *l. b.* Longitudinal band. *m.* Mouth. *m. b.* Muscular band. *mes.* Mesoblast. *m. g.* Mid-gut. *n. f.* Layer of nerve-fibres. *œs.* Œsophagus. *pr. b.* Pre-oral band. *proc.* Proctodæum. *p. s.* Pigment spots. *s. c.* Supporting cells. *s. o.* Apical sense organ. *s. p.* Sense pits. *v.* "Heart," or proboscis sac.



G. C. Bourne del. Glyptographie Silvestre et Cie, Paris.



G. C. Bourne del.

Glyptographie Silvestre et Cie, Paris.

Notes on the Marine Oligochæta of Plymouth.

By

Frank E. Beddard, M.A.,

Prosector to the Zoological Society of London; Lecturer on Biology at Guy's Hospital.

THE Oligochæta form a division of the Annelida, of which the most familiar type is the common earthworm (*Lumbricus terrestris*); the group comprises also a great number of smaller worms, which are for the most part inhabitants of ponds and streams, such as the red River worm (*Tubifex rivulorum*). The Oligochæta were at one time believed to be entirely terrestrial or inhabitants of fresh water, and to be distinguished thus from the Polychæta, which were supposed to be exclusively marine in their habitat. Although the progress of research has not broken down the structural distinctions between these two divisions of the *Annelida chætopoda*, it has been proved that no absolute line of demarcation can be drawn between the Oligochæta and the Polychæta as regards their habitat; on the one hand Polychæta have been found in fresh water, and, on the other hand, certain species of Oligochæta are now known to inhabit the mud and gravel of the seashore.

There are three species common in the Sound at Plymouth, which are apparently identical with certain species described by Claparède* from the shores of Scotland and France.

One of these is a small whitish worm about half an inch in length, which is abundant in gravel between tide marks in Rum Bay. It belongs to the genus *Pachydrilus* of Claparède, but I have not yet satisfactorily determined to which of the several known species of the genus it should be referred.

The two remaining species are found in mud at Drake's Island and on the shores of the Sound, where they are extremely abundant. They can be distinguished from each other by a slight difference in the transparency of the body wall. One worm is much more transparent than the other, and is therefore of a brighter red colour, this colour being, of course, due to the blood-vessels; this species appears to be Claparède's *Clitellio arenarius*. The other worm has a more dusky appearance, caused by the presence of a

* Mém. Soc. Phys. Geneve, 1862.

quantity of minute papillæ, filled with a greyish-green pigment, which cover the body except at the anterior and posterior end, and on the clitellum when developed. The opacity of the body walls renders the contained blood-vessels less conspicuous. I identify this worm with Claparède's species *Clitellio ater;* it is probably also identical with d'Udekem's* *Tubifex Benedii.*

The preliminary list of the Marine Fauna of Plymouth, published in the second number of the 'Journal of the Marine Biological Association,' contains a single Oligochæt—*Tubifex lineatus.*

Tubifex lineatus is, however, a most mysterious species; it was originally described by Hoffmeister;† but there is nothing in Hoffmeister's description which renders its identification possible, unless he is right in stating (by implication) that there are no hair-like setæ in the dorsal fascicles; in this case it cannot be a *Tubifex;* but the generic name *Sœnuris,* which Hoffmeister applied to it, includes several species which are now assigned to different genera. I should be inclined myself (at least provisionally) to regard "*Sœnuris lineatus*" as being the same form as *Clitellio arenarius,* for in that Annelid also, as Claparède stated, there are no hair-like setæ.

Another marine species, found on the coasts of the North Sea, is *Tubifex hyalinus,* d'Udekem. Vejdovsky‡ considers it probable that this is a *Limnodrilus,* since it only possesses bifid setæ. This is, however, as already stated, no reason against regarding the species as a *Clitellio,* inasmuch as all the species of *Limnodrilus,* which have been adequately described, are fresh-water forms; it is more probable, though of course by no means certain, that *Tubifex hyalinus* is a *Clitellio,* and perhaps also identical with *Cl. arenarius.* Claparède was unacquainted with d'Udekem's paper when he described *Clitellio arenarius.*

Clitellio also agrees with *Limnodrilus* in the presence of a pair of "hearts" in each of segments 8 and 9. It is in fact only to be distinguished from that genus by (1) the absence of "prostate" glands, (2) the shortness and breadth of the vasa deferentia, and (3) the structure of the spermathecæ, which are composed of two sacs united by a very narrow tube; in the lower sac lie the spermatophores.

The species which Claparède termed *Clitellio ater,* and only very briefly described, cannot be referred to the genus *Clitellio* at all. The peculiar papillæ, already referred to, distinguish the species,

* *Nouvelle classification des Annelides Sétigeres Abranches,* Bull. Acad. Roy. Belg., T. xxii, Pt. ii (1855).

† Die bis jetzt bekannten Arten aus der Familie der Regenwürmer.

‡ System u. Morphol. d. Oligochæten.

and lead me to infer its identity with d'Udekem's *Tubifex Benedii*, which appears from the woodcut in Udekem's* paper to possess similar papillæ ; this has been already urged by Vaillant. Claparède does not mention the presence of hair-like setæ ; these indeed are present in some individuals and absent in others ; when present they exist only in the dorsal fascicles. The only genus of Tubificidæ in which this capricious arrangement of the setæ occurs is Eisen's genus *Hemitubifex* ;† but the only species of that genus is fresh water. *Clitellio ater* furthermore agrees with *Hemitubifex* in the dilatation of the termination of the vas deferens connected with the atrium ; I am not, however, convinced that this species is an *Hemitubifex*, though there does not appear to be any other genus to which it can be unhesitatingly assigned.

I have already communicated to the Zoological Society of London a fuller account of the anatomy of these two Tubificidæ.

* Loc. cit., p. 544.

† *Oligochætological Researches*, Report of the (U. S.) Commissioners for Fish and Fisheries for 1883.

The Mackerel Fishery in the West of England.

By

R. J. Ridge.

The mackerel fishery began off Plymouth in January, and boats from Yarmouth, Lowestoft, Newhaven, Brighton, Eastbourne, Hastings, Plymouth, together with a considerable number of Mount's Bay boats (Porthleven, Newlyn, and Mousehole) were engaged in the above fishery. Fish were found about the 13th January fifteen to twenty-five miles south-west of the Start Point, of a very fine quality, and were caught in considerable quantities for some few nights, catches from two lasts (20,000) down to few hundreds per boat. Westerly and south-west winds prevailing (strong breezes), very stormy weather set in, and fishing operations were interrupted for three weeks, when the boats got to work again, meeting only with light catches for some weeks, February and March were not very successful months, easterly winds set in and continued throughout above months, and practically nothing was done till latter part of March and beginning of April, when boats fell in with fish south-west of Eddystone fifteen to twenty-five miles. There fish were not so fine in quality as those of January, and appeared to be quite distinct from the latter. Some good hauls were secured, one last (being about the largest catch) to few hundreds per boat. The fishing continued up to May, and boats did fairly well, a good average earnings was obtained; prices kept up, especially during Lent.

The spring fishing off the Lizard was practically a failure, no doubt the result of strong east winds; generally the Mount's Bay boats meet with good catches of fish during March and April from five to twelve miles south-west to west of the Lizard. In 1887 it was late in April before they were met with in any considerable quantities, but this year (1888) very few indeed were secured on this ground.

A few nights' good fishing were secured twenty-five to thirty miles south to south-south-east of Lizard, and the quality very clearly indicated them to be of the usual Lizard spring shoal.

