lake is a great depth, so that this hill of 200 feet or more rising from the bottom represents a vast amount of solid matter, to say nothing of the thick deposits of dust all over the island. The lake was still bubbling in places, and things are by no means settled down yet. At Vavau, where we touched two days ago, they had just had a very severe earthquake, and shocks are still going on at Niuafoou (vertical, *I was told*, but my informant's wits were much shaken by recent events) daily on the level ground near our landing-place, from which it is inferred that the danger is not over. Strong gases too are perceptible rising from the ground near the coast, which is always where they apprehend most danger, and an outburst of lava. I suppose the solid matter coming up through the deep lake is pulverised into the (to life) comparatively harmless dust. During the earthquake of August 12, the captain of a ship at anchor found that, whereas he had paid out twenty fathoms of chain over-night, he had only eight fathoms under him in the morning. I never saw such big coco-nuts anywhere, though the trees are not exceptionally big, indeed there seem to be no very fine or old trees of any kind on the island, which favours the theory of a modern origin, for the soil is very fertile. The name means New Niua, the Old Niua being probably the neighbouring Keppel Island or Niua-tobu-dabu. I wish I could give you a better or fuller and more interesting account of the whole affair, but the visit was a very hurried one, and, in fact, I had not more than two hours on shore. Still it may interest you, as it is written on the very spot: no other account is likely to reach England. I send a pinch of 'sand' from the crater. "C. T."

This "sand" or "dust" is a very dark-brown—almost black—colour. When examined with a lens it seems composed mainly of fragments of glass, and has a slightly speckled aspect, owing to the mixture of lighter and darker fragments; one or two glassy-white fragments may also be noted. When some of the dust is placed under the microscope, it is seen to consist almost wholly of fragments—some rudely polygonal in shape, others flattish chips—of a brown glass; the former being the commoner. The majority of the bits vary from about ·01 inch to ·03 inch in diameter, and the latter measurement is but rarely exceeded. Minute chips are also present, but they do not form at all an important constituent in the mass A conspicuous characteristic is the (apparently) entire absence of the tiny pellets of "cindery" scoria, so frequent a constituent of volcanic dust, and of the fine pulverulent material, the presence of which commonly makes it needful to mount the dust on a slide before it can be properly studied. I have found no difficulty in examining this Niua-fu dust, and even the finer chips—often less than ·001 inch in diameter—by simply spreading it over a sheet of glass. The glass fragments, even when very minute, have a tinge of brown: when about ·01 inch in thickness, they are fairly translucent, and a rich olive-brown in colour; but as they approach ·03 inch in thickness they become opaque, light only passing through the thinner edges. Small cavities, spherical, or egg-shaped, are not infrequent, but the glass is remarkably free from microlithic inclosures. No granulation of the colouring-matter is perceptible, as a rule, with a magnification of 150 diameters; opacite dust and trichites (especially the latter) are very rare; and of other microlithic inclosures I have only seen an occasional lath-shaped crystallite (? feldspar). I have not identified among the fragments either biotite, augite, or hornblende; so that if any of these minerals are present they must be very rare. The clear glassy fragments mentioned above are feldspar—probably labradorite. They do not in number exceed about 2 or 3 per cent. of the whole. Many of the flatter brown-glass fragments exhibit ropy folds or the remains of a cellular structure, evidencing that they are due to the destruction of a very vesicular glass, while the more solid polygonal fragments may be the detritus of the thicker parts of the same or of a more uniform glass. The strong brown colour of the fragments reminds me of specimens of the more glassy lavas of the Sandwich Islands in my collection; and like them I should, from microscopic examination, consider the rock a basalt-glass (tachylyte) with a silica percentage, which was probably above rather than below 50. This view accords, I find, with Cohen's statement concerning the lava of Niua-fu, which, judging from his description, is very similar to that above described (*Neues Jahrb. für Min.* 1880, vol. ii. pp. 36 and 41); he says that it is almost identical in composition with the "basalt-obsidians" (*i.e.* tachylytes) of the Sandwich Islands. It contains 50·74 of silica; their analyses show from 50·82 to 53·81.