The commencement of May Bay-boats* shifted nets (took on

* The fishing boats belonging to Mount's Bay are usually spoken of in the West of England as the "Bay-boats."—Ed.

board a large mesh net), and as usual went to the ground off Scilly. During first part of the month very unsettled weather set in and very little could be done. The month, however, closed with a very good fishing and some very fine hauls were taken and the quantity excellent.

During May the greater part of the Lowestoft boats continued to find fish in considerable quantities forty miles south of Mount's Bay, and the quality also was very fair though not equal to those from the Scilly ground.

The fishing during June off Scilly was fairly well maintained, and mackerel kept in capital condition, maintaining a flavour somewhat superior to ordinary June fish.

The season held on till the very end of the above month, and even several boats continued fishing the whole of July, getting catches of 1000 to 200 per boat.

Owing to prevalence of light winds Scilly fishing was closed in June, and the fishing during July was prosecuted off Mount's Bay twelve to twenty miles.

September.—Bay-boats met with fish again off the Bay in fair quantities, the quality being most excellent.

December.—The fleet fitted out again for the mackerel fishing off Plymouth, and the first that were taken was on the night of Friday, December 7th, nine miles south-west Start, by the "Mizpah," of Porthleven, 1000 fish being her catch.

Tuesday, 11th December, five boats landed from same ground 3000, 2900, 2600, 500, and 300 respectively, quality most excellent.

13th inst., catches from 2700 down to 100 per boat were landed.

During the week the very bright moonlight has somewhat been against good fishing.

The year's fishing has been above the average during the last nine years financially for the fishermen, as prices have been rather higher on the whole.* Quantity a little below. Quality very satisfactory.

* The high prices of mackerel, and consequent high returns to the West of England fishermen, are due to the failure of the Kinsale mackerel fishery, which has been unprecedentedly bad during the past year.

Further Investigations on the Function of the Electrical Organ of the Skate.

By

Prof. Burdon Sanderson, M.D., F.R.S., and F. Gotch, M.A.

During the month of September, 1888, we availed ourselves of the facilities afforded by the Laboratory for the purpose of continuing the investigations began by us the year before, of the function of the electrical organ of the skate. In the record of the work done by us in 1887 at St. Andrews, published in the Journal of Physiology, vol. ix, p. 137, we indicated several new lines of investigation which we hoped to pursue if the opportunity offered. Two of these indications we have now been able to fulfil satisfactorily, namely, those relating to the electromotive force of the shock, and to the way in which the function of the electric organ is controlled and influenced by the central nervous system. In the first of these inquiries, we used apparatus which was brought from the Oxford Physiological Laboratory, and temporarily fitted up in the room at Plymouth, which is set apart for physiological researches, and which we found well adapted for this purpose. For the second, a large number of experiments and consequently a considerable number of fish were requisite. Forty skates of various species (*Raia Batis*, *R. clavata*, *R. microcellata*, and *R. maculata*) were supplied to us and used in our researches, of which the result will shortly be ready for publication.

We desire to express in the strongest terms our appreciation of the advantages afforded by the Laboratory for physiological researches. We would also record our personal obligation to the Director for his uniform courtesy and untiring zeal in obtaining for us, in spite of considerable difficulties, the material required for our work.

The Scientific Work of the Fishery Board for Scotland.

By

T. Wemyss Fulton, M.B.,
Scientific Secretary, Fishery Board for Scotland.

Up to 1882 the control of the Scottish Fisheries was vested in the Commissioners of British White Herring Fishery. This body, which was instituted in 1808, had for its functions the general superintendence of the herring fishery, the branding of herring barrels, the collection of trade statistics, and the administration of an annual grant from the Government for the construction and repair of fishery harbours. Later on, the cod and ling fisheries were also brought under its care. But the duties of the Commissioners were strictly limited to the fish cured, no cognisance being taken of the fish landed and used in a fresh state.

It was therefore scarcely to be expected that a Fishery Board whose operations were thus circumscribed would concern itself much about the scientific aspects of fishery questions. It is only in recent years that the full value of systematised knowledge concerning such questions has been generally recognised. Occasionally, however, the Commissioners, yielding to the petitions of fishermen or others connected with the industry, instituted inquiries of a scientific character into such points as the distinction between sprats and herrings, the destruction of immature herrings by sprat fishers, or of their spawn by trawlers.

Such investigations were, however, desultory and spasmodic. So soon as the temporary agitation which gave them birth had died away the inquiries lapsed; and from this lack of continuity little of value was accomplished.

In 1882, in response to the growing feeling that the effective management of fisheries should be based upon more extensive and accurate knowledge, and should include every branch and detail of the industry, the old Fishery Board was dissolved, and the present organisation was established in its stead. All the duties of the old Commission were relegated to the new Board, which, in addition, had to take cognisance of the coast and deep sea fisheries, and the salmon fishery; and it was further empowered to "take such measures for their improvement as the funds under their administration might admit of." While the traditions of the old Board to some extent survived, and regulated in many ways the operations of its successor, the infusion of new blood, and the presence of one or two scientific men who fully recognised the importance of scientific investigations in connection with the fisheries, led to important departures in the consideration and treatment of fishery questions. It is needless here to defend the value of the application of scientific methods and inquiries in reference to the fisheries; but Professor Cossar Ewart and Sir James Gibson-Maitland had to contend with much official inertia and unenlightened obstruction before such methods and inquiries could be made fruitful of results. The lack of funds and of suitable appliances also at the outset hampered the scientific investigations; but means were found to gradually extend their scope as their value became more and more recognised.

A word must be said as to the means at disposal and the methods adopted for carrying on the scientific fishery work of the Scottish Board. The staff of Fishery Officers, gradually formed by the old Board, was utilised as far as possible in the collection of scientific statistics, &c., and the fishery cruisers were also made use of, so far as their defective qualities allowed, in carrying on the investigations. Temporary laboratories were established for the purpose of prosecuting systematic inquiries; but owing to financial difficulties their utility was somewhat interfered with, and even the use of the large tanks in the Rothesay Aquarium had to be discontinued. At the present time the Marine Laboratory of the Board at St. Andrews is the only one in active operation. As a matter of fact, however, a considerable amount of the scientific work in connection with the Fishery Board has been carried on in the Natural History Department of the University of Edinburgh. Two years ago the Board bought a small steamer (the "Garland"), which has been employed, so far as the annual grant permits, in active investigations into the condition of the fishing grounds, the influence of different modes of fishing in the inshore waters, the habits of the food-fishes, &c. Hitherto the results of the scientific inquiries have been incorporated with the Report on the commercial aspects of the fisheries, but arrangements have now been made for publishing the scientific portion of the Annual Report separately.

The scientific work of the Board may be grouped under three heads:

(1) Inquiries into general fishery questions, such as the influence of beam trawling, especially in inshore grounds, and of other methods of fishing; the destruction of immature fish; the supplies of bait;

the collection of special statistics; the survey of fishing grounds, the preservation of fish, &c.

(2) Biological investigations into the marine Fauna, the structure, distribution, migrations, food, habits, &c., of the edible fishes, crustacea and molluscs.

(3) Physical inquiries into the temperature, salinity, and composition of the waters around the coast.

It is not always easy to draw a line of distinction between the first and second classes, but this division will be enough for practical purposes.

General Fishery Inquiries.