While the above was passing through the press, I received from my friend Dr. S. Rideal a determination of the specific gravity of the volcanic material (powdered to get rid of cavities). The specific gravity is 2·726. As the feldspar is included, and it is slightly the lighter, the specific gravity of the glass itself must be a little higher, about 2·73. Hence we need not hesitate to call it a tachylyte. The average of six Sandwich Island glasses is 2·71 (see Judd, *Q. J. G. S.*, xxxix. 444).

T. G. BONNEY

FOURTH ANNUAL REPORT OF THE FISHERY BOARD FOR SCOTLAND

THE Report of the Fishery Board for Scotland increases each year, not only in size, but in interest for the general public, as well as for those readers whom it specially concerns; and, unlike ordinary Blue-books, its pages are to a large extent devoted to scientific papers which appeal to many not directly concerned with the fishery industry.

The herring-fisheries continue to be most productive. A very striking feature of the summer herring-fishery of 1885 is, that many in-shore grounds, where herrings were previously found in great abundance, but which had recently been all but deserted, were restored to their former fertility. The increase of the herring-fishery in the Shetland district, which now ranks as the most important in the country, still continues, greatly to the improvement of the condition both of the people and of their boats. The fish are of finer quality than those taken on other parts of the east coast. The takes of other sea fish and salmon were also very large. The gross total estimated value of the sea and salmon-fisheries for Scotland was 2,859,822*l.* 15*s.* The Board have already expressed their regret that so many tons of sprats are annually used as manure. Could they be transmitted to populous districts at a reasonable rate, they would be a cheap and valuable addition to the food-supply, or, where this was impracticable, preserved as anchovies as in Norway, or as sardines as in Canada. The importance of utilising the by-products of the fisheries is now widely recognised. Papers by Dr. Stirling and Mr. Haliburton give an account of certain economical products obtained from fish, and experiments are being made on a fairly large scale by Mr. Sahlström at Aberdeen, which may, it is hoped, lead to some practical results. Investigations on whitebait by Prof. Ewart and Mr. Matthews showed it to consist almost entirely, and at all seasons, of young sprats and young herrings, varying according to the season of the year and the place of capture. It might, therefore, be advantageous for the Firth of Forth and other in-shore waters to send supplies of whitebait to the English markets.

The Scientific Committee of the Board had the assistance of Mr. Brook, Prof. Stirling, and Mr. Duncan Matthews, of Aberdeen; Prof. McIntosh, of St. Andrews; Prof. Greenfield and Dr. Gibson, University of Edinburgh; the Rev. A. M. Norman, D.C.L. of Durham; and Mr. Haliburton, of University College, London. Though the Marine Laboratories at Tarbert and St. Andrews admitted of several important inquiries being initiated, the Board is still greatly hampered for want of proper boats, and throughout the year the limited amount of dredging and field-work done was rendered possible by boats supplied by Prof. Ewart. It is to be hoped that arrangements will be made by the Admiralty, which will admit of the superintending vessels undertaking a complete survey of the spawning-banks and assisting in work of a like nature when required. A small steamer has already been provided for trawling experiments and other work on the east coast. At the Rothesay Aquarium the spawning of the cod was studied by Prof. Ewart and Mr. Brook, who generally confirmed the observations of Sars, and gained further information as to the natural and artificial fertilisation of the eggs, and their buoyancy before and after fertilisation in different kinds of water. The appendix contains part ii. of a paper by Mr. Brook on the development of the herring. Experiments made in artificial fertilisation of herring eggs appear to justify the following conclusions:—