It would be out of place here to enter into details as to many of the general questions connected with fisheries which have received scientific treatment. One important investigation has been into the influence of beam trawling, especially in the inshore waters. While these inquiries have shown that a great increase of fish, and especially of flat-fish, has occurred in the waters protected from this mode of fishing, they have been the means of throwing light upon the distribution of the edible fishes, their relative abundance at different times of the year, the proportions of immature and adult fish, and other questions of practical and biological interest. These observations were made on board the "Garland" at various parts of the coast. The precise localities and the methods adopted are described in the Report for 1886,* the results being discussed more fully in the Report for 1887,† where all the details will be found. From these observations it is evident that by continuing them for a year or two a great deal will be learned of the habits and migrations of the food-fishes. Abstracts of several papers relating to the spawning of fishes will be found below; and a system has been devised by which continuous observations will be made throughout the entire year as to the condition of the reproductive organs and the stomach in different sized specimens of each kind of fish. By this means we shall discover (*a*) the minimum size of mature individuals of both sexes, (*b*) the duration of the spawning period, (*c*) the nature of the food in different seasons, (*d*) whether there is any variation in the amount of food taken during the period of reproduction, &c.

The collection of special scientific statistics has been particularly attended to. Besides the Tables of the amounts and values of the different kinds of fish landed, supplied by the Fishery Officers, a scheme has been adopted by having correspondents at the chief

* Fifth Ann. Rep. Fishery Board for Scotland, Appendix F, p. 43, 1887.

† Sixth Ann. Rep., Part iii, p. 25, 1888.

fishing villages in most districts along the east coast, who furnish details regarding the daily catch, the number of boats fishing, the relative size of the fish, whether got in the inshore or offshore waters, the bait used, the condition of the weather, &c. Above forty East Coast fishermen have also been supplied with books, and keep records of their daily catches, with particulars as to state of weather and tide, depth, bait, quality and size of of fish, &c., and by supplying them with charts divided into areas of square miles it will be possible to localise with greater precision the most productive localities. These statistics are given in a large number of Tables,* and have been discussed in last year's Report.†

Another point which requires notice is the study of the appliances used in fishing, especially in relation to the capture of immature fish. Experiments are at present being carried on with specially devised trawls with the object of lessening the great destruction of young fish by this mode of fishing. Professor Ewart published a paper last year giving the results of his investigations into the kinds of herring nets used around the Scottish coast, and showing how, by the substitution of light cotton nets for the old hempen ones, and the diminution in the size of the mesh, combined with the earlier commencement of the herring fishing and the greater prevalence of surface fishing, a vastly greater proportion of young herrings are now captured than was previously the case. Other general questions regarding the sprat and herring fisheries are considered in several of the papers referred to below.

The question of bait is one of increasing importance to Scottish fishermen from the growing scarcity of supplies. The common mussel is the chief bait used, and it has been shown‡ that the East Coast line fishermen are put to great expense in order to procure the requisite supplies, and that the total yield of Scotch mussels is rapidly diminishing. The cultivation of mussels is recommended, and experiments have been begun, under the direction of Professor Ewart, with this object in view.

The condition of the shore fisheries is also demanding attention. In a paper in last year's Report§ on the *Scottish Lobster Fishery* it is shown by Professor Ewart and the writer, that the numbers of this crustacean are rapidly diminishing, and that there is a corresponding reduction in the average size of those taken.

The best modes of preserving fish have been made the subjects of exhaustive investigation by Professor Ewart, but as this is closely

* Fifth Report, p. 82, *et seq.*, 1887.

† Sixth Report, pp. 95—188, 1888.

‡ The Scottish Mussel Fishery. J. C. Ewart. Edin., 1888.

§ Sixth Report, Part iii, p. 189.

linked with certain scientific researches referred to below it will be better to consider them together.

The Report for 1885 contains a short paper by Mr. Wilson, the Fishery Officer of the district, on the *Fisheries of the Solway Firth*;* a similar paper on *The Fishing Grounds of the Stonehaven District*, by Mr. J. Murray, is given in last year's Report;† Professor Stirling, of Owens College, has a suggestive paper in the Report for 1885 on *Some Economic Products from Fish*,‡ a subject which deserves far more attention in this country than it has yet received; and in the Report for 1886 Mr. C. E. Fryer, Inspector of Fisheries for England and Wales, furnishes an account of much practical value on *The Preparation of Sprats and other Fish as Sardines*.§

Biological Investigations.

One of the earliest questions which engaged the attention of those conducting the scientific investigations was the natural history of the herring. Several papers have appeared in the annual reports on this subject. In that for 1886 there is a long and elaborate memoir by Mr. Duncan Matthews *On the Structure of the Herring and other Clupeoids*,‖ which is illustrated with four plates, and contains the fullest description of the skeleton of the herring which has yet appeared. The skeletons of the shad, the pilchard, and the sprat are also described. It is scarcely possible to give an abstract of this paper, which consists of minute descriptions of every part of the skeleton; but it forms a valuable contribution to the osteology of the Teleostean fishes. In the Reports for 1885 and 1886 Mr. Matthews has given the first and second parts of a report dealing with the question of *Variety among the Herrings of the Scottish Coasts*.¶ These papers embody the results of the examination and measurement of a very large number of herring from both the east and west coasts in winter, spring, and summer, and some idea of the extent and minuteness of this research may be obtained when it is stated that about 16,000 measurements were made. A large number of Tables are included in the report, giving the ratios of the positions of the fins, the relative length of the body and head, the

* Fourth Report, p. 255, 1886.

† Sixth Report, p. 223, 1888.

‡ Fourth Report, pp. 256—260, 1886.

§ Fifth Report, pp. 218—221, 1887.

‖ Fifth Report, Appendix F, pp. 257—292, pls. xv—xviii, 1887.

¶ Fourth Report, Append. F, pp. 61—98, 1886; Fifth Report, Append. F, pp. 295—316, 1887.

number of fin-rays, &c. The general conclusions of the author are: (1) That there is no true racial distinction between the herrings at different parts of the Scottish coasts; (2) That the only difference in favour of a distinction between the summer and winter herring consists in the more posterior position of the dorsal, pelvic, and anal fins, the doubtfully smaller head, and the slightly lesser size of the summer herring; but although this holds for the majority of each season, all the extremes of every variation are repeated among the herrings of both seasons.

In the Report for 1883 Mr. Matthews gives the results of his investigations into the *Difference between Herrings and Sprats.** Considerable differences existed among the specimens of each species examined. Various external differences are described, such as the general shape and curve of the body, the position of the operculum and suboperculum, the length of the jaw, &c. These variations are, however, slight and not always easily detected. The best distinctions are the position of the fins and the presence or absence of ventral serration. The scales of the ventral margin have the posterior termination of the median keeled portion sharp and projecting in the sprat, and scarcely developed in the herring. The number of these scales also differs in the young herring and sprat, as does also the number of the scales of the lateral line (fifty-six to fifty-eight in herring and forty-eight in sprat) and the transverse scales (sixteen and eleven or twelve respectively). In the sprat the pelvic fin is anterior to the first ray of the dorsal, but posterior in the young herring. The variations in the position of the other fins is considerable but inconstant; and the number of rays in the fins varies, except in the pelvic, which has seven in the sprat and nine in the herring. Mr. Matthews states that the distinction based upon the presence of vomerine teeth in the herring and their absence in the sprat is difficult to determine in practice. The chief internal or structural differences are: (1) forty-eight vertebræ in the sprat and fifty-six in the herring; (2) a less number of gill rakers and branchial filaments in the sprat; (3) seven or eight pyloric cæca in the sprat, and eighteen to twenty-four in the herring, and they are differently arranged; (4) in the herring each of the two anterior ducts passing forwards from the swim bladder to the head becomes spindle-shaped and bifurcates, each tubular bifurcation terminating at the ear in a spherical capsule, but in the sprat the spindle-shaped dilatation and subsequent bifurcation are absent. Thus there are four anterior spherical capsules in the herring and only two in the sprat. The most certain distinction, of course, is the presence of ripe milt or roe in the sprat. In winter the reproductive organs in young herrings

* Second Report, Append. F, pp. 48—60, pl. iii, 1884.

and sprats could not be differentiated, but about March in many sprats they were larger, and in June the sprats were nearly all "full" and ripe, while the specimens identified on the above characters as young herring showed no signs of increasing maturity, even when eight inches long. The spawning of the sprat thus occurs in May and June on the east coast of Scotland.* The largest sprat obtained by Mr. Matthews was six inches, the smallest one and three quarter inches, the average size being four to four and a half inches.