(1) The ova retain their vitality, and are capable of being fertilised from forty to forty-eight hours after the female is dead. In the experiments performed, forty-eight hours seems to be a little outside the limit at which the eggs are capable of being fertilised, but it is probable that temperature may have an influence on the vitality of the ova. (2) The spermatozoa do not retain their vitality for nearly so long a period. Three hours appears to be the limit indicated by the above experiments. (3) The egg capsule never separates from the yolk excepting under the influence of spermatozoa. It would appear that when the ova and spermatozoa have partly lost their vitality a partial separation of the egg membrane from the yolk may take place, although the ovum is not truly fertilised. Experiments proved conclusively that the egg capsule is not permeable to water until after it has been penetrated by spermatozoa. (4) The egg membrane is covered with a viscous secretion when the ovum leaves the oviduct, which serves for the attachment of the ovum. This viscous layer gradually hardens in sea-water. Active spermatozoa are able to penetrate this layer some hours after it has set, but this power appears to be confined to the first twenty-four hours after deposition. (5) There is no collection of germinal protoplasm at the surface of the yolk in the ripe ovarian ovum, nor is a germinal disk ever found so long as an ovum remains unfertilised. The formation of the germinal disk cannot be made out in living ova, and its true nature can only be determined from a study of sections. Investigations on the formation of the blastoderm, and examination of a large number of sections, lead to the conclusion that the animal pole of the ovum gives rise to the ectoderm. In many forms the animal pole at the time of the formation of the segmentation cavity consists only of true archeblast cells. In the herring, and probably some other forms, the animal pole receives an addition of cells from the parablast prior to the formation of the segmentation cavity. The primitive hypoblast, which is almost entirely derived from the parablast (*i.e.* from the vegetative pole), gives rise to the mesoderm, and the secondary hypoblast (endoderm) remains as a single row of cells in connection with the parablast.

If these conclusions are correct, the similarity between the development of teleosteans and amphibians (*Rana*) cannot fail to be noted. The derivatives of the animal and vegetative poles are in both cases practically identical. The secondary segmentation (budding) in the parablast of teleosteans must then be regarded as the necessary consequence of the relative distribution of protoplasm and yolk in the vegetative pole. The primitive hypoblast, as here described for the herring, is precisely homologous with that of Amphioxus. In both cases the primitive layer gives rise to mesoderm, notochord, and true endoderm. The position here brought forward is one advocated by Mr. Brook over a year ago, but from the nature of the material then at his disposal he failed to observe the details of the process. Quite recently, Dr. Ruckert, who has been studying the behaviour of the parablast in Elasmobranchs, has come to conclusions practically identical with those here advocated for Teleosteans.

The question, "Are herring ova likely to develop normally on the deep off-shore fishing-banks?" is discussed by Prof. Ewart in a way which shows that the Board aims at practical results as much as mere scientific investigations.

Until comparatively recent years nearly all the herring taken in summer were captured by small boats within a few miles from the shore. In 1852, *e.g.*, immense herring shoals reached the Moray Firth to spawn on the Guillam and other in-shore banks. Since 1852 the fishing boats have greatly increased in size, and owing to the introduction of cotton nets, each boat has added greatly to its catching power.

As the boats have increased in size and sea-worthiness, the fishermen have proceeded farther and farther to sea in search of the herring shoals, and now the greater number of the herring are taken from forty to sixty miles from the coast. It is often alleged that it was owing to the herring deserting the in-shore grounds that the fishermen proceeded to sea in search of the shoals, and also that it is because the fishermen disturb and break up the shoals early in the season that they no longer or seldom visit their old spawning-grounds. There is no doubt that during the last fifteen years comparatively few herring have been captured during the summer over the in-shore banks of the Moray Firth; but whether this is the result (as is alleged) of the fishermen intercepting and breaking up the shoals before they have had time to reach the in-shore ground it is impossible to say. It is, however, a question of great interest, and one which could in all probability be easily settled. If the fishermen were to refrain from fishing for one year in the various districts along the east coast until the fish had reached maturity, this problem would most likely be solved. In all probability the herring would be found as abundantly as in former years in the in-shore waters, and the fish captured would be larger and riper than those taken early in the fishing-season of former years from the corresponding shoals.

That the takes during recent years have consisted chiefly of small fish (so-called maties), will be evident by a reference to Reports of the Fishery Board. It is generally admitted that the great depression of the fishery industry which now prevails would, to a great extent, have been prevented if half of the small herring (the maties) had been left in the sea. Many of those who account for fewer herring being captured in-shore, by saying it is impossible for them to run the gauntlet of the thousands of nets that are night after night drifting across their path, assert that the eggs are incapable of developing in deep water, and that in course of time the off-shore shoals will diminish or disappear. Of this there is in the meantime no evidence. As a matter of fact, for all we know there may have been immense shoals of herring spawning on the banks which lie at a distance of from thirty to sixty miles off the Scottish coast for centuries.