The intermixture of sprats with shoals of young herrings, and the great destruction of the latter by sprat fishers, are then discussed. The proportion of young herrings varied from 3 to 80 per cent. In the winter sprat fishing of 1883 along the east coast of Scotland close upon 150,000,000 young herrings were taken by sprat fishers, 98 per cent. of the total being used as manure.

I may here refer to a paper in the Fourth Report, *On the Nature of Thames and Forth Whitebait*, by Professor Cossar Ewart and Mr. Duncan Matthews.† The question whether "whitebait" forms a distinct species of *Clupea* has been often discussed. The authors, after referring to the diverse views held on this subject at various times, give the results of an examination of several thousand specimens of whitebait. Of about 6000 from the Thames, procured in monthly samples between February and August, almost every individual was either a young herring or a young sprat. The percentage of sprats varied from 95 in March to 13 in June. In the Forth the percentage of sprats was 99·5 in the winter. In both the Thames and Forth samples less than 1 per cent. consisted of other small fish, such as gobies and sand launces. In the Report for 1882 Professor Ewart published a paper on the *Natural History of the Herring*,‡ dealing with the supposed existence of varieties, the migrations, the character of the spawning ground, and the spawning process, and describing the artificial fertilization and hatching of herring ova. In regard to the first point it is shown that there is as much difference between specimens caught at the same time and place, as between the spring and autumn varieties of the Baltic herring, established by Heincke. The migrations of the herring and the causes most likely to influence them are discussed. The most important part of the paper deals with the spawning of the herring. The famous spawning grounds at Ballan-

* This agrees with the observations of Dr. Hensen, of the Kiel Commission, who has also shown that the herring and sprat differ markedly in the mode of depositing their ova. In the sprat the eggs are translucent, dispersed and buoyant, floating freely in the water. (*Vide* Fünfter Bericht der Kommis. z. wissenschaft. Untersuchung d. deutschen Meere, p. 40, 1887.)

† Fourth Report, Append. F, pp. 98—100, 1886.

‡ Second Report, Appendix F, pp. 61—72, pls. iv—ix, 1884.

trae were surveyed, and the spawn was found in greatest abundance in the hollowed gravel-covered areas, where for many square yards it formed a layer nearly half an inch thick. The depth at the banks is from seven to thirteen fathoms, while around it, where the bottom is muddy or sandy, it is about twenty fathoms. The relations of salinity and temperature are described, and it is shown that a probable cause of the desertion of spawning grounds may sometimes be the loss of full trammel nets, which were found during the survey filled with putrefying fish. The spawning process, and the mode of fertilization, are fully described. It is shown that while the great spawning periods are spring and autumn, spawning goes on to some extent in nearly every month of the year. It is not known how long herring frequent the banks before spawning begins, but they probably remain several days after its commencement; and the males longer than the females. The appearance of the spawn as naturally deposited is described; by transferring ripe herring to the tanks in the Rothesay Aquarium, the whole process of spawning was fully studied, and a number of experiments were made as to the influence of currents, light, &c. Professor Ewart artificially fertilized and hatched herring ova, hatching occurring in from eighteen to twenty-two days; a full account of the process is given, and of the habits of the liberated fry.*

In the Report for 1884, and in that for 1885, Mr. George Brook gives an account of his investigations *On the Development of the Herring*.† The first part consists of a *résumé* of what was already known on the subject, with especial relation to the labours of Kupffer, several of whose figures are reproduced. Kupffer's paper, *Ueber die Entwicklung des Herings im Ei*, is discussed *seriatim* chapter by chapter, notes from other papers being added. In the second paper the results of the investigations carried on at the Rothesay Aquarium with artificially fertilized ova are described. The retention of vitality by sperms and ova after the death of the adult is discussed, and a full description of the developmental phenomena is given.

In the Report for 1885, Professor Ewart gives an account of experiments carried on as to the *Development of Herring Ova in Deep Water*,‡ a subject of importance in relation to offshore fishing banks. Herring may spawn normally on the gravel-coated grounds in the North Sea in water from 60 to 100 fathoms deep; but these banks have never been well examined or surveyed. Professor Ewart

* See also a paper *On the Natural and Artificial Fertilization of Herring Ova*, by J. C. Ewart, M.D., Proc. Roy. Soc., London, 1884.

† Third Report, pp. 32—50, pl. i, 1885; Fourth Report, pp. 31—41, pls. i, ii, 1886.

‡ Fourth Report, pp. 43—46, 1886.

experimentally proved that artificially fertilized ova can be hatched in water 98 fathoms deep, although the process is slower than in shallower water, and that the fry would have no difficulty in reaching the surface waters.

In the same Report there is a paper by Mr. Brook *On the Herring Fishery of Loch Fyne and the Adjacent Districts during* 1885.* Many questions connected with this fishery are discussed, —the migration of the herring, its food, spawning times and places, &c. It is stated that there are probably at least two migratory races of the herring in the Firth of Clyde.

There are several papers dealing with the food of fishes. In the Report of 1885 the result of the inquiries into the food of the herring, haddock, and cod are given by Mr. Brook and Mr. W. L. Calderwood,† and in the Report for 1886 the food of the whiting is described by Mr. Duncan Matthews‡ and that of *young Gadidæ* by Mr. Brook.§ In the Sixth Report there is a paper by Mr. Thomas Scott on the *Food of the Herring and Haddock.*‖ In regard to the *herring* the researches show (1) that the nature of the food varies considerably in different districts and in different seasons; (2) that although it is probable that during the spawning time very little or no food is taken, such abstinence does not appear to be confined to the spawning season; (3) that on the east coast most food is taken in winter and spring, and on the west coast in summer. The food comprises almost all of the smaller pelagic organisms; and hence a study of the food of a widely distributed fish like the herring may furnish a clue to the relative abundance and distribution of the pelagic Fauna at different times of the year, on the assumption that the fish does not exercise much selection. On the east coast the chief food during winter and spring is furnished by *Hyperia galba* (a rare species on the west coast), especially in the region lying between the Firths of Forth and Cromarty. Two Schizopods supply a large amount of the herring's food, namely, *Nyctiphanes norvegica* and *Boreophausia Raschii*. On the east coast *Nyctiphanes* gradually replaces *Hyperia* after February, and it is most abundant in those areas where *Hyperia* is most scarce; on the west coast it is widely distributed, the Schizopods forming the main diet of the herring during winter. Copepoda furnish the chief food during summer, especially on the west coast, and notably in Loch Fyne, but in autumn they are gradually replaced by Schizopods. Ostra-

* Op. cit., pp. 47—61.

† Fourth Report, pp. 100—147, 1886.

‡ Fifth Report, pp. 317—325, 1887.

§ Op. cit., pp. 326, 327.

‖ Sixth Report, Part iii, p. 225, 1888.

cods and embryo molluscs were rare, larval Decapods frequent, and *Sagitta* was abundant on the east coast in winter. At certain times and places the food consists largely of sprats or of the ova or young of the herring. On the north-east coast sand-eels form a fair proportion of the herring's food.