The existence and continuance of off-shore shoals will, to a great extent, depend on whether the herring are able to reproduce themselves without visiting the in-shore spawning-banks, and the success of the herring industry will depend on whether the herring shoals, which are invaded annually by our fishing fleet, continue to spawn sufficiently near the coast to render their capture a profitable enterprise for our fishermen. For this it is necessary to have large shoals moving in limited areas, and these are only found on the east coast during the winter and summer spawning-seasons. If herring ova are capable of hatching in deep water (say from 60 to 100 fathoms) it may be taken for granted that any of the many gravel-coated banks of the North Sea may serve as spawning-beds. The North Sea is remarkably shallow, there being only one small area near our shores (generally known as the "Pot," and lying two to five miles off Fraserburgh), where a depth of 100 fathoms is reached. The most certain way of proving whether herring ova hatch or not in deep water would be to dredge herring spawn from one of the off-shore banks in an advanced stage of development; but, after several unsuccessful attempts to do this, it occurred to Prof. Ewart that the question might be practically settled by depositing fertilised eggs in specially constructed hatching-boxes in deep water. This was done in the "Pot," but without result, as a storm swept away all traces either of buoys or boxes. The Moray Firth being in many respects unsuitable for this experiment, Prof. Ewart turned his attention to the West Coast, and found a comparatively sheltered spot in Loch Fyne, with a depth of 104 fathoms. To insure success, a small tank was constructed of thick slate slabs firmly bound together by iron rods. The tank, though only about 20 inches square, weighed nearly 2 cwts. In the top and in two sides of this tank small windows were made about 6 inches square. Each window was carefully fitted with a teak frame, across which a single layer of horsehair cloth was stretched. These windows admitted a sufficient current of water to pass through the tank. All the necessary preparations having been made for depositing the tank during last autumn. Mr. Brook, who was engaged at the Fishery Board Tarbert Station during the autumn, undertook to obtain eggs and superintend the sinking of the tank in the 100-fathom water. Eggs were obtained on September 11 from herring caught in Kilbrannan Sound in water varying from 8 to 12 fathoms. All the eggs were placed at first in the laboratory in water which had an average temperature of 54° F. Most of the eggs kept in the laboratory hatched out on the 19th, while others only hatched on the 24th, thirteen days after fertilisation. On the 16th, one of the glass plates, coated with eggs, was introduced into the tank above mentioned, which was immediately conveyed to the middle of the channel, and deposited in 98 fathoms water, about three miles off Tarbert. The surface temperature was 54° F., the bottom temperature was 49° F. The bottom around the tank was chiefly composed of mud. On the 24th—*i.e.* thirteen days after fertilisation, and eight days after the eggs were deposited in 98 fathoms water—the tank was raised. On examining the glass plate, it was found a number of the eggs in the centre had been destroyed by a fine coating of mud, which had entered through the hair-cloth screen, while those near the margins contained vigorous embryos almost ready to hatch; in a few cases hatching had taken place. The average bottom temperature while the eggs were deposited was 49°·3 F.; the average surface temperature, 54° F.,—the difference being 4°·7. The difference of 4°·7 during the eight days which the eggs were deposited delayed hatching for about five days. This experiment clearly shows that the only difference between the hatching of herring ova in deep and shallow water is one of time; hence we are safe in concluding that if herring deposit their eggs on suitable ground, in any depth of water not exceeding 100 fathoms, they will undergo development. It is conceivable, however, that the depth of the water in which the eggs are deposited may have some influence on the time of spawning—in other words, on the fishing-season; and the immature condition of the fish caught in August during recent years may to some extent be accounted for in this way. If the herring which formerly spawned on the in-shore banks of the Moray Firth in from 10 to 20 fathoms water now spawn off-shore in from 40 to 60 fathoms water, the hatching will be delayed for several days, and maturity will not be reached as early as formerly. This is an argument in favour of beginning the herring-fishing later in the season than at present. It may be objected that the fry, if hatched out in deep water, would never succeed in reaching the surface; and supposing that they could, the necessary food might not be found forty to sixty miles from shore. Observations, however, show that the young herring are likely to have little difficulty in ascending 200 fathoms before the yolk-sac is exhausted, and that though no one is yet well acquainted with the food of the fry, there can be no doubt about the richness of the surface fauna beyond even the fifty-mile line.