The food of the *haddock* was found to consist chiefly of Echinoderms, especially the common brittle-star (*Ophiothrix pentaphyllum*), but Asteridea were very rare. Crustacea came next, principally Anomura (*Pagurus, Galathea*), but also Brachyura (particularly *Hyas coarctatus*), Macrura and Amphipoda. Only one species of Cumacea and one of Isopoda were obtained. Twenty-one species of Mollusca were identified, almost all being young. Annelids were well represented, especially *Aphrodite* and others of the Errantia group, and Hydrozoa occasionally occurred. In eight stomachs of the ninety examined, fish remains were found, and herring ova in four, three being full of them.

About 300 stomachs of *cod* were examined, almost all from the east coast, and representing a period from January to June inclusive. These investigations demonstrate the great voracity and gastronomic impartiality of this fish. In one part of a sea-fowl was found, in another the whole of a lark. In 247 stomachs the remains of fish were found, chiefly haddock, young flat-fish (mostly flounders), herring, and whiting; in 184 there were Crustacea, almost exclusively Decapods, especially *Hyas coarctatus, Pagurus Bernhardus,* and *Crangon Allmanni*; in sixty-seven Annelids were present (*Aphrodite*); in forty molluscs, of which ten species, including *Eledone cirrosa*, were identified. From thirty stomachs the remains of Echinoderms were obtained, the brittle star, as in the haddock, forming the greater proportion, but no Asteroids occurred. The general conclusions in regard to the food of the cod are thus stated: (1) The cod feeds chiefly and constantly on Crustacea, Gadidæ, and Pleuronectidæ; (2) *Aphrodite* forms an important part of the food in the spring and summer in districts where this form is plentiful; (3) in the winter the cod is attracted to our shores by the large shoals of herring seeking their spawning ground, and at this time herring and herring ova form the staple food material; (4) Echinoderms and Mollusca do not contribute an important part of the food supply; (5) the cod feeds much more on fish and much less on Echinoderms than is the case with its ally the haddock.

Of the *whiting*, 400 stomachs were examined, obtained mostly during autumn and winter, and from the east coast. The food of the whiting is almost limited to small fish and Crustacea; no Echinoderms were found, and of molluscs only a few fragments of the common mussel, probably nibbled from the hooks of line fishermen.

The Crustacea (found in 53 per cent. of the stomachs) were almost wholly confined to shrimps and prawns, but they were not quite so abundant as the small fish (in 57 per cent.), chiefly young cod and haddocks and sprats. The above papers contain a large number of Tables giving full details.

The food of *young cod and saith* (which were found frequenting the *Zostera*-beds in Loch Fyne in enormous numbers) was investigated. In the case of the young cods—measuring from one and a quarter to three inches in length—the smaller specimens contained almost nothing but Copepods, and the larger ones also Amphipods, Mysidæ and Isopods. The stomachs of the young saith (two and a half to five inches long) contained Copepods, *Sagittæ,* young Gasteropods, Amphipods, Schizopods, and Isopods.

In the Report for 1884 there is a paper by Professor Ewart and Mr. Brook on the *Spawning of the Cod** in which an account is given of the natural process as observed in the tanks at the Rothesay Aquarium, and of experiments which were conducted in artificial fertilization. It appears that the process of spawning occurs chiefly at dusk and in the early morning, the spawn being shed while the fish are freely swimming about, and fertilized as they rise towards the surface.

Tables giving the *Spawning Period of the British Food-fishes,* compiled by Mr. Brook from various sources, will be found in the Report for 1885;† and an account of the *Spawning of the Pike,* by the same author, in the Report for 1886.‡

The *Artificial Hatching and Rearing of Sea-fish,* is dealt with by Professor Ewart in a paper in the Report for 1886.§ The fundamental problems connected with this subject are discussed in the light of the knowledge acquired by the culture of the Salmonidæ, and the operations which have been carried on in the United States, Norway, and Germany, in the cultivation of edible fish. Various apparatus for the hatching and rearing processes are described and figured; and it is pointed out that by systematic hatching and rearing of marine forms, such as the more important flat-fishes, lobsters, &c., a great deal might be done to recruit the inshore fisheries. Professor Ewart also contributed a *Report on the Progress of Fish Culture in America* to the Report for 1884,|| which contains a full account, based upon personal observation, of the methods adopted in the United States and of the results accomplished up to 1884.

* Third Report, pp. 52—55, 1885.

† Fourth Report, pp. 242—254, 1886.

‡ Fifth Report, pp. 347—349, 1887.

§ Op. cit., pp. 230—244, pls. vii—x, 1887.

|| Third Report, pp. 78—91, 1885.

In the Report for 1883, Professor Stirling gives a paper on the *Chemistry and Histology of the Digestive Organs of Fishes*,* which contains an account of the digestive processes in the herring, cod, haddock, and skate, and of the histology of the alimentary tract of the herring. The reactions of the various parts of the digestive canal were found to agree with those in mammals. In the herring peptic extracts were obtained from the stomach; a stronger one from the crop or "cardiac sac," and a weaker one from the gizzard-like "pyloric sac." The pyloric appendages yielded a tryptic ferment, *i. e.* were pancreatic in function, and they probably also secrete a diastatic ferment. The bile was neutral or faintly alkaline and contained a diastatic ferment. In the cod and haddock the gastric extract was purely peptic; trypsin was present in the pyloric appendages, and the bile contained a diastatic ferment. In the skate also pepsin was demonstrated in the stomach, a diastatic ferment in the bile, and glycogen and sugar in the liver. The histology of certain portions of the digestive tract in the herring is fully described.

The results of an elaborate research by Professor Ewart into the phenomena of *rigor mortis* in fish, and its relation to putrefaction,† and of another on the presence of bacteria in living fish,‡ have been recently published. In the former the gradual onset of rigor, the conditions which accelerate or retard it, and its relation to the subsequent processes of putrefaction, are set forth in detail, and a large number of experiments are described. In the latter the occurrence of bacteria in the blood and tissues of living fresh-water and marine fish is described; the causes and results of their presence being considered. In a third paper,§ Professor Ewart goes fully into the practical consequences of these researches, and gives the results of his researches into the action of various reagents and processes in the preservation of fish, together with many details and suggestions as to the best mode of applying them in practice.

Professor Stirling, in the Report for 1885, furnishes a paper on the *Red and Pale Muscles in Fishes*.|| After summarising our knowledge concerning the dark and pale muscles in animals belonging to various groups, and referring to the anatomical disposition of the muscles in an osseous fish, the arrangement and microscopical appearance of the red and pale muscles in the herring, whiting, mackerel, haddock, and plaice are described.

Dr. W. D. Halliburton, in the same Report, gives the results

* Second Report, pp. 31—46, pls. i, ii, 1884.

† Proc. Roy. Soc., vol. xliii, p. 438, 1887.

‡ Proc. Roy. Soc. Edin., 1887.

§ The Preservation of Fish, London, 1887.

|| Fourth Report, pp. 166—170, pls. iii—v, 1886.

of an investigation on *The Blood of* Nephrops norvegicus.* The appearance and properties of the blood when shed, the process of coagulation, the composition, the proteids of the plasma and serum, and the nature of the colouring matters are described in detail.

In the Reports for 1885 and 1886, Mr. John Wilson furnishes an account of his studies on *The Development of the Common Mussel.*† The reproductive organs, spermatozoa, and ova are described ; the method adopted for artificial fertilization explained ; and, especially in the second paper, a full account of the development of the embryo, so far as observed, is given.

In a series of papers read before the Royal Society, Professor Ewart has given the results of his investigations into the structure and development of the curious electric organs in the skate.