In the Report for 1883, Prof. Ewart called attention to the fact that the German Commission had arrived at the conclusion that the Baltic herring differed sufficiently from the North Sea herring to be worthy of being considered a special variety. It has long been held by fishermen and others that each district has its own peculiar variety. From some 500 specimens examined in 1883, no evidence of the existence of such varieties was found. In order to settle this question finally, Mr. Duncan Matthews has been examining, for a considerable time, samples of the herring captured around the Scottish coast, and now communicates an important paper on this subject. The method of investigation adopted was to take accurate measurements of the length of the head, and of the caudal, dorsal, and anal fins, to note the position of the fins on the body, &c., and, by a comparison of these data with the length of the body, to ascertain the amount of their actual variation, and especially whether these variations were so constant in the herrings of any one or more localities or seasons as to indicate a distinction of races. From this inquiry it seems that there are as large herring now as there were some generations ago, and that, although each district yields large herring, the north-east coast has a slight advantage in this respect over the south-east and west coasts. A table giving the size, &c., of the largest fish examined includes representatives from every fishery district, and shows that there is no practical difference in size between the male and female, nor in the numbers of each of these which were taken. The winter fish are found to be rather larger than those taken in summer, while among the fish commercially termed "maties" there are (1) immature herring, *i.e.* herring which, in addition to being small in size, have undeveloped milts or roes; (2) small herring in all degrees of ripeness up to maturity; (3) small herring which have spawned—small "spent" herring. Hitherto, the size of the fish, rather than the sexual condition, has apparently determined whether the term "matie" should be applied. In the same districts, and even in the same shoals, *large* sexually immature herrings are often found along with *small* ripe, or nearly ripe, herring; hence herring appear not only to vary in size in their fully adult condition, but also to vary in the size at which they reach sexual maturity. It is pointed out that these results, as well as the fact that the undivided ova vary in size in ratio to the size of the fish, are likely to cause considerable variation in the progeny which result from the interbreeding of fish of varying *size* and age. Of the fish caught in the early part of the season, a much larger proportion are immature and small, and probably also younger than is the case later on. The adult fish appear to reach a more advanced stage of ripeness before they approach the spawning-banks. From the measurements made, it is shown that the length of the head varies considerably the extremes being found in herrings of all localities and both seasons, the percentage with the larger size of head being rather greater among the winter than the summer herring; but this difference, like that of the total length, is considered insufficient to prove a racial distinction. The position of the centre of the dorsal fin in a majority of the winter herrings is anterior to the centre of the body, whereas among the summer herrings a large percentage have it behind the centre. In the immature fish, however, the fin-centre is generally anterior to the body-centre. The anal and pelvic fins show a corresponding difference in position. As regards the pelvic fin, however, this condition is limited to the adult and larger young herring, the pelvic fin being found, like that of the sprat, anterior to the dorsal fin in young herring below 60 millimetres in length. The pectoral fin varies very slightly in its relative position on the winter and summer herring. The relative basal length of both the dorsal and anal fins conveys no indication of racial distinction between the summer and winter fish. The dorsal fin is in all the herrings generally longer than the anal; only about 1½ per cent. of the summer herrings, and 7½ per cent. of the winter, having the anal fin longer than the dorsal. Further details are given respecting the number of fin-rays, keeled scales, circumstances of spawning, &c., but which scarcely affect the question of racial distinction. The inquiry, so far as it has gone, tends to prove that there is no racial distinction between the herrings found in the various localities around the Scottish coast. Judging, however, from the more backward position of the dorsal pelvic and anal fins, the doubtfully smaller head, and the slightly lesser size of the summer herrings, more minute inquiries may indicate a slight difference between the winter and summer herrings.

Mr. Brook reports on the herring-fishery of Loch Fyne and the adjacent districts during 1885, and under his "Ichthyological Notes" gives a short account of the rare fishes met with during the year.

Naturalists and fishermen alike have long felt the absence of accurate information as to the spawning period of fishes. In order to have a basis on which to found further investigations, Mr. Brook has prepared a provisional list of the spawning period of various food-fishes. This list brings out the great lack of accurate information on the subject, but gives an idea of the opinions as to the spawning periods held by fishermen and others around our coast. These opinions are in many cases conflicting, and in most cases they will require to be altered. Prof. McIntosh contributes an account of the work undertaken at St. Andrews since the last Report, including notes on the eggs and young of fishes studied during the past year. Recently considerable attention has been devoted by Mr. Wilson to the development of the common mussel, and an account of his investigations up to the present time will be found in the appendix. During the summer and early autumn several attempts were made to fertilise the eggs artificially at St. Andrews. The early stages of development were studied from ova obtained in this manner, while the free-swimming embryos were frequently obtained in pools amongst the mussel beds in the Eden and in other localities. In the Board's last Report it was mentioned that Prof. Greenfield had undertaken to investigate the lower organisms met with in some of our more important salmon-rivers. This investigation has been advanced a step, and numerous forms have been isolated and cultivated by the methods previously described.

Mr. Brook and Mr. Calderwood give the further results of examination of the food of these "useful" fishes, the herring, the cod, and the haddock. Mr. Calderwood also sends notes on the Copepods of Loch Fyne, and on the Greenland shark; Canon Norman reports on a Crangon, some Schizopoda, a member of the order Cumacea, new to, or rare in, the British seas; Dr. Stirling, on red and pale muscles in fishes, and on economic products from fish and corresponding vegetable products; Mr. Haliburton, on the blood of *Nephrops norwegicus*; Dr. John Gibson, on physical observations made for the Fishery Board in the Moray Firth during the autumn of 1883.

Ten plates accompany the appendix. It is greatly to be regretted that the Board has not yet been able to survey some of the fishing-banks, more especially those which are supposed to extend along the western shores of the Hebrides, and that the part of the Report dealing with scientific work is not published separately.

THE ELECTRIC CHARGE ON THE ATOM

Although considerable attention has been given of late to electrolysis and the subjects connected therewith by English chemists, more especially since the Helmholtz Faraday Lecture of 1881, yet some of Prof. Helmholtz's deductions from Faraday's experiments have been curiously neglected.

I refer more especially to the bearing of the facts on the true nature of valency, and I purpose in this paper to point out one or two fairly obvious consequences which follow from the results of Faraday's researches, but which have not, I believe, been stated before.

Prof. Helmholtz has shown that it follows from Faraday's experiments on electrolysis that while a monovalent atom carries to the electrode one charge of electricity a divalent atom carries two charges of electricity. For instance, when we electrolyse potassium chloride, we have each potassium atom delivering a charge of electricity at the one electrode, and each chlorine atom delivering an equal charge of electricity at the other electrode, all monovalent atoms, carrying with them an equal charge of electricity, which we may call the unit charge.

When, however, we electrolyse magnesium chloride, we have two atoms of chlorine set free for one of magnesium, and consequently while each chlorine atom carries its unit charge with it, the magnesium atom carries two units of electricity to the electrode. In fact electrolysis proves that differences of valency mean differences in the electrical charge on the atom. All this is so familiar to us now that I have perhaps repeated it at unnecessary length.

But we have many elements which vary in valency. For instance, copper is capable of forming two series of compounds, in one of which it is monovalent, and in the other divalent, that is, in one of which the copper atom carries one unit charge of electricity, and in the other carries two units of electricity.

We are able, then, under certain conditions to alter the electrical charge on an atom, increasing it by some simple multiple.

There are therefore a special group of chemical reactions, such as the oxidation of the cuprous salts, in which we have not merely combinations between two or more substances, or ordinary double decomposition, but in which, besides such changes, an additional electrical charge is given to, or removed from, an atom. I think it follows from this that all such reactions are of very special interest, and deserve careful study.

For instance, take the case of the saturation of an olefine by chlorine. We must look on this reaction from one of two points of view. Either on the addition of chlorine an additional charge is supplied to the carbon atom, in which case by-products of less saturation are probably formed; or the carbon atom is already fully charged, in which case the double bond is not merely a shorthand statement of a possible reaction, but expresses a physical fact.

There is also another point worthy of note in connection with this addition of electricity to the atom. If we take the case of the two copper chlorides—cuprous and cupric chloride—we find that their heat of formation per chlorine atom is not very different. Now it is well known that the heat of formation of a salt approximates to the heat of formation as calculated from the electromotive force developed when that salt is formed in a voltaic cell.