The first‡ deals especially with the development of the organ in the common skate, each step in the process of the conversion of simple muscular fibres into the highly complex electric discs having been followed. The development of the discs is very fully explained. In a second paper§ the electric organ of *Raia circularis* is fully described and compared with the corresponding organ in other species. In another paper|| the structure and development of the electric organ in *Raia radiata* are explained in detail and compared with the organs in *R. batis* and *R. circularis,* and the author shows that the less complex structure of the organ in *R. radiata* must be looked upon as evidence that it is in a state of progressive development rather than in a stage of degeneration.

Mr. R. D. Clarkson contributes a paper to the Report for 1886, *On the Nutritive Value and Digestibility of Fresh Fish,*¶ which contains a review of what has been done on this subject, the labours of Atwater, Chittenden, and others being discussed. It would appear, from the variation in the methods employed by different investigators and the diversity of the results obtained, that there is much yet to be done on this subject.

Scattered throughout the Annual Reports are several papers dealing with the marine Fauna of special localities.

Mr. W. L. Calderwood has given a list of the Copepoda obtained in Loch Fyne, with brief descriptions of each species.** Twenty-eight species were collected by the tow-net, ten belonging to the

* Op. cit., pp. 171—176, 1886.

† Op. cit., pp. 218—222, 1886 ; Fifth Report, pp. 247—255, pls. xii—xiv, 1887.

‡ Phil. Trans., vol. 179, p. 399, 1888.

§ Op. cit., p. 410.

|| Phil. Trans., vol. 179, p. 539.

¶ Fifth Report, pp. 221—229, 1887.

** Fourth Report, pp. 147—154, 1886.

Calanidæ, fifteen to the Harpacticidæ, two to the Artotrogidæ, and one to the Cyclopidæ. The list has been since extended.

In the same report the Rev. Canon Norman supplies descriptions of *A Crangon, some Schizopoda, and Cumacea new to, or rare in, the British Seas.** A new species of Schizopod (*Siriella Brooki*) from Loch Fyne is described. Species here first recorded as British are : *Crangon* (*Cheraphilus*) *neglectus*, G. O. Sars; *Erythrops pygmæa*, G. O. Sars; *Mysidopsis gibbosa*, G. O. Sars; *Leptomysis lingvura*, G. O. Sars; *Siriella Clausii*, G. O. Sars; *Lamprops fasciata*, G. O. Sars; *Diastylis rugosa*, G. O. Sars; *Pseudocuma cercaria* (van Beneden). All were obtained in Loch Fyne.

Also, in the Fourth Report, there is a *List of the Marine Fauna collected at the Tarbert Laboratory* (*Loch Fyne*) *during* 1885,† by Mr. Brook and Mr. Scott. This list includes fifty-seven species of fishes, 147 species of Mollusca, 127 species of Crustacea (exclusive of Amphipods), twenty-three species of Echinoderms (exclusive of Holothurians), and forty species of Foraminifera. Those which are known to furnish food to fishes are specially indicated.

Dr. Brady, in the Report for 1886, supplies *Notes on Entomostraca.*‡ A list of fifteen Ostracoda is given, including a new variety (*Cypris virens*, var. *monilifera*, nov.) and a form (*Cypris Browniana*, Jones) previously known only in the fossil condition. In describing the occurrence of *Peltidium purpureum*, Philippi, for the first time in British seas, Dr. Brady points out that this species is not synonymous with *Peltidium depressum*, Baird (as it was doubtfully made in his classical Monograph on the British Copepoda), but that the two species are separated by characters of generic importance. Hence the three species referred to *Peltidium* in the monograph must henceforth take Baird's generic name, *Alteutha*. A full definition of the genus *Peltidium* is given.

In the Report for 1887, Dr. Brady gives a description and figures of a new Copepod, *Cyclops Ewarti*;§ and Mr. Thomas Scott of another, *Artotrogus papillatus*.‖ Mr. Scott also furnishes a *List of the Crustacea of the Firth of Forth*,¶ by far the fullest yet published, several species new to Britain being described.

Mr. W. L. Calderwood, in the Report for 1885,** contributes *Notes on the Greenland Shark* (*Læmargus microcephalus*), em-

* Op. cit., pp. 155—166.
† Op. cit., pp. 231—242.
‡ Fifth Report, pp. 328—330, pl. xix, 1887.
§ Sixth Report, p. 232, pl. viii, 1888.
‖ Op. cit., p. 232, pl. viii.
¶ Op. cit., p. 235.
** Fourth Report, pp. 228—231, pl. x, 1886.

bodying the results of his dissections of two specimens. The same gentleman, in last year's Report, furnishes *Notes on an Intra-uterine Specimen of the Porbeagle.**

A *Note on the Ova, Fry, and Nest of the Ballan Wrasse* (*Labrus maculatus*), by Mr. Duncan Matthews, appeared in the Report for 1886.† The very curious nests of this species, the ova, and the appearance and remarkable habits of the embryo, are carefully described.

Descriptions of new or rare fishes, which have been obtained by the Fishery Officers or otherwise, have been given from time to time. Thus a new British blenny (*Lumpenus lampretiformis*) has been described and figured by Dr. Francis Day;‡ and *Torpedo nobiliana, Rhombus maximus,* and *Lampris luna* have been described, and the two first figured by Professor Ewart.§ Among the rarer fishes obtained may be mentioned *Carelophus ascanii* (Walb.); *Ctenolabrus rupestris,* L.; *Centrolabrus exoletus,* L.; *Motella cimbria,* L.; *Zeugopterus unimaculatus* (Risso)—which is figured—*Pristiurus melanostomus* (Raf.), &c.‖ Mr. Brook gives an account of the remarkable chromatic changes in the Dragonet (*Callionymus lyra*).¶

Several papers have appeared in the Reports dealing with pathological conditions in fish, and with the presence of micro-organisms in river-water.

Dr. Barret gives *A Note on the Liver of a Haddock, in which a Sand-eel was partly Embedded,*** describing the naked-eye and microscopic appearances; and Dr. Woodhead gives an account of *Caseous Tumours found in the Muscles of the Hake.*††

There are three papers by Professor Greenfield (who was assisted in this research by Dr. Griffiths, Dr. Woodhead, and Dr. J. Gibson), *On the Examination of River-Waters for Micro-organisms.*‡‡ The object of this investigation was to discover and describe the various forms of minute fungi, and especially bacteria, which are present in river water, and which form an important factor in its impurity in relation to fish life. Specimens of water from important salmon rivers such as the Tweed, the Dee, and the Tay, were examined. Full details are given as to the methods adopted in

* Sixth Report, Part iii, p. 263, 1888.
† Fifth Report, pp. 244—247, pl. xi, 1887.
‡ Second Report, p. 78, pl. x, 1884.
§ Op. cit., pp. 79, 80, pls. xi—xiii.
‖ Fourth Report, pp. 222—227, pl. ix, 1886.
¶ Third Report, p. 68, 1885.
** Op. cit., p. 70, with three plates.
†† Op. cit., p. 76.
‡‡ Op. cit., pp. 73—76; Fourth Report, pp. 176—188, 1886; Fifth Report, pp. 331—347, 1887.

obtaining the samples and in carrying on the research, and a large number of micro-organisms are described.

The results of a bacteriological investigation of "red" cod, by Dr. Alexander Edington, are given in the Report for this year,* and a *Note on the Nature of Red Cod*, by Professor Ewart.†

In each Annual Report Prof. McIntosh has supplied a number of brief but interesting notes dealing with a great variety of topics concerning marine life, such as the ova, development, and young of fishes, the diseases of fishes, new or rare forms, &c. These notes are, as a rule, so brief and numerous that it is not possible to make an abstract of them. In this year's Report Prof. McIntosh refers to the use of Annelids as bait, and shows how pressing the question of bait is becoming.

PHYSICAL INVESTIGATIONS.

The investigation of the physical conditions of the sea forms an important part of the scientific work connected with fisheries. It is not, however, always easy to carry on such inquiries as thoroughly as might be desired, for it is a matter of great importance that they should be continuous, and conducted at as many points as possible. The measures adopted by the Fishery Board have consisted (1) in utilising as far as possible the fishery cruisers in the service of the Board; (2) in instituting special cruises to investigate the physical conditions of particular areas; (3) in carrying on series of observations on board the "Garland" during the trawling experiments. The data supplied from the first source have not as yet been published, owing chiefly to want of space for the extensive Tables; the "Garland's" observations have been given in the Tables in connection with the trawling reports, and the investigations into particular areas are referred to below. The system of physical inquiries is now in process of reorganisation, and it is to be hoped that it may be found possible to carry on continuous observations at several parts of the Scottish coast. Arrangements have been completed with the Northern Lighthouse Board by which daily observations on the temperature and density of the sea will be recorded by the officers on board the lightships and at the various lighthouse stations in the area embracing the estuary of the Tay, St. Andrew's Bay, and the Firth of Forth. Since this area includes that in which the principal biological investigations are going on,

* Sixth Report, p. 207, pls. vi, vii, 1888.

† Op. cit., p. 204.

and is from its conformation and the position of the observing stations singularly well adapted for obtaining data to bring the phenomena of atmospheric meteorology and marine physics into relationship with those of marine life, these observations will furnish very valuable results.

In 1883 special physical work was carried on by Dr. Gibson during a cruise of the "Jackal" in the Moray Firth. The methods and results are given in the Report for 1883,* the paper being illustrated by a chart; several Tables showing the temperature, the density, and the ratio of total halogen to density at different depths at the various stations. In 1886, during a cruise of the "Garland" in the Moray Firth, physical observations were made by Dr. Gibson and Dr. H. R. Mill, who has done so much in the study of marine temperature. The results of these investigations are embodied in two papers in last year's Report,† which are illustrated by four plates and furnished with many Tables. In the same Report there is a paper by Drs. Mill and Gibson describing the apparatus required for marine physical observations;‡ and another by Dr. Mill (illustrated by a chart and two plates) dealing with the physical conditions of the sea to the west of Lewis.

To the Report for 1886 Dr. Mill contributed a paper *On the Physical Condition of the Firth of Forth*,§ which is accompanied by a Table giving the density, salinity, and alkalinity of the water, three plates showing the curves of salinity and temperature, and a large bathymetrical chart.

During September last H.M.S. "Jackal" was engaged in a cruise of physical investigations, under the charge of Dr. Gibson, along the east coast of Scotland, and across the North Sea to Bergen and Copenhagen. A large number of stations were formed, at which vertical series of temperature, density, and alkalinity observations were made, the gaseous constituents determined, and samples of water collected for analysis.

* Fourth Report, pp. 189—201, pls. vi, vii, 1886.
† Sixth Report, Part iii, pp. 313—347, pls. xi—xiv, 1888.
‡ Op. cit., pp. 309—312, pls. ix, x.
§ Fifth Report, pp. 349—354, pls. xx—xxiii, 1887.

NOTES AND MEMORANDA.

The Vernacular Names of Common Fishes.—If confusion is to be avoided it must be borne in mind that very often a vernacular name is applied to a different species at almost every different fishing port. The following analysis is intended to show the applications of vernacular names which have come within my own experience or reading.

Names used by Plymouth Fishermen.

Acanthopteri:

Capros aper	Cuckoo.
Trigla lyra	Piper.
Trigla hirundo	Tub.
Trigla cuculus	Red gurnard.
Trigla gurnardus	Grey gurnard.
Zeus faber	John Dorey.
Pagellus centrodontus	Bream (when young, Chad).
Pagellus erythrinus	Snapper.
Labrax lupus	Bass.
Caranx trachurus	Scad.
Callionymus lyra	Miller's thumb.
Atherina presbyter	Smelt.

Anacanthini:

Rhombus maximus	Turbot.
Rhombus lævis	Brill.
Solea vulgaris	Sole.
Solea variegata	Thickback.
Pleuronectes microcephalus	Merry sole.
Pleuronectes platessa	Plaice.
Pleuronectes flesus	Flounder.
Pleuronectes limanda	Dab.
Arnoglossus megastoma	Megrim.
Arnoglossus laterna	Scald-back or scald-fish.
Gadus morrhua	Cod.
Gadus æglefinus	Haddock.
Gadus pollachius	Pollack.
Gadus merlangus	Whiting.
Gadus luscus	Pouting or whiting-pout.
Merlucius vulgaris	Hake.
Molva vulgaris	Ling.

Physostomi.

Conger vulgaris	Conger.
Clupea pilchardus	Pilchard.
Clupea harengus	Herring.
Belone vulgaris	Gar-fish.

The technical names given above are in all cases those used by Day in his Fishes of Great Britain and Ireland, 1880—1884.

The following are the names given by Yarrell for some of the species where vulgar nomenclature is the most uncertain.

Names given by Yarrell, British Fishes, 1836.

Species.	*Name preferred.*	*Synonyms given.*
Pleuronectes microcephalus	Lemon dab, or smooth dab	Smear-dab; sandfleuk, *Edinb.*; town dab, *Hastings*; Mary sole, *Devonshire.*
Arnoglossus megastoma	The whiff	Carter, *Cornwall.*
Arnoglossus laterna	The scaldfish	Megrim, *Cornwall*; smooth sole.
Solea lascaris	Lemon sole	French sole, *Sussex coast.*
Solea variegata	Variegated sole.	
Atherina presbyter	Atherine or sandsmelt.	

With these may be compared the vernacular names given by Couch.

Names given by Couch in his Fishes of the British Islands, 1864.

Species.	*Name preferred.*	*Synonyms given.*
Pleuronectes microcephalus	Smear dab	Lemon dab, lemon sole, queen, smooth dab.
Arnoglossus megastoma	Carter	Mary sole, queen's sole ?, lanthorn fish, whiff.
Arnoglossus megastoma	Sail fluke (described as a distinct species).	
Arnoglossus laterna	Megrim	Scald-fish.
Solea lascaris	Lemon sole	Sand-sole.
Solea variegata	Variegated sole	Thickback, bastard sole, red-backed sole.
Solea minuta	Solenette	Little sole.
Atherina presbyter	Atherine	Smelt, sand smelt, guid (meaning white) *in W. Cornwall.*
Gadus luscus	Bib	Whiting pout, blens, blinds.

As will be seen from the above, *Pleuronectes microcephalus* is a species whose vernacular name is highly variable. In Plymouth I have never heard it called by any other name than "merry sole;" this is obviously the same as "Mary sole," which Yarrell says is applied to it in Devonshire, and by which it is known on the West Coast of Ireland (Co. Kerry). In the neighbourhood of the Firth of Forth this fish is invariably called the "lemon sole," a name for it which is mentioned by Couch. In London also it is sold under this name. Plymouth fishmongers sell *Arnoglossus megastoma* as the lemon sole, while the fishermen of that port always call it the "megrim."

Couch gives the name Mary sole to *Arnoglossus megastoma* and megrim to *A. laterna*. As he lived at Polperro it is possible that the names are used there as he gives them, for I am informed by Mr. Dunn, of Mevagissey, that the names are applied there in quite a different way from that in which they are used at Polperro. At Mevagissey, according to Mr. Dunn, the name megrim is quite unknown, and the two species of *Arnoglossus* are called, "carter" and "scaldfish," or either of them may be called the "lanthorn;" the *Pl. microcephalus* is called the "butter-fish," but lately a few call it the "merry sole," this name having apparently been recently introduced from Plymouth. The name lemon sole appears to be confined to *Solea lascaris*. It is noticeable that both Yarrel and Couch assert that *Arnoglossus laterna* is called the megrim in Cornwall, although it is quite certain that among Plymouth fishermen megrim always means *A. megastoma*. But Couch alone ascribes the name Mary sole to *A. megastoma*, and as both Yarrell and Plymouth custom agree in giving this name to *Pl. microcephalus* perhaps Couch made a mistake.

Two flat-fishes which are common on the Scottish coasts seem to be entirely absent from the coasts of Devon and Cornwall; at least I have not yet met with a specimen of either. These are *Pleuronectes cynoglossus* and *Hippoglossoides limandoides*. The former is called the "witch," the latter the "long rough dab," on the shores of the Firth of Forth, while the former is usually called the "pole flounder" by British naturalists.

All the fishes I have given in the list of names used by Plymouth fishermen have a value in the market as food with four exceptions, namely, *Capros aper*, *Callionymus lyra*, *Arnoglossus laterna*, and *Caranx trachurus*.

The Netherlands Zoological Station.—Professor A. A. W. Hubrecht has kindly furnished some particulars relative to the history and work of this institution. The Netherlands Zoological Association recognised in 1875 the necessity of having an establishment on the Dutch coast suitable for anatomical and microscopical investigation of marine Fauna and Flora. A Committee was appointed to take the steps necessary for realising this scheme, but reported early in the following year that a suitable locality was not to be had in those places on the Dutch coast where a zoological station might be built with a prospect of success, and that the funds at the disposal of the Association did not permit of a permanent building being erected on a suitable scale. Accordingly, it was determined, on the recommendation of the committee, which consisted of Drs. Hoffmann, Hoek, and Hubrecht, to purchase a movable wooden building which might be transported every season to such a locality as might be deemed desirable. The necessary funds were raised by public subscription, and in July, 1876, the station was placed for the first time on the great dyke near the seaport of Helder, opposite to the island of Texel. The work was continued for eight weeks, and was greatly assisted by a small steamer lent for the purpose by the Minister of Marine. Since this date the station has been erected at different points of the Dutch coast, such as Welfzyl, Terschelling, Nieuwe Diep, Flushing, Bergen op Zoom, Tholen, and this year at Enkhuiren on the Zuyder Zee. The original object of the station was purely scientific, and it stood at its commencement in no official relation to the Netherlands Fishery Commission, although the latter body from the first gave it encouragement and supported its applications for Government aid. Before long, however, the services of the skilled naturalists who directed the station were requisitioned for practical purposes, and in 1881, '82, and '83 elaborate investigations on the life-history and development of the oyster were undertaken by the Zoological Station, and the results were published in a separate volume under the title Recherches sur l'huitre et l'Ostreaculture, Leiden, 1883–4.

In 1886 the Association was brought into closer relations with the Government, being entrusted with the disposal of a grant from the funds of the Fisheries Commission, which was spent in the investigation of the life-history and development of the anchovy (*Engraulis encrasicholus*). The results of this investigation were published in the report of the Fisheries Commission for 1886, and included Wenckebach's account of the anchovy.

Recently the Netherlands Government has appointed Dr. P. P. C. Hoek as scientific investigator of the Fisheries, his duties being to investigate such fishery problems as may be brought under his notice by the Fisheries Commissioners. Dr. Hoek was from the foundation of the Zoological Station one of its most active members, and secretary of the managing committee, and on his appointment the Netherlands Zoological Society, the founders and owners of the marine station, placed the transportable building with its inventory and apparatus at the service of the newly-constituted official, on the condition that its members should always have access to the working tables and should enjoy such facilities as the naturalist might be able to afford them. Now that a definite relation between the Fisheries Commission and the Marine Station has been established, it is hoped that a permanent building may be erected, probably at Nieuwe Diep, and that the scientific knowledge of the Dutch

Fisheries may with its help be greatly increased. In the meantime the scientific work of the Dutch Station has been, considering its limited accommodation, remarkable. Although inconvenient in some respects a movable station has the great advantage of enabling the naturalists working in it to extend their researches over a wider area, and to study more perfectly the distribution of marine animals along the coast. The reports of the work done at the station have appeared yearly in the Dutch language.

OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

THE ASSOCIATION was founded at a Meeting called for the purpose in March, 1884, and held in the Rooms of the Royal Society of London.

Professor HUXLEY, the President of the Royal Society, took the chair, and amongst the speakers in support of the project were the Duke of ARGYLL, Sir LYON PLAYFAIR, Sir JOHN LUBBOCK, Sir JOSEPH HOOKER, the late Dr. CARPENTER, Dr. GÜNTHER, the late Lord DALHOUSIE, Professor MOSELEY, Dr. ROMANES, and Professor LANKESTER.

The Association owes its existence and its present satisfactory condition to a combination of scientific naturalists, and of gentlemen who, from philanthropic or practical reasons, are specially interested in the great sea fisheries of the United Kingdom. It is universally admitted that our knowledge of the habits and conditions of life of sea fishes is very small and insufficient to enable either the practical fisherman or the Legislature to take measures calculated to ensure to the country the greatest return from the "harvest of the sea." Naturalists are, on the other hand, anxious to push further our knowledge of marine life and its conditions. Hence, the Association has erected at Plymouth a thoroughly efficient laboratory, where naturalists may study the history of marine animals and plants in general, and where, in particular, researches on food fishes and molluscs may be carried out with the best appliances.

The Laboratory and its fittings have cost some £12,000, and are now complete. The number of naturalists who can be employed by the Association on special investigations, and definitely retained for the purpose of carrying on researches throughout the year, must depend on the funds subscribed by private individuals and public bodies for this purpose. The first charges on the revenue of the Association are those for the working of the sea-water circulation in the tanks, the payment of servants and fishermen, and the salary of the Resident Director. The gentleman holding this post receives £200 a year and a residence. A naturalist has also been appointed at a salary of £250 a year, whose duties are almost entirely confined to the study of food fishes. THESE ARE THE ONLY SALARIED OFFICERS OF THE ASSOCIATION: the entire work of conducting its affairs has been done hitherto by voluntary service. It is confidently expected that valuable researches will be carried on at the Plymouth Laboratory by naturalists who will come there as volunteers, and will pay a small rent for the use of a working-table in the Laboratory and other appliances. It will be part of the business of the Superintendent and Naturalist to organise and direct these voluntary researches as far as possible, so as to obtain definite and practical results.

The Association has actually received, or has in promise, altogether about £15,000, of which £5000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £950, of which £500 a year for five years is granted by the Treasury, whilst £180 is in the uncertain form of Annual Subscriptions.

The admirable Marine Biological Laboratory at Naples, founded and directed by Dr. Dohrn, has cost about £20,000, including steam launches, &c., whilst it has an annual budget of £4000.

It is obvious that the MARINE BIOLOGICAL ASSOCIATION urgently needs additional funds in order to purchase such accessories as a steam launch and boats, and in order to increase the permanent staff engaged at Plymouth. The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

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NOTICE.

Persons desirous of joining the M. B. A. can do so on application to the Director, The Laboratory, Citadel Hill, Plymouth. Members pay One Guinea annually, or a Composition Fee of Fifteen Guineas for Life Membership. Founders pay £100. Governors (Life-Members of Council) £500. Members of the Association have the following rights and privileges: they elect annually the Officers and Council; they receive the Journal of the Association free by post; they are admitted to view the Laboratory at Plymouth, and may introduce friends with them; they have the first claim to rent a place in the Laboratory for research, with use of tanks, boats, &c., and have access to the books in the Library at Plymouth.

For a statement of the objects and organization of the Association, see page 3 of the wrapper